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Designing Persuasive Sustainable Waste Management Application for Urban Community in Malaysia: Understanding End-User Perspectives

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ABSTRACT

Solid waste management in urban areas in Malaysia is a critical issue that requires immediate attention. Waste management in Malaysia will become even more complex and difficult in the future due to the tremendous growth of the economy, urban population, and consumption patterns. The primary issue in this situation is the growing amount of waste production, which is outpacing the growth in disposal capacity. The Malaysian government has introduced the Waste Separation at Source Initiative (SSI), which mandates the Malaysian community to sustainable waste management practices in their daily lives. However, most urban Malaysians are unaware of these environmentally friendly waste management practices, despite the government's numerous attempts. Therefore, how to motivate the Malaysian community to adopt sustainable waste management practices has been of concern. A variety of persuasive technologies (PT) applications have been developed within sustainable HCI to promote sustainable waste management. However, its effectiveness among the urban community in Malaysia remains unknown. Accordingly, to develop an effective persuasive application for sustainable waste management, this study attempts to investigate end-user perspectives on effective persuasive design principles based on the Persuasive System Design (PSD) model. In-depth interview sessions were conducted with seven (7) participants, aged 31 to 47 years residing in various regions in Klang Valley. During interview sessions, participants were presented with several user interfaces (UIs) of waste management applications showing how each persuasive design principle had been applied. Next, we conducted a thematic analysis of positive and negative reviews of end-users to identify effective persuasive design principles to encourage sustainable waste management. Our results uncover 20 positives, 3 negatives, and 5 mixed views (positive and negative) perceptions. The positive perceptions fall under the following categories: *reduction, tailoring, personalization, self-monitoring, simulation, praise, rewards, reminders, liking, social role, trustworthiness, expertise, surface credibility, real-world feel, verifiability, social learning, normative influence, and cooperation* principles. Some of the negative perceptions include *rehearsal, similarity, and recognition* principles. Meanwhile, *tunnelling, suggestion, authority, third-party endorsement, competition, social comparison, and social facilitation* principles with mixed views (positive and negative) perceptions.

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1. Introduction

Most developing Southeast Asian nations like Malaysia are progressively being confronted by various environmental problems including greenhouse gases, air, and water pollution, flooding, and toxic waste management. A major contributor to this problem is people's incompetence and negligence toward the environment and the resulting environmental problems. For example, a significant portion of waste produced in most developing nations including Malaysia currently relies on landfills or open dumps [1] indicating a situation where people like discarding rubbish on the streets and in the river [2]. According to Pariatamby [3], 81.5% of the nation's garbage is dumped in landfills, while only 17.5% is recycled and 1% is composted. This poor recycling rate contributes to an annual increase in the amount of solid waste dumped in landfills. The government of Malaysia (SWCorp) reports a steady rise in municipal solid waste (MSW) production. It was recorded at 38,563 tonnes per day in 2015 and rose to 44,888 tonnes per day in 2018. According to projections, Malaysians will produce 51,655 tonnes of waste per day by 2025 [4]. To overcome these challenges, sustained behavior change at the individual and household level is required to reduce our individual ecological footprint, educate ourselves as well as alter or enhance our behavior to care more about the environment.

Persuasive technology (PT), sometimes known as "persuasive sustainability," is a widely used strategy in sustainable human-computer interaction to encourage people to alter or improve their behavior and attitudes without coercion or deception. The employment of various persuasive strategies or principles can result in these attitudes and behavior modifications. The design of PT makes use of persuasive principles to encourage people to alter their behavior. Research has shown that persuasive sustainability has mostly been utilized in various domains, including health and wellness, e-commerce, and education, to encourage individuals to reach a particular goal [5-7]. To encourage users to adapt their waste management behaviors, numerous interventions have been designed to promote waste management behaviors utilizing persuasive technology. For instance, prior research offered a comprehensive assessment of mobile apps for sustainable waste management. These apps support a variety of sustainable waste management activities, including self-tracking, regional waste disposal, recycling, games, managing conferences, managing food waste, DIY projects, etc. [8]. However, the effectiveness of these persuasion applications, particularly for Malaysia's urban community, is still unknown.

Accordingly, to design an effective persuasive sustainable waste management application for the Malaysian community, this study aims to investigate end-user perceptions of persuasive design principles that could potentially encourage them to adopt environmentally friendly waste management practices.

2. Background and Related Works

2.1 Persuasive Technology and Persuasive Design Principles

The concept of persuasive technology was pioneered by Fogg [9], concentrating on computer and information technology that seeks to alter attitudes or behaviors by making desired results easier to achieve. Fogg stated that technology must satisfy three requirements to be called persuasive technology (PT). First, persuasiveness must result through human-computer interaction (HCI), not computer-mediated communication (CMC). Second, the technology's ability to persuade users must be intentional and planned. Third, the interactive technology's persuasive aim must be endogenous rather than derived from an exogenous persuasive intent. Additionally, endogenous persuasion comes in two levels, such as macrosuasion and microsuation. Changing user behavior is the primary

goal of macrosuasion, which is persuasion at a large scale (e.g., Nike + is a fitness and exercise app). Microsuasion is persuasion at a micro level, when the system is not built exclusively on behavior change but instead incorporates persuasive design aspects to accomplish a particular purpose (for instance, Amazon.com's one-click purchasing feature encourages consumers to buy multiple items). According to Kukkonen and Harjumaa [10], persuasive technology is a type of emerging information system that supports behavior modification without force or deception, where the information systems could be a web portal, a smartphone application, or a traditional information system.

Over the years, several research efforts have been conducted to identify effective persuasive design principles to encourage behavior change. Earlier research by Fogg [9] enlisted seven persuasive principles by persuasive technology tools to persuade people of desired behavior namely reduction, tunneling, tailoring, suggestion, self-monitoring, surveillance, and conditioning.

In the meantime, Kukkonen [10] listed 28 persuasive design principles in four categories mainly: a) primary task support, b) dialogue support, c) system credibility support, and d) social support. The design principles in the primary task category include seven principles that support users in performing primary tasks and achieving their goals. The dialogue support category relates to computer-human interaction and focuses on supporting the user by providing some level of feedback that could increase the user's motivation to achieve their target behaviour. The system credibility support category includes principles that make the system more credible and persuasive. The design principles in the social support category largely influence the user's interpersonal relationships with other people (family, friends, colleagues) to increase the user's motivation and confidence to achieve the targeted behaviour [10].

