The Effect of Environmental Knowledge on Improving Recycling Behavior:

A Case Study at University of California, Berkeley's International House

Thao T. Tran

ABSTRACT

Research of recycling behavior has primarily focused on environmental concerns and values. However, there is a need for the investigation of the relationship between recycling behavior and environmental knowledge. Obtaining more environmental knowledge, specifically on waste and proper recycling, could potentially improve an individual's recycling behavior. Using University of California, Berkeley's International House as a case study, I organized two outreach activities to increase residents' knowledge on waste and recycling in order to test the effectiveness of these interventions in improving recycling behavior. Following these activities, I distributed a survey to the general International House community with questions focused on previous environmental involvement, demographic characteristics, self-reported recycling behavior, and their perceived behavioral changes following participation in the interventions. The surveyed participants with more exposure to various sources of environmental information recycled more than those with less exposure. However, the relationship between exposure to general environmental knowledge and recycling habits was not statistically significant. Likewise, there was no statistical significance in the correlation between recycling behavior and the respondents' gender, education level and region of origin. Meanwhile, based on the post-intervention survey results from the activity participants, providing information specifically on waste and recycling showed to improve individual recycling behavior, albeit only with people with certain characteristics. The results suggest that effective environmental education in small institutions, such as the International House, requires improved effort in environmental knowledge and delivery. In addition, understanding the background of the target population characteristics can potentially improve the effectiveness of environmental knowledge-building activities. There should be more research in the future to better understand which types of educational tools should be used for different populations to maximize their effectiveness.

KEYWORDS

waste, recycling, environmental knowledge, behavior, university

INTRODUCTION

Waste has become a key environmental issue due to the increasing production and consumption of materials. In 2014, the U.S. produced 258.5 million tons of municipal solid waste. Municipal solid waste includes yard trimmings, food, plastic, paper, glass, metals, clothes and electronics from households as well as commercial and institutional sources. Waste disposal practices have generated many environmental problems, including water pollution, air pollution and increase in greenhouse gas emissions (U.S. EPAb 2016). For example, the irresponsible landfilling of waste results in water pollution. Water pollution not only affects all sorts of aquatic animals, but also contaminates groundwater – an important source of human drinking water (Apgar and Langmuir 1971). The burning of waste increases greenhouse gas emissions, which further contributes to global climate change. Additionally, disposing of organic materials in landfills generates methane, a potent greenhouse gas. The process of managing waste is also very environmentally damaging since the burning of waste requires a great amount of energy (U.S. EPAa 2009). As a result, there have been efforts made to reduce and handle the growing amount of waste more efficiently.

One of the most urgent focuses of protecting the environment has been to improve sustainable waste management. The US EPA developed "the non-hazardous materials and waste management hierarchy," also called "the waste management hierarchy." This hierarchy ranked the effectiveness of sustainable waste management approaches. The most effective practice is source reduction and reuse, followed by recycling/composting, energy recovery, and the last one is treatment and disposal (U.S. EPAc 2017) (See Figure 1.).

Figure 1. Waste Management Hierarchy (U.S. EPAc 2017).

Recycling and composting are both promising solutions to reducing landfill waste. A study by the US EPA estimated the energy consumed in different waste management scenarios in 2009. For example, for approximately 14 million tons of steel cans, three percent increase in the recycling rate could help reduce almost 700 million tons of carbon dioxide emitted (U.S. EPAa 2009). In 2014, the amount of recyclable waste collected in the U.S. was 89.4 million tons, and this amount accounted for less than 30 percent of the total waste (U.S. EPAb 2016). Besides the fact that recycling efficiencies are never one hundred percent, there is still a significant amount of recyclable waste that ends up in landfill, and the rate of recycling materials is not as fast as the rate at which they are produced, consumed and disposed of. These issues seem to come from insufficient recycling facilities, consumers' behavior due to a lack of knowledge and understanding about proper disposal of waste. In Yolonda Wright's study about knowledge and recycling behavior, she stated that "I observed that those with negligible recycling behavior expressed almost negligible knowledge on the proper way to recycle materials. Without practical knowledge on how to properly recycle, recycling amount cannot occur" (Wright 2011).

Therefore, this research explores the effectiveness of environmental education on changing human behavior and actions towards waste and recycling through a case study at the International House at University of California, Berkeley (UC Berkeley). The objectives of my study are stated below:

1. Understand how exposure to various sources of environmental information plays a role in individual behaviors towards recycling.
2. Understand whether demographics are also contributing factors to human's recycling behavior.
3. Study the effectiveness of improving waste knowledge on recycling behavior.

My goal was to investigate and analyze improved sustainability outreach activities at UC Berkeley's International House to see if they would change people's recycling behavior. Taking the advantage of being one of the sustainability coordinators since 2016, for this research, I designed, implemented new outreach projects for the building, and kept track of how responsive the residents were to these programs and activities, and analyzed the outcomes. In order to do this, I conducted a survey for the residents to collect their self-reported recycling amounts, information about their environmental and demographic background and self-reported changes of recycling behavior after the outreach activities.

Environmental education

According the US EPA, environmental education is defined as "a process that allows individuals to explore environmental issues, engage in problem solving, and take action to improve the environment…. Environmental education helps the public make responsible and informed decisions" (U.S. EPAd 2018). There are many resources, such as news and environmental organizations, for people to learn about current environmental issues and conservation. However, there are also people who do not have access to environmental knowledge; therefore, they are not aware and informed about the environment. In one study about teaching solid waste management, the majority of students were not well-informed about proper waste disposal. However, the more exposed the students were to environmental issues and how waste plays a role in environmental degradation, the more aware they became, and they started to adjust their actions. "As they realize that they can use and must take a stand, this will provide impetus for the development for better environmental education curricula in schools and universities and will also serve to improve awareness within the community" (Morrissey and Závodská 2016). Environmental education has been very effective, yet, the challenge is to make these curricular changes broader and more feasible.

Environmental education plays an important role in individual behaviors towards waste. Ari Altman's study about environmental behaviors of UC Berkeley students showed that changes of behavior were a result of both environmental concern and understanding. While Altman acknowledged environmental education as a "reform tool," the remaining question was whether "environmental education efforts" was "the key to instilling environmental concern." It is likely that decision-making is often based on understanding about the living systems and sustainability. The author also emphasized that college environment is where training can take place effectively, because it is the transition from academics to real life (Altman 2000). According to a study about "green citizens" done by Boerschig and De Young, they identify different types of knowledge including: "action skills, attitude, personal responsibility and sensitivity;" yet, they find that recognition is not sufficient enough to change behavior (Boerschig and De Young 1993). Therefore, in my study, I used certain educational variables, such as environmental background and participation in sustainability activities, to look for correlation between them and people's changes in recycling behavior.

