

Behavioral economics of waste management: Identifying factors that influence personal waste sorting practices

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Abstract: The University of California system-wide goal of Zero Waste by 2020 continues to both encourage and challenge campuses to increase their waste diversion practices. While the infrastructure necessary for improving waste management practices has been introduced at University of California, Santa Barbara (UCSB), waste audits have revealed that poor personal waste sorting practices are a limiting factor in the overall effectiveness of waste programs, and have the ability to negate many benefits of the structural improvements. The Refuse & Recycling Research Center at UCSB has focused on analyzing individuals' interactions with their waste in order to improve better personal waste management practices. Over 1,300 individuals were observed and data on their specific interactions with their waste materials, receptacles, and signage were recorded. After identifying common trends, it was determined that the initial signage created confusion and was inhibiting individuals from correctly sorting their waste. New signage was developed and introduced, which ultimately resulted in an overall 10% increase in the waste diversion rate in total. While there are additional strategies that can be applied, the implementation of the new signage prompted a behavioral change in how individuals disposed of their waste.

Keywords: landfill; compost; recycling; BigBelly Solar; PLA 7; diversion rate; serviceware; chi-square analysis

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INTRODUCTION

The University of California-wide goal of Zero Waste by 2020 continues to encourage and challenge UC campuses to increase their waste diversion practices. The University of California, Santa Barbara (UCSB) has been successful in implementing sustainability programs through infrastructure updates and behavioral modification. However, with new products and technology being continuously introduced, in addition to the annual turnover of students, behavioral modification towards sustainability initiatives is an important factor in helping UCSB achieve its sustainability goals. In regards to waste management, UCSB currently diverts 70% of its waste from the landfill; however, in order to improve the waste diversion percentage, focusing on behavioral modification is of the utmost importance, as an individual's decision of where they place their waste is the determining factor of success for many waste management programs.

The Refuse & Recycling Research Center (R³C) at UCSB has sought to improve the University's waste management practices. The purpose of this study was to gain a better understanding of the relationship that exists between individuals and the campus' waste infrastructure as they dispose of their waste. A total of around 1,300 individuals and their interactions with the waste that they disposed of at campus waste receptacles were observed.

The UCSB campus is approximately 1,055 acres and is home to around 26,000 students, faculty and staff, as well as many visitors. At UCSB, the waste infrastructure is comprised of three waste streams: landfill, recycling, and compost. While landfill and recycling receptacles can be found throughout the campus, many of the compost receptacles are located within the vicinity of the campus eateries. The following materials can be accepted in aforementioned waste streams:

- Recycling: Plastics 1-7, glass, metal, newspaper, cardboard, office paper, magazines, plastic wrap
- Landfill: chip bags, snack bags, candy bar/granola wrappers, Styrofoam, contaminated materials, tape, Mylar
- Compost: all food scraps, soiled paper products, PLA 7 products, compostable serveware that meets ASTM D6400 requirements

While there is not a definite campus standard for waste receptacles at UCSB, the most commonly found outdoor bins are (APPENDIX I):

- Open-top: round cylinder bins with a circular opening; many of these have now been paired to include both recycling and landfill
- Bertha Clusters: a receptacle with four openings, one for the following – newspaper, aluminum and plastics #1-6, office pack, and landfill
- BigBelly Solar: solar-powered compacting receptacles used for recycling, landfill, and compost; each has a hopper door

In total, the University has 316 landfill receptacles, 97 recycling receptacles, and 6 compost receptacles. The BigBelly Solar receptacles are the main public outdoor receptacles that are designated for compost, which are located around the central public eateries.

Based on previous campus waste audits and informal observations at each of the central public eateries, it was believed that personal waste sorting practices could be improved, which would have a notable impact on increasing the University's overall waste diversion percentage. Given that these are high traffic areas and significant amounts of materials are disposed of in these locations relative to other parts of campus, the campus eateries and their patrons were quickly identified to be the focus of this study. It was predicted that individuals would look at both the bin signage and at their specific items in hand in order to aid them with disposing their materials into the correct waste receptacles. In addition to this, it was believed that individuals would be exceptionally knowledgeable of recycling practices and that the majority of recyclable waste would be placed into the recycling bin.

