IMPACTS TO PUBLIC RECYCLING FROM PSYCHOLOGICAL AND TECHNOLOGICAL STIMULUS

by

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(Under the Direction of Jenna Jambeck)

ABSTRACT

Pro-environmental activities are often cumbersome for people and lack of commitment can limit conservation of natural resources. An important pro-environmental activity is on-the-go recycling since a significant percentage of waste is generated outside the home. This project involves the use of different modifications of a public on-the-go recycle bin, representing specific types of positive stimuli, in order to provoke responses from people that can provide valuable information about public recycling behaviors. The objective of the research is to shed some light on what factors may influence public recycling based on data collection from baseline and interventions groups. This study will provide the environmental community with valuable information on psychological and technological stimuli that can be used to inspire people to participate in on-the-go public recycling programs.

INDEX WORDS: Recycling, Eco-feedback, Stimuli, Technology, Human Behavior.

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CHAPTER 1

INTRODUCTION

Technology has been explored to better the lives of people, and it has influenced the way people see their world. Unfortunately, this had had a negative effect in pro-environmentalism since people adjusted to see only the side that technology presented forgetting or ignoring what happens "behind the curtain" (Katzev, 1992). In order to tackle this problem, engineers enlisted the help of technology to try and reverse the damage by developing interfaces that would remind people of the importance of natural resources conservation (Froehlich et al., 2010). However, in order to achieve successful results and products, it is still imperative that designers take into account the effects of human behavior and the complexity of the human mind.

Human behavior is related to conserving natural resources and reducing environmental impact, not only because people can directly affect their environment in a positive or negative way, but also because resource conservation can be a hard task to commit to by people. Within the last few decades, researchers have dedicated time and effort to studying different methods of engaging people in environmentally conscious activities (Oskamp, 1995); however, only a few scientists have examined this engagement for specific efforts, and even less have examined methods to make these activities enjoyable. Working in a community in order to achieve a better life for future generations, though it is a moral issue for many, still includes "working," and in people's busy lives, it is practically impossible to put time and effort into solving a problem that is often being managed by large companies and governments (Thogersen, 1996). With this in mind, it is not surprising that many individuals do not feel compelled to participate, much less engage, in pro-environmental activities such as recycling and water and energy conservation (Berglund and Matti, 2006), and this lack of commitment by most people is a critical component to any environmental approach that depends on community participation and response.

Approximately forty years ago, the environmental psychology discipline was created to tackle this problem. This new discipline was dedicated to exploring how to trigger a positive human response to environmentally conscious activities. Since the discipline was created, researchers have studied a variety of psychological stimuli that trigger the desired positive reaction from different communities (De Young, 1999). This research has led, in part, to the statement of the most basic stimuli categorization (conscious and subconscious triggers) that produces a positive performance in pro-environmental activities, as well as many important techniques to implement the mentioned stimuli.

Years later, with the use of technology as a tool, another discipline examining people's reactions to different stimuli was born. Works based on human computer interaction in "Eco-feedback technology" (Froehlich et al., 2010) also started to experiment with creating attractive stimuli to provoke environmentally conscious reactions. Although the results of this approach are valuable in establishing the importance of new stimuli into the variation of human behavior, they are often lacking the extended theoretical research that environmental psychology has (Froehlich et al., 2010). A combination of these research disciplines such as socio-techno solutions (grounded on both social sciences and technology research) to environmental engineering problems can address their particular issues through engineering, along with quantitative and qualitative analyses.

The two disciplines have strengths that appropriately complement each other and that can be used to design a strategy to inspire people to recycle. The issues that people have with this specific pro-environmental activity, according to earth911.com, can be reduced to three major categories: 1) Inconvenience: People have trouble finding recycling bins and programs near them; 2) Lack of information: Users find that recycling rules and information can be quite difficult to find for which they decide not to recycle; 3) Trade-offs: Some people do not recycle for the simple fact that they get no immediate benefit from it.

Objectives and Expected Results

The overall objective of the project is to establish the relationship between certain psychosocial stimuli (or techno-social event) with recycling rates as well as with changes in human responses to recycling in different social environments. Specifically, we want to 1) analyze and test different stimuli to evaluate their impacts on recycling; 2) create and modify different testing devices (*e.g.*, visual aids and/or electronic human-computer interfaces) to test the different models, and 3) evaluate different social environments in order to establish the relationship between each stimulus and a macro or micro social environment.

It was expected that technologically provided psychological stimuli would increase the recycling rates and improve commitment among the UGA college community compared with rates calculated from a baseline, and from non-technological psychological stimuli. It was also expected that recycling strategies success would depend on the social environment in which they were tested, being more effective on a macro social environment (community event, football games), than on a micro/individual (everyday) environment.

Experimentation and Evaluation Approach

This study focused on finding valuable stimuli that would inspire people to recycle. Three experiments involving different engineered systems designs and human subjects were performed (IRB approval #: 2012-10091-1). The experiments are reported as consecutive chapters in this document. The first two experiments were designed to take a more inclusive (value-oriented) social approach towards behavior modification by including the social ecological system framework, which includes micro (individual) and macro (community) systems. The third, and last, experiment was informed by the theory of design based research (DBR). Upon reflection on experiments one and two, we found we had included concepts of DBR, albeit unintentionally, and so we consciously used DBR for the third experiment.

The first experiment, explained in Chapter 2, was to deploy an eco-feedback prototype during the macro social environment of a University of Georgia football game. After observing behavioral patterns and organizational change features, it was imperative to analyze if the stimuli would be equally successful in the micro social system. Then, as shown in Chapter 3, a new experimentation design was created to observe recycling in the micro social environment during non-technological and technological interventions to be compared with a baseline phase of data collection. During this experiment, learning methods and organizational change features were observed, which lead the creation of a different experiment that would enhance the experience for participants.

At this point, the research had serendipitously included two of the three principles of design based research by including practitioners on the design of the research and using technology to aid the learning and adaptation process. The missing principle consisted of the analysis of earlier iterations to refine the design and general environment of the educational tool. Concluding that support system of a community was important for faster adaptation, a third experiment, presented in Chapter 5, was designed to evaluate macro social characteristics along with technological eco-feedback by analyzing illustrative data.

Quantitative and qualitative data were collected including, counting of recycled items at specific locations for every experiment, field observations, and electronic and website counters. The time periods and locations were different among each experiment; however, items were collected, counted, and weighed to be compared quantitatively among interventions for each. For qualitative data, the observation field notes were the primary source of analysis, and reflection about human behavior during the different experiments. An interview protocol was designed to evaluate each strategy more objectively (every third participant was to be interviewed); however, out of six attempts, only one participant agreed to the interview, so data was primarily limited to observations. Therefore, participant reflection and learning was inferred from the context of the observations. Interestingly, the study not only evaluated recycling strategies, but shed light into behavior modeling in pro-environmentalism, and also explored the potential of educational and organizational change features on sustainability learning.

CHAPTER 2

LITERATURE REVIEW

The design of this study includes a wide variety of fields that could influence and be influenced by the findings of this research. Since the study focuses on behavior modification to promote pro-environmentalism, some human behavior and environmental psychology basic concepts were explored in order to be applied to this project. In addition, since technological tools were also used, the possibilities that human computer interaction and eco-feedback technology could offer were also explored, along with their applications to solid waste management strategies. Lastly, we explored and compared related work on educational and organizational change, human behavior, and human computer interaction related recycling.

Basic Concepts

Human Behavior & Environmental Psychology

The behavior of human beings has been studied by different disciplines throughout history, *e.g.*, social sciences such as Psychology, and Social Work. This division appeared after Sigmund Freud and his Individualistic theories raised new questions for why people behave the way they do. At that moment, new theories such as developmental, behavioral, humanist and even neo-Freudian psychology theories tried to explain some of the gaps left by Freud. Psychoanalysis, with Freud as its father (Moore and Fine, 1968), focuses mostly on the individual rather than the social context or environment in order to make assessments about human behavior, which limits behavioral evaluation.

However, more socially centered theories focused greatly on people's social environment, offering enlightening theories about human behavior. For instance, the humanist theorist Abraham Maslow established a pyramid of needs that would lead to a successful and socially functional individual (Schott, 1992). This pyramid was based on the physical and social needs that must be satisfied before reaching self-actualization. Starting with the physiological needs such as food, shelter, and even sex, the pyramid gets to the concept of respect for others and compassion, which inherently cannot be reached if one of the primary needs is not satisfied (Zastrow and Kirst-Ashman and Ashman, 2010). Developmentalists Erik Erikson and Daniel Levinson take the evolution approach, attributing certain behavioral characteristics to different age groups and stating that each of the stages has to provide an individual with specific traits that would ensure a mentally and socially healthy human being (Commons, 2002). According to Levinson, the most decisive changes and future habits are developed between the ages of 17 to 33 years, in which an individual looks for stability and the development of a unique lifestyle (Zastrow and Kirst-Ashman, 2010). The problem with Levinson's theory is that it is mostly applicable in males, for which other theories like Erikson's developmental theory, although older, are popularly used. Erikson gives great importance to each of his stages, since success in the next would depend directly on the outcome of the previous step (Zastrow and Kirst-Ashman, 2010). However, the most appropriate stages to make changes are the Fidelity and Love stages in which the individual is trying to identify his or her needs and interact with the world based on them. These stages are attributed to the age group between 12 to 19 years (Zastrow and Kirst-Ashman, 2010).

Another difference between many individual psychosocial approaches and social approaches is that individual theories tend to be mostly problem oriented while social theories tend to be more value oriented (Zastrow and Kirst-Ashman, 2010). This difference was likely the main reason for which the study of human behavior related to environmental conditions took the name of Environmental Psychology. Thus, although Environmental Psychology has been proclaimed as value and problem oriented, it mainly evaluates the human-environment interaction issues and problems in order to find appropriate solutions to them (Proshansky, 1987).

According to Environmental Psychology studies, human behavior can be influenced by stimuli such as feedback, and interaction (Hattie and Timperley, 2007). The use of these stimuli has been a powerful tool to change people's lifestyle over many years, generally for marketing and publicity (Nakajima et al., 2008). Few researchers have attempted to encourage environmentally conscious behaviors by using the same stimuli. Engineering has been widely diverged from the human sciences for many years, and even though recently there have been engineering branches dedicated to human computer interaction, the gap (on experimentation, evaluation, and general research techniques) between engineering design and humanities has not come much closer (Froehlich et al., 2010). Because of this gap, it has been difficult for scientists to try a technological/behavioral approach towards pro-environmental activities.

Relevant literature describes different psychological models that define the main categories of psychological stimulus with great influence on human behavior, which have also been demonstrated to be effective when tested for a specific purpose (Froehlich et al., 2010). Environmental Psychology studies focus on testing how humans react in the presence of a stimulus when evaluated in their own habitat (Vicente and Reis, 2008). By conducting experiments in the field and comparing the results to a baseline, Environmental Psychology studies have tested how various models have effectively reduced energy, water, and/or natural gas consumption by 15% to 20% among the tested households when delivered in their own defining circumstances (Froehlich et al., 2010). These circumstances are unique for each model and they often make a model easier to test and handle, more effective, and/or more appropriate for specific experiments, which could determine the popularity of a model.

Some of the most popular models are *information*, *feedback and incentives / disincentives and reward / penalties* due to their relative independence of human involvement in the stimulus delivery phase. The *information* model states that in order to achieve better results the information provided must be easy to understand, trusted, attractive, and as close to the event as possible. It is based in the premise that better information would help to awake the environmentally conscious side of people (Brewer, 2005; Cialdini, 1991). The *Incentives/Disincentives and Reward/Penalties* model establishes the difference between these two by clarifying that the former usually happen before the action as opposed to the latter, which happens afterward (Geller, 1990). It also explains that the incentives and rewards could be economic, of status or fun incentives, and that they are more effective than their counterparts (Valente, 2002). The *Feedback* model has been successfully included in all the other models due to its proven effectiveness since any reinforcement or information "feeds back" to the user influencing present or future use. All the research done in this model has proven its efficacy in resources consumption reduction when giving constant, detailed, and interactive feedback (low-level feedback) instead of high-level feedback such as bills and energy consumption (Becker, 1978).

Other models involving preliminary human response are the *Goal Setting* model, *Comparison*, and *Commitment*. The Goal-Setting model is based on comparing the present state with a future desirable state, but this model has not been popularly studied (Yates, 1983). The *Comparison* model could be applied to individuals or groups and has been proven to have excellent results when combined with feedback about performance (Froehlich et al. 2010). The *Commitment* model talks about how making a public pledge or promise to attain a goal has reduced utility bills by 15-20% of the baseline (Pallak and Cummings, 1976). Analysis of these models suggests that the study of the models has not been fully propagated, probably due to the complexities that human behavior adds to the research project.