Demographic factors can have significant influences in understanding recycling behaviors and the effectiveness of various sustainability practices. As Altman studied recycling behaviors through self-reported surveys about students' environmental background and attitudes towards environmental issues, he concluded that recycling behaviors turned out not to be "a particularly useful gauge of environmental action." He found that there were other factors that could help increase recycling rates such as "parents' knowledge," facility convenience and so forth (Altman 2000). In another paper by Gambro and Switzky, surveys' results revealed that males had more environmental knowledge than females; surprisingly, it was because they did not receive similar treatment in classrooms (Gambro and Switzky 1999). Yet, Vining and Ebreo concluded, from their findings about recycling behavior, that concern does not predict behaviors (Vining and Ebreo 1992). There was limited of findings about populations of multicultural and diverse communities, like the I-House at UC Berkeley where domestic students accounted for less than 30 percent. Thus, in my surveys, I particularly investigated not only genders, educational levels, but also regions of origin, and their relationship with recycling behavior.

Small organizations, such as Berkeley International House, have a very great potential in providing environmental information through different outreach activities. Altman recognized that there were different "channels" for developing and delivering environmental materials to people from local to regional levels or within non-profit organizations (Altman 2000). For example, Gillian et al. used advertisements and campaigns in the county to promote environmental awareness and learned that effective strategies should target human attitudes and behaviors instead of providing too much information (Gillian et al. 1996). In a different research, other factors appeared to be convenience and pressure from peer and social influences (Vining and Ebreo 1992). However, the scales of these research are usually very large; their target populations were campuses or county with more than 10,000 people. Hence, I conducted my research in the organizational level, particularly the I-House dormitory of around 580 residents, with different outreach activities and a survey aiming at residents' behaviors towards recycling.

Waste practices on UC Berkeley Campus

Since 2012, the University of California System has encouraged and informed the campus community about proper waste disposal. Different strategies and practices have been implemented.

For example, the University of California System established an institutional commitment to achieving "Zero Waste by 2020." Yet, this goal is very unlikely to be achieved as only 69 percent of the total waste is currently composted and recycled (University of California 2017). At UC Berkeley, current projects do not seem to be effective enough, because they could not reach their goal to have a 75 percent diversion rate by June of 2012. Diversion rate is the rate at which waste is diverted from landfill to recycling. The campus recycles various waste such papers, beverage and plastic containers, electronic waste and metals. They also compost food waste, green waste and compostable plastics. UC Berkeley's current diversion rate is 50 percent, which is lower than the rate of the University of California System (Berkeley Sustainability and Energy n.d.). The main challenge is how to create more effective policies and strategies to improve the process of achieving zero-waste. In a study about recycling at the University of Wisconsin, Werff and James concluded that "residential hall staff members play a large role in the development of individual accountability. They are a great resource for teaching recycling" (Werff and James 2008). Therefore, there is a need for better sustainable waste management, especially improving environmental education in different residential locations.

Sustainability effort at UC Berkeley's International House

As part of the UC Berkeley campus, the UC Berkeley's International House (I-House) initiated sustainability programing since 2015. As being new to the zero-waste movement, I-House has introduced two student staff positions called Sustainability Coordinators to assist the community in generating green initiatives and engaging residents with these initiatives in order for them to be informed about campus sustainability goals. In I-House, there are recycling bins with signage on every floor, and each room is provided with one blue and one black bin for recycling and landfill waste, respectively. In the I-House's first sustainability report, the sustainability coordinator Annika Min described her tasks and how she observed residents' response to different environmental programs. She also believed that the I-House should continue hiring sustainability workers, because she could see positive results from the residents, such as minor changes in their behaviors towards waste and their curiosity about environmental issues. However, she also noticed challenges such as difficulties in renovating infrastructures and applying new policies. Another major challenge was that there were residents who did not want to get involved in any sustainability

programs or activities (Min 2016). Both opportunities and challenges are very critical in helping the I-House with future sustainability projects, particularly focused on environmental education.

METHODS

The research took place at UC Berkeley's International House where the majority of residents were international students. I designed and implemented two interventions to provide education and information to I-House residents: 1) A social event called "coffee hour," and 2) Informational flyers. After implementation of both interventions, I generated a survey to ask residents different questions about their recycling behavior, their background information and self-reported behavioral changes after interventions. The purpose of my study was to understand the environmental background of the residents and to test whether the intervention efforts improved their recycling behavior.

Intervention one: Sustainability coffee hour

Coffee Hour is held every Wednesday night, from nine to ten o'clock and is a community-building tradition at I-House in order for residents to socialize and relax after classes. Topics vary for each coffee hour. On February 21, 2018, I took over a coffee hour event to promote environmental sustainability and the "Zero waste by 2020" commitment. Because most people came from different places in the world where waste disposal may be different, I provided them with information and instructions about proper waste disposal practices through questions. People answered questions and those with a correct answer received an I-House mug. I also had a 'Sustainability Meme-making Contest," in order to attract more participants who were interested in competitions, and the winners received a twenty-dollar and a fifteen-dollar Amazon gift card. The purpose of this sustainability outreach event was to understand more about how much people know and care about sustainability and waste.

Intervention two: Three informational flyers

In I-House, a flyer is a great tool of communication and informing residents about sustainability since they can stay in public places for a longer time compared to the informational screens. The flyers posted as part of this intervention were to increase residents' knowledge and understanding about waste and proper recycling (See Appendix B for the complete flyers). For each flyer, 80 copies were posted in all residential bathrooms, two elevators and the floor bulletin boards. Electronic versions of these flyers were also posted on the I-House Sustainability Facebook Page. Each flyer was focused on a sustainability theme:

- First flyer, "Be Informed, Be considerate," was about the "Zero waste by 2020" goal of the campus, posted on January 16, 2018
- Second flyer, "New Semester, New Start" was a list of tips on how to create a green lifestyle, posted on February 4, 2018.
- Third flyer, "Proper Waste Disposal," was instructions about how to dispose of waste responsibly, posted on March 4, 2018

Post-intervention survey

The post-intervention survey was open from March 17 to 21, 2018 through the "I-House at UC Berkeley 2017-2018" Facebook page (See Appendix A for the complete survey). I generated this survey using Berkeley Qualtrics. Participants required approximately three minutes to complete the fourteen-question survey. The incentive for participation was entry to win an fifteen-dollar Amazon gift card. I collected a total of 96 responses. The survey questions examined the following specific aspects:

- Their involvement in environmental activities
- The amount of waste that they recycled the past week
- How easy residents found recycling in and outside of I-House
- Whether they participated in any of my interventions
- Self-reported changes in recycling behavior after the interventions
- Their comments and suggestions to improve sustainability at I-House
- Demographic information

Data analysis

All survey responses from residents were analyzed using the chi-square goodness-of-fit test with a 95-percent confidence level for the statistical significance, combined with the Monte Carlo simulation, in RStudio (RStudio Team 2016). I also installed the package Dplyr for data manipulation (Wickham et al. 2017). My first analysis was to study the relationship between recycling behavior of the residents and their environmental background, including knowledge of the zero-waste campaign, previous environmental involvement and recycling practice at home. My second analysis were based on recycling behavior and demographic information, which were gender, region of origin and education level. For these two analyses, I had to exclude 10 responses because these residents did not remember the amount of waste that they recycled; thus, I analyzed 86 responses. For each set of analysis, my response variables were the recycling amount reported by individuals. These relationships were also illustrated by pie charts and bar graphs.