METHODOLOGY

Locations

The observations of this study were focused at three main campus eateries: The Arbor, Coral Tree Café, and Courtyard Café, each of which are operated by the University Center (UCen), UCSB's on-campus dining services unit; however, each eatery has their own defining characteristics.

The Arbor is centrally located on the Main Campus and receives consistent foot traffic from the campus community, as it is located along the main campus corridor and across from the library. Items sold at The Arbor include products from the UCen and snack items from a variety of outside vendors. The Arbor is also home to two leased tenants, Woodstock's, a pizzeria, and Subway. In addition, two food carts operated by outside vendors are located in the vicinity of The Arbor. The Arbor has outdoor seating and table arrangements of around 29 tables with approximately 116 seats, which are set up in a rectangular formation. While The Arbor features one of the BigBelly Solar receptacles, it also has six open-top landfill receptacles scattered throughout the outdoor seating area.

The Coral Tree Café is located on the Main Campus adjacent to academic and administrative buildings. Items sold at Coral Tree Café include products from the UCen and snack items from a variety of outside vendors. There are no outside vendors or leased tenants at Coral Tree Café. It has both indoor and outdoor seating. The outdoor seating features around 40 tables with a mix of two-person and four-person tables. The outdoor waste infrastructure originally included one BigBelly Solar receptacle along with three open-top landfill receptacles, all of which were dispersed throughout the outdoor seating area. In between the initial and second observational periods, the three open-top landfill receptacles were removed.

The Courtyard Café is located on the outer edge of the Main Campus adjacent to academic buildings that primarily have a science focus. Items sold at Courtyard Café include products from the UCen and snack items from a variety of outside vendors. Courtyard Café is also home to one leased tenant, Yoshinoya. Courtyard Café has both indoor and outdoor seating. The outdoor seating features around 20 tables with approximately 80 seats. The tables are arranged in an “L” shape with the majority being located on the east side of the building. The outdoor waste infrastructure originally included one BigBelly Solar receptacle along with four open-top landfill receptacles. In between the initial and second observational periods, three of the four open-top landfill receptacles were removed.

Initial Observations

Approval for this project from the Office of Research at UCSB was received prior to the start of observations. Individuals were initially observed at the outdoor seating areas of the Coral Tree Café, Courtyard Café, and The Arbor (described above). Observations were conducted by two student-researchers at each of the sites. The initial observation period was seven weeks long (October 1st – November 18th, 2013) and included a total of around 50 hours of observation. Observations were primarily conducted between the hours of 11am-1pm, in order to target the busiest times at each of the eateries.

During each of the observation sessions, notes were recorded on individuals and their waste sorting practices as they approached the bins and at the time of disposal. The following notes were recorded by the observers: gender, alone or in a group (if in a group, number of individuals); whether or not they looked at the materials; whether or not they looked at the bin signage; student or non-student; appropriate waste stream for the material; the waste stream the material was placed; notes on the specific material type in hand. Additional information was recorded on the individual’s specific interactions when pertained to the overall purpose of the study. On particular occasions, notes were taken on the individual’s specific path to and from the waste receptacles; observations were also conducted for open-top receptacles in the nearby areas (APPENDIX II).

Additional Variables

Aggregating data from initial observations encouraged a two-day waste audit. The waste audit for each location was conducted using methods outlined by Associated Students Recycling at UCSB. The waste audit provided additional insight about personal waste sorting practices, which included individuals combining different materials into a single container, as well as the confusion around certain materials and their appropriate waste streams. In addition, the initial observation revealed that compostable and recyclable material were being disposed of in the unpaired, open-top landfill bins at each location due to their abundance and spatial convenience. It was also observed that individuals that did take the time to read the waste signage often sorted their waste incorrectly. The

aforementioned observations promoted the development and pilot of new waste signage along with the removal of all outdoor open-top landfill receptacles at Courtyard Café and Coral Tree Café.