Eco-feedback Technology & Human Computer Interaction

More recently, environmental psychology has added technological aids to some experiments, consulting with engineers and designers, who then started developing the new field of eco-feedback technology. The technologically based approach to environmental issues brought also the need for the development of electronic tools or devices that complemented the concept of eco-friendliness while stimulating the user to perform a certain action (DiSalvo et al., 2010). For this reason, the design of these tools needed to be thoroughly analyzed from the user's perspective, therefore, the need for human-computer interaction models and techniques. Human-computer interaction (HCI) research provides engineers with a great variety of conceptual models that promote more successful designs. Most of these models are based on a user-centered design that counts with strict requirements such as the analysis of the user experience and the usability of a design (Sharp et al., 2007). Among the human processes that represent significant challenges for technological design are attention, perception, learning, and memory (Sharp et al., 2007). Fortunately, HCI has developed principles such as proximity, clearness, pictorial realism (designs that make sense), and replacing memory with visual information, in order to deal with each challenge respectively (Sharp et al., 2007).

However, HCI has shown some disadvantages when compared to Environmental Psychology, who in turn could also benefit from more extensive exploration on human-computer interfaces. Environmental psychology studies conducted field experiments with up to two hundred participants, lasting as long as 10 months, they focus only on human behavior; while HCI research developed small laboratory experiments with an average of 12 participants for only a couple of weeks and their main focus was the devices or interfaces testing (Froehlich et al., 2010). It is obvious then that each one of the disciplines mentioned studies deeply their own field without involving much the other, so that HCI lacks study and field experimentation while Environmental Psychology lacks human interfaces design. The importance of HCI inclusion on pro-environmental activities has been demonstrated by the popularity of human-computer interaction among eco-feedback designers and the fact that it has become one of the most important strategies to inspire pro-environmental behaviors such as water conservation or solid waste management, specially recycling (Wang, 1990; Stern, 1999; Holstius et al., 2004).

Solid Waste Approaches & Strategies

In regards to solid waste management, the human component has always been important. In comparison, for wastewater, people simply flush a toilet; for water, people simply turn a faucet. Both of these behaviors are fairly easy to modify to provide some conservation of these resources (Arroyo et al., 2005; Kapel and Grechenig, 2009). However, waste management, even in the home, takes some effort, and recycling, even more effort. In public places, the effort required is often greater as recycling bins may not be obvious to the user ("London," 2009). For this reason, a variety of approaches and strategies have been taken in the field to inspire the user to take that extra step necessary for a better solid waste management leading to a better economy and resources administration.

Recycling, for example, has proven economic and environmental efficiency considering the externalities that the natural environment welfare introduced to the equation. For instance, the United States Environmental Protection Agency (US EPA) stated that recycling reduced carbon emissions in 2005 by 49 million metric tons in the US as well as 10-15 metric tons in Great Britain. Aluminum and plastic, more than other recycling items, are the most efficient materials to be recycled with 95% and 70% energy savings from recycling, respectively, and 95% air pollution savings by recycling rather than producing new aluminum containers (Economist, 2007).

The economic improvement would also be significant in the landfill management investments, since most of the current amount of land-filled items could be reused beneficially, not only by recycling 68% of it, but also because another 20% could be composted to produce energy, which would leave as few as 12% of the currently generated solid waste to deal with on the landfills according to the Georgia Department of Community Affairs in 2005. Recycling is especially beneficial on public places or events where there is an average of 2.44 pounds of waste generated per individual (Cascadia, 2006). Also, according to the US EPA 30% - 40% of waste is generated outside the home for which it is important to involve the community in recycling activities and initiatives like the US EPA "Recycle on the Go" (Bivens and Johnson, 2006).

Analysis of Basic Concepts

The literature review supports the notion that environmental psychology and technology approaches have evolved to a point where each other's strengths complement the other one's weaknesses respectively and it is left to future research to utilize portions of each technique, combining them in such a way that a new approach could provide more insights and results. In this way, it is important to explore not only the appropriate combination of approaches, but also the stimulus and delivery that will result in the greatest human behavior change.

In the human behavior aspect, the experiment has to be performed within a community that complies with two important characteristics. First, the community should be able to achieve a behavioral change, for which, it must have the possibility to grow through the change phases and reach the tipping point, where the change reaches a social and organizational stability so as to become permanent (Burke, 2011). It also has to be composed of individuals on the verge of change, according to Erik Erikson and Daniel Levinson (for which a behavioral change would have higher probabilities), and that, according to Abraham Maslow, should have their basic needs satisfied at the maximum possible level (Zastrow and Kirst-Ashman, 2010). Furthermore, this community must provide the option to evaluate behavior in a macro, as well as a micro social environment. The University of Georgia community meets the above requirements in various ways (students have most of their basic needs satisfied, diversity and size allow for observation in the micro social environment, and shared goals in the macro social environment) and also offers another advantage, the possibility of implementing the strategy in a public organization where recycling initiatives could be critical to achieve a valuable change.

The design and physical requirements of the experimentation environments for this project will have to include collaboration from the organization as well as specific characteristics to develop a good user-centered design. Having the support of the office of sustainability at UGA, a standard setup could be chosen in order to collect data without disturbing normal behavior or environment for the users, thus, making the experience with a new design as smooth and non-invasive as possible, giving a higher chance of success (Kappel and Grechenig, 2009).

Related Work

It is important to understand that in a diverse environment (e.g., UGA Tate Center) people may not have much in common and are fairly dispersed in proximity to each other. Learning (and decisions based upon learning), may not be as powerful as when ideas are exchanged and contribute to a community (Burke, 2011). It is also the communal exchange of ideas and information that create a more valid sense of accomplishment, hence a positive experience based on the welfare of the community, the sense of belonging, and/or the praise coming from early adapters or innovators

(Chaisamrej, 2006). Leaders (innovators guiding change) in a community can facilitate new behavior adoption (Burke, 2011).

In a small-sized community, experienced individuals (e.g., who have some knowledge on recycling) transmit information easily and serve as “mavens”, thus enhancing the experience of new users (Burke, 2011). Mavens create a scaffolding process that allows more timid participants to explore new technology with the feeling of safety that others have tried it before. Scaffolding theory, which is a strategy for achieving behavior changes in organizations, is also used by educational theorists such as Vygotsky to inspire more effective learning outcomes (Russell, 1999).

As human beings, we are surrounded by possibilities for learning as we are constantly trying to make sense of the world, and it is this collected knowledge that influences our decisions (Norman, 2004). Specifically, in regards to this project a positive attitude could offer the option of transforming recycling into a fun and exciting activity worth of investing time. In order to transmit a positive attitude and instill the importance of recycling, it is necessary to design and implement real-world application tools and guided experiences (Hassard, 2009), since a clear connection between the quality of the experience and the learning outcome has been established (Dewey, 1998).

This study differs from recent work, in that, despite presenting a relationship between cognition and recycling, Sinatra (2012) does not evaluate the change of environments and the inclusion of technology. Although realized later in the process, the approach for this research came directly from the analysis of previous work and included DBR principles. DBR ensured that we included practitioners in our evaluations to address the lack of recycling commitment in a real context, that we integrate design principles and technological approaches to find possible solutions, and that we rigorously and reflectively adjust the experimentation environment and design to achieve the best results (Reeves, 2006).

For example, previous research on recycling in a university setting showed that there were benefits to involving a large part of the university community to develop, analyze and participate in recycling strategies. One study found that visibility, convenience, and information would be great allies to encourage a recycling mentality among university communities (Kelly, 2006). In another study, Katzev (1992) found that information about the amount and type of material recycled at a certain location fills a part of the information gap that people find discouraging about recycling. By providing this information, the participants get to "peek behind the curtain" of what happens when they recycle, which increased their desired to participate in recycling (Katzev, 1992). In general, providing information or feedback appeared to motivate the public to recycle.

Other type of motivations come from playful technological interfaces, Froehlich et al. evaluated three human-computer interfaces targeting human behavior modification for recycling. The first, Wang et al. (1990) found that commitment is a powerful force for continuity of behavior at the individual level; however, it does not have long-term effects when it is a group commitment. The second, Stern (1999) analyzed the effects of interactive information, concluding that it has a different function than incentives and using only one or the other could be misplaced, but when deployed together they can have synergistic effects on recycling. Lastly, Holstius et al. (2004) explored a more technologically focused study that concentrated on evaluating the interface. Simultaneous interfaces were used to attract people to a certain location and compared for a short period of time. However, the study did not include any human behavior change that could have emerged from a previously observed baseline (Holstius et al., 2004). Other purely commercial or technological approaches include The SmartBin Company products ("Smartbin," n.d.), the Dream Machine by Pepsi.co ("PepsiCo," n.d.), and countless other electronic recycle bins ("Dyscario," n.d.; Chen, 2012). Currently this type of bins have limitations such as geographical unavailability of the Dream Machine, which has not yet been deployed on at least ten states ("PepsiCo," n.d.) and the lack of user feedback at reasonable (approximate to current prices) price options on the other bins.

One of the most helpful works used in this study was the Steg's framework to encourage pro-environmental behavior (Steg, 2009). The framework consists of: 1) identifying the behavior to be changed, 2) analyzing the main factors underlying this behavior, 3) applying interventions to change the relevant behaviors and their determinants, and 4) evaluating the effects of the intervention on the behavior, determinants, environment and life quality. In this research, the framework applied as follows: 1) The behavior to be changed is the lack of recycling; the desire was to increase public on-the-go recycling; 2) It was surmised that people were not noticing recycle bins and there was a lack of information and immediate benefit to the public from recycling; 3) The design was visible, provided information as close to the recycling event as possible, in an environment where social reinforcements were possible; 4) Experiments were conducted collecting quantitative and qualitative data to evaluate the intervention.

CHAPTER 3

IMPACTS TO RECYCLING FROM TECHNO-SOCIAL STIMULI DURING A UNIVERSITY COMMUNITY EVENT[1]

[1]Mozo Reyes, E., J. Jambeck and K. Johnsen. To be submitted to Proceedings of Computer Human Interaction CHI.

Abstract

It is now widely recognized that the climate of our planet is changing and that there is an imminent need for people to take action in order to conserve natural resources. In this paper, we explore the potential benefits of introducing eco-feedback technology and environmental psychology to public on-the-go recycling in a community-based organization, such as a university or college. We present human-computer interaction and social principles used in the design of an electronic recycling bin prototype that provides constant interactive feedback. We collect and count recyclable items, and perform field studies to track the recycling activity of a variety of users in a community that could follow principles of organizational change. Finally, we discuss and summarize successful quantitative and qualitative results that offer a better understanding of the human behavior behind practicing sustainability outside the home.

Introduction

Strategies to inspire sustainable behavior and encourage pro-environmentalism can come from disciplines such as human computer interaction with eco-feedback technology or environmental psychology, where the goal is to motivate people to practice sustainable principles and behaviors. Eco-feedback and environmental psychology focused studies have primarily targeted water and energy consumption, with also a few studies focused on solid waste management (Froehlich et al., 2010). The research presented in this paper focuses on engaging people in the pro-environmental activity of on-the-go recycling, which occurs outside the home.

A large, public, community event was chosen to observe the reaction of people towards recycling in the presence of a recycling bin based on environmental psychology models/stimuli and eco-feedback technology. The UGA SmartBin was carefully thought-out and designed based on the human-computer interaction (HCI) principles of: focusing on the task and users from the early design, performing constant empirical evaluations and completing iterations of the process to achieve a successful, non-invasive, and user-centered product. We placed an upper bound on cost keeping in mind that recycling bins are already known to be too expensive.

The purpose of the study was to observe recycling interactions of a variety of users in a community environment that could go through adaptation and behavioral change as well as could provide a better understanding of the human behavior behind practicing sustainability outside the home.

Related Work

Environmental psychology and eco-feedback technology are interventions and approaches that have been a part of different disciplines for many years. Although, environmental psychology research attempts to understand the lack of commitment to environmentally conscious activities and eco-feedback technology explores more behaviorist approaches when trying to modify behavior, they both focus on analyzing human behavior as an important factor of their studies; therefore, it is logical that human behavior is an essential component of improving sustainability and the quality of the environment. These two disciplines have been primarily disparate, but more recent research provides an innovative approach that uses principles from both (Froehlich et al., 2010).

In their 2010 research, Froehlich *et al.* examined the differences between environmental psychology and eco-feedback technology HCI (specifically, in evaluation, experimentation, and analysis techniques), highlighting the need for establishing the importance of interactivity, information presentation, and context on creating more effective approaches. From Froehlich's review of 200 various studies, they analyzed 27 on HCI and 12 on environmental psychology, finding that some environmental activities were more explored than others. Water and Energy consumption, for example, was addressed by 24 out of 39 papers while solid waste management and recycling was addressed by only 3 of them. This discrepancy reflected the need for more exploration of recycling and waste management activities that require people's involvement and effort.