For the third analysis on the effectiveness of I-House's sustainability efforts on residents' recycling behavior, I only focused on the data from those who reported participating in the interventions. After asking them about their participation, I also asked those participants whether their recycling behavior had changed or improved after the interventions and used this information as my response variable. Similar to the background analysis, I used the chi-square goodness-of-fit test to study the association between self-reported changes in recycling behavior and participation. Finally, to understand whether the impact was different among certain groups of people, I analyzed the self-reported change by gender, being informed about "Zero waste by 2020," recycling at home and involvement in environmental programs, using the Fisher's exact test and the chi-square test.

RESULTS

Environmental background survey

Using the chi-square goodness-of-fit test looking at quantity recycled as the response variable and being informed about the zero-waste campaign, I found that the residents who were informed recycled more than those who were not informed. Figure 2. showed the distribution of self-reported amount of waste that 86 I-House resident participants recycled the past week. There

were approximately 84% (72) of the respondents who were informed about the "Zero Waste by 2020" goal of the UC campus. Of these 72 respondents, 83% of those recycled some to all of their total waste. Meanwhile, only 76% of the 14 residents who were not informed about this campaign recycled the similar amounts of waste. However, the chi-square goodness-of-fit test showed that the relationship between being informed and the amount of waste recycled was not statistically significant (χ^2 (4, N = 86) = 7.05, *p-value* = 0.12). It was due to chance that the people who were informed about "Zero Waste by 2020" recycled more than those who were not.
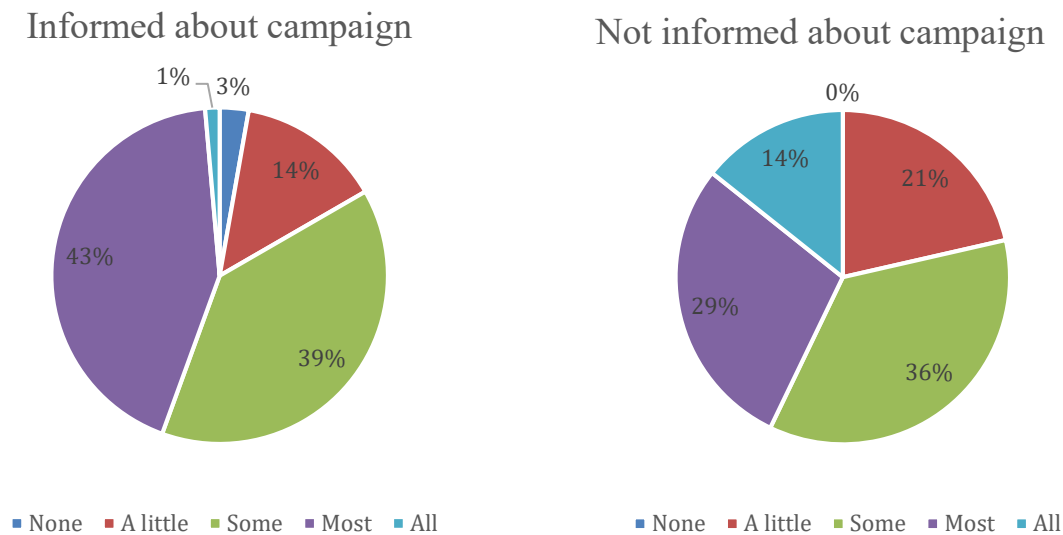

Figure 2. The amount of waste recycled self-reported by residents who were and were not informed about the UC's commitment to achieving "Zero-waste by 2020" (N = 86).

For the self-reported recycling behavior from 28 residents who followed the "I-House Sustainability 2017-2018" Facebook Page, the members appeared to recycle more than the non-members. 92% of these residents recycled some to all the total waste they generated the past week. For the 58 people who were not members of the page, 77% said that they recycled from some to all of their waste. Figure 3. showed how much the differences in recycling behaviors of the respondents who did and did not follow the Facebook page. My analysis showed that there was no statistical correlation between being members of the sustainability Facebook page and recycling behaviors (χ^2 (4, N = 86) = 5.87, *p-value* = 0.20).

Followed on Facebook

Did not follow on Facebook
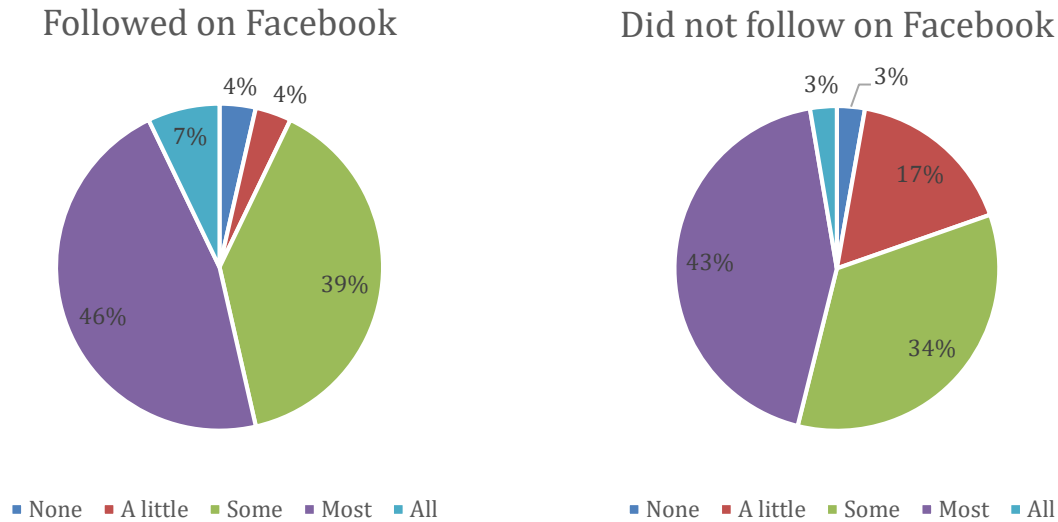
Figure 3. The amount of waste recycled self-reported by residents who did and did not follow the I-House Sustainability Facebook Page (N = 86).

I found that residents who had been involved in at least one environmental organization recycled more than those who had not been involved in anything. Figure 4. showed the distribution of how much the residents, who did and did not have any previous environmental involvement in an environmental organization. The people who had involvement with an environmental organization reported to recycle more than those who were not (85.4% compared to 80.7% recycled from some to all). The chi-square test results were χ^2 (4, N = 86) = 5.87, *p-value* = 0.20. Thus, since the *p-value* was far from 0.05, the relationship between environmental involvement and recycling behavior was not statistically significant. It was due to chance that people who recycled more were more engaged in different environmental programs.