Figure 1 displays the categories, descriptions, and persuasive strategies of the PSD framework. According to Kukkonen and Harjumaa [10], the PSD model can be used to study and deconstruct the persuasive techniques employed in any system. The persuasive principles outlined in the PSD model had been gradually implemented in a variety of systems or behaviour change applications to engage users and help them achieve desired behaviour change outcomes [11]. However, this framework is rather conceptual. Previous research revealed that when developing the application, designers needed to recognize the various needs of users with varied cultural backgrounds and values [12]. In order to successfully persuade someone and change their behaviour, it is important to understand how diverse cultural backgrounds affect how persuasive messages are received and how easily they are rejected [13]. Therefore, when designing waste management applications for urban communities in Malaysia, understanding end-user perceptions towards these persuasive design principles are very imperative to ensure the behaviour change applications to be developed would be effective at encouraging sustainable waste management practices among the urban community.

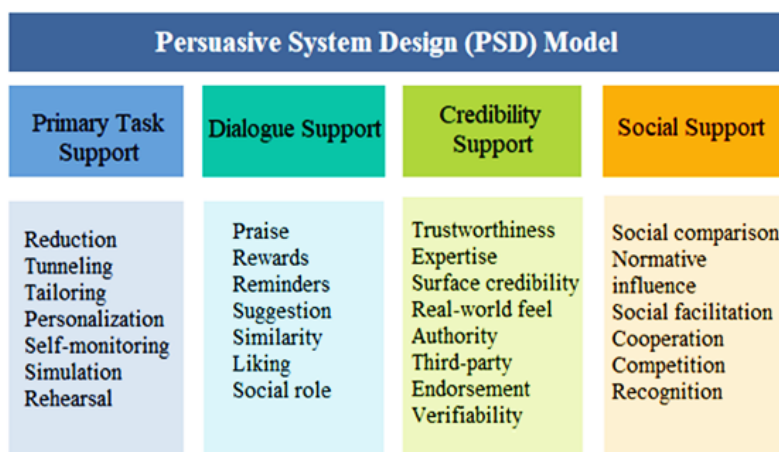


Fig. 1. Persuasive system design (PSD) model

2.2 Persuasive Principles Applied in Waste Management Applications

Both within and outside of academia, persuasive technology has been used as a tool to address unsustainable waste management behavior. The most present and relevant existing persuasive technology projects are: (1) Trash Game, (2) BinCam, (3) Household Recycling Behaviour (HRB), and (4) Bota. These are described below.

Trash Game is a gamified system which aims to educate people about the correct separation of waste and encourage better recycling behaviour [14]. This game consisted of (1) several bins which are augmented with a camera to capture the waste and display to present feedback and (2) a mobile application which is designed as a game. In game, the users manage a recycling company and one of their main activities is to sort waste to improve their revenue. The crowd feedback is also presented on the screen of the bins. The participants in an early evaluation study reported that they liked the application and augmented bins, but they concentrate more on the classification task rather than the game.

BinCam is a social persuasive system designed to capture waste-related activities [15]. BinCam is an enjoyable and collaborative activity that melds smoothly into users' regular schedules. The overall objective is to persuade users to consider the recycling and food waste behaviors of young adults. The evaluation of this intervention revealed a successful outcome: it was interactive, encouraging, socially collaborative, and successful in promoting recycling and food waste management habits. Later, to increase involvement and encourage sustainable environmental practices, the BinCam social application was updated and integrated into a Facebook application. The findings of this study demonstrated that users' knowledge, contemplation, and motivation to enhance their waste management abilities all increased [16].

Household recycling behavior (HRB) is a mobile phone application was designed to promote sustainable household recycling behaviour among adults in Sweden [17]. This persuasive technology intervention was found to spark the target users' curiosity, repeated use and help to break unsustainable household recycling habits.

Finally, a high-fidelity prototype of Bota is a tailored persuasive mobile application was designed to encourage people to adopt waste-friendly behavior [16]. Findings from the study showed a positive result in motivating people to make the desired behavior change toward sustainable waste management.

The Trash Game, BinCam, Household recycling behavior and bota follow the popular eco-feedback technology, which provides feedback on individual or group behavior to promote more sustainable choices [18]. However, these studies have a lack of religious or spiritual values that may not motivate the Muslim majority of the Malaysia's population. Accordingly, the objective of this study was to identify effective persuasive principles that could encourage sustainable waste management behavior among the urban community in Malaysia. These identified persuasive principles will be used to inform the design and development of a mobile-based sustainable waste management application.

3. Methods

In this study, an in-depth interview was carried out to identify end-user's perspectives on the persuasive behaviour change principles that could encourage them to apply green practices of MSW disposal in Malaysia. In order to present the concept of persuasive design to the participants, user interface integrated with persuasive principles for the waste management prototype were presented

to them. The following table 1 summarized the persuasive principles applied in the prototype of waste management application.

Table 1

Persuasive features of waste management application integrated with 28 persuasive strategies