Signage Redesign

Signage redesign was based on the observations made from the initial observational period. Although uniform in formatting for each waste stream, the initial signage (Signage A) at UCSB contained significant amounts of pictures and words (APPENDIX III). Specifically it displayed cluttered photos that did not address materials specific to what would be disposed of at the public receptacles, the words listed were repetitive and difficult to read due to the small font, and many of the materials were outdated since new compostable materials had been introduced to the eateries. Two formats of new signage were piloted, both with updated pictures pertaining to what specifically was being disposed of at the public eateries. An all pictorial signage (Signage B) was created in addition to another format that contained both pictures and words (Signage C). In the new signage, each of the pictures were enclosed with a circle and enlarged, in an effort to draw attention to the items. The font was also significantly enlarged in the new signage that contained words (APPENDIX III).

The new signage formats, in addition to the initial signage were displayed together, and then an informal survey to the campus community was conducted at the on-campus farmers market. Data from the survey suggested that Signage C was the most appealing and would help individuals sort their waste more effectively and efficiently.

Additional Variables Applied

In addition to bin signage, three different types of informational signage were introduced at each location. At The Arbor Café, signage at the cashier check-out stand was introduced that reminded individuals throw their items away at the BigBelly Solar receptacles outside; at the Coral Tree Café small signage was placed on the shelves inside the café that indicated if the material was recyclable, landfill or compostable; at the Courtyard Café signage was placed on the entrance/exit door reminding individuals to dispose of their items in the BigBelly Solar receptacles (APPENDIX IV).

Secondary Observation

The secondary observation followed the same methodology as the initial observational period. The secondary observational period included around 26 hours of observation over the course of 5 weeks (April 1st – May 1st, 2014). Again, on particular occasions, notes were taken on the individual's specific path to and from the waste receptacles.

Data Analysis

Throughout both observational periods, a diverse amount of materials were disposed of. In order to ease the process of analyzing the amount of data collected the most commonly thrown away items were identified and grouped together under consistent headings. For example, there were many different types of paper products disposed of, such as fliers, magazines, and envelopes; yet, for the sake of analyzing the data, these related materials were categorized under the more general heading of “paper,” as the aforementioned paper products can be recycled together at UCSB.

After organizing the data into specific groups of materials, the data from both the initial and secondary observations were analyzed into the following main categories:

- Total Properly Sorted Material: percentage of the total materials correctly sorted into each of the three waste streams (recycling, landfill, and compost) at all three eateries (APPENDIX V)
- Properly Sorted Material at The Arbor: percentage of the total materials correctly sorted into each of the three waste streams (recycling, landfill, and compost) from The Arbor
- Properly Sorted Material at Coral Tree Café: percentage of the total materials correctly sorted into each of the three waste streams (recycling, landfill, and compost) from Coral Tree Café
- Properly Sorted Material at Courtyard Café: percentage of the total materials correctly sorted into each of the three waste streams (recycling, landfill, and compost) from Courtyard Café

In addition to the categories listed above, the data was further broken down into the following two categories:

- Specific Material Sorting Rates: individual sorting rate calculations for specific materials (APPENDIX V)
- Contents of Waste Receptacles: what the contents and their respective waste stream were of each recycling, landfill, and compost bins. (APPENDIX V)

RESULTS

In the initial observation period of 50 hours, 638 individuals along with 1,218 discarded materials were observed. In the second observational period of around 26 hours, 661 individuals along with 1,221 discarded materials were observed. In total, 1,299 individuals and 2,439 discarded materials were recorded in 76 hours of observation.