Involved
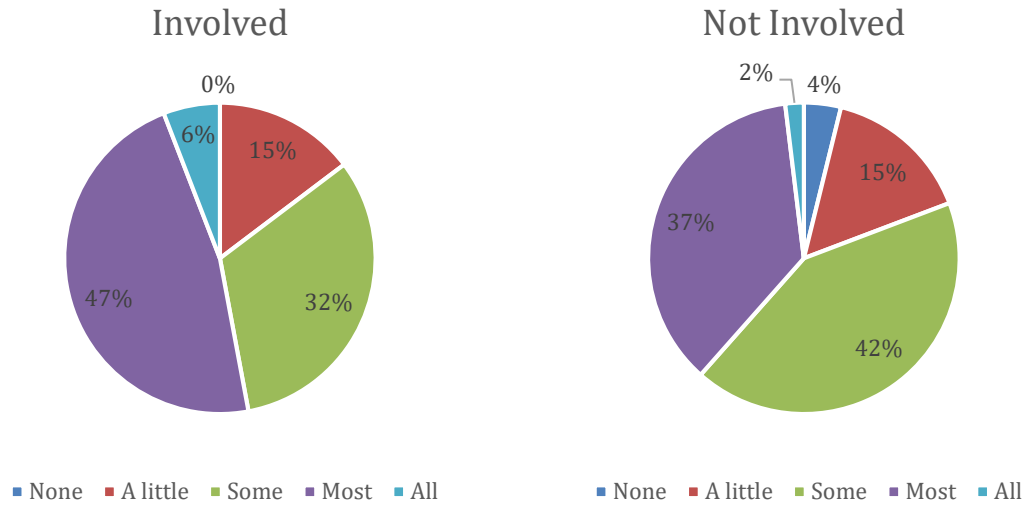
Not Involved

Figure 4. Self-reported recycling behaviors from the residents who were and were not involved in any environmental organizations (N = 86).

Unlike above statistically insignificant findings about recycling behavior and previous exposure to environmental knowledge, the chi-square test results (χ^2 (4, N = 86) = 12.6, *p-value* = 0.02) between previously recycling at home and the amount recycled were statistically significant. Residents who had practiced recycling at home were likely to recycle more than whose who did not recycle before (Figure 5.).

Recycled at home
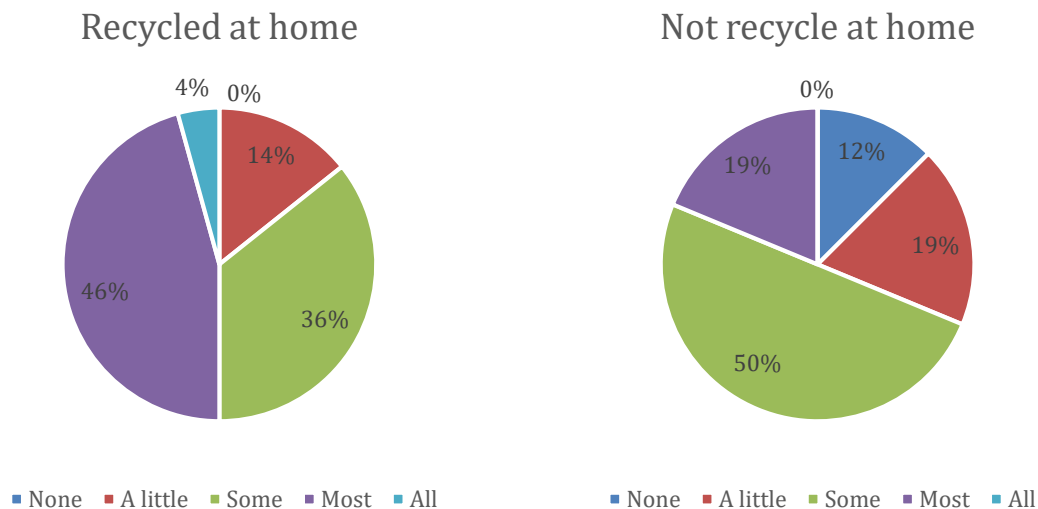
Not recycle at home

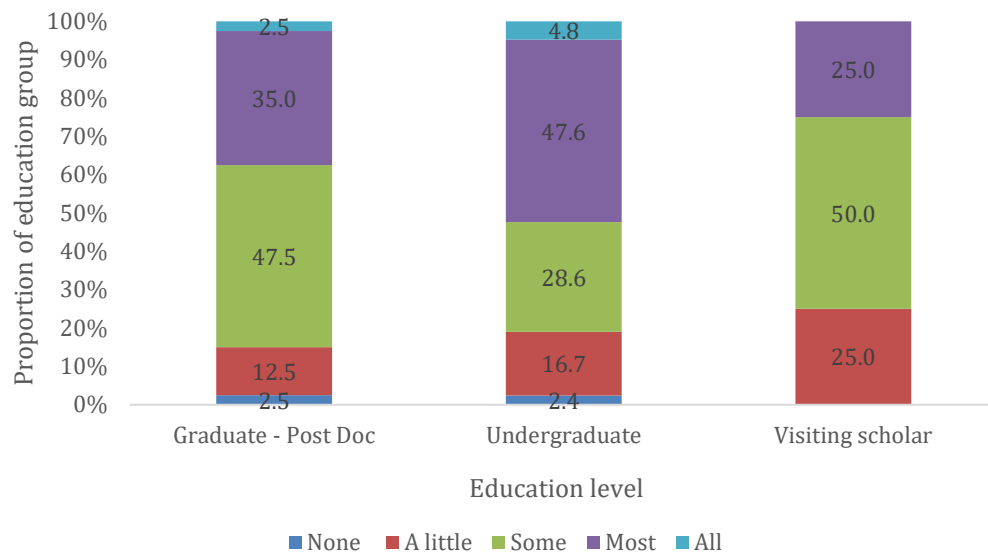**Figure 5. The amount of waste recycled from residents who did and did not recycle at home (N = 86).**