Recycling

Working in a community in order to achieve a better life for future generations, though it is a moral issue for many, still includes "working," and in people's busy lives, it is extremely difficult to put time and effort into helping to solve a problem that is managed by large companies and governments (Thogersen, 1996). With this in mind, it is not surprising that many individuals do not feel compelled to participate, much less engage, in pro-environmental activities such as recycling, and water and energy conservation (Berglund and Matti, 2006); and, this lack of commitment by most people is a critical component to any environmental approach that depends on community participation and response.

In regards to solid waste management, the study of the human component has been vitally important since it encompasses time and effort. In comparison, for wastewater, people simply flush a toilet; for drinking water, people simply turn a faucet. Both of these behaviors are fairly easy to modify to provide some conservation of resources. However, waste management, even in the home, takes some effort, and recycling, even more effort. In public places, the effort required is often greater as recycling bins may not be obvious to the user ("London," 2009). For this reason, different approaches and strategies have been attempted to inspire people to take the extra action required for improved recycling and solid waste management.

Human Behavior

Behavioral change has been primarily the focus of social workers, who analyze various community contexts and their impact on individual behavior. Ecosystems theory in social work establishes that individual behaviors depend greatly on interaction between micro, mezzo, and macro systems. These macro systems include culture, communities, institutions, and organizations. Organizations are structured groups of people who come together to work towards a mutual goal and perform established activities divided in units; communities are composed by people who have something in common that connects them in some way and distinguishes them from others (Zastrow and Kirst-Ashman, 2010). Communities and organizations may follow the same steps towards change that can be characterized by three principles: 1) the law of the few, 2) the stickiness factor, and 3) the power of context (Burke, 2011). Most behavioral changes in various communities follow these principles to some extent, as will be explored further in the results section.

Previous research on recycling in a university setting showed that there were benefits to involving a large part of the university community to develop, analyze and participate in recycling strategies. One study found that visibility, convenience, and information would be great allies to encourage a recycling mentality among university communities (Kelly, 2006). In another study, Katzev (1992) found that information about the amount and type of material recycled at a certain location fills a part of the information gap that people find discouraging about recycling. By providing this information, the participants get to “peek behind the curtain” of what happens when they recycle, which increased their desired to participate in recycling (Katzev, 1992). In general, providing information or feedback appeared to motivate the public to recycle.

Human-Computer Interaction

Information and feedback are key elements to promote behavioral change and HCI methods can be used to promote this exchange through the design of technologic interactive interfaces that shorten the time between the event and the stimulus. This shorter time frame creates more effective interventions (Froehlich et al., 2010). Froehlich et al. evaluated three human-computer interfaces targeting human behavior modification for recycling. The first, Wang et al. (1990) found that commitment is a powerful force for continuity of behavior at the individual level; however, it does not have long-term effects when it is a group commitment. The second, Stern (1999) analyzed the effects of interactive information, concluding that it has a different function than incentives and using only one or the other could be misplaced, but when deployed together they can have synergistic effects on recycling. Lastly, Holstius et al. (2004) explored a more technologically focused study that concentrated on evaluating the interface. Simultaneous interfaces were used to attract people to a certain location and compared for a short period of time. However, the study did not include any human behavior change that could have emerged from a previously observed baseline (Holstius et al., 2004). Other purely commercial or technological approaches include The SmartBin Company products ("Smartbin," n.d.), the Dream Machine by Pepsi.co ("PepsiCo," n.d.), and countless other electronic recycle bins ("Dyscario," n.d.; Chen, 2012). Currently this type of bins have limitations such as geographical unavailability of the Dream Machine, which has not yet been deployed on at least ten states ("PepsiCo," n.d.) and the lack of user feedback at reasonable (approximate to current prices) price options on the other bins.

The research discussed herein is a convergence of several of the disciplines previously discussed. On-the-go recycling is explored, which currently represents 30-40% of municipal solid waste according to the US Environmental Protection Agency (Bivens and Johnson, 2006), as well as public event waste generation and recycling (where an average of 2.44 pounds of waste is generated per individual) (Cascadia, 2006). In terms of human behavior, opportune interactive stimulus is explored to evaluate its impact on people recycling. Lastly, eco-feedback technology was evaluated and beyond testing the functionality of the interface to observe and analyze recycling, human behavior was studied by including social sciences research techniques.

Methodology

A framework to encourage pro-environmental behavior has been previously developed (Steg, 2009) and was used in this study. The framework consists of 1) identifying the behavior to be changed, 2) analyzing the main factors underlying this behavior, 3) applying interventions to change the relevant behaviors and their determinants, and 4) evaluating the effects of the intervention on the behavior, determinants, environment and life quality. In this research, the framework applied as follows: 1) The behavior to be changed is the lack of recycling; the desire was to increase public on-the-go recycling; 2) It was surmised that people were not noticing recycle bins and there was a lack of information and immediate benefit to the public from recycling; 3)The prototype UGA SmartBin 2.0 design (Figure 3.1) was more visible, provided information as close to the recycling event as possible, all provided in an environment where social reinforcements were possible; 4) A short experiment was conducted collecting quantitative and qualitative data to evaluate the intervention.

Figure 3.1. UGA SmartBin 2.0 Prototype

Design of Prototype

A standard UGA public recycle bin was modified using HCI design principles and eco-feedback technology (Figure 2.1). The design features visual feedback with a numerical display that shows the number of items recycled in the bin. It also has the option of audio feedback with programmable sounds that can be used as positive reinforcement. An advantage of this design is that the audio feedback can be personalized for different communities, and this personalization allows for more effective responses towards recycling (Medland, 2010).

Being this the second empirical iteration of the UGA SmartBin, (UGA SmartBin 1.0 included a small and hard to read red scrolling display), the UGA SmartBin 2.0 follows HCI principles by using low-energy indoor green lights in a large enough static display that helps visibility and by being intuitive enough to keep the exact functionality of a standard recycling bin. Therefore, external components of the design include the pre-programmable speaker (40mm diameter sound card type speaker/ 40 recordable seconds), the large numerical display (three one digit 7-segment displays of 1.5 inch size characters), and a constant ring of red LED's around the lid of the bin to increase visibility that also change color when an item is disposed of (two 7ft-long strings of battery operated LED lights red and green, intercalated every two inches). These components were installed in a factory-made standard "Cans & Bottles Only" UGA recycling bin (consisting of a green trapezoidal lid of Base:22"x22"/Height:7"/ Top:4"x4" and a brown trapezoidal bin of Base:19"x19"/ Height:32"/ Top:21.5"x21.5") with one round opening of 3.5" diameter at each side of the lid offering access from any of the four faces of the bin. In order to not disrupt this feature and provide versatility, a funnel (following the dimensions and shape of the lid) was attached to the lid to direct items through a main opening (4 inches diameter) where the sensors would be located.

Although extensive lab testing of the funnel showed that the opening met the requirements (cans and bottles were passing through), there was no account for large sized items incorrectly disposed by the users (paper or biodegradable cups). This effect would end up having interesting consequences that will be discussed in the results section of this paper. As mentioned before, the purpose of the funnel was to direct items through the main opening where the sensor/transmitter system was concealed from possible disturbances (external lights changes, hands, camera flashes, etc).

Concealed internal components include a coupled infrared sensor/transmitter system (TSOP1236/TSAL7400 modulated by a TLC555) that sends a signal to the PIC microcontroller (PIC18F45K20). This microcontroller was programmed using C++ language and followed a series of steps that ultimately led it to change the three-digit number, activate the customized sound, and change the color of the LED lights. Lights changing from red to green, color that has a calming or soothing effect (Kaya and Epps, 2004), allows the participants experience comfort and enjoyment, thus promoting the use of the interface (Sharp et al., 2007). Other positive reinforcements that the UGA SmartBin 2.0 uses and are directly linked with modifying human behavior strategies include the repetition of the message of recycling as a good action by changing the lights color, the display to a higher number and providing an encouraging sound when the item is thrown. This audio message was selected based on the social characteristics of the experimentation environment, thus targeting the specific population in which the experiment was to be developed.

Environment for Experimentation

The experiment was designed as a cross-sectional study, conducted in a community environment where the participants could be compared amongst each other, but also where they were able to identify themselves as part of a community. The study was designed so that recycling could be connected to a sense of belonging or a social reward, within a community. Community comparison methods (an individual feeling included or excluded from a certain community) have been shown to be an effective way to promote pro-environmental change (Schultz et al., 2007).

A UGA football game was chosen as the ideal experimentation environment and the large, heavily visited Tate Student Center food court as the experimental location. One recycle bin in this area was chosen for the experiment. A two-day window (24 hours before the football game and 24 hours after) of two popular UGA football games was used to establish a baseline and for deploying the UGA SmartBin 2.0. Football games have strong characteristics of organization and community since the fans of each team share the desire to see their team win and come together to support their team, thus working towards that goal. The community environment in football games at the University of Georgia is filled with a sense of belonging and strong bonds between individuals when compared to other events on campus. This environment allowed for a non-intrusive evaluation of human response towards the UGA SmartBin in a real-world community-gathering with minimal disruption of normal behavior.

Data Collection and Evaluation

Covert observational data collection was conducted three hours before the start of the game and one hour after. In order to identify if the intervention modified behavior, we developed an observation protocol that would help us identify if people would demonstrate interest towards not only the interface but recycling itself. During the observational time period, visits and items recycled were counted. In addition, the full quantity of recycled items (from the two-day deployment) in the bin were counted and weighed.

Both qualitative and quantitative methods of analysis were utilized to evaluate the data. Qualitative methods include quasi-statistics, analytic induction, and logical analysis (Hill, 2012) based on an observation protocol (Appendix A) while quantitative methods included statistics and visual comparisons of tables and graphs based on the number of items recycled, visits to the bin, and the quantity of items collected from the bins. Total recycling weight for the two football games was provided by the University of Georgia Office of Sustainability while daily attendance to the Tate Student Center was obtained from the UGA Office of Facilities and Operations of the Tate student center.

Results

Quantitative

Table 3.1 presents the total attendance in the Tate Center, the total tonnage recycled, the weight recycled at the experiment location, and the total number of items recycled for each respective game. Total attendance was higher at the baseline game, which led to a higher overall recycling tonnage; however the weight and the number of items recycled at the SmartBin were greater. The difference is also illustrated in Figure 3.2, which presents the four-hour observational window for both the baseline and the UGA SmartBin.

Table 3.1. Recycling Rates Before and During the UGA SmartBin 2.0 Intervention.

	Tate Building Attendance (people)	Total Game Recycling (Tons)	Location Recycling (Kg)	Location Recycling (items)
Baseline Football Game	21,411	7.21	0.30	13
UGA SmartBin 2.0 Game	10,719	3.78	0.45	21

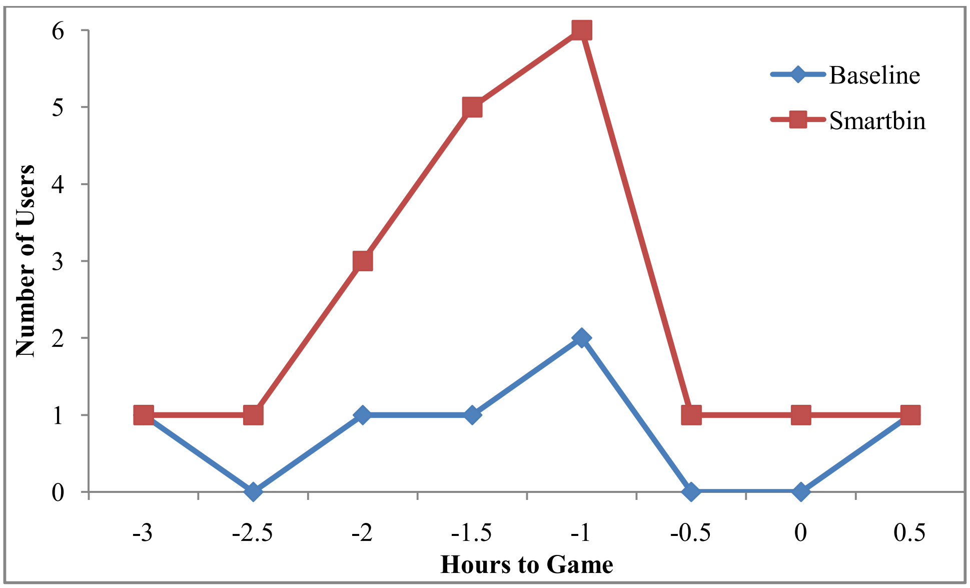

Figure 3.2. Comparison between UGA SmartBin 2.0 Observed Visits and Baseline Observed Visits

Figure 3.2 also illustrated a pattern, which is consistent for each game. As people get ready for the game, recycling builds to a peak as they recycle more just before the game starts with a dramatic decrease after. In addition to the visual difference observed between the baseline and the UGA SmartBin 2.0 use, a Wilcoxon Signed Rank Test concluded with a 95% probability that the number of visits (persons who used the bin to recycle) and recycling rates were significantly higher at the UGA SmartBin 2.0 than the baseline (Visits: $T+=21$, $Po= 0.016$; Items: $T+=15$, $Po=0.031$).

