



Research Paper

Persuasive Technology: An Overview of SMS-Based Persuasion for Waste Management in Low-Income Areas

Ugah John O¹, Obabueki Omo-Okhirelen², Tihamiyu Olalekan³

¹(Computer Science, Sciences, Ebonyi State University (EBSU) Abakiliki, Nigeria)

²(Directorate of Information Communication Technology, Lagos State University of Science and Technology (LASUSTECH), Ikorodu, Nigeria)

³(Computer Science, Lagos State University of Science and Technology (LASUSTECH), Ikorodu, Nigeria)

Corresponding author: Obabueki Omo-Okhirelen

ABSTRACT: In Nigeria, waste management research has focused on government policies and the performance of government agencies entrusted with waste management, as well as on improving payments through the use of information and communication technologies (ICTs). Government regulations and communication between waste agencies and communities have failed to produce positive results, as many states continue to see massive piles of rubbish, primarily in low-income areas, despite significant government investment. Research showed that persuasive technologies (PTs) helped in the improvement of human behavior across a range of application areas, while studies on the application of persuasive technology in waste management for low-income nations have proved beneficial. Short Message Service (SMS) intervention methods, using the basic mobile phone message service have grown in popularity worldwide, particularly in low-income countries, due to their low cost, high delivery rate, open rate, and no data requirement. Several studies on SMS-based persuasion have shown positive results in the behavioral change of participants across diverse age groups, genders, and socioeconomic backgrounds. In this paper, we will explore what persuasive technology is and discuss its application in selected domains. We will also show the effectiveness of SMS-based persuasive methods and their applicability in reorienting waste management practices in low-income areas.

KEY WORDS: Information Communication Technology (ICT), Low-cost interventions, Mobile communication, Persuasion Technology(PT), Short Message Service (SMS), Solid Waste.

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I. INTRODUCTION

Today rural areas are becoming urbanized without proper and immediate resources to meet this growth. This fast urbanization of rural communities puts a strain on the people, environment, and the agencies responsible for the environment [1][2] [3] [4] [5]. One area of grave concern for developing countries is waste management, and according to the World bank, this is so due mostly to their urbanized poor who tend to cluster in low-income areas of developing urban cities. Today, Lagos state accounts for the highest influx of in-country migration in Nigeria and has an estimated population of about 23,437,435 million according to a 2018 estimate by the Lagos state government. Many migrants to Lagos stay in low-income areas due to the cheaper cost of living in these places that are mostly with little government presence. This high influx to those areas has resulted in a strain on the environment and one such strain is the domestic solid waste generated by the inhabitants.

Previously, Lagos state exclusively manages its waste through the Lagos State Waste Management Agency (LAWMA) but since 1997 has partnered with the private sector using Private Sector Participation (PSP). LAWMA categorizes its service areas within the Lagos metropolis as high-income, medium-income, and low-income areas and in conjunction with the PSP operators employs a door-to-door policy in the domestic solid waste evacuation process [6]. These low-income areas are mostly unplanned, with street roads that are unpaved, small, potholed, and generally difficult to drive on. The buildings are predominantly what is locally called “face me I face you” houses with shared conveniences. Families in these types of housing keep their domestic solid waste in their kitchens, at the back of their residences or rooms, or inside the building property.

Compared to high and medium-income areas with the planned neighborhood, waste is placed in drums in front of houses provided by the refuse evacuation agency or the inhabitants. It has been observed that waste managers simply collect the waste from drums hence there is no need for pre informing the people of their presence in the areas.

In low-income areas, it has been observed that LAWMA PSP operators carry out refuse collection and evacuation using established days and two main communication methods. They send a member of their group to ring bells to inform the citizens of their presence or they alert the households by honking. Most trucks assigned to low-income areas are dilapidated and worn out which breaks down most of the time even in these neighborhoods. This has caused the waste evacuation activities in many instances to be erratic and when they do come, do not have access to the waste of the residents unless the residents of the compound are aware of their presence. It has also been observed that the PSP trucks maintain a safe distance from the majority of streets due to the poor condition of the roads, expecting residents to bring their waste to that point. This distance prevents neighbors from assisting others who are not available in disposing of their refuse. This has caused some of those residents to leave home at dusk taking their refuse with them which they then dump illegally at street intersections, or going out late at night to dump the refuse at illegal points. They also carry out refuse burning or the services of illegal garbage evacuators such as Mallams, who indiscriminately dispose of rubbish.