Genders, educational background and ethnicities on recycling behavior

Even though I observed that there were differences in recycling behaviors between residents with different demographic backgrounds, my analyses showed that these relationships were not statistically significant. Figure 6. showed recycling behaviors between genders. Approximately 85% of the female residents and 80% of the male residents reported they recycled from some to all of their waste the past week. Even though females appeared to recycle more than males, the *p-value* calculated from the chi-square analysis was much greater than 0.05 (χ^2 (4, N = 86) = 2.29, *p-value* = 0.68).
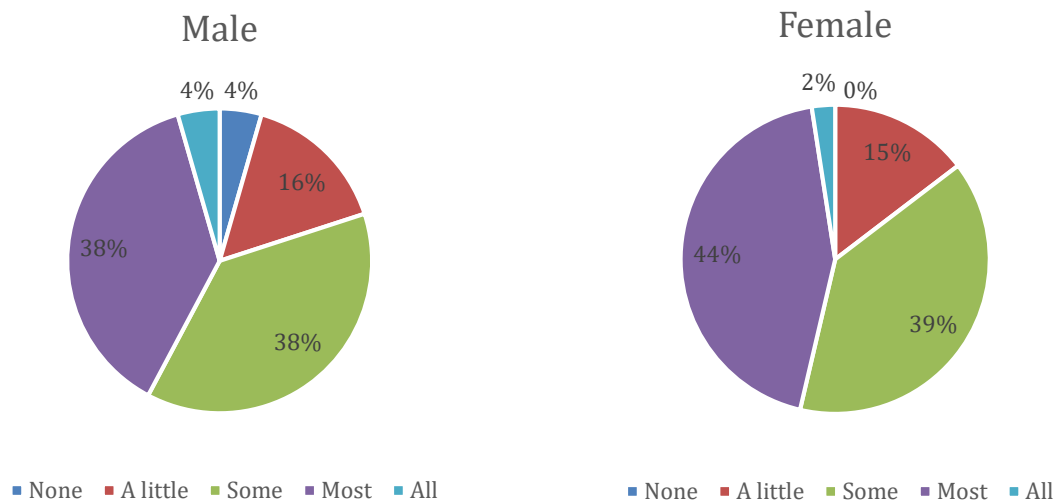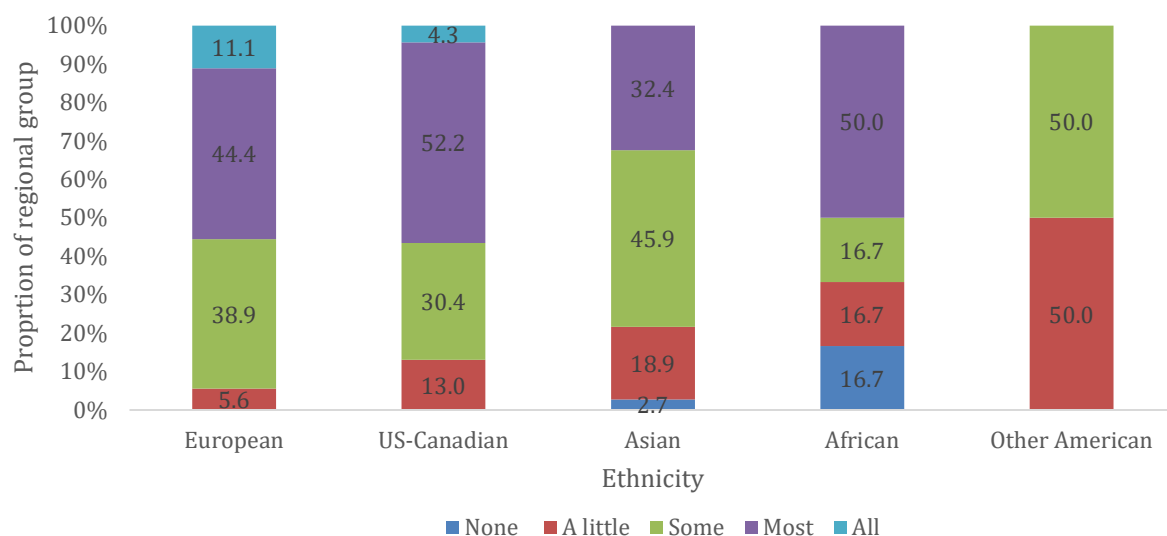

Figure 6. The amount of waste recycled between genders (N = 86).

Moreover, when analyzing education level (Figure 7), graduate and post-doc residents were the group that recycled the most from looking at the amount from some to all, undergraduates came second, then the visiting scholars recycled the least. However, the chi-square test results showed no statistical significance between educational levels and recycling behaviors (χ^2 (8, N = 86) = 4.17, *p-value* = 0.79).

.

Figure 7. The average amount of waste recycled from residents of different educational backgrounds.

Similar to the independence between educational level and recycling behavior, region of origin did not affect recycling behavior. I found that the residents from the U.S., Canada and Europe were the people who recycled the most. Yet, with the obtained statistics (χ^2 (16, N = 86) = 18.18, *p-value* = 0.31), there was no correlation between recycling behavior and where residents were from (Figure 8.).

Figure 8. The average amount of waste recycled from residents of different regions of origin.

The effect of interventions on recycling behavior

The effect of the "Love the Earth" coffee hour

37 of the 96 survey participants attended the coffee hour. Based on my collected data, more than half of the people who came to the coffee hour were not previously involved in any environmental organizations or programs (Table 1.). Approximately half of the participants were females, and the other half were males (Table 2.).

Table 1. Gender the participants of the coffee hour (N = 37).

Category	Male	Female
Number	19	18
Percentage (%)	51.4	48.6

Table 2. Previous environmental involvement the participants of the coffee hour (N = 37).

Category	Involved	Not involved
Number	17	20
Percentage (%)	45.9	54.1

Within those 37 survey respondents who came to the coffee hour, 21.6% of those participants responded that they recycled more after the event (Table 3.). I also performed a further analysis on the background of these people. Table 4. showed that more males seemed to improve their recycling habit after attending the event more than females. People who were not part of any environmental organizations had more likelihood to change. Also, people who had already recycled at home had more potential to change. Interestingly, changes were only observed in the residents who were informed about "Zero Waste by 2020." Yet, all the relationships between the background information and the self-reported changes in recycling behavior in response to the coffee hour were not statistically significant.

Table 3. Self-reported changes in recycling behavior after attending the coffee hour (N = 37).

Category	Recycle more	No change
Number of residents	8	29
Percentage (%)	21.6	78.4

Table 4. Self-reported changes in recycling behavior and genders, environmental involvement, recycling at home and being informed about "Zero Waste by 2020." The statistical test used was the Fishers' exact test.

Category	Recycle more	No change
Gender		
(N = 37, *p-value* = 0.43)		
Female	2	16
Male	6	13
Environmental involvement		
(N = 37, *p-value* = 0.43)		
Involved	5	12
Not involved	3	5
Recycling at home		
(N = 37, *p-value* = 0.59)		
Yes	6	25
No	2	4
Being informed about "Zero Waste by 2020"		
(N = 37, *p-value* = 0.60)		
Yes	8	24
No	0	5

The effect of the flyers

Based on the intervention survey data, 78 out of 96 residents reported that they had read at least one informational flyer. Table 5. showed that the majority of the residents were not part of any environmental programs and organizations prior to reading the flyers. In addition, more than half of the readers were males (Table 6).

Table 5. Previous environmental involvement the flyer readers (N = 78).

Category	Involved	Not involved
Number	30	48
Percentage (%)	38.5	61.5

Table 6. Gender of the flyer readers (N = 78).

Category	Male	Female
Number	43	35
Percentage (%)	55.1	44.9

Similar to the statistically insignificant relationship between participation in the coffee hour and changes in recycling behavior, I found that there was no effect of reading the flyer(s) towards improving recycling behavior of people of different backgrounds. Even though there was no statistically significant correlation between current recycling behavior and gender, previous environmental involvement and recycling at home, Table 8. showed similar results to the effect of the coffee hour: the people who had more potential to change were males, never involved in any environmental organizations, recycling at home but informed about the zero-waste campaign Surprisingly, the correlation between changes in recycling habits and being informed about "Zero Waste by 2020" was statistically significant (*p-value* = 0.04) which meant that those who were informed recycled more than those who were not.

Table 7. Self-reported changes in recycling behavior after reading the flyer(s) (N = 78).

Category	Recycle more	No change	Recycle less
Number of residents	22	55	1
Percentage (%)	28.2	70.5	1.3

Table 8. Self-reported changes in recycling behavior and genders, environmental involvement, recycling at home and being informed about "Zero Waste by 2020." The statistical test used was the Chi-square goodness-of-fit test.