Qualitative

The fact that people used the SmartBin more represented interest, however, the qualitative data were more descriptive of the attitudes of the users. For example, users of the SmartBin were talking to each other and sharing advice about recycling: "Wait, take off the cap from the bottle," "You are doing it wrong, let me show you."

Based upon the quantitative and qualitative results, it is clear that as the game gets ready to start, people congregate in the Tate Student Center to eat and mingle and then throw any trash they have away before they go to the game. For the baseline game, people were observed throwing some recyclables in the trash. Half of the people who were observed recycling appeared to be from one group or family (likely a family that is used to recycling, since they were all different ages, sitting at the same table, and each of the members got up when they finished their drinks and threw away the containers). Other participants would throw one item generally when leaving and/or when throwing trash. From the users' reactions, there did not appear to be any kind of interest towards the bin or the recycling activity. In general the users' bodies were turned away from the bin with no notable facial expressions. Recycling for these users may be a subconscious activity that is likely based on a personal decision.

During the UGA SmartBin experiment, many people close to the bin who had any empty recyclable item threw it in the UGA SmartBin 2.0. One third of the interactions with the UGA SmartBin were made by the same group (called Group A), who were likely used to recycling since one of them instructed others to remove the cap from the bottle before recycling it. At the beginning of the SmartBin observation, a man from this group made the comment: “I ain’t touching that,” but he later picked up a bottle from another table to throw into the UGA SmartBin bin, which demonstrated the potential of the interface as a behavior modifying tool. However, the first person of this group who threw a bottle was a young boy, participant 2, and when the bin reacted, the entire group cheered and celebrated, which brought attention to the bin. Most of the participants from Group A had the opportunity to try the bin individually. There was a slight non-planned technical issue that impacted feedback for every user (the funnel opening was too small for some inappropriately disposed items so items were getting stuck and the mechanism was not working correctly), but it worked to the bins advantage creating an intermittent social reinforcement that showed behaviors that could not have been observed otherwise. Since the feedback worked for most users but not all, people surrounding the bin began to ponder the “right way” of placing items in the bin.

Soon, the UGA SmartBin was receiving attention from people who had been encouraged by others to watch or use it, which started to create a domino effect (the law of the few, first principle) laying the basis of a possible organizational change. The manifestation of the second principle of organizational change occurred when non-recyclable or large-sized items (paper cups, biodegradable cups, large bottles, etc.) were getting stuck after thrown (non-intentional in design), and people started to think about the appropriate items to be thrown in the bin. Users started to see the feedback as a reward or social reinforcement, but they realized that they would have to recycle correctly to get the reward, which acted as a very basic “stickiness factor”. The third principle came based on the pressure of the group, being on the spot, the nervousness of doing something right, which is very powerful in the macro social environment (the power of the context). By this point, the environment was filled with comments about the SmartBin, laughter, and a positive attitude promoting interest.

People demonstrated engagement when they paused beside the bin after using it and when their body and facial expressions showed interest and excitement. Users stood by the bin waiting for a reaction (even though sometimes none came). There was such an interest towards the bin that we saw people recycling in the bin even though they said they would not. We provide a possible model for user behavior during intervention in Figure 3.3.

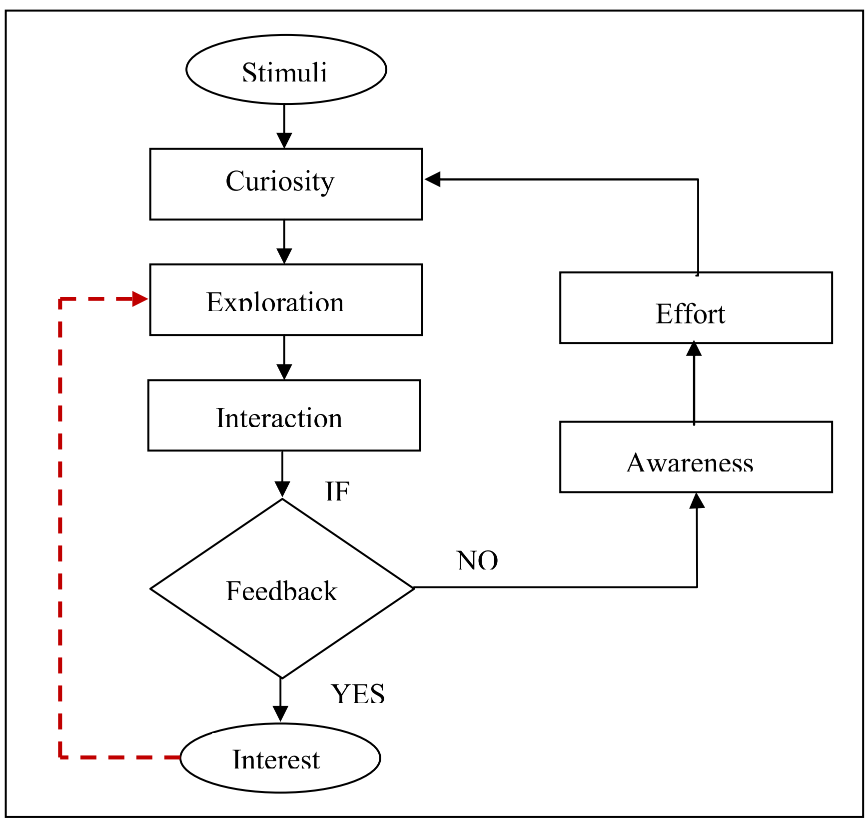

Figure 3.3. Steps of the Behavioral Process that People Undergo when Exposed to the UGA SmartBin

Figure 3.3 represents how a participant might be attracted to the UGA SmartBin from one or more of the sensory stimuli: lights, numerical display, sound or hearing/observing the feedback from another user's interaction. Next, the participant may feel curious about the functionality of the SmartBin, and explore it by interacting with it in some way, usually recycling an empty item. After an item was recycled, if the bin worked correctly, the participants got feedback and they would want to recycle again (shown by the multiple times that the one participant would recycle, participant 2 recycled 3 times and also accompanied other participants). If there was no reaction from the SmartBin, the user would reflect on their own action, making extra effort to change their behavior to receive the feedback including, longer or different interactions with the SmartBin. Interactions grew from simply recycling bottles and cans to looking inside to check if the mechanism was working or even pushing a bottle if it got stuck.

Conclusion

Introducing electronically delivered stimuli to a community in a public event can increase recycling by appealing to the psychology behind group change and group behavior. People became more interested in recycling when they got immediate feedback from simple lights giving a color change and a counter increasing, turning it into a fun or exciting activity worth investing time. In a macro social environment, it is then easier to transmit the fun and excitement for the activity since these types of environments follow organizational change principles.

The UGA SmartBin helped create a positive attitude around recycling and behavioral changes were observed not only at a community level, but by individuals who changed their opinion and attitudes towards the activity. People felt the feedback provided them positive social reinforcement and when the reinforcement became intermittent they reflected on their own behavior. They explored “better” ways to recycle and put effort towards figuring out a way to receive the feedback, including avoiding the disposal of non-recyclable items in the SmartBin. The intermittence also worked as a way to keep people interested on the activity. It can be concluded from observations that people enjoyed the interface and that it fulfilled the purpose of positively influencing recycling to be perceived as an exciting activity.

It is not known if introducing the same interface on a micro social environment would have a similar impact over a baseline. Therefore, future work will explore the effect of different types of stimuli (including technological and non-technological) on individual behavior and micro social environments.

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CHAPTER 4

IMPACTS TO RECYCLING FROM TECHNO-SOCIAL STIMULI IN A UNIVERSITY MICRO SOCIAL ENVIRONMENT[2]

[2]Mozo Reyes, E. and J. Jambeck. To be submitted to Journal of Waste Management.

Abstract

In this paper, we present our three-month study of recycling behaviors at a university campus in a micro social environment based on concepts of individual behavior modification techniques explored by social and pro-environmental scientists. In a three-step, three-month experiment, we compared technologically delivered feedback and information provided by Human-Computer Interaction techniques with static feedback, information, and the possibility of interaction from a non-technological approach, as well as with a baseline data collection period for control and comparison purpose. Finally, we discuss the results from the study offering valuable conclusions and findings, and we recommend different approaches to improve recycling strategies. The use of the recycling prototype as well as the non-technological setup provided valuable information for recycling strategies including the effect of different stimulus and the potential benefits of including technology on the behavior modification process.

Introduction

Previous work had established the relationship between electronic interactive stimuli and the positive response from groups. However, based on macro social environment observations (Chapter 3), it was impossible to determine if the strategy was going to be as equally effective when trying to modify individual behavior. In order to explore the characteristics and possible effective stimuli in the micro social environment, more in-depth field studies were performed. This experiment utilized longer observations in an everyday setting while exploring the effects of different interventions on behavior modification towards pro-environmentalism (in this case, recycling).

Behavior modification techniques have proven to be effective in a great variety of fields (Nakajima et al., 2008) including one of the latest trends, behavior modification in pro-environmental activities (Froehlich et al., 2010). The purpose of this study was to evaluate college students in their everyday environment while introducing different stimuli that could prompt a behavior modification to increase recycling and promote awareness. Evaluating and influencing behavior depends greatly on the characteristics of the target population since various stimuli are more effective for certain people and different situations (Medland, 2010).

Environmental psychology models (Froehlich et al., 2010) were reviewed to determine the type of stimulus to be used in our behavioral recycling study. Based upon this review, it was found that the most efficient stimuli models would be those prompting reflection on the recycling experience, thus leading to apprehension of the importance of recycling. Some of these models include information, incentives / disincentives and reward / penalties, and feedback, which are relatively independent of human involvement in the stimulus delivery phase. The Information model states that in order to achieve better results the information provided must be easy to understand, trusted, attractive, and as close to the event as possible. It is based in the premise that better information would help to awake the environmentally conscious side of people (Brewer, 2005; Cialdini, 1991). Incentives/Disincentives usually happen before the action of interest and Reward/Penalties happen afterward, while both can influence behavior (Geller, 1990). In this model, the incentives and rewards could be economic, of status, or fun incentives, and that they are more effective than disincentives and penalties (Valente, 2002). The feedback model has been successfully included in all the other models due to its proven effectiveness since any reinforcement or information "feeds back" to the user influencing present or future use. All the research done in this model has proven its efficacy in resources consumption reduction, especially in public recycling (Osbaldiston, 2012). Research has shown the feedback model is effective in reducing resource consumption when providing constant, detailed, and interactive feedback (low-level feedback) as opposed to high-level feedback such as bills and energy consumption (Froehlich et al., 2010). All of these models can be used as stimuli for individuals in an everyday setting also known as a micro social environment.

In the Micro social environment, behavioral changes occur based on individual perceptions and reactions. Strategies to prompt environmental activities, such as recycling, need to utilize the correct tools that are the most efficient, with the least investment. In order to find an appropriate strategy for individual behavior modification, we explored a combination of stimuli that provide individuals different experiences while exploring novel concepts on recycling.

Environmental psychology has also added technological aids to some experiments, developing eco-feedback technology. While environmental psychology studies conducted field experiments with up to two hundred participants, lasting as long as 10 months, they focus only on human behavior, while HCI developed small laboratory experiments with an average of 12 participants for only a couple of weeks and their main focus was the devices or interfaces testing (Froehlich et al., 2010). Experiments in eco-feedback technology, however, have not used all the research from environmental psychology to test the interfaces, for which not much information can be found in regard to effectiveness percentage of models and stimuli using HCI (human-computer interaction) in eco-feedback technology. Human-Computer Interaction techniques that have been popular on products design, but also in environmentally conscious behavior modification. The use of technological stimuli has been a powerful tool to change people's lifestyle over many years, generally for marketing and publicity (Nakajima et al., 2008) and Human-computer interaction has provided engineers with a great variety of conceptual models that promote more successful designs. The majority of these models are based on a user-centered design that requires involving the analysis among others of the user experience and the usability of a design (Sharp et al. 2007). Human computer interaction and its valuable input on design has become very popular among eco-feedback designers as well as one of the most important strategies to inspire pro-environmental behaviors such as water conservation or solid waste management, especially recycling.