Several factors lead to poor waste management in low-income areas They include a lack of adequate knowledge on the hazards associated with poor solid waste management [3][4][1], waste disposal habits of citizens [7], weak enforcement of sanitation laws [2][8], ineffective communication channels [8] and an epileptic appearance of waste evacuators due to incessant break down of trucks assigned to cover the low-income areas. In light of the factors mentioned above, it is pertinent therefore to echo [8], who advocated for the persistent use of information technology to disseminate information to the public on waste management.

Furthermore, [9][10][11] describe waste management as a process in which one very important part is the creation of awareness. Lagos state and other state governments have also tried to communicate with residents through interpersonal advertisements and enactment of environmental laws to curb illegal waste disposal. But these laws have not deterred residence and we still find them finding ways to beat these laws [5][12]. These methods used for communication have not been adequate as observed by the magnitude of waste disposed of in unsafe places within low-income neighborhoods. Therefore, there is a need to find better communication methods that will be able to cause a change in the waste disposal attitudes of residents.

II. BACKGROUND

Research on waste management in Nigeria has been carried out on government policies and on evaluation of the performance of government agencies saddled with the responsibility of ensuring proper waste disposal. [6][13][14][15]. Others have focused on improving waste collection and payments using ICT [16][17][18]. Recent studies by [12][19][20], on building persuasion into interactive mobile devices to improve waste management attitudes in developing countries have shown positive results This paper looks at how Waste Management in low-income areas of Lagos state can be improved by using SMS-based persuasive technologies to capture the implications of illegal waste disposal on the health and the environment

2.1 Persuasive Technology (PT)

[21], describes persuasion as a method of communication that is used to persuade others without using deception or coercion. There is evidence that interactive systems can be purposely built to foster desirable habits or to induce desired behavior change through the use of various persuasive methods [22]. This is possible because these technologies offer the benefits of direct communication, empowerment, and crowdsourcing for collective problem solving [23]. The process of designing persuasion into interactive communication technologies is known as persuasive technology or PT. [24], defines persuasive technologies as interactive computing systems that are designed to modify people's attitudes and behaviors, hence increasing the likelihood of achieving desired outcomes. Additionally, they can be information systems or computational systems designed to reinforce, influence, or shape attitudes or behaviors, or a mix of the two, without resorting to coercion or fraud [25].

At the moment, persuasive technology is utilized to convince and inspire people in a variety of sectors, including healthcare, environmental and individual sustainability, education, and marketing, to engage in a variety of individually and collectively good activities. These approaches have been demonstrated to be beneficial in supporting individuals and organizations in attaining their growth goals [26]. Persuasion technologies have become an important aspect of our lives as they help in improving and sustaining a positive attitude towards different aspects of our lives such as education. health and fitness energy management, waste management, and climate change[27][28][12][29][30].

2.1.1 Types of computer persuasion

Persuasive technologies can be designed as computer-mediated persuasion or computer-human persuasion.

i. Computer-mediated persuasion: In Computer-mediated persuasion (CMP), the computer acts as a conduit for human connection. Individuals residing in different locations can connect via computer technologies such as instant messaging, Twitter, email, Facebook, LinkedIn, and electronic whiteboards and they can persuade and can also be persuaded through those technologies. In this situation, the computer facilitates conversation; it does not persuade. [25] stated that persuasive technology cannot be used to describe computer-mediated persuasion approaches. This is because the computer does not receive the persuader's intentions; rather, the computer acts as a conduit for communication.

ii Computer-human persuasion: In CHP, the persuader in CHP is the computer. Computer-Human Persuasion (CHP) is a technique in which individuals or organizations use computers/digital devices to motivate users to accomplish a specific goal [12]. This is in contrast to the CMP technique, in which the computer serves as a vehicle for persuasion and the persuader's goal is not passed to any computing equipment. Fogg used the term "functional triad" to describe the roles the computer plays in their interaction with people and how those should be considered in the design of a persuasive system. The triad is further described in figure 1 below.