Persuasive principles	Description of the principle	Examples of features implemented in waste management application
<i>Primary task support</i>		
Reduction	A system that simplifies complex activities to into simple one to assists users in carrying out the desired activity.	The application displays a color-coding calendar for a garbage collection schedule making it easier for people to know a specific day/date for a specific type of waste collection (e.g., Thursday, for recyclable waste, Tuesday for burnable garbage).
Tunnelling	Using the system to guide the user progresses through a procedure.	The application provides step-by-step guide instructions on recycling and reusing waste.
Tailoring	A system that offers information that is more compelling when it is tailored to the potential needs, interests, personalities, context of use, or other aspects of a particular user group.	The application provides information about garbage and recycling items collection schedules based on the user home address.
Personalization	A system's capability to persuade is increased when it provides personalised content or services.	The application offers personalized users' preferred languages, upload personal images, addresses, and garbage payment collection alternatives
Self-monitoring	A system that allows users to monitor their own performance or status aids them in accomplishing their objectives.	The application shows different types of waste produced for each day, weekly and monthly.
Simulation	Systems that offer simulations can persuade by allowing users to see the connection between cause and effect.	The application shows the impacts of waste being recycled on the environment. In this example, the application informs that the user has created 57 new plastic products by recycling 4% of the plastic waste generated.
Rehearsal	A system that offers tools for rehearsing a behavior can help people alter their attitudes or actions in the real world.	An application that encourages me to rehearse waste sorting and recycling behaviour within the app.
<i>Dialogue support</i>		
Praise	A system can encourage users to be more receptive to persuasion by praising them.	An application that praises and congratulates me for completing a level of recycling and disposing of waste.
Rewards	Systems that reward desired behaviour may have strong persuasion abilities.	An application that offers rewards points after completing a certain level of recycling.
Reminders	Users are more likely to succeed in their goals if a system constantly reminds them of their desired behaviour.	The application reminds me to follow green practices of waste disposal (reduce, reuse and recycle) by sending push notifications about disposing of garbage, interesting events, and new events, waste or recycling pickup dates.

Table 1 Continued

Persuasive features of waste management application integrated with 28 persuasive strategies

Persuasive principles	Description of the principle	Examples of features implemented in waste management application
Suggestion	A system that provides appropriate suggestions will have more persuasive powers.	An app that provides suggestions on alternative ways of reducing waste. (e.g., reusing plastic bags when shopping, reusing boxes for storage, etc., making an art/craft from old clothes.)
Similarity	Systems that meaningfully remind people of themselves will persuade them more easily.	The application speaks the user's language, showing images and quotes that remind them of their religion or culture. Any aspects that make users feel familiar with the application.
Liking	A system that is visually attractive to its users is probably more persuasive.	The app presents information for recycling activities that are visually appealing to the user.
Social role	Adopts a social function, such as facilitating communication between system users and experts.	Having a respected and prominent person as an ambassador or role model that practices a sustainable lifestyle and adopts green practices of waste disposal.
<i>System credibility support</i>		
Trustworthiness	A system that gives users accurate, reasonable, and unbiased information.	An app that provides truthful, reasonable, and unbiased information such as about the basics of composting, composting-related products, and composting methods.
Expertise	A system with the perception of incorporating expertise will have more persuasive power.	The app provides a platform for seeking experts to get advice about waste management practices.
Surface credibility	People base their early evaluations of the system's credibility on a personal inspection.	The user interfaces (UIs) of the waste management application have a competent look and feel. (e.g., respond to the feedback and email, don't oblige to fill a Registration Form, no Mobile Advertising, Send Appropriate Push Notifications)
Real-world feel	A system will have more credibility if it identifies the people or organizations that are responsible for its content or services.	The application provides information about recycle council's services and waste facilities, frequently asked questions, and relevant contact details of the organization.
Authority	A system that influences roles of authority will have stronger persuasive abilities.	Facilitate residents to submit waste collection and public cleansing complaints to Waste Management authority.
Third-party Endorsement	Endorsements from third parties, especially well-known and respected sources, increase the perception of credibility of the system	The used of the application was encourage and endorsed by the ministry/government (any well-known respected sources).
Verifiability	If a system makes it simple to verify the accuracy of site material through external sources, credibility perceptions will improve.	In order to verify the accuracy, the application provides the name of the waste management organization (e.g., KDEB Waste Management Sdn. Bhd.), a link to their website, and contact details.

Table 1 Continued

Persuasive features of waste management application integrated with 28 persuasive strategies

Persuasive principles	Description of the principle	Examples of features implemented in waste management application
<i>Sosial support</i>		
Social learning	If a person can utilize a system to see others engage in a specific behaviour, they will be more inspired to perform the same target behaviour.	The application provides opportunity for me to learn about recycling behaviour from other people. For example, after sharing recycling daily other people see the recycling behaviour e.g., uploading images of their separate waste at home, or their handmade art/craft they made with old clothes - reuse)
Social comparison	System users will be more motivated to perform the targeted behaviour if they can compare their performance with others.	The application provides an opportunity for me to compare my 3Rs performance with others.
Normative influence	A system allows users to get together with people who have similar goals in order to experience the norms.	Application such as recycling app provides a platform that allows governments, recyclers, and the whole community to all work together to gather, share and update recycling information to support an individual to adopt positive waste management behaviours.
Social facilitation	A system user is more likely to engage in a particular behaviour if the user sees through the system that others are engaging in the same behaviour as them.	The application allows me to recycle better when I feel others are recycling with me.
Cooperation	A system can motivate users to collaborate with one another in order to accomplish a behaviour's purpose.	This app provides an opportunity to work together with other people in a team to achieve the target behaviour (e.g., to reduce and recycle plastics as much as possible, donate an unused item for charity or good causes)
Competition	Users can compete with one another in a system to carry out the desired behaviour.	The application provides the leader board to see how your recycling habits compare with other members of the community.
Recognition	By providing public recognition, a system can make it more likely for a person to engage in a specific behaviour	The app provides a public scoreboard, a wall of fame honouring great performers in reducing waste, and publicly accessible ratings for garbage service providers.

The examples of the waste management user interfaces integrated with persuasive principles from primary task support, dialogue support, system credibility support, and social support are shown in Figures 2, 3, 4, and 5.