Category	Recycle more	No change	Recycle less
Gender			
(χ^2 (2, N = 78) = 1.68, *p-value* = 0.45)			
Female	9	26	0
Male	13	29	1
Environmental involvement			
(χ^2 (2, N = 78) = 0.72, *p-value* = 0.89)			
Involved	8	22	0
Not involved	14	33	1
Recycling at home			
(χ^2 (2, N = 78) = 3.03, *p-value* = 1.00)			
Yes	17	44	1
No	5	11	0
Being informed about "Zero Waste by 2020"			
(χ^2 (2, N = 78) = 8.29, *p-value* = 0.04)			
Yes	21	47	1
No	1	8	0

DISCUSSION

Environmental background and self-reported recycling behavior

The survey demonstrated that that residents who had more previous exposure to different sources of environmental knowledge (e.g. social media and knowledge of zero waste campaign) or were involved in at least one environmental organization were likely to recycle more than those who were not. However, there was no statistical significance in the relationship between pre-exposure to environmental knowledge and recycling behavior. Multiple studies have found that the link from environmental knowledge to behavior was still questionable (Gillian et al. 1996,

Altman 2000); however, knowledge is considered one of many important factors in inducing behavioral change (Smith-Sebasto 1995, Werff and James 2008, Wright 2011). Thus, more research should be done to understand how knowledge interacts with other important factors such as context or social pressure to impact change.

However, I found that the relationship between current recycling behavior and whether that person recycled at home was statistically significant. This implied that people who already had recycling experiences before had the tendency to continue recycling. Moreover, these residents might have recycled more because they were more knowledgeable about waste and proper recycling, while those who were new to this practice might have difficulties understanding the differences between the recycling bins. Since it seemed that previous recycling experience was important, programs that focus on getting people to recycle at home at young ages (such as introducing recycling in K-12 education) might be promising.

Genders, education levels and regions of origin on recycling behavior

Similar to the results between environmental backgrounds and recycling behavior, the relationships between demographic factors and recycling behavior were not statistically significant. In my results, females recycled more than males. Also, some studies have shown that females may be more likely to sustain environmental behaviors than males did. In Mainieri et al.'s research about environmental behavior, they studied purchasing behaviors and found that females made more environmentally-friendly choices of products than males made (Mainieri et al. 1997). As a result, my study and Mainieri et al.'s study showed that depending on the type of environmental activities, it was likely that gender could affect environmental behaviors.

With regards to education levels, there was no statistical correlation between education levels and recycling behavior. Undergraduate and graduate students recycled more than the visiting scholar group, potentially because they have spent a longer time at UC Berkeley where the zero-waste campaign has been going on for a few years. Freshmen and sophomores cannot live in the I-House which also explained why the undergraduate group recycled more because most of I-House undergraduates have spent at least two years at UC Berkeley. However, there was also a good number of international undergraduate and graduate students who were in exchange programs for one or two semesters. The education backgrounds differed dramatically. In addition,

the visiting scholars were shown to recycle less due to the fact that there were only four responses, which was too small of a sample from which to draw a conclusion. Therefore, education levels did not correlate with recycling amount.

I also found that there was no relationship between regions of origin and recycling behavior. Europeans, US citizens and Canadians recycled the most, probably because recycling facilities in these countries are more advanced than others. In a study entitled "Plastic recycling: challenges and opportunities," the authors showed that Switzerland, Denmark and Germany are the top three countries that achieve the highest plastic recycling efficiency and energy recovery (Hopewell et al. 2009). Therefore, Europeans appeared to be more familiar the practice of recycling than other groups such as Africans and Asians. South Americans, naming Ecuadorian and Paraguayan, recycled the least; yet the size of this groups was really small which made it difficult to draw a conclusion. As a result, in my study, regions of origin did not have an effect on recycling behavior.

The effect of interventions on recycling behavior

Regarding the effects of the flyers and the coffee hour, there were several explanations for the effectiveness of these interventions even though the proportion of the population who reported the change was small. First, the flyers and the coffee hour were specifically about waste and recycling; the specificity of knowledge helped the residents focus on only one environmental problem, which would be easier than expecting them to understand many other environmental problems, such as water pollution, deforestation or loss of biodiversity. The purpose of my interventions was to increase residents' specific knowledge on waste and recycling in the I-House and on campus rather than to change their values and concerns about the environment broadly. Similarly, in a study about behaviors and concerns, Vining et al. explored the correlation between "generalized concerns for the environment" and recycling experiences; their results supported "the idea that feelings of responsibility for generating solid waste were more closely connected to respondents' experiences than with other broad beliefs" (Vining and Ebreo 1992). Therefore, specificity of concern seemed to affect conservation behavior more than general environmental concerns and values.

Secondly, the effectiveness of my interventions could have been due to the incentives and behavioral commitment. In my flyers, I informed them about the institution's progress towards achieving zero waste by 2020, and I encouraged residents to participate in this movement as part of the community. They might have developed a sense of community that motivated them to participate in the recycling program. Moreover, in the coffee hour, I prepared games and activities with many incentives, such as food and prizes, to get more residents to come. The coffee hour's attendants seemed to really enjoy the activities while learning about waste and recycling. Gillian et al.'s future implications for improving environmental outreach was to have "programs that combine information with incentives, ease of performance, or behavioral commitment" (Gillian et al. 1996).

Because the interventions did not have an impact on all the flyer's readers and the event attendants, I found that it was important to investigate the background of the people who reported changes to understand the limitations. Interestingly, for the people who said that they had recycled more after each intervention, I identified that the majority had very similar characteristics. Most of them were males, informed about "Zero Waste by 2020," had never been involved in any environment-related organizations, and previously recycled at home. However, the relationships between whether they had changed or not were not statistically correlated to each of the background information. Still, this suggested that outreach activities to promote environmental knowledge could have significant or no impact depending on the target population. In this case, people who were more familiar with the practice of recycling were more responsive to environmental knowledge, specifically on waste and recycling. Therefore, more research should be done to understand how different interventions can be targeted towards different populations.

Limitations and future directions

The uncertainties in the results were caused by several limitations of the study. First, self-reported behavior might not have been accurate because it can be very challenging for people to recall and estimate how much waste they generated and recycled. Additionally, they were informed that this was a study about waste and sustainability in I-House in the survey form; thus, the sense of awareness might have affected how they answered the questions. Specifically, respondents could have answered questions to seem more environmentally responsible since that is a socially-

valued trait. Third, the study population was a population of students, scholars and mostly international students which was not a good representation of the general population. Lastly, my study population shared the same living environment, which was a dormitory setting, so they were very likely to deal with similar types of waste and experience the same recycling facilities.

For similar research in the future, before and after surveys might be a better alternative to understanding behavioral changes than self-reported surveys. Furthermore, collecting quantitative data, such as how many bottles or sheets of paper got recycled, can help study recycling habits more thoroughly and capture actual instead of self-reported behaviors.

Broader implications

As waste has become an urgent issue, institutions should dedicate more effort to educating people specifically about waste and recycling. Because there might be a direct relationship between behavior and knowledge, there is a need for more focus on environmental education and how to select and use the appropriate information tools, such as outreach activities or social media, on appropriate groups of people. For future sustainability planning in small organizations and institutions, it can be very helpful to first study the background of the target population to apply suitable strategies and policies later.