The following figures represent the percentage of materials sorted correctly at each of the three eateries along with the total percentage of materials sorted correctly for both the initial and secondary observational periods:

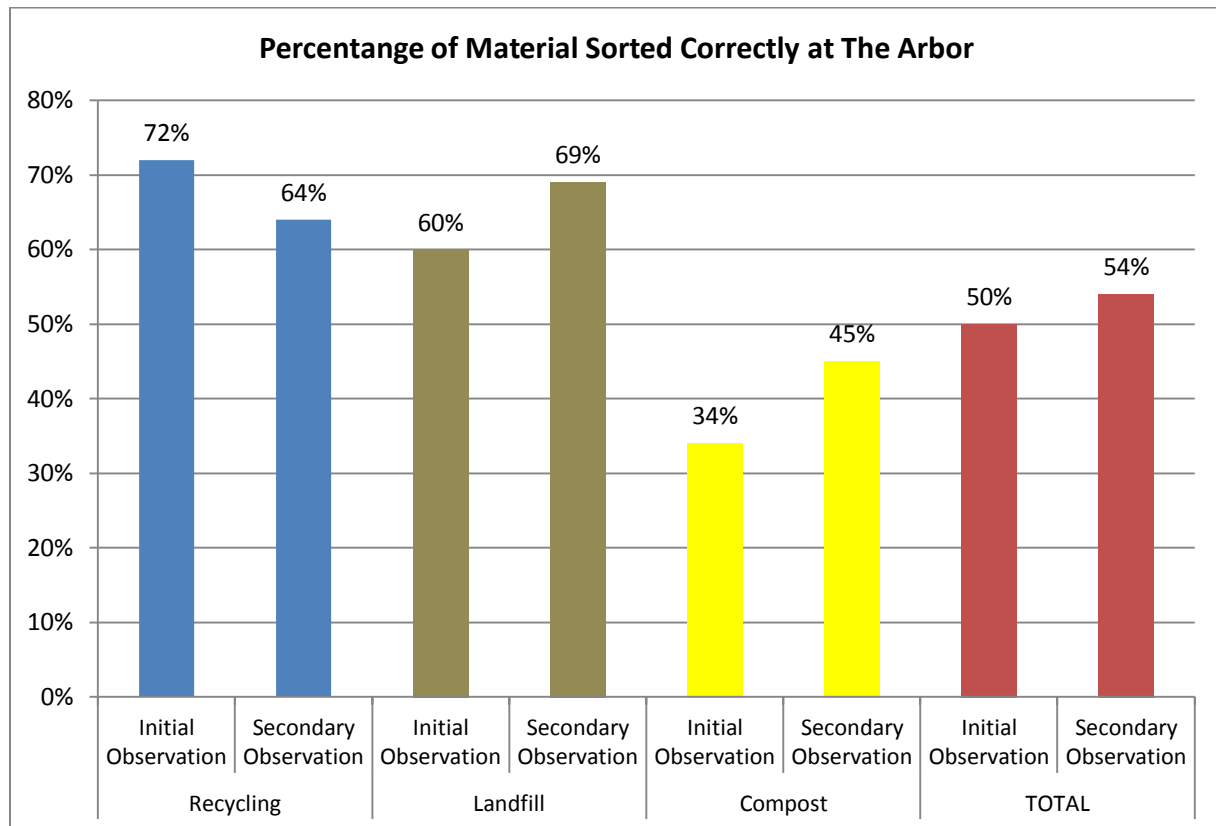


Figure 1: Percentage of material sorted correctly at The Arbor for both the initial and secondary observational periods

From the initial to the secondary observational period, the correct sorting rate for recycling at The Arbor decreased by 8%. However, the correct sorting rate for landfill materials increased by 9%, and the correct sorting rate for compostable materials increased by 11%. This resulted in an overall 4% increase in the correct sorting rate at The Arbor.