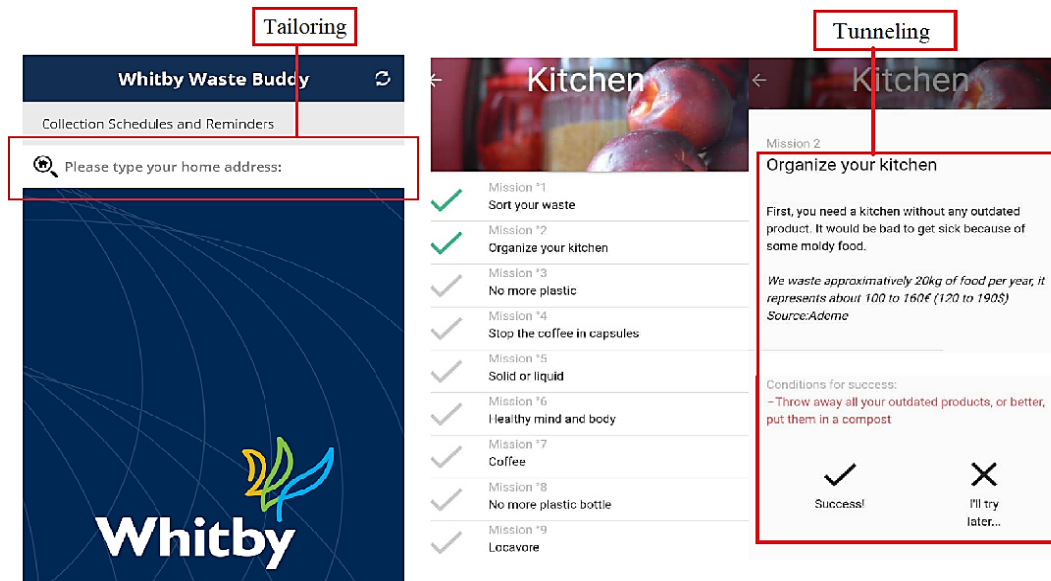


Fig. 2. Examples of *tailoring* principle (right) and *tunnelling* principle (left) from the primary task support category

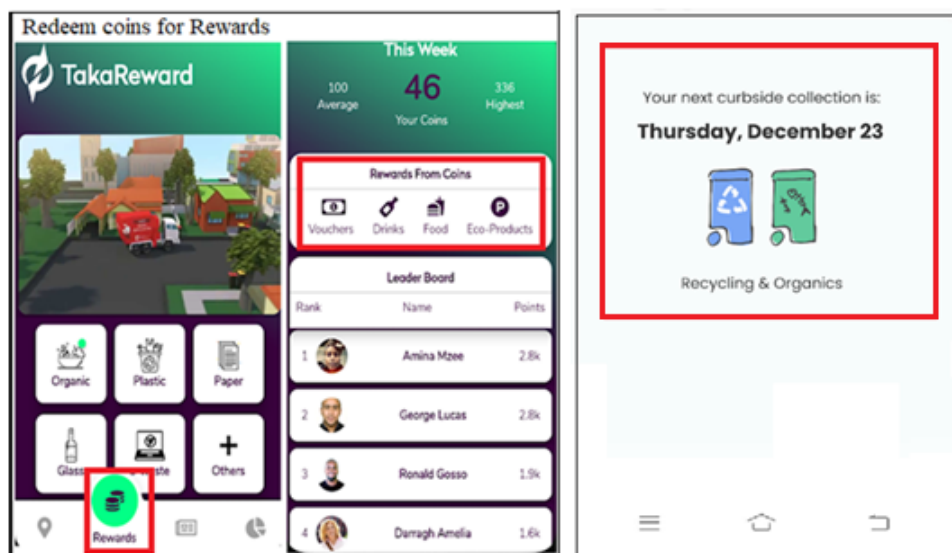


Fig. 3. Examples of *reminder* principle (right) and *rewards* principle (left) from the dialogue support category

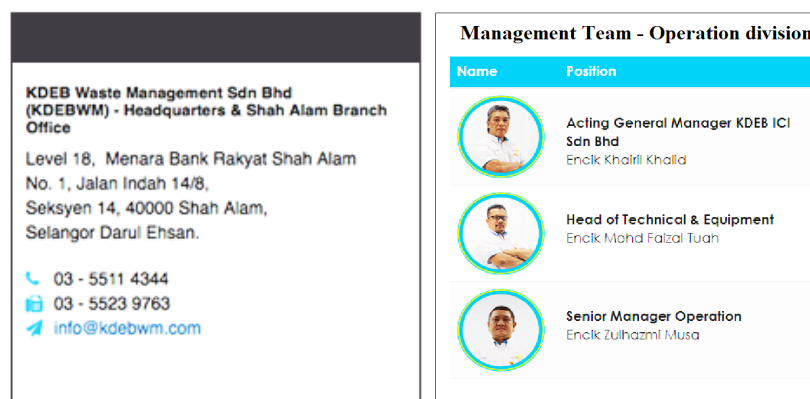


Fig. 4. Examples of *real-world feel* principle (right) and *verifiability* principle (left) from system credibility support category

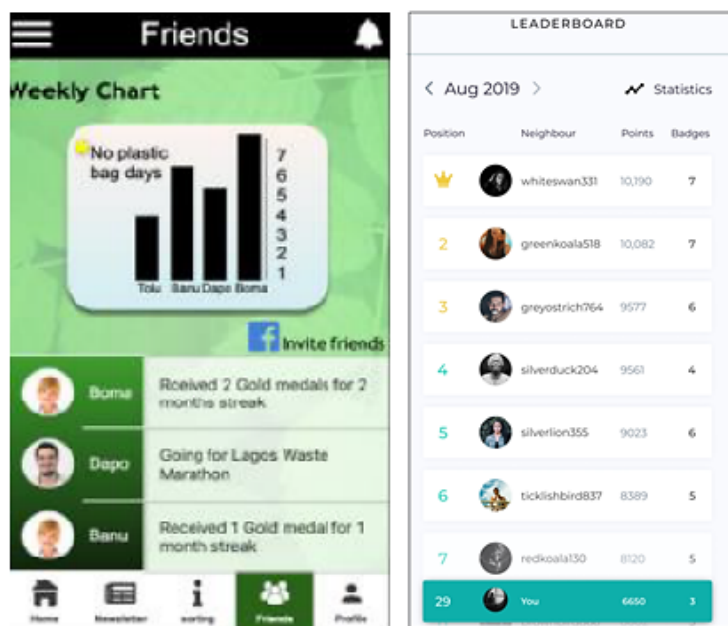


Fig. 5. Examples of *competition* principle (right) and *social comparison* principle (left) from the social support category

3.1 Participants Recruitment

Using a purposive sampling method, a total of seven (7) participants (6 females and 1 male) with ages ranging from 31 to 47 years participated in the study. In order to reduce prejudice, we specifically selected interviewees who had different viewpoints on the focal phenomenon. The following are the inclusion criteria for the study's chosen participants: 1) have at least 1 year of experience with smartphone usage, 2) have the intention to adopt green practices of MSW disposal using smartphone applications, 3) have lived in an urban area at least one (1) year. Five participants were recruited from previous study that investigated urban community awareness on MSW disposal based on Maqasid al-Shariah perspectives [19]. They were re-invited to participate in this study via email. The remaining two participants was personally invited by the researcher due to their interest in waste management practices using smart phone application. All the participants in this study gave their consent, including those from the previous studies who were asked for their consent again.