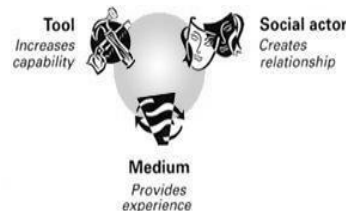


Figure 1. Functional triad [24]

As a tool the computer facilitates and accelerates the completion of tasks when and enables users to perform tasks that would be practically impossible without technology. And as a medium, the computer is utilized to influence attitudes or behaviors via simulations. Furthermore, the computer acts as a social actor due feelings that individuals or users have when interacting with interactive technology. People frequently behave as if the computer were alive.

I.

2.2 Persuasive strategies

Persuasive strategies are procedures that can be used in the design of PTs to drive changes in behavioral determinants, and hence in the behavior and/or attitude of subjects [31]. Numerous authors have developed and used different persuasive design strategies including Cialdini's six persuasive principles, Fogg's seven persuasive tools [24], Oinas-Kukkonen's expansion on Fogg's strategies to develop 28 persuasive system design (PSD) principles [31], and Orji's adopted 10 strategy approach for gamification of health systems [31]. The most frequently discussed strategies in literature are [24][25].

2.2.1 Fogg's seven persuasive design strategies

- Reduction: By reducing complex actions to simple ones, we increase the probability of users being motivated to perform them.
- Tunneling: When computing technology is employed to guide users through a method or experience, persuasive options become available.
- Personalization: Information gained through computing is more interesting when it is tailored to an individual's requirements, interests, personality, usage context, or other criteria.
- Suggestion: If a computing system provides suggestions at the appropriate time, its persuasive power increases.
- Self-monitoring: Self-monitoring enables individuals to keep track of their performance and judge how effectively they are carrying out the desired behavior. This increases their likelihood of exhibiting the desired behavior.
- Surveillance: Monitoring the conduct of others through computing technology enhances the likelihood of getting the desired behavior.
- Conditioning: In computing technology, positive reinforcement can be used to shape complicated actions or to convert existing behaviors into habits.

2.2.2 Persuasion system design (PSD) strategies

The PSD strategy is an adaptation and modification of the functional triad [21][31]. This was done (1) to overcome the limitations on its applicability during the design and development of persuasive systems. (2) its lack of explanation on how to transform and implement the persuasive principle in software requirements and system features. The PSD framework uses 28 strategies that are classified into four categories namely primary task support, dialog task support, credibility support, and social support.

- i. Primary task:** The primary objective of the strategies in this category is to influence the target behaviors. They are concerned with users' real-world tasks that are intended to support the behavior change for which the system was built. The strategies in this category are reduction, tunneling, tailoring, personalization, self-monitoring, simulation, and rehearsal.
 - Reduction: Making complex simple, makes them doable tasks.
 - Tailoring: Consider the user's needs as a component of persuasion.
 - Tunneling: Guiding users through the process.
 - Personalization: provide the option of personalized content
 - Self-monitoring: Allowing users to monitor their progress on their own.
 - Simulation: Enable users to observe the link between cause and effect immediately.
 - Rehearsal: PT system should Provide means to practice target behavior.
- ii. Dialogue support:** The strategies in this category allow communication between the user and the system and assist users in achieving their goals or desired behavior. The strategies used in this category include praise, rewards, reminders, suggestions, similarity, liking, and social roles.
 - Praise: Complimenting users can augment persuasion.
 - Rewards: Provide rewards for target behavior achieved.
 - Reminders: Provide users with reminders of elements related to the primary task.
 - Suggestion: Suggestions can make target behavior more successful.
 - Similarity: Prompting users with a meaningful reminder of themselves can be more persuasive.
 - Liking: Having an appealing look and feel for users.
 - Social role: PT Systems should adopt social roles.
- iii. System credibility:** This method is referred to as the perceived system credibility design strategy, and it outlines how to build a system in such a way that it is more trustworthy, and hence more persuasive. The strategies in the credibility category include trustworthiness, expertise, surface credibility, real-world feel, authority, third-party endorsements, and verifiability.
 - Trustworthiness: PTs should provide information that is truthful, fair, and unbiased.
 - Expertise: Information should show knowledge, experience, and competence.
 - Surface credibility: Competent look and feel.
 - Real-world feel: Make information about the operation and/or the people who provide content and services available
 - Authority: Referring to people in the position of authority.
 - Third-party endorsement: Present recommendations from valued sources.
 - Verifiability: Users should be able to independently check the site's content.
- iv. Social support:** Social influence is the process of using the power of others to persuade someone to adopt the desired behavior. Social learning, social comparison, normative influence, social facilitation, cooperation, competition, and recognition are all tactics included in this category.
 - Social learning: Watching other users perform target behavior and seeing the results as desirable.
 - Social comparison: Allow users compare their performance with other users.
 - Normative Influence: Bringing like-minded people together to achieve a common purpose.
 - Social facilitation: Helps to Identify other users who engage in the behavior.
 - Cooperation: Providing means for cooperation.
 - Competition: Providing means for competing with other users.
 - Recognition: Recognize users who engage in the desired behavior publicly