<div align="center">

ACKNOWLEDGEMENTS

</div>

REFERENCES

Altman, A. G. 2000. A Case Study of Education, Understanding, Concern, and Action: Recycling and Consumption at UC Berkeley.University of California, Berkeley: Energey and Resources Group.

Apgar M. A. and D. Langmuir. 1971. Ground-Water Pollution Potential of a Landfill above the Water Tablea. Wiley Online Library. https://doi.org/10.1111/j.1745-6584.1971.tb03582.x

Berkeley Sustainability and Energy. n.d. Berkeley Sustainability and Energy. https://sustainability.berkeley.edu/waste.

Boerschig, S. and R. De Young. 1993. Evaluation of Selected Recycling Curricular: Educating the Green Citizen. Journal of Environmental Education. 24:17-22

Gambro, J., and H. Switzky. 1999. Variables Associated with American High School Students' Knowledge of Environmental Issues Related to Energy and Pollution. The Journal of Environmental Education 30:15-22.

Gillian, S., C. Werner, L. Olson, and D. Adams. 1996. Teaching the Concept of Precycling: A Campaign and Evaluation. The Journal of Environmental Education 28:11-18.

Hopewell, J., R. Dvorak, and E. Kosior. 2008. Plastics recycling: challenges and opportunities. The Royal Society. http://doi:10.1098/rstb2008.0311

Mainieri, T., E. Barnett, T. Valdero, J. Unipan, and S. Oskamp. 1997. Green Buying: The Influence of Environmental Concern on Consumer Behavior. The Journal of Social Psychology 137:189-204.

Min, A. 2016. Sustainability Coordinator Report International House, University of California, Berkeley Academic Year 2015- 2016. Berkeley.

Morrissey, A. J., and A. Závodská n.d.. Teaching Solid Waste Management at University, 34–45.

RStudio Team. 2016. RStudio: Integrated Development for R. RStudio, Inc., Boston, MA URL http://www.rstudio.com/.

Smith-Sebasto, N. J. 1995. The Effects of an Environmental Studies Course on Selected Variables Related to Environmental Responsible Behavior. The Journal of Environmental Education 26: 30-34.

U.S. EPAa. 2009. Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices:1–98.

U.S. EPAb. 2016. Advancing Sustainable Materials Management: 2014 Fact Sheet:1-22.

U.S. EPAc. 2017. Sustainability Materials Management: Non-hazardous Materials and Waste Management Hierarchy. n.d. United State Environmental Protection Agency. https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy

U.S. EPAd. 2018. Environmental Education (EE). n.d. United State Environmental Protection Agency. https://www.epa.gov/education

University of California. 2017. Zero Waste 2020. https://zerowaste2020.universityofcalifornia.edu/.

Vining, J., and A. Ebreo. 1992. Predicting Recycling Behavior from Global and Specific Environmental Attitudes and Changes in Recycling Opportunities1. Journal of Applied Social Psychology 22:1580-1607.

Werff, V. D. J., and K. James. 2008. Teaching Recycling: The Relationship between Education and Behavior among College Freshmen and its Effect on Campus Recycling Rates. University of Wisconsin System Solid Waste Program.

Wickham, H. Francois R., H. Lionel, and K. Müller 2017. dplyr: A Grammar of Data Manipulation. R package version 0.7.4. https://CRAN.R-project.org/package=dplyr

Wright, Y. L. 2011. Relating Recycling: Demographics, Attitudes and Recycling Behavior among UC Berkeley Students.

APPENDIX A: Post-intervention survey

Hello I-House residents!

Please fill in this survey about sustainability at I-House as it will help us understand you more. It should take less than five minutes to answer all the questions. Also, after completing this survey, you will enter a raffle with a chance to win a $15 Amazon gift card.

Thank you very much for your participation!
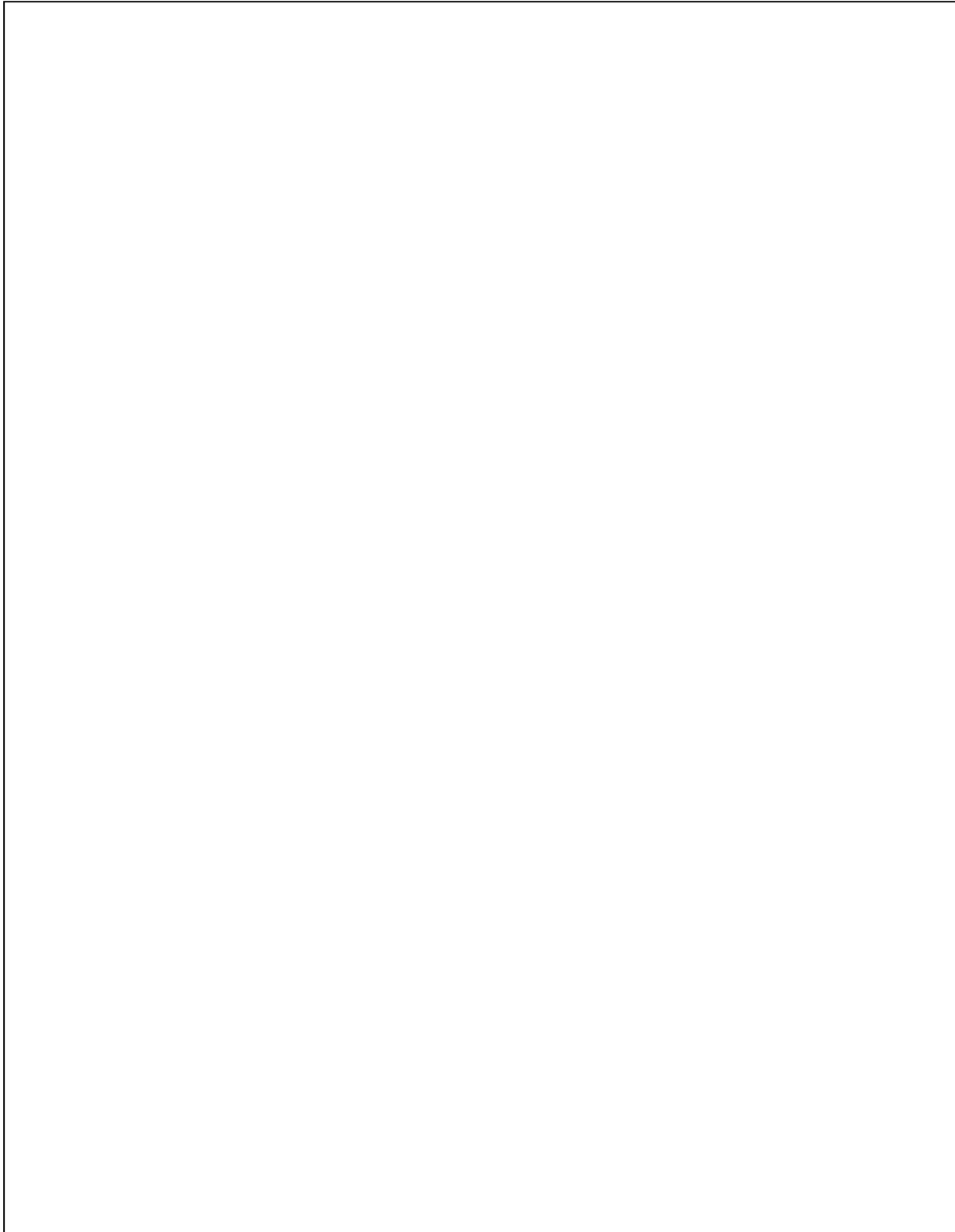
Thao and Hannibal

Your Sustainability Coordinators

1. How much of your total waste gets recycled? (recyclables include glass, plastic bottles, paper and cardboard, and metals)

   a) None

   b) A little

   c) Some

   d) Most

   e) All

   f) I don't know

2. How strongly do you agree with the following statements (Liker Scale: Agree, Somewhat Agree, Neither Agree nor Disagree, Somewhat Disagree)?