Between June 2022 and July 2022, the researcher conducted seven structured interviews with residents through in-person and virtual interview platforms via google meet and Microsoft Teams that covered the discussion about the effective persuasive principles to be considered in designing waste management interventions for sustainable behaviour change and sustainable waste management in Klang Valley.

In qualitative research, the specific number of participants cannot be determined before the study is conducted. At the point when data reaches at a point of saturation, for instance when new themes stop arising, the researcher can presume that there is no requirement for additional interviews [20, 21]. In this study, total 7 interviews were conducted, and it was observed that data reached an acceptable saturation point and the researcher decided that all the questions were responded to satisfactorily. During interview, the researcher noticed that little new data was being obtained by the four interviews. Nonetheless, additional three interviews were led to ensure that saturation point had indeed been reached. The last interview affirmed the data acquired in interviews and in this way shown that the data gathered had reached a point of saturation. At this stage, the researcher chose to close the interviewing process and proceed to analysis.

3.2 Procedures

The interviews were conducted in two (2) stages. In the first stage, participants were required to complete a demographic survey requesting personal data such as age, nationality, race, religion, number of years they have lived in the Klang Valley, the area in which they currently reside, and their experience using a smartphone application.

Then, in the second stage, participants were requested to interact with each 'persuasive design element' of the waste management applications. In this study, the 'persuasive design element' referred to the user interface (UI) feature of the waste management prototype that was integrated with the persuasive design principles.

As none of the participants were experts in persuasive design principles and might not be aware of their interaction with persuasive design elements in the waste management prototype, a number of screenshots of user interfaces (UI) of waste management prototype that used persuasive design principles were presented to them. As participants interacted with each persuasive design principle in the UIs, they were asked to respond to the following query: "Do you think the features of persuasive principle [x] would be effective or not effective to persuade their behaviour towards sustainable waste disposal?"

Participants' feedback and facial expressions were audibly and visually captured during each session, which lasted about an hour. At the end of each interview session, each participant received a token of appreciation for their cooperation.

The statements made by the participants during the interviews were then transcribed. Afterward, the transcribed data were coded in accordance with the PSD model using NVivo (launched in March 2020), a qualitative analysis software package released by QSR International. Next, to analyse the qualitative data by open-ended questions, we used a thematic analysis approach to identify the positive and negative perception of each PSD principle that will encourage the sustainable waste management practices.

4. Results and Discussion

Table 2 summarized the characteristics of all seven (7) participants from different regions in Klang Valley, Malaysia. In this study, all the participants fulfilled the inclusion criteria with having a smartphone uses for more than six (6) years.

TABLE 2
 The demographics of the participants

Participant no.	Gender	Age	Occupation	Residency	Years of living	Smartphone experiences
P1	Female	47	Lecturer	Petaling Jaya	17	>6 years
P2	Female	31	Self-employed	Kuala Lumpur	12	>6 years
P3	Male	32	Company Employee	Kuala Langat	9	>6 years
P4	Female	34	Syarie Lawyer	Gombak	14	>6 years
P5	Female	35	Syarie Lawyer	Gombak	16	>6 years
P6	Female	39	Student	Petaling Jaya	1	>6 years
P7	Female	37	Student	Petaling Jaya	1	>6 years

Further, the findings of this study were presented based on the categories of the PSD model of persuasive system design features: (1) primary task support, (2) dialogue support, (3) credibility support and (4) social support. However, it is important to note that that participants in this study came from a variety of occupations and different regions in Klang Valley who were responding to an

email invitation and indicated their interest and motivation to practice the waste management using smart phone application. The following Table 4 presents an example of one participant's excerpt in persuasive design principles of waste management application. Besides, based on the thematic analysis of this study, 20 positives, 3 negatives, and 5 mixed views (positive and negative) perceptions of participants towards the use of waste management applications were identified.

Table 4

Participant's perceptions of persuasive design principles in waste management application

Persuasive principles	Participant's perceptions
<i>Primary task support</i>	
Reduction	Positive: 'People are really so busy if some slots are given for picking up trash. Then it will be good. Then people will be interested in disposing of trash. Because then they do not have to look for those places and they do not have to drive to those places' (P6, 39 years old)
Tunnelling	Mixed views: 'Some people may be very reluctant or some people who are very stressed they might not use it. Because people are very busy. To me, I am not sure, whether I might use it or not use it.' (P7, 37 years old)
Tailoring	Positive: 'Yes. That will be effective. So, for me at least I know where I can throw my waste instead of roaming around. and do not know where to throw instead of that I just open this app and find the nearest centre to throw my waste.' (P3, 32 years old)
Personalization	Positive: 'This is a common thing. It must be in the app. If you cannot personalize you will not be able to use the app. The language is very important and how I can upload my profile. This should be there. Otherwise, the app will be incomplete.' (P7, 37 years old)
Self-monitoring	Positive: 'For me it is helpful. So that at least I can understand what kind of waste I produce and so what's other impacts on the environment. That creates more awareness for me. I will be more aware in the future.' (P3, 32 years old)
Simulation	Positive: 'It's very effective. Because we do not see the immediate result (what is the impact to the environment, society, and my life) why we do not do it? I want to see I am contributing. It will make me feel good that I have done something good for the environment or human beings.' (P7, 37 years old)
Rehearsal	Negative: 'I like to practice physically, not into the game.' (P5, 35 years old)
<i>Dialogue support</i>	
Praise	Positive: 'We need motivation even though in the system.' (P5, 35 years old)
Rewards	Positive: 'This will be effective and will be also interesting. With this reward, people will start doing all those things (adopt green practices). If you are giving a voucher, then it will be a good option.' (P6, 39 years old)
Reminders	Positive: 'This will be effective in our busy schedule. because although we are having a schedule and you showed some schedule about a particular date for waste collection. In our busy schedule, we don't remind those dates.so if we get some notification for a date then it will be good.' (P6, 39 years old)
Suggestion	Mixed views: 'I think suggestion strategy will not be effective because this suggestion is everywhere. Even in the shop itself the suggestion is there that we must buy plastic bag by using our money. Still people are buying that is it. Suggestion will not work.' (P7, 37 years old) 'We need suggestion strategy to manage our waste properly. We need daily updates with suggestions. For example, it is not good to buy plastic bottles, so we need a daily strategy with suggestions. Today we do not need plastic bottles. So, tomorrow what we need to focus. So, what is the suggestion to replace plastic bottle.'(P4, 34 years old)
Similarity	Negative: 'Actually, I do not know how this can help me.' (P3, 32 years old)