2.3. PT design models

In persuasive system design, two widely used design methods for developing persuasive applications are Fogg's eight-step process for persuasive system designs described in [32] and the PSD method [31] [33][21].

2.3.1 Fogg eight-step design process

Fogg proposed an eight-stage process for persuasion technology design and development. The goal is to increase the chance of success for persuasion technology developers.

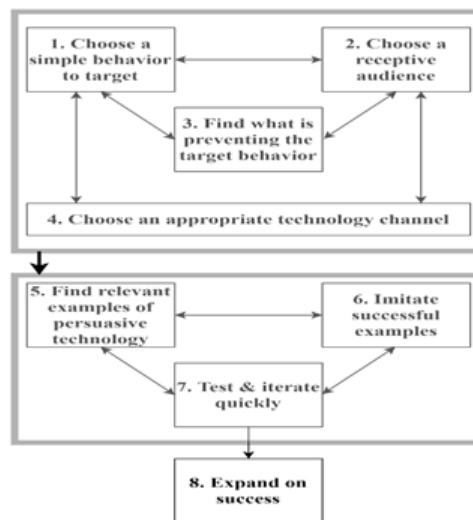


Figure 2. Fogg persuasive design model [32]

The design model follows a sequential flow of operation but allows two steps to be undertaken at the same time and also a design team can go back to a stage or retry or rethink a process. In the process, a persuasive system developer should choose a simple behavior to target, choose a receptive audience, find what prevents the target behavior, choose a familiar technology channel, find relevant examples of persuasive technology, imitate successful examples, test, and iterate quickly and expand on success.

2.3.2 Persuasion system design (PSD) model

Currently, the most complete persuasive application design model is the PSD approach by [34]. It addresses [32] design limitations once more by structuring the design processes and giving a list of system features and requirements for development and it has been applied successfully in research [21][35]. The PSD method is divided into three phases: the key issue, the persuasion context, and the system qualities phase. The key issue phase employs seven postulates to assist the designer in comprehending the main issues involved in the development of persuasion systems; two of these postulates concern the designer's assessment of the user, two concern persuasive strategies, and the remaining three concern system features. The persuasive context phase conducts an analysis of the intent or desired behavior change type, investigates the persuasion event, and evaluates the effectiveness of various techniques for achieving the desired outcome. The third step, or systems quality, defines the actual design of system qualities by utilizing four support categories: primary task, dialogue, system credibility, and social support. These support categories are designed, reviewed, and implemented at the feature level.