With this in mind the purpose of the study was to use characteristics from Environmental Psychology and Eco-feedback Technology in order to establish a set of stimuli capable of modifying behavior that could be demonstrated through rate increases and attitudes towards recycling. In order to objectively observe these attitudes and rates, a longitudinal field study was performed where quantitative as well as qualitative data were collected, evaluated, and interpreted while comparing the people's behavior. Specifically, on-the-go, public recycling was studied, which differs from other existing works on the recycling management and promotion strategies in curbside, household, and other strategies of campus recycling (Davies et al., 2002; Holstius et al., 2004; Katsev and Mishima, 1992; Kelly et al., 2006; Stern, 1999; Shultz, 1999; Thieme et al., 2012; Wang and Katzev, 1990). Therefore, we looked into the characteristics of individual (micro social system) behavior while exploring possible combination of stimuli that can influence the personal decision to recycle.

Methodology

The stages and prototypes for experimentation were designed based on the most popular, as well as the most recommended, social models in order to measure a reasonable behavioral change. The first phase was the collection of baseline data using a standard UGA recycle bin. The second phase consisted of non-technological interaction surrounding the UGA recycle bin. The third phase consisted of a technologically modified recycle bin that counted the items recycled and provided feedback to the user, the UGA SmartBin (Mozo Reyes et al., TBS), shown on location in Figure 4.1.

The three stages or phases were conducted at the same location during an observation period of four weeks, collecting field notes Monday through Friday during three consecutive random hours every day (between 9am-7pm) for a total of 20 observations (60 hours). The recycle bin was for aluminum cans and glass or plastic bottles only; any additional thrown items in the bin were considered contaminants.

Figure 4.1. UGA SmartBin on Location at the UGA Tate Student Center Food Court

Experimentation Environment

We decided to observe a college community during a daily environment as a part of the strategy to find effective stimuli and delivery systems for public recycling. The most effective stimuli for public recycling have been found to be justification, convenience, cognitive resonance, and pledges (Osbaldiston, 2012). This research utilizes justification, convenience, and cognitive resonance, in addition to interactive feedback features. Pledges were not utilized in order to be able to observe natural behavior. Pledges can alter participants' behavior if they become aware of a study (Sharp et al., 2007). In order to perform a field study where recycling can be convenient, the UGA Tate Student Center food court was chosen for the experimental location. There are multiple recycling bins and the experimental bin location had a trash can right beside the recycling bin and was observable from many angles in the food court.

Experimentation Stages

This experiment was conducted in three phases. Phase 1 was the baseline phase, where no modifications were made to the recycle bin or the surrounding environment. During the baseline collection stage (Phase 1) the primary purpose was to keep track of recycled items by counting the items thrown at a standard UGA recycling bin. It is also important to observe people's behavior towards recycling in this stage since it would be the basis for comparison for other stages.

During the non-technological stimuli phase (Phase 2), a large poster was placed near the bin that showed a picture (children recycling) with the following message: "We know that recycling means a better planet for us...", Users could complete the following sentence on a white board "What do you know about recycling?" as shown in Figure 4.2. The whiteboard was used to collect comments on site promoting interactivity, and the entire setup was designed to promote information exchange while providing justification and information. The exchange of ideas and information that the openness of this stage could provoke was carefully monitored in order to remove, if necessary, any possible identifiers and/or comments using inappropriate language (however there were none).

Figure 4.2. Non-technological Stimuli Phase Setup on Location at the UGA Tate Student Center Food Court

During the UGA SmartBin phase (Phase 3), a technologically modified recycle bin called the “UGA SmartBin” was used to electronically register the number of items recycled in the bin and present it as a three-digit number to the user providing immediate and direct feedback to the participant. The feedback was reinforced by LED lights lining the top of the bin that changed from red to green when an item was recycled providing subtle pictorial information about the positivity of the action (Plaue et al., 2004). This interface also had a small sticker with an email address for the participant to submit comments, questions, and suggestions if they so desired.

Data Collection and Evaluation

Both quantitative and qualitative data were collected in this study. Qualitative data were collected by covert participant observation with field notebooks according to a previously developed observational protocol (MozoReyes et al., TBS). The collection of the data was performed as a field observation study for three hours every weekday during four weeks The attitudes towards recycling and general behavior around the bin, as observed by the researcher, were analyzed using analytic induction and logical analysis methods (Hill, 2012). The method chosen to analyze emailed comments, questions, and suggestions was through affinity diagrams (Sharp et al., 2007).

Quantitative data collection consisted of number of visits to the bin and number of items recycled during the observational periods and the total number and weight of items recycled in each bin over the entire 28-day time period. Daily attendance to the Tate Student Center was obtained from the UGA Office of Facilities and Operations of the Tate Student Center. Attendance is recorded by sensors located at every door of the Tate Center Building and is calculated by dividing the total amount by two (to compensate entries and exits from the building). The quantitative data were analyzed using graphical comparison and statistical methods, but we also explored other qualitative as well as quantitative methods of data analysis.

Results

Quantitative

From the 4-week collected items, we found differences between the recycling rates at different stages of the experiment. Table 4.1 presents the total attendance to the Tate Center, the total number of observed visits, the total mass of recycling and the total numbers of items recycled for each phase. Attendance was lowest during Phase 2, followed by Phase 3 and then Phase 1. The number of recycled items was highest for Phase 3 followed by Phase 1 and Phase 2.

Table 4.1. Recycling Rates during the 4-WeekBaseline, Non-Tech Stimuli, and UGA SmartBin Phases

	Dates of Intervention Start-End	Tate Building Attendance Total (people)	Total Observed Visits	Total Recycling (items)	Total Recycling (Kg)
Phase I Baseline	09/29/11-10/27/11.	169,781	17	60	1.18
Phase II Non-Tech	01/30/12-02/27/12.	143,753	9	44	0.90
Phase III UGA SmartBin	03/22/12-04/19/12.	156,912	20	83	2.18

In order to take into account the fact that the number of visitors impacts the number of items recycled in a public setting (US EPA, 2001), the number of recycled items was divided by the number of visitors to the Tate Center for each day of the Phase (Figure 4.3). There is no overall trend to each data set; however the Phase 3 data appears higher than Phase 1 and 2. Figure 4.4 presents the daily average and one standard deviation of this same data. The daily average of recycled items per person was significantly higher for Phase 3 (by one standard deviation) when compared to Phase 1 and Phase 2. No significant difference was observed between Phases 1 and 2. The superiority of Phase 3 was also shown statistically through two-means hypothesis tests that established a 99% probability of recycling rates increase during the SmartBin intervention ($t_{32} = 12.45$, $P_{32} = 2.75E\text{-}15$; $t_{31} = 11.48$, $P_{31} = 8.99E\text{-}15$).

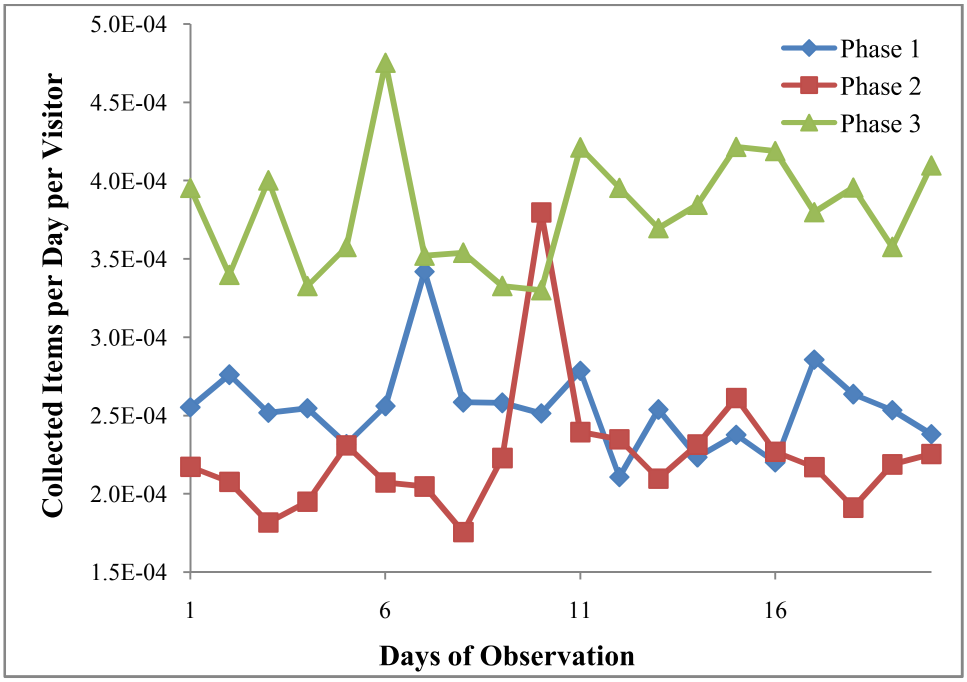

Figure 4.3. Normalized Collected Items during the Baseline, Non-Tech Stimuli, and UGA SmartBin Phases

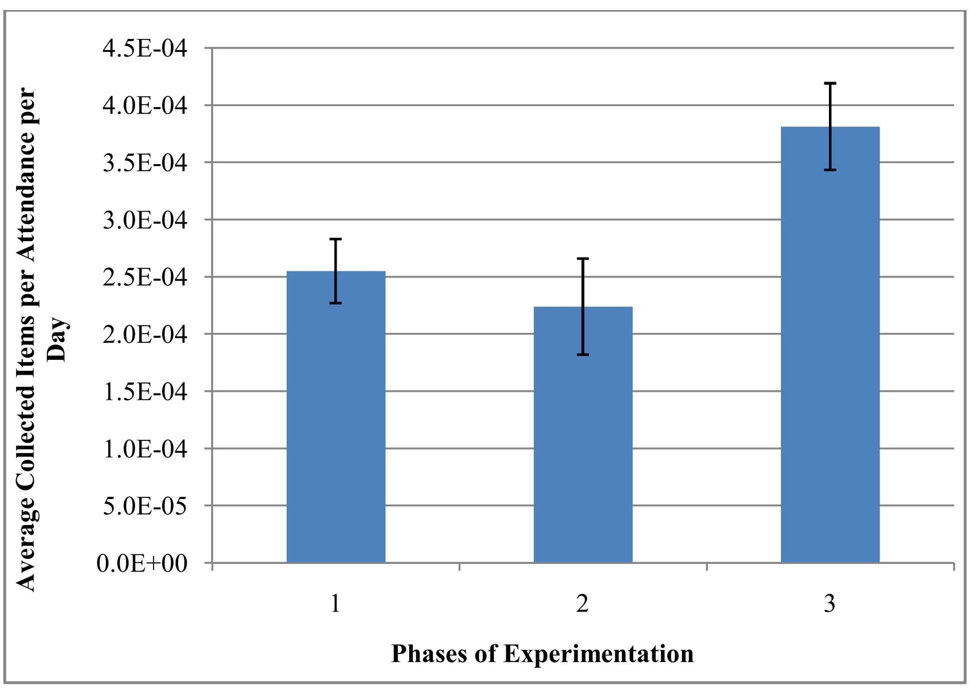

Figure 4.4. Average Collected Items per day per visitor during the Baseline, Non-Tech Stimuli, and UGA SmartBin Phases

Phase 3 had the least amount of contamination in the recycling bin (23 items), followed by Phase 1 (42 items) and Phase 2 (60 items). Other interesting quantitative results include the randomness of the observed recycling behavior for the whole group since, as shown in Figures 4.5 and 4.6, the group did not have a preferred day or time to recycle. Based on averages comparison, the study found that there was no significant difference between phases according to the time of day, even though certain peaks in Figure 4.5 might suggest the opposite. Although there was not a preferred day to recycle according to average comparison, Figure 4.6 showed that the days with less recycling were Monday and Friday, which was attributed to the slight decrease (2.5-12.5% average) in attendance during those days.