Table 4
 Participant's perceptions of persuasive design principles in waste management application

Persuasive principles	Participant's perceptions
Liking	Positive: 'If you give a liking point. And if you link it with rewards. Then it will be effective.' (P6, 39 years old)
Social role	Positive: 'Actually, for me, I do not bother who are they. As long as I have the information I will rely on that information, and I will do it on my own. This may be helpful for some people. Their role model is doing something good, so they will follow them.' (P3, 32 years old)
<i>System Credibility Support</i>	
Trustworthiness	Positive: 'This is really effective for those who are doing farming. If we are doing composting, then we need to do dispose of those things. These people will be really interested. The people who are doing farming only will be interested of doing this thing. Same thing is for recycling. If it is a mandatory thing then may be all will watch it.' (P6, 39 years old)
Expertise	Positive: 'This will be effective because if people are watching and reading this expertise comments then they will be knowing that this already happening or happened here.so, the public will be aware in this situation.' (P6, 39 years old)
Surface credibility	Positive: 'This is actually the challenge. Most of the applications have advertisements and everything. Sometimes it is annoying. So having a good visual interface helps a lot.' (P3, 32 years old)
Real-world feel	Positive: 'This will be effective so the public will get awareness or information about these services and whom we should contact. This is really effective.' (P6, 39 years old)
Authority	Positive: 'Contacting the authority is always troublesome. If the app makes it easy for us. This is another motivation point will get.' (P7, 37 years old)
Third-party Endorsement	Positive: 'It is good because most of the people will trust (the application)' (P1, 47 years old)
Verifiability	'Verification is very important. We should have this in the app.' (P4, 34 years old)
<i>Social support</i>	
Social learning	Positive: At least I can see and learn from other people what they are doing so it's kind of push factor for me. they are doing better so why not me. (P3, 32 years old)
Social comparison	Mixed views: Comparison can be benefit but comparison is not good for us. If its physically then it is good. I do not like comparison through online. (P5, 35 years old)
Normative influence	Positive: At least we know we are not producing solid waste; we can recycle and make money instead of throwing away waste. For example, From the platform, I watched video, I can learn to reduce my expenditure or reduce the use of plastic bags. (P3, 32 years old)
Social facilitation	Mixed views: Because I can observe people and people can observe me. For me sometimes it is not comfortable because some of the people tent to compare and I don't like being compare. So, from point of my view this is still good, but we have to better control how we can control. Because end of the day it's all come from my own behaviour my own self. I decide to throw it based on the information that you have provided earlier (other persuasive strategies). Meaning to say, this application I will do my own myself so I will not be reliable from others. (P3, 32 years old)
Cooperation	Positive: Cooperation is good for me to arrange the appointment for garbage collection. (P5, 35 years old)
Competition	This will be effective. Because we are competing with others, and it will give the motivation. (P6, 39 years old)
Recognition	Negative: I do not think people's names should be there. Sometimes it will make harassment. (P2, 31 years old)

Based on Table 4 above, for Primary Task Category, the *Reduction* principle was perceived positively by our participants because it reduces complex tasks for busy people to easily adopt appropriate waste management practices. This finding is in line with earlier studies suggested that reduction makes it suitable for people to reduce time spent in searching for a garbage collection schedule and allows them to quickly perform target behaviour [8,11]. Meanwhile, *Tunnelling* principle received both positive and negative views. In this study, some participants were accepting of *tunnelling* features while others did not consider *tunnelling* to be an important aspect of persuasive applications due to their reluctance and hectic schedules. According to their comments: "Some people may be very reluctant or some people who are very stressed might not use it. Because people are very busy. To me, I am not sure, whether I might use it or not use it." (P7). Another participant (P2) mentioned that people do not have the time to read the instruction, they need something which can really be seen and easily understood. However, other participants mentioned that they need the guidance and instruction so that they can make plan and learn more about how to reduce, reuse or recycle. A previous study highlighted the number of waste management applications implemented by *tunnelling* strategy in different categories and found that the *tunnelling* strategy was most used in the education category of waste management compared to cloth, plastic, food waste management and regional waste disposal, and others [16]. For *Tailoring* principle, all participants highlighted that the principle will be effective to encourage them to do proper waste management as it help them to check their schedules and waste disposal consequently. These findings are consistent with previous study [23]. Meanwhile, for *Personalization*, participants indicated the importance of a *personalization* strategy by selecting a preferred language, a personalized profile with personal photos, addresses, and recyclable waste pickup options in user preferences to make the system more effective. They also mentioned that they may abandon the apps if it does not support personalized access. This is in line with earlier research by Price *et al.*, [24] which found that an app's usability would increase if users could alter the colours and backgrounds as well as other options. Additionally, research has demonstrated that personalized persuasive technologies outperform the one-size-fits-all design strategy in terms of inspiring people to engage in specified behaviours [25]. According to a recent study [16], this is also true for interventions in sustainable waste management. *Self-monitoring* is another primary task support strategy that was positively perceived by our participants. They indicated that they are more motivated to tackle a task when they can monitor their performance. As one of the participants pointed out, "For me, it's helpful. At least this way I can understand what kind of waste I produce and what impact it has on the environment. It creates more awareness for me. I will be more aware in the future". (P3) Another participant said, "This is good. Because when I look at this, I know if I am managing my waste properly, and that has an impact on the environment" (P5). This finding is consistent with previous research that *self-monitoring* help users visualize their contribution to the environment, which in turn promotes responsible and conscientious citizens of society and motivates sustainable behaviour [8]. Our study also shows that *Simulation* is another important strategy to persuade users by observing the impact of waste recycling on the environment, health, and wellness of the people. One of the participants (P7) described that "Simulation is very effective. Because I am doing something and if I see the effect or my contribution even its small. I want to see I am contributing. It will make me feel good that I have done something good for the environment or human beings". Previous research has shown that *simulation*-based instruction can have significant effects on learners' attention, memory, judgment, and problem-solving approaches, as well as their motivation to engage in learning behaviours [26]. Therefore, to improve waste management practices, *simulation* principles play an important role in the interaction of individuals with their environment. The *Rehearsal* principle in