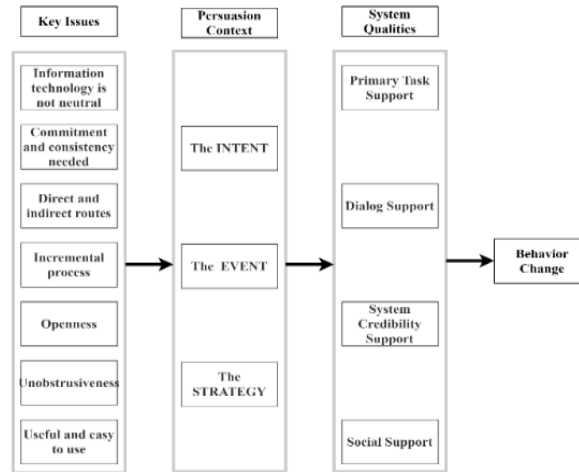


Figure 3. The PSD model for persuasive design [31]

III. APPLICATION of PTS in SELECTED DOMAINS

Many aspects of our lives being influenced by PT. in this section we look at some domains in which PTs have been widely implemented.

3.1 PT in health

Persuasive health technology (PHT) is any technology purposely designed to influence, reinforce, change, or shape health-related attitudes or behaviors. Behavioral interventions can be developed to maintain or improve a person's health status. Delivering behavioral interventions via PHTs is a promising approach for encouraging healthy behaviors among individuals and populations [36]. [30], describes PTs for health as PTs for health promotion and prevention and PTs for disease management. PTs for health promotion and prevention targets behaviors taken by individuals to prevent illness, detect early symptoms, and maintain general well-being. They include PTS designed for physical activity, healthy eating, smoking cessation, avoiding risky sexual behavior and unwanted pregnancies, and proper dental health. PTs for disease management help patients improve health-related self-management skills such as teaching them to manage certain illnesses, helping them to comply and adhere to treatment directives.

In recent years, our way of life has become increasingly sedentary, which has led to significant public health issues such as obesity, diabetes, cancer, cardiovascular diseases, and other conditions [38]. Compared to previous generations, our life now involves more sitting. For instance, some people spend more time in environments that limit physical activity and require prolonged sitting. The need for improving physical activity today is overwhelming due to the attendant problems associated with inactivity. We find mobile phones now with fitness trackers to monitor the number of steps a user makes daily which helps users understand and identify opportunities to improve physical activities. In research, [38] studied persuasive technologies for improving physical activities and reducing sedentary behavior. The study outcomes showed a 51% successful outcome and a 21% successful outcome from a selection of 170 published papers in the Physical Activity and Sedentary Behaviour domains between 2003 and 2019. Many types of research have been carried out and apps designed to improve physical activity and reduce sedentary lifestyles. They include Pretty Pelvis [39], VRabl [40], KidLED [41], BENFIT [42], FitCoach [43] etc.

3.2 PT in education

Many schools now use ICT for enhancing the process of teaching and learning which has allowed them to meet the needs of a variety of learners. Also, the use of interactive systems and the internet allows teachers to meet the needs of students by providing effective channels for the distribution and delivery of learning resources to them. It has been observed that despite the advantages provided by computing technologies for learning, many students have not been able to improve in learning on their own, at their own pace and convenience [44]. This is due to the many distractions that compete for the student's attention like watching videos, chatting on the different social media platforms, the craze for regular status updates on platforms like TikTok, Instagram, WhatsApp, etc., listening to music, and so on. Therefore, the objective of persuasive technology in education is to increase the student's motivation to learn and engage actively in learning activities, and studies have shown that persuasive strategies such as reward, social comparison, social learning, and competition motivate students to achieve their goals [45].

Studies by [44][45][27][46] on persuasion technology to improve positive behavior in education have shown improvement by participants. In [45] seven characteristics of persuasive educational technologies were identified that have been applied in various researches on PTs for education. They are listed in table no 1. In [47] persuasive technology was used in the development of the HANDS (Helping Autistic Diagnosed young people Navigate and Develop Socially) project which helped students with diagnosed autism improve behavior towards educational interaction. Also, in [48][49] SMS based persuasive technology was used to send SMS at regular intervals to low-income students which helped to reduce dropouts by 33% and increased enrolment by 5.7% respectively.

Characteristics	Description
Persuasive strategies	Techniques used during the study's development to influence the user.
Susceptibility	The likelihood that a user will respond favorably to a persuasive strategy.
Personalized persuasion	Designing the study around the strategies that potential users are most receptive to.
Gamification	Game elements were incorporated into the study's development.
Context	Environmental factors that influenced the study's development.
Student areas	Elements or characteristics of the student are taken into account during the study's development.
Theories	Non-persuasive principles or knowledge are incorporated into the study's development.