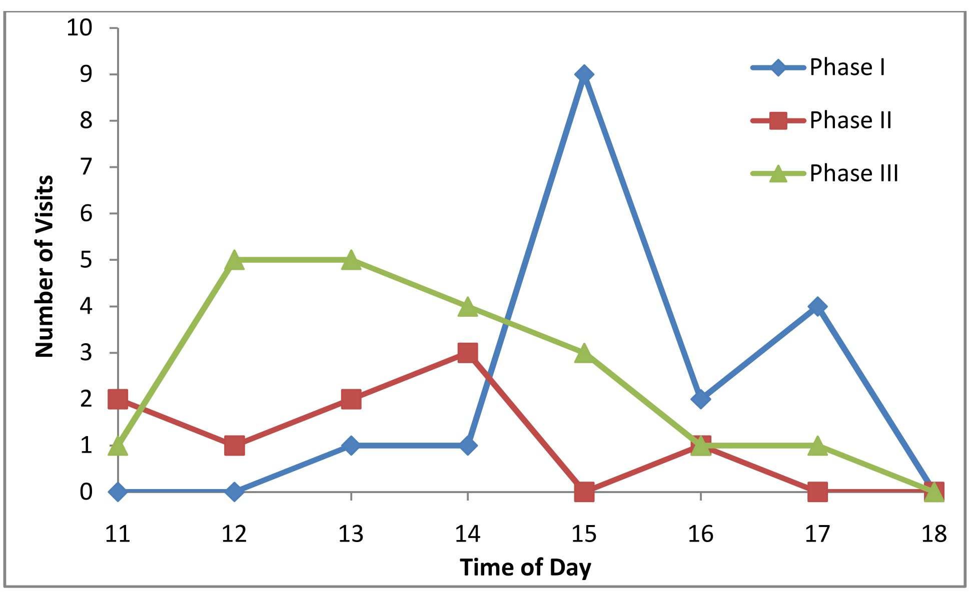

Figure 4.5. Distribution of Observed Visits per Time of Day during the Baseline, Non-Tech Stimuli, and UGA SmartBin phases

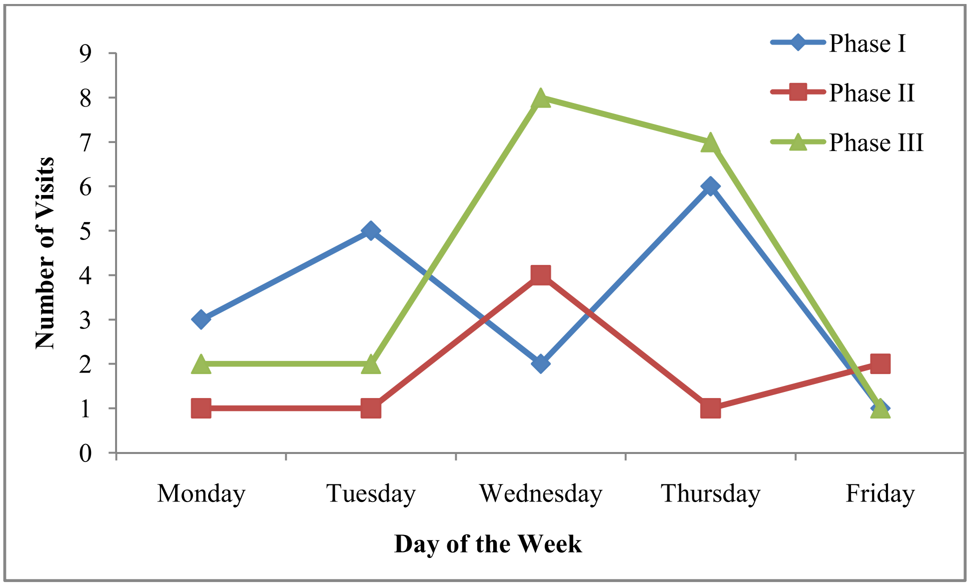

Figure 4.6. Distribution of Observed Visits per Day of the Week during the Baseline, Non-Tech Stimuli, and UGA SmartBin phases

Qualitative

During Phase 1 (baseline), people recycled as a normal part of their daily activities, behaving naturally, with neutral face and hand expressions, spending two to three seconds around the bin. People would normally recycle when they got up to dispose of other items and/or they would recycle when leaving the food court. In the later case, people would recycle in the bin closest to them as they left. People would typically stand at a distance of two feet or more from the bin or they would simply recycle items in the bin while they kept walking.

In Phase 2, the setup did help to change the indifference towards the activity since the majority of the participants stared at the poster and board, but it also brought some unexpected negative effects (people avoiding the bin location). The number of participants observed decreased compared to the baseline. Observations were then focused on the whiteboard in the hopes to more deeply analyze this phenomenon. Based upon observations (participants who wrote something checked their surroundings before writing), we hypothesis that people did not want to write on the whiteboard in front of others (be "put on the spot") or because people found the whiteboard too invasive for the recycling activity. People who actually used the bin were similar to the baseline in that they had neutral expressions and natural behavior suggesting that there was no promotion of recycling on new audiences.

The most interesting effect during Phase 2 was the quantity of contaminants in the bin. The most common contaminants encountered were paper, paper cups, and paperboard. Upon reflection of the visual stimulus in Phase 2 (the poster of kids with a recycle bin), it was determined that the poster may have mislead participants since the recycle bin in the poster contained paper items, as well as cans and bottles. So, although the bin stated clearly that it was for cans and bottles only, many participants followed the picture example recycling what the kids were recycling.

During Phase 3, positive reactions towards the UGA SmartBin were observed from people recycling, as well as from people in the surrounding area. People stared at the bin and looked in expectation at it before and after using it. People took photographs of the bin with cell phones and other cameras. From the six attempted interviews only one of the participants was interviewed (the rest of participants simply stated their lack of time and did not answer any questions), and this participant stated that the lights and the counter attracted him to the bin. Corresponding to the higher recycling rates discussed earlier, participants were getting excited when recycling, exclaiming things like *"Woah,* *that was so cool!."* Contamination was lowest in Phase 3 and so the SmartBin may have increased people's general awareness for recycling properly. Some users made a point or went out of their way to use the UGA SmartBin; some came from near a standard bin and others walked a considerable distance to use it on their way out of the food court.

During the last week of Phase 3, some participants started to bring others to recycle in the bin, while explaining what would happen when they used it. They would stand by the bin talking about how they recycled and how the bin worked showing the item counter as well as the lights changing colors. Potentially, an organizational change was emerging based upon promotion of the SmartBin by "innovators" (Burke, 2011), who offered recycling advice to new participants.

The thought processes from personal beliefs to possible decisions and outcomes for all three phases are shown in Figure 4.7. In this figure, each color and line style represent the path taken by a participant according to the intervention phase and the possible process of thought. The blue line would represent the process for participants during the baseline, the red one would represent Phase 2, and processes on the SmartBin would be presented in green. Since there were no distinguishable attitudes during the baseline, it was reaffirmed that individuals were relying on their own system of beliefs to make the decision of recycling or not. After the introduction of a stimulus, participants would either take a reaction of curiosity, caution or in the case of Phase Two simply avoidance. From this point they could go directly to an enjoyment or achievement state (Phase 3) that would lead them to individual or group reflection, generally resulting in recycling, and also becoming a part of the new systems of beliefs. Otherwise, participants could take a reflective learning step in the middle that would reassure or discourage the individual to reach the reflection step. From group reflection an exchange of information is generated that has organizational change characteristics.

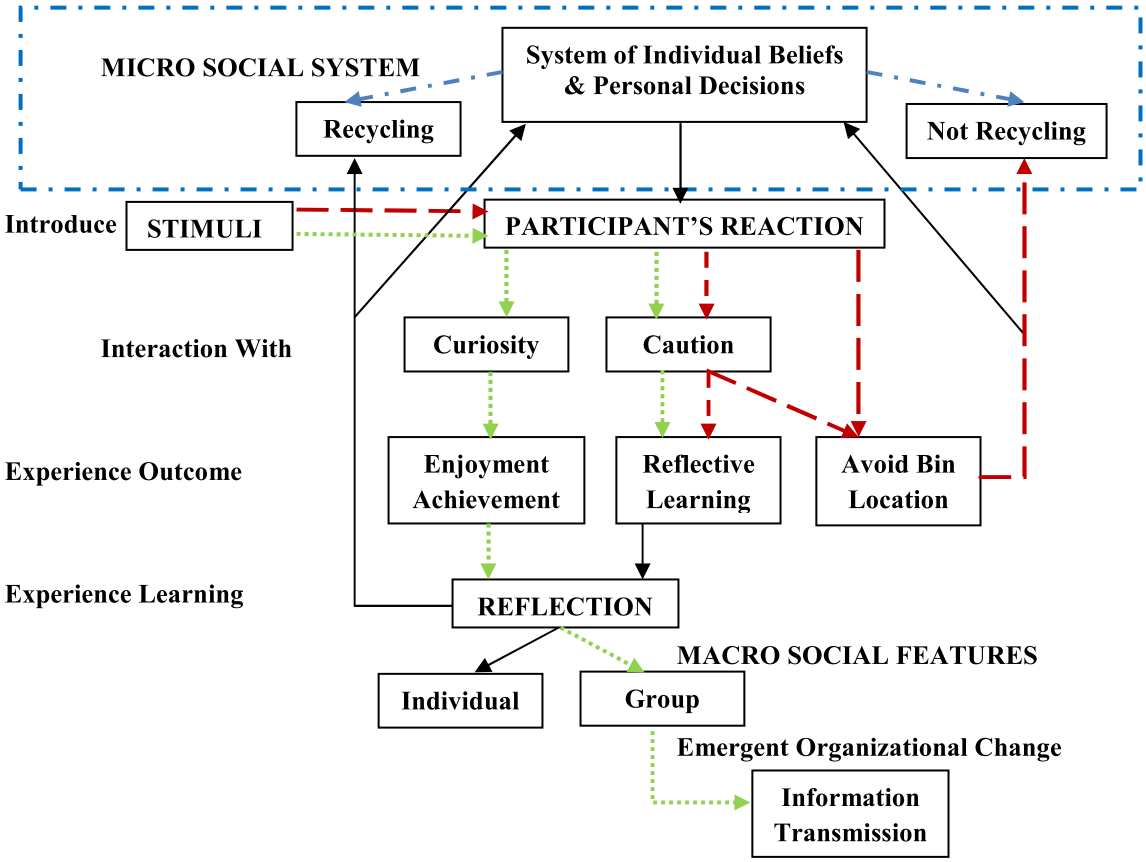

Figure 4.7. Possible Paths and Outcomes from Stimuli Interventions on the Baseline (Blue ·─), Non-Technological Stimuli (Red - -) and the UGA SmartBin (Green ··) phases

Discussion and Conclusions

Our technologically delivered combination of Information, Feedback, and Social Reinforcements demonstrated superiority by increasing recycling rates and promoting positive attitudes towards recycling when compared to our non-technological approach and a baseline collection phase. We attributed the low recycling rates during Phase Two to the invasive design of the interface since there are certain stimuli or modalities of delivery that instead of promoting environmentally friendly activities, specifically recycling, manage to discourage people from performing the activity (Schultz et al., 2007; Franz and Papyrakis, 2011). However, Phase Two demonstrated that pictorial signage can make a difference on the type of items thrown in a recycling bin.

Interactivity demonstrated to be one of the key elements that make the UGA SmartBin a more effective approach towards recycling, but HCI characteristics such as subtlety and pictorial realism (performing a green activity) were also decisive factors to make this a successful strategy. The UGA SmartBin also demonstrated that people are individually receptive of interactive stimuli although not as effectively as when the intervention is applied in a Macro Social environment (Schultz et al. 2007; MozoReyes et al., TBS).

Characteristics of Macro Social systems (information exchange and scaffolding) were observed during the fourth week of the experiment when recycling rates started to increase. For this reason, further research is needed that either extend the experiment over a longer period of time or include a combination of macro and micro social environmental characteristics that would facilitate behavioral changes and learning outcomes associated with the behavior modification.

The use of the recycling prototype as well as the non-technological setup provided valuable information for recycling strategies including the effect of different stimulus and the potential benefits of including technology on the behavior modification process. From observation, we learned that some stimuli have the ability to modify certain behavior almost immediately, but we also learned that some important behaviors probably need other factors to consider when designing strategies in order to achieve the best results. We also learned from the items collection that recycling can happen at any time or day of the week for which it is important to maintain the strategy running at all times. We also started to see some behavioral patterns that would suggest a learning process from these experiences.

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CHAPTER 5

IMPACTS TO RECYCLING FROM TECHNO-SOCIAL STIMULI IN A UNIVERSITY MICROSOCIAL ENVIRONMENT WITH COMMUNITY CHARACTERISTICS[3]

[3]Mozo Reyes, E., J. Jambeck, and P. Reeves. To be submitted to Journal of Environmental Science and Technology.