contrast was perceived negatively. Majority of our participants indicated that they would like to practice waste disposal in real life rather than 'rehearse' the behaviour in application.

For Dialogue Support Category, *Praise* principle was perceived positively by all participants. They indicated that they are motivated to perform better when they are praised by the system followed by the comment of one user, "We need motivation even though we are in the system." Further, another participant expressed that they like to see the appraisals that they made "Praising is also good. This is actually like a record that I have done". This finding is similar with previous research which stated that positive motivation or reinforcement can be attained by praising each sustainable waste management action through virtual praise [8]. Meanwhile, *Rewards* principle was highlighted by our participants as a strong motivator to create awareness and reduce waste. Besides, it is undeniable that people love to be rewarded for their behaviour change as shown by the comments: "It's given me motivation. People all love to get rewards. It's a true fact" (P5). "This reward creates more awareness. Then people are willing to do this. We know if we get a reward then we will reduce my expenditure and other things" (P3). Previous study mentioned that *rewards* are essential because they provide positive reinforcement regardless of whether it is virtual or real rewards [8]. This principle is important for the continued performance of the target behaviour. *Reminder* principle also had been perceived positively by all our participants. In this study, end users emphasized the importance of reminders in their daily lives because we are always forgetful. Another participant (P6) said "This will be effective in our busy schedule". This finding is consistent with the results of the earlier study that found that generic *reminders* were sent out daily or weekly to encourage users to keep using the application [27]. *Reminders* also are typically sent to users who do not meet their goals to keep them motivated [27]. Meanwhile our participants have mixed views towards *Suggestion* principle. Some end-users appreciated apps that include a *suggestion* principle, and they believe that *suggestions* should be more reliable to properly manage our waste. This is in line with a previous study that *suggestion* strategy is important for waste management to provide feedback to users to make them behave in a certain way [8]. However, another user stated that she does not like the suggestions in the apps. Therefore, we believed that the *suggestion* strategy will not be very effective in making changes to adopt an environmentally friendly lifestyle as different users has different preferences. For *Similarity* principle, five participants indicated that it is not "effective" while two users indicated that they did not know how the principle of similarity could help them adopt green practices in their daily lives. A previous study systematically evaluated 148 sustainable waste management apps and interestingly found that *similarity* was not employed in any other waste management app [8]. Similarly, *Liking* principle also perceived positively among majority of our participants. One participant mentioned that awarding points or credits would be better with linking rewards. She said, "If you give a liking point. And if you link it with rewards. Then it will be effective (P6)." Other users also highlighted that *liking* would give them encouragement to adopt green practices. "It gives some kind of encouragement" (P5). Previous study also revealed that the *liking* strategy motivates users by displaying relevant information in visually attractive and descriptive formats [8]. Besides, for *Social Role* principle, our participants indicated that the strategy is effective and attracts them to adopt waste management practices because the information is posted by a prominent person. Generally, this strategy positively influences behavioural norms within the forum. Ironically, despite its potential, a previous study attested that the *social role* is the most underutilized strategy dialogue support strategy in waste management apps [8].

For system credibility support category, *Trustworthiness* principle was implemented in the app to provide truthful source and reasonable information about waste management practices. Our study found that the conveying trustworthiness in the app is an important aspect of the design because participants trust the source. This agreement is supported by Oinas-Kukkonen and Harjumaa [10],

who mentioned that a system that is trustworthy has greater persuasive power. Besides, *Expertise* principle also was positively perceived by our participants. They indicated that experts are influential people, and they are more likely to follow an expert's advice and suggestions because it gives them awareness and knowledge. Prior research also demonstrates that applications developed by recognized sources or by professionals were regarded as having greater influence [27]. Meanwhile, *Surface Credibility* principle was found important strategy highlighted by our participants. A 37-year-old participant said that a good interface of the app is attractive. In addition, being able to respond to user's feedback and emails through the app, an app without add-ons is practical and useful for maintaining a competent app appearance. Another 32-year-old participant shared that the challenges are that the app allows users to ask questions or receive feedback from the apps. Additionally, an effective persuasive application must enhance users' confidence that their confidential personal data (such as their home addresses in apps) is in trustworthy hands. Oinas-Kukkonen and Harjumaa [10] claimed that a professional appearance and full disclosure of the owners' details make an app credible. Due to the sensitive nature of the app, Nkwo *et al.*, [8] assert that *surface credibility* is crucial for integrity, emotion, and pleasant feelings. Apps must look professional, be responsive, and have a visually appealing interface to be adopted because users in these areas are often wary and serious about them. Any app that lacks these qualities can be considered unreliable. *Real-world feel* principle emerged as the most popular credibility strategy in the apps, providing details about the individuals or organizations behind the app's content [11]. Our participants feel that application that highlight the people behind the system's content, providing information about recycling council services and waste management facilities, and relevant contact information for the organization is important for them to gain more knowledge, information, and who to contact. According to a previous study, the *real-world feel* is important for integrity, emotions, and positive feelings because it is a sensitive app. Therefore, it is important for apps to look professional, and be responsive [8]. The principle of *authority* was also cited as a concern by our participants. Applications designed to complain about garbage collection and public cleaning to the solid waste management authority were perceived as more influential. Majority of our participants indicated that it is important to communicate with the authority when the environment is polluted by waste disposal. They indicated that: "*Contacting the authority is always troublesome. If the app makes it easy for us. This is another motivation point will get*" (P7). Another participant (P6) highlighted that "*Information about authority is also effective. Because the public should have the freedom to communicate with the authority if something is polluted in the environment. so, they can directly communicate with them.*" Previous study has shown that only a few waste management applications (n=11) have implemented the principle of *authority* in a feature that allow user to contact with the authority [8]. Similarly, majority of our participants also perceived the *third-party endorsement* principle positively as the credibility of a system is enhanced by the application being promoted and endorsed by the ministry/government (or other known and respected source). *Verifiability* principle also has positive views as our participants express their trust in the app as they able to verify the accuracy of the waste management centres through their official websites. This makes the app more credible and thus increases the likelihood that users will trust it. This agreement is supported by Oinas-Kukkonen and Harjumaa [10] who pointed out that credibility is increased when a system makes it simple to confirm the accuracy of website content via outside sources.