   - I-House community is a very environmentally friendly.

   - I find it easy to **recycle in I-House**.

   - I find it easy to **recycle outside of I-House**

   - I-House has helped me to learn more about waste and recycling.

   - I find it easy to learn more about waste and recycling at I-House.

   - I would like to receive more information about waste and recycling from I-House.

3. Before moving to I-House, did you recycle at home?

   a) Yes

   b) No

4. Have you ever got involved in any environmental organizations or programs?

a) Yes

b) No

5. Were you informed about UC's commitment of achieving "Zero-waste by 2020"?

   a) Yes

   b) No

   5.1. If yes, were you informed about "Zero-waste by 2020" through I-House?

   a) Yes

   b) No

6. Do you follow the "I-House Sustainability 2017-1028" Facebook Page?

   a) Yes

   b) No

7. Which sustainability flyers have you read?

   a) First flyer, "Be Informed. Be Considerate"

   b) Second flyer, "New semester, New Start"

   c) Third flyer, "Proper Waste Disposal"

   d) None

   e) I have not seen these flyers anywhere

   7.1. If yes, from reading the flyer(s), has your recycling habit changed or improved?

   a) Yes, I have recycled more than before

   b) No, my recycling habit has not changed

   c) Yes, I have recycled less than before

8. Did you attend the sustainability coffee hour "Love the Earth" on Feb., 21, 2018?

   a) Yes

   b) No

   8.1. If yes, after attending the coffee hour has your recycling habit changed or improved?

   d) Yes, I have recycled more than before
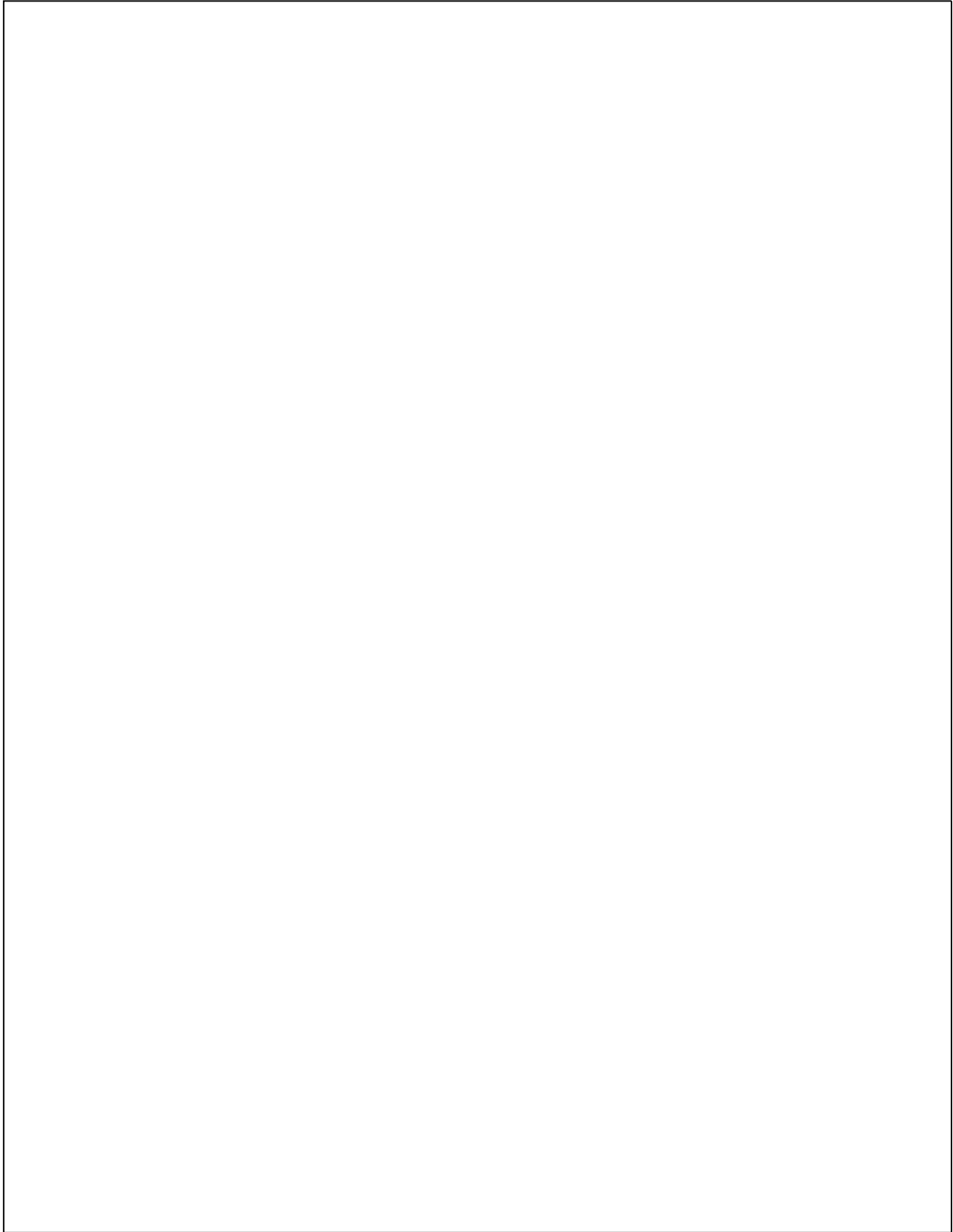
   e) No, my recycling habit has not changed

    f) Yes, I have recycled less than before

9. How confident are you in your knowledge of proper waste disposal?

    a) To a great extent

    b) Somewhat

    c) Very little

    d) Not at all

10. Can you think of anything, information tools, that I-House could provide to make recycling and composting easier?

11. Are you an international student?

    a. Yes

    b. No

    11.1.   If yes, what country are you originally from?

12. What is your gender?

    a) Male

    b) Female

    c) Other. Please specify

13. Is this your first semester at I-House?

    a) Yes

    b) No

14. What best applies to you?

    a) Undergraduate

    b) Graduate

    c) Visiting scholar

    d) Post Doc

    e) Other. Please specify:

APPENDIX B: **Informational flyers**

Flyer One

Flyer Two

Flyer Three