Table 1: Characteristics of a persuasive educational system

3.3 PT in waste management

Research has shown the advantages of designing persuasion into mobile interactive media for waste management [50][51][52][20][53]. In [50][51][52], the research studied ways of improving the recycling behavior of users in developed countries and was dependent on the use of augmented waste containers or bins controlled by attached mobile devices such as mobile phones, tabs, or PDAs. In [54], an app was created that used geolocation to identify positions of waste bins within the city and users can use the app's search function to find the nearest waste bins. It also allowed users to set reminders to remember to recycle or evacuate waste and also know which waste bin was empty or full. [12] discusses a waste management app for encouraging students in a higher institution in eastern Nigeria to adopt clean and sustainable behaviors and protect the university environment via the provision of various personalized persuasive displays and support. Reviews on the design of persuasive technology show that the focus is on the design of mobile apps as persuasive technology for improving the behavior of individuals for waste management. For example, in two reviews by [55] and [56], the study was on the predominant persuasive strategies employed in the design of mobile apps for waste management. The results of those research showed that the most persuasive designs for waste management focused on mobile apps and the use of the primary task support strategy [34].

IV. SMS-BASED PERSUASIVE TECHNOLOGY

SMS, or short message service, is a text-only protocol that was initially codified in the GSM standards, which were released in 1985. Typically, a mobile device will send an SMS to another using a cellular network. Although some services employ 5-bit mode, which permits 224 characters, the messages can normally be up to 160 characters long. Currently, the use of low-cost message-based interventions is being increasingly used to promote target behaviors, especially in low-income countries. Short Message Service (SMS) intervention methods have become popular around the world due to their low cost, effectiveness, high arrival, and open rate.

The effect of SMS is robust regardless of population characteristics and can be received by anyone regardless of the socioeconomic import of the owner's mobile phone. Another advantage of SMS is that it can

be read via mobile phones in any situation even without data. Research in diverse domains on the applicability of SMS-based persuasion has been carried out and has shown success in improving the behaviors of participants in the different studies across varied age brackets, genders, and socioeconomic statuses. SMS has been used in low-income and middle-income countries to conduct public health interventions due to its low cost [57].

Reminders in form of SMS are effective in behavior change in different areas[58], and some unhealthy habits such as smoking, sedentary behavior, excessive calorie intake, have been corrected using SMS as persuasive reminders[57]. In [59] using SMS to inform teenagers about recycling proved to be an efficient means of persuasion while in a study by [60], text messages as an intervention for increasing the rate of cancer screening showed an increase in screening rates. In Pakistan, a study by [61] using SMS was able to change the attitude of young people towards politics positively, also in [62] SMS persuasion helped obese women reduce weight after birth. Another area that SMS persuasion helped in providing a positive attitude has been in response to the Covid-19 pandemic in developing countries. In [57], a study to determine the effectiveness of public interest SMS in curtailing the spread of Covid-19 proved advantageous. In [63] sending SMS-based emergency alerts on good covid-10 practices was found to be effective in combating and encouraging preventive behavior in public.

V. CONCLUSION AND FUTURE RESEARCH

5.1 Conclusion

In this research work, we have carried out a study on persuasive technologies (PT, s), persuasive strategies, and PT application design models. We also looked at some areas in which persuasive technology has been used to influence positive change in the attitude of people and, also looked at research in persuasive technology for positive waste management behavior. Finally, we considered research in SMS-based persuasion as a basis for understanding its applicability in waste management research. The characteristics of SMS and the outcomes of the various studies show that SMS interventions can also be applied in low-income areas to influence a change in the attitude of residents towards better waste management.

5.2 Future work

As a continuation of this study, we intend to survey selected low-income areas in Nigeria to determine

- i. The effectiveness of the communication methods employed by waste managers.
- ii. The mindset of citizens in low-income towards waste and its implications.
- iii. Create an SMS-based persuasive system to improve waste disposal attitudes in these areas.

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