Abstract

Design-Based Research (DBR) promotes the evaluation and improvement of educational approaches based on rigorous analysis and iterative processes. In this paper, we evaluated previous work using DBR techniques establishing the most successful features of past approaches. We explore how providing technological stimuli as well as promoting macro social and constructivist features enhance recycling to be perceived as an enjoyable task, thus engaging people with the activity. We reduced the size of the community and ensured that a strong bond existed among its members to generate a more effective organizational change. We deployed a technologically modified recycling bin and tracked the recycling activity in a departmental building in order to observe the effects that virtual information and social support would have in a small community. The results demonstrated the strategy is successful and offers new insights into the fields of environmental psychology, eco-feedback technology, and informal education.

Introduction

Previous experiments had indicated that people went through a process of information absorption, ideas exchange, and reflection on recycling experiences (Chapter 3 and 4); hence, including educational approaches to evaluate and improve the experience for each user could promote further exploration and learning. Design based research (serendipitously discovered at this point) offered insights into the previous experiments. In order to apply DBR principles, it was necessary to compare previous work and continue to design, test and iterate the process until a sound educational strategy for enduring behavior modification could be established.

Some of the key elements on modifying behavior include experience and the cognitive process behind it. Although cognition is fairly unexplored as a factor of change in purely behaviorist theories, it is undeniable that mental processes influence the action-axiom of present and future experiences even when a behavior is specifically related to certain stimulus (Boettke and Leeson, 2006). Therefore, our actions are directly or indirectly related with the notion of our previous knowledge or a set of preconceived notions coming from past experiences (a priori) and learning outcomes.

As human beings, we are surrounded by possibilities for learning as we are constantly trying to make sense of the world, and it is this collected knowledge that influences our decisions (Norman, 2004). Decisions to recycle, or not, for example, come from previous positive or negative experiences on the topic. For people who do not have previous knowledge of recycling or whose experiences with it have been neutral, however, there is always a chance of promoting good experiences that will allow them to learn how positive and necessary recycling is. In order to transmit a positive attitude and importance of recycling, we should be able to design and implement real-world application tools and guided experiences (Hassard, 2009) that can offer knowledge and information exchange in a constructive and efficient manner.

In terms of behavioral change, for example, we should be able to find the best methods to influence behavior (“law of the few”), the appropriate context or environment (“power of context”), and the factors that will keep people engaged with the activity (“stickiness factor”) (Gladwell, 2000). In previous studies, we found that interactive feedback and information were effective methods to keep people engaged with recycling. In this research, we are also including the use of an informal coaching tool that will promote seeking for knowledge, exploration, and positive reactions (Leadbeater, 2000). Previous research also showed that the characteristics of the environment where the learning is taking place can make a difference in the learning outcomes. For instance, in a diverse environment where people do not have much in common and are most of the time scattered, learning (and decisions based upon that learning) may not be as powerful as when ideas are exchanged and contribute to a community (Burke, 2011). It is also this exchange of ideas and information that creates a more valid sense of accomplishment, hence a positive experience based on the welfare of the community, the sense of belonging, and/or the praise coming from early adapters or innovators (Chaisamrej, 2006).

The influence that a group of innovators could have in a whole community has been established in previous work (MozoReyes et al, TBS) and this phenomenon will be further analyzed through the short study presented in this paper. This study will analyze the effects of introducing constant feedback through an electronically modified recycling bin into the everyday life of a diverse community who shares a strong bond. So, although the community is well established, there is also enough diversity, individuality, and independence to be considered as a micro social (individual) environment (Zastrow and Kirst-Ashman, 2010). This type of environment depends greatly on the personal beliefs and decisions made by each person, which in turn depend on their experience and their previous knowledge.

The purpose of this study is to explore the learning possibilities and behavior modification behind the re-creation of macro social characteristics in the everyday life for college students through human resources management and location. A modified UGA

SmartBin 2.0 prototype (MozoReyes et al. TBS) was deployed in the UGA Engineering departmental building where the community shares common goals and purposes while still in their own micro system. An educational support system was built by offering links to websites and information, as well as providing access to social support (through virtual social networks and other the interaction with other people) in the tight engineering community. It is demonstrated in organization change theory that this experience could be made easier or smoother by introducing the appropriate leadership system (innovators guiding change) (Burke, 2011).

The approach for this research came directly from the analysis of our previous work and differs from recent work in that despite presenting a relationship between cognition and recycling, Sinatra (2012) does not evaluate the change of environments and the inclusion of technology that we evaluated with design-based research principles. Design-based research ensures that we include practitioners in our evaluations in order to address the lack of recycling commitment in a real context, that we integrate design principles and technological approaches to find possible solutions, and that we rigorously and reflectively adjust the experimentation environment and design to achieve the best results (Reeves, 2006).

Methods and Materials

Taking a design-based research (DBR) approach in this study, we evaluated past experiments in order to modify recycling interfaces and target specific educational environments to achieve better learning outcomes. From our previous work in Macro and Micro social environments in college groups, we learned that not only it is faster to achieve change on a macro social environment, but also that technologically delivered stimuli are more effective when trying to increment recycling rates and positive attitudes towards recycling (MozoReyes et al., TBS; MozoReyes and Jambeck, TBS). We also learned that the means to deliver information can make a difference on deciding whether to recycle, but the message to convey needs to be as clear as possible to be accurately assimilated by cognition.

In previous work, an emergent organizational change was observed while monitoring individual behavior. In addition during the community event, more successful recycling rates and better attitudes were observed. In this case, we decided to re-create various macro system characteristics in order to achieve a faster change on a micro social scale. The experiment was conducted in an engineering building location where, despite the diversity of individuals (six different engineering program disciplines), there is still a strong bond in the community that could influence personal beliefs and actions. This commonality and sense of belonging (Zastrow and Kirst-Ashman, 2010) can act as a "power of context" (Burke, 2011) that could be reinforced by the environmentally friendly ambience (environmentally conscious messages and advertisement) of the building. The experimental location was also where it was likely to find groups of people, who could act as innovators and motivators for other people (Burke, 2011). The "stickiness factor" was also considered; attempting to keep people interested on the action, for which besides the clearly attractive visual stimuli we ensured intermittence (people did not know what to expect) on the sound produced (Burke, 2011).

A previously designed UGA SmartBin was used for this experiment, since the bin provided the greatest improvement to recycling using a combination of interactive feedback, visually attractive stimuli, and non-invasive information. However, we learned that the information needs to convey a clear message in order to avoid conflicting behaviors (MozoReyes and Jambeck, TBS). Information should also be presented in a way that inspires people to reflect upon the action, so the SmartBin 2.0 (second iteration), shown in Figure 5.1, was modified by including an optional feature for additional information in the form of a QR code that could be scanned connecting participants to a previously developed WeRecycle website. The WeRecycle website was specifically designed in conjunction with a phone app to provide, among other features, information about recycling on the UGA campus, and the SmartBin project.

Figure 5.1. UGA SmartBin 2.0 Prototype

The SmartBin 2.1 was introduced as an additional recycling bin (Figure 5.2) to avoid the subjectivity of replacing one of the most used recycling bins. This also meant we could observe if the UGA SmartBin 2.1 was diverting recycling from other bins.

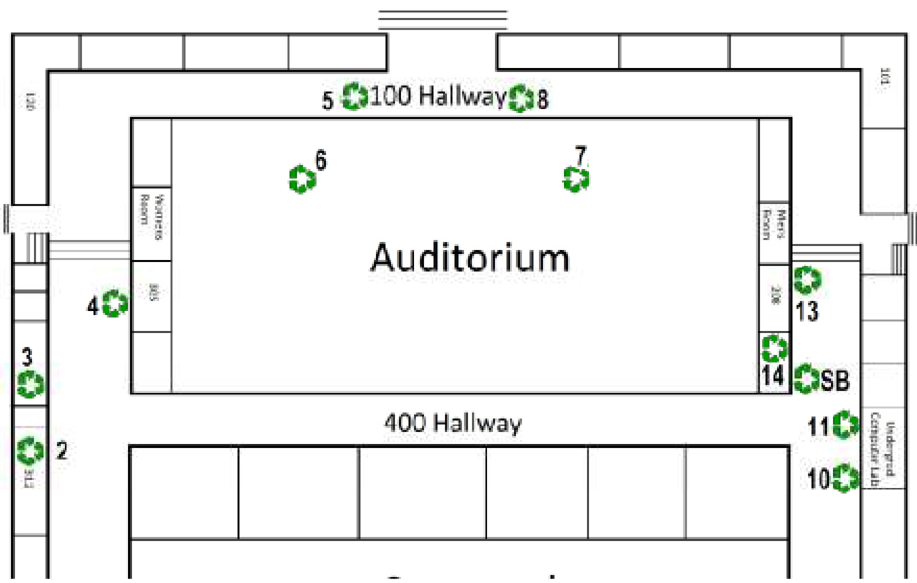

Figure 5.2. UGA SmartBin 2.1 Location

In a relatively small community environment, the macro social characteristics could result in increased recycling in a shorter period of time. Also in a community this size, experienced individuals (especially in the environmental engineering program) transmit information more easily and serve as "mavens" thus enhancing the experience of new users (Burke, 2011). Mavens create a scaffolding process that allows more timid participants to explore the new technology with the feeling of safety that others have tried it before. Scaffolding theory, besides being a good strategy for achieving behavior changes in organizations, is also used by educational theorists such as Vygotsky to inspire more effective learning outcomes (Russell, 1999).

Data Collection and Evaluation

A clear connection between the quality of the experience and the learning outcome has been established (Dewey, 1998). Based on the experiment design principles mentioned previously, we expected participants to learn about the importance of recycling. As a baseline, recycling in every recycle bin in the Driftmier Engineering Center (building at the University of Georgia, Athens, GA, USA) was tracked for one week. Both the weight and number of items recycled were counted. The second week the UGA SmartBin 2.1 was deployed and all the same quantitative measurements were taken. Items recycled in the SmartBin were counted each day.

Visits to the WeRecycle website were tracked through Google Analytics. Behavior around the UGA SmartBin 2.1was casually observed and comments were received about the interface. Statistics (two proportion hypothesis test) were used to compare the baseline with the experimental week data.

Results

The total amount of recycling increased for the entire building during the experimental week. In addition, as shown in Table 5.1, the recycling in bins surrounding the UGA SmartBin 2.1 was diverted to the SmartBin.

The table also shows that the most diverted recycling occurred at Location 10, which was directly across the hall from the UGA SmartBin 2.1, inside the computer lab.

Other surrounding bins illustrated decreased quantities as well during the experimental week, which is supported by the information on Figure 5.3

Table 5.1. Recycling Rates Before and After the UGA SmartBin 2.1 Intervention.

	Driftmier Total Recycling		Location Recycling										
	(lbs)	(items)	(Kg)					(items)				
			10	11	SB	13	14	10	11	SB	13	14
Baseline Week	7.98	179	0.67	0.24	n.d.	0.40	0.01	23	12	n.d.	19	1
UGA SmartBin 2.1	12.24	231	0.06	0.28	2.34	0.23	0	8	10	64	4	0

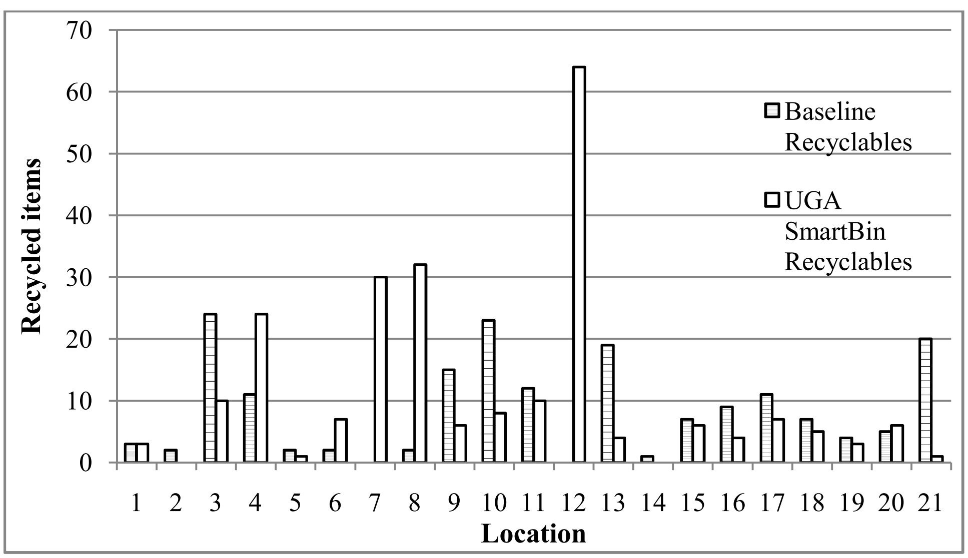

Figure 5.3. Recycling Rates UGA SmartBin 2.1 Collection Week and Baseline Collection Week

Figure 5.3 also shows increased recycling rates at other locations during the experimental week, mostly around the entrances of the building and offices. In addition, the highest recycling rate in one bin during the baseline week was significantly lower (99% of a two proportion hypothesis test: $z = 3.67$; $p = 0.0001$) than the recycling on the UGA SmartBin 2.1. The recyclable items on the SmartBin, however, were not the only indicator of interest from the participants.