For Social Support category, *Social Learning* principle was perceived positively as all our participants felt that it is a part of the learning process that can be learned by people in the community. The participants would be inspired to accomplish a similar objective if they could see what others have accomplished successfully. As a result, software design and employment of a *social learning* strategy will enable users to follow the progress of other users who exhibit similar

behaviours [28]. *Social comparison* principle provides users with the ability to compare their performance level with other users. In our study, the results show that our participants perceived *social comparison* differently. A 35-year-old participant said, "It's also an encouragement. Comparison can be beneficial, but the comparison is not good for us. If it is physical, then it is good, but I do not like online comparison (P5)." A 37-year-old participant said, "It depends on the age group. At my age, I am not interested in knowing how much my friend is making (P7)." The *social comparison* might be upward or downward, as Orji *et al.*, [23] noted. When used for self-improvement, it has an upward bias because the person using it compares themselves to others who are performing the same task. It is downward biased when people use it to boost their self-esteem by comparing themselves to those who are superior to them. Therefore, the design of software and the implementation of *social comparison* strategies should enable users to compare their performance with others. Besides, *Normative influence* principle was perceived positively by our participants. *Normative influence* is an important persuasive strategy for participants. The *normative influence* strategy is implemented in apps through positive peer pressure to increase the likelihood that users would adopt good waste management habits. One of the participants said of this principle, "At least we know we are not producing solid waste, we can recycle and make money instead of throwing away waste. For example, From the platform, I watched video, I can learn to reduce my expenditure or reduce the use of plastic bags." (P3). Therefore, the developers of sustainable behaviour change interventions should allow users and groups to share activities with each other and feel that the norm increases their engagement and motivates them to adopt healthy, long-term habits. *Social facilitation* principle which encourages recycling activity by indicating that other users perform the behaviour along with them received mixed views among our participants. Some participants said that sharing recycling activities can motivate others, as one of them said, "I think it's good. This kind of interaction with something environment that I am doing like this, he is doing like this (P4)". In this way, the app can better motivate other users who engage in the same behaviour. While other participants mentioned that they will be less motivated because some people do not want to rely on others to adopt green practices. *Cooperation* principle provides the ability to work with other people in a team to achieve a specific behavioural goal. For example, the waste management app can offer users the opportunity to donate an unused item to charity or good causes. An important aspect of the *cooperation* strategy emphasized by our participants is the encouragement, mutual support, and sense of making a collective contribution to feel like a part of bigger whole. This outcome is consistent with a prior study that found that a *cooperation* strategy can be used to increase the persuasiveness of technology designs [29]. Meanwhile, *Competition* principle received mixed views among our participants. Some of the participants appreciated *competition* because it allowed them to compare their accomplishments with other users [30]. Users that got social feedback generally exhibited increased competitiveness and exercise more [27]. "This is kind of fun. At least we can know that other people also joining us. So, we are not alone" (P3). However, two participants are not willing to compete with others. This might discourage them from using the intervention of persuasive technology. One of their comments is "I don't like leader board to compete with other members of the community. It might discourage us if we keep losing." Therefore, designers ought to set up a system where users can compete to better one another and be rewarded accordingly. This could supplement the traditional competitive strategy and even replace it for those who react poorly to compete against others to behave better [29]. *Recognition* principle is operationalized in the system by listing the names of top performers of sustainable waste disposal on a public scoreboard and showcasing their achievement that have successfully carried out the behaviours. In our study, this principle unfortunately was perceived negatively by our participants as they are concerned about privacy issues and harassment since *recognition* is visible to all. They want to focus on how the app

can help them with their daily waste management to protect the environment and the people. This is contradictory with finding from previous study which mentioned *recognition* as an effective way to encourage eco-friendly behaviours [31].

5. Limitations and Future Work

This study attempted to identify effective persuasive principles based on end-user perceptions that would encourage them to sustainable waste management practices in a Malaysian urban setting. The study involves interviewing seven (7) participants residing in different regions in Klang Valley. The focus on the participants of this study in the Klang Valley might not represent the whole population. Nevertheless, this study has highlighted the significance of understanding end-user perceptions towards PSD's persuasive principles. In future, the identified positive and mixed viewed persuasive principles based on end-user perceptions will be validated by an expert review which will help researcher to implement the most appropriate strategies in mobile application prototype that may successfully improve the waste management behaviour among Malaysian community.

6. Conclusions

This study contributes knowledge of how PSD principles can be applied effectively to support behaviour change toward sustainable waste management practices. The findings indicate that the perceptions of end users towards persuasive principles are influenced by their waste management practices. While the persuasive principles such as *reduction, tailoring, personalization, self-monitoring, simulation, praise, rewards, reminders, liking, social role, trustworthiness, expertise, surface credibility, real-world feel, verifiability, social learning, normative influence, and cooperation* generally received positive perceptions, and *tunnelling, suggestion, authority, third-party endorsement, competition, social comparison, and social facilitation* principles were highlighted the mixed-viewed perceptions by the participants. On the other hand, the *similarity, rehearsal, and recognition* principles were adversely viewed by the Malaysian community with a low level of adoption of waste management practices. Hence, this study has highlighted the importance of understanding end-user perceptions, which are not only useful for ensuring acceptance and implementation of the application but can also assist designers or developers to better understand user needs and requirements that may lead to design an effective waste management application.

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