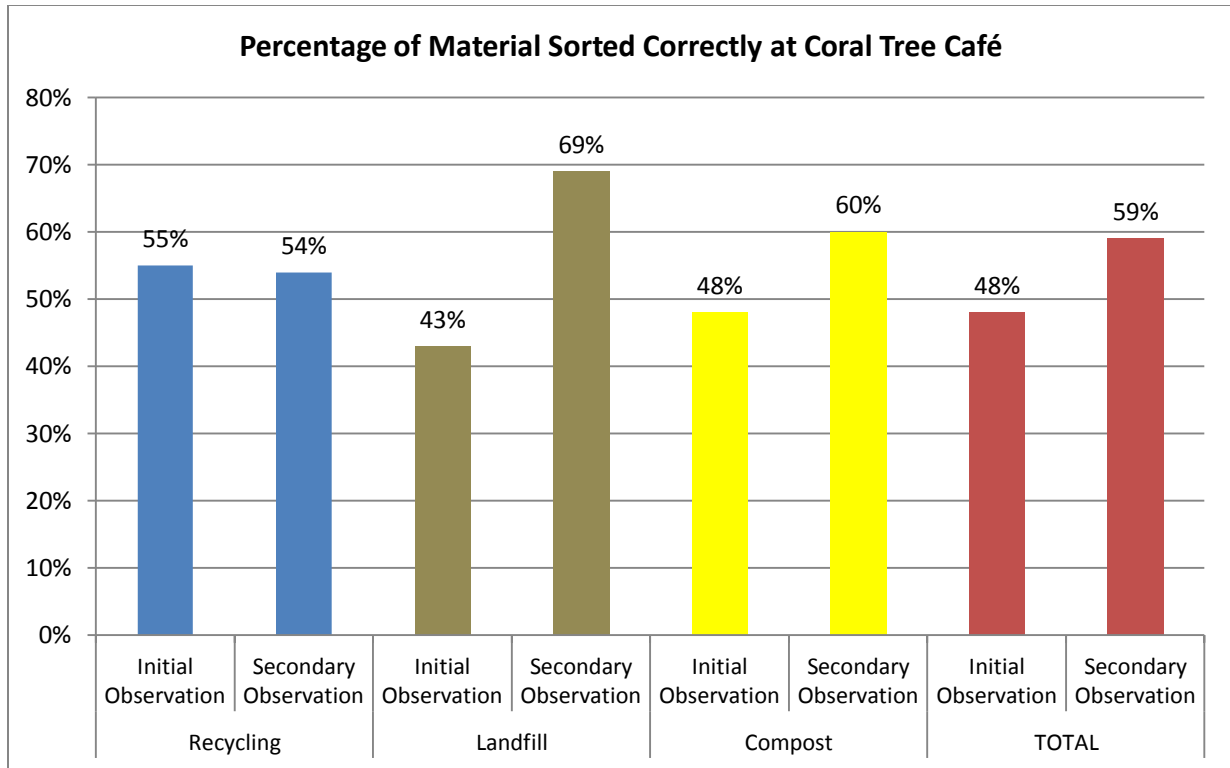


Figure 2: Percentage of material sorted correctly at Coral Tree Café for both the initial and secondary observational periods

From the initial to the secondary observational period, the correct sorting rate for recycling at Coral Tree Café decreased by 1%. However, the correct sorting rate for landfill materials increased by 26%, and the correct sorting rate for compostable materials increased by 12%. This resulted in an overall 11% increase in the correct sorting rate at Coral Tree Café.

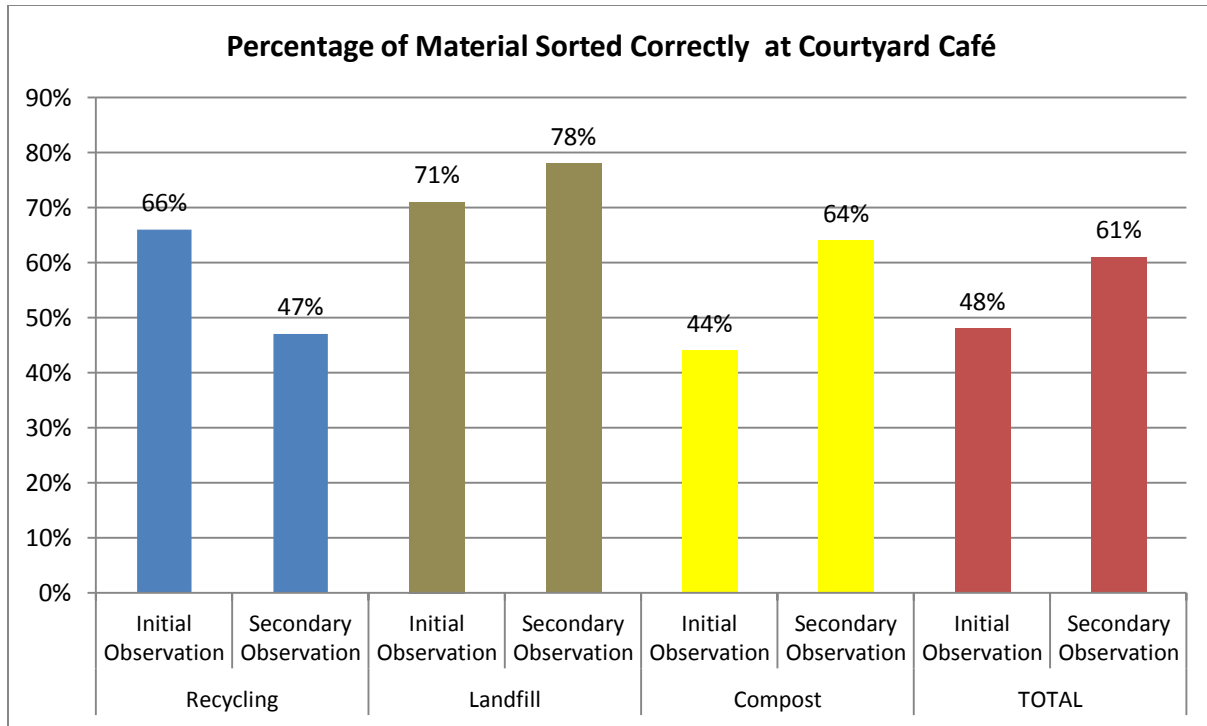


Figure 3: Percentage of material sorted correctly at Courtyard Café for both the initial and secondary observational periods

From the initial to the secondary observational period, the correct sorting rate for recycling at Courtyard Café decreased by 19%. However, the correct sorting rate for landfill materials increased by 7%, and the correct sorting rate for compostable materials increased by 20%. This resulted in an overall 13% increase in the correct sorting rate at Courtyard Café.

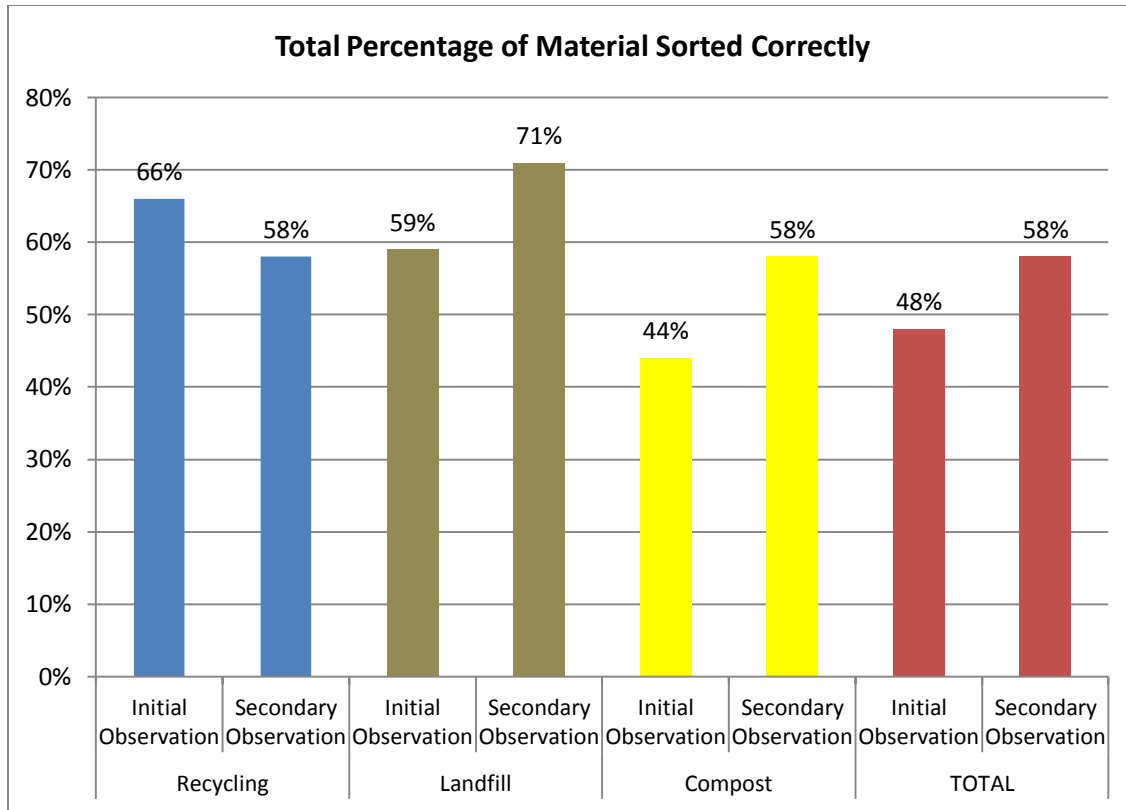


Figure 4: Percentage of material sorted correctly for both the initial and secondary observational periods

From the initial to the secondary observational period, the combined correct sorting rate for recycling at each of the three eateries decreased by 8%. However, the comprehensive correct sorting rate for landfill materials increased by 12% and the comprehensive correct sorting rate for compostable materials increased by 14%. This resulted in an overall 10% increase in the total correct sorting rate at each of the three eateries.

Chi-Square Analysis

A chi-square analysis was conducted with Professor Dusty Perkins in order to determine if the correlation between signage redesign and implementation was statistically significant. For recycling, the results show that X^2 exceeds the test statistic for $P = 0.05$ ($X^2_{table} = 3.84$), indicating that there is less than a (5%) chance that the relationship between signage redesign and the change in pre-signage vs. post-signage waste sorting practices are due to chance alone. In this case however, the post-signage period had significantly lower sorting rates than expected by random chance.

The chi-square analysis for landfill's waste sorting habits provides that the test statistic from the X^2 analysis falls between $P = 0.1$ and 0.05 on the contingency table, indicating that there is a greater than 5% (and less than 10% chance) that the results observed are due to chance alone. Because the probability value is greater than the pre-determined value of $P = 0.05$, there is no significant difference in landfill sorting rates based upon pre and post-signage periods. However, because the test result is less than

$P=0.1$, there is the possibility that signage alteration would have a different effect. The lack of statistical significance found here can most likely be attributed to the fact that incorrect sorting values differ little among pre- and post-signage observation periods. Further sampling to increase the sample size may offer statistically significant support for this analysis.

Lastly, for compost the test statistic from the χ^2 greatly exceeds the test statistic for $P=0.05$ (χ^2 table=3.84). This indicates that there is much less than (5%) chance that the results observed here could be due to chance alone, and conclude that there is a significant difference in compost sorting rates based upon pre and post-signage periods.

DISCUSSION

Differences between Eateries

There are many notable distinctions between each of the three eateries which can aid in understanding the differences between the graphs above. Due to the specific location of each eatery in relation to the campus layout, different types of groups of the campus community tend to frequent certain eateries more than others, and in addition to this, tend to utilize each eatery for different purposes. Several other factors such as the arrangement of the outdoor seating areas and the variety of products sold at each eatery impacted the results of this study.

The Arbor

Since The Arbor is located directly across from the campus library and is in the middle of the central walkway that cuts through the campus, it is frequented by students, faculty, staff, and visitors but primarily used by undergraduate students as they make their way through campus. Thus, the Arbor's data reflects waste that was more often thrown away by individuals who were passing by on their way to their next destination rather than stationary individuals that had recently finished a meal. The Arbor also functions as the main location on campus where student and off-campus organizations table and advertise their groups by handing out fliers and other promotional materials. In addition to the presence of off-campus and student organizations, The Arbor also contains two leased tenants along with two nearby food carts. This means that The Arbor's waste stream is significantly diverse and varies on a daily basis. The more diverse a waste stream is, the more confusing and complex it is for individuals to sort and dispose of their materials properly.

The overall percentage of recyclable material sorted correctly at The Arbor decreased between the initial and secondary observational periods. One possible explanation for this could be that during the secondary observational period, fewer groups