The interest and curiosity towards the bin were also demonstrated by the electronic counter and the visits to the website to a lesser extent. While we counted 64 recyclable items plus three contaminants in the UGA SmartBin 2.1, the electronic counter registered 111 counts as shown in Figure 5.4.

Figure 5.4. UGA SmartBin 2.1 on Location (in front of Computer Lab Driftmier Engineering Center, University of Georgia, Athens, GA, USA)

We attributed these extra counts to people putting their hands inside the bin to provoke a reaction from the mechanism. Additionally, flash pictures could also alter the mechanism (after taking a very close picture the sensor system got interrupted and acted as if an item had been thrown) due to sensitivity of the sensors. These experiences provoked comments addressed directly to people related to the project and also provoked some visits to the website (Figure 5.5).

Figure 5.5. Website Visits per Day during the Baseline and UGA SmartBin 2.1 weeks

Figure 5.5 shows an increase in visits to the website (from the baseline) from May 2nd to May 8th, 2012 except during the weekend when the building is closed to undergraduate students. The week from April 25th to May 1st, 2012 was the week of the baseline and the average number of visits during this week was 2.9 while the average number during the SmartBin week was 5.4. Although no mathematical significant difference could be made from these numbers, we did observe people taking pictures of the code and connecting to the website during the intervention.

It was observed that the UGA SmartBin 2.1 worked as a point of meetings as well as a piece of conversation and exchange of ideas. From the first to the last day, we observed students around the bin talking about its technological features and about recycling in general as well as professors (not associated with the project) talking to their peers about the technology behind the construction of the SmartBin.

It was observed that by following an appropriate leadership (scaffolding from innovators), not only recycling increased on the building, but it became more conscious. With probability 99%, the proportion of contaminants in the SmartBin was less than the proportion in the bin with the highest amount of recycling during the baseline ($z = 2.66$, $p = 0.0039$). As was witnessed in previous research, an older member of a family guiding the action of a young boy to avoid contaminants in the UGA SmartBin 2.0 (MozoReyes et al TBS), more experienced recyclers could also have influenced the amount of contaminants found during the experimental week in this case. The consciousness of recycling the appropriate items according to the bin could be seen as an important learning outcome that would be influenced by the process of thought and action-axiom of new recyclers shown in Figure 5.6.

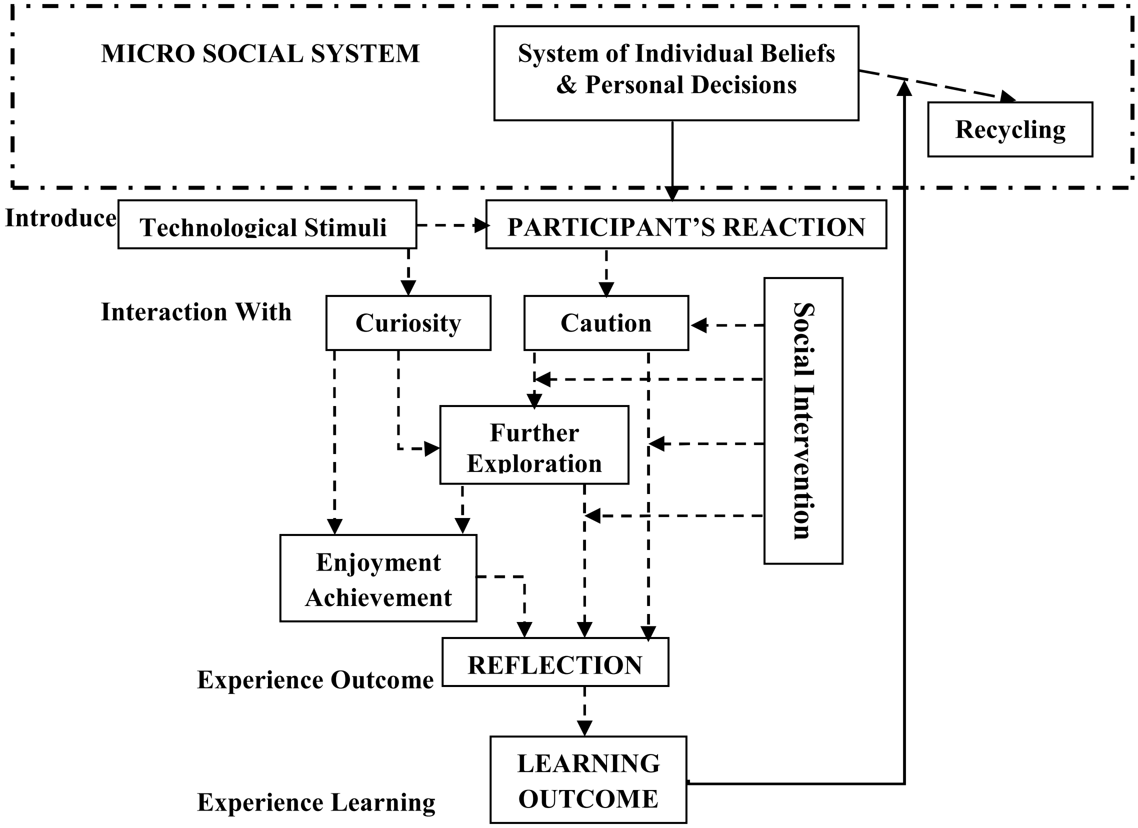

Figure 5.6. Possible Paths and Outcomes from Interventions during the UGA SmartBin 2.1 week

It appears our experiment effectively re-created a macro social system in the everyday life of the students in the College of Engineering that allowed for a feeling of solidarity in which learning and adopting a new behavior would be supported (Noddings, 2005).

Discussion

In our small community environment, some of the most experienced recyclers took the task to guide and enhance the experience for their closest friends and since their friends did the same, the community followed rules of organizational change that ensured a more successful outcome and a more positive attitude toward recycling. The innovators acted as leaders prompting smoother reactions and offering guided experience to other participants thus becoming the few that lead the community to increase recycling.

We noticed that after applying a design-based research approach, we could identify and implement a more accurate strategy to encourage recycling in a short period of time. During this time, we also observed that people went through learning processes that would make them more aware of recycling, thus leading to conscious recycling with less contamination. These learning processes could be analyzed using theories from Vygotsky, Noddings, and Bandura, who stated in 2001 that "learning occurs as an emergent result of a dynamic relationship between human behavior, environment, and human agent" (Bandura, 2001).

Finally, we noticed that if it is true that information alone is not enough to promote a conscious change on recycling practices, behavior modeling could also benefit from the inclusion of constructivist educational approaches and tools that would help people to make informed decisions about pro-environmental activities encouraging perhaps that extra effort needed to be more engaged with recycling. Therefore, further research is required on the field of constructivist educational approaches to explore their applications on pro-environmental activities promotion.

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CHAPTER 6

CONCLUSIONS

The overall objective of the study was to establish the relationship between certain psychosocial stimuli (or techno-social event) with recycling rates as well as with changes in human responses to recycling in different social environments. We demonstrated that certain stimuli are more effective in changing behavior when applied under specific circumstances. Personalized sounds, for example, are very popular on communities that share strong bonds. Pictures are more effective when providing information than words. Frustration or negative reinforcements could also lead to other type of responses that did expand the scope of the research. This study illustrated how people are capable of change and adaptation in different environments if they are provided a technological stimuli and a social structure with the appropriate support system.

Chapter 2 showed how introducing electronically delivered stimuli to a community in a public event can increase recycling by appealing to the psychology behind group change and group behavior. People became more interested in recycling when they got immediate feedback from simple lights giving a color change and a counter increasing, turning it into a fun or exciting activity worth investing time. In a macro social environment, it is then easier to transmit the fun and excitement for the activity since these types of environments follow organizational change principles.

The UGA SmartBin 2.0 helped create a positive attitude around recycling and behavioral changes were observed not only at a community level, but by individuals who changed their opinion and attitudes towards the activity. People felt the feedback provided them positive social reinforcement and when the reinforcement became intermittent they reflected on their own behavior. They explored “better” ways to recycle and put effort towards figuring out a way to receive the feedback, including avoiding the disposal of non-recyclable items in the SmartBin. The intermittence also worked as a way to keep people interested on the activity (Zastrow and Kirst-Ashman, 2010). It can be concluded from observations that people enjoyed the interface and that it fulfilled the purpose of positively influencing recycling to be perceived as an exciting activity.

Chapter 3 explored more deeply the differences between stimuli demonstrating that the technologically delivered combination of Information, Feedback, and Social Reinforcements presented was superior when compared to our non-technological approach and a baseline collection phase since it helped increasing recycling rates and promoting positive attitudes towards recycling. Low recycling rates during Phase Two were attributed to the invasive design of the interface since there are certain stimuli or modalities of delivery that instead of promoting environmentally friendly activities, specifically recycling, manage to discourage people from performing the activity (Schultz et al, 2007; Franz and Papyrakis, 2011). However, Phase Two demonstrated what Plaue *et al*. had stated in 2004, pictorial signage can make a difference on the type of items thrown in a recycling bin (Plaue et al., 2004).

Interactivity demonstrated to be one of the key elements that make the UGA SmartBin 2.0 a more effective approach towards recycling, but HCI characteristics such as subtlety and pictorial realism (performing a green activity) were also decisive factors to make this a successful strategy. The UGA SmartBin also demonstrated that people are individually receptive of interactive stimuli although not as effectively as when the intervention is applied in a Macro Social environment (Schultz et al., 2007; MozoReyes et al. TBS) since characteristics of Macro Social systems were observed during the fourth week of the experiment when recycling rates started to increase.

The use of the recycling prototype as well as the non-technological setup provided valuable information for recycling strategies including the effect of different stimulus and the potential benefits of including technology on the behavior modification process. Observation showed that some stimuli have the ability to modify certain behavior almost immediately, but it also showed that some important behaviors probably need other factors to consider when designing strategies in order to achieve the best results. In turn, the items collection showed that recycling can happen at any time or day of the week for which it is important to maintain the strategy running at all times. Some behavioral patterns observed during the experimentation in Chapter 3 that would suggest a learning process from these experiences.

In the small community environment studied in Chapter 4, some of the most experienced recyclers took the task to guide and enhance the experience for their closest friends and since their friends did the same, the community followed rules of organizational change that ensured the successful outcome and positive attitude toward recycling. The innovators acted as leaders prompting smoother reactions and offering guided experience to other participants thus becoming the few that lead the community to increase recycling. Also, after applying a design-based research approach in this study, it was easy to identify and implement a more accurate strategy to encourage recycling in a short period of time. During this time, it was observed that people went through learning processes that would make them more aware of recycling, thus leading to conscious recycling with less contamination. These learning processes could be analyzed using theories from Vygotsky, Noddings, and Bandura who stated that *"learning occurs as an emergent result of a dynamic relationship between human behavior, environment, and human agent"* (Bandura, 2001). In general, this research contributed to broaden the scope of environmental engineering approaches by including social sciences and educational points of view that can make a significant difference when designing for promoting organization changes in any field.

Finally, it was concluded that if it is true that information alone is not enough to promote a conscious change on recycling practices, behavior modeling could also benefit from the inclusion of constructivist educational approaches and tools that would help people to make informed decisions about pro-environmental activities encouraging perhaps that extra effort needed to be more engaged with recycling. Therefore, further research is required on the field of constructivist educational approaches to explore their applications on pro-environmental activities promotion and more general in the engineering field, where human behavior should be acknowledged as a major decisive factor in design.

For this reason, further research is needed that explores the human side of technology and can determine the difference made by the introduction of technology in environmental issues like recycling. It is recommended to extend the experiment over a longer period of time including the combination of macro and micro social environmental characteristics that would facilitate behavioral changes and learning outcomes associated with the behavior modification.

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APPENDIX A. OBSERVATION PROTOCOL

Date: _______________ Time: _____________

1. Participants:

   Number of people by the bin: _____ Number of people using the bin: _____

2. Interaction with the bin:

   Complete Stop ☐ Quick Stop ☐ Passed & Went back ☐ No Stop ☐

3. Distance to the bin:

   <18” ☐ 18”- 4’ ☐ 4’ - 12’ ☐

4. Body Position:

   Head position and movement:

   Arms position and movement:

   Legs position and movement:

   Feet direction:

   Hands comments:

   Facial expressions:

5. Participant brings external attention to the bin:

6. Approximate time of Interaction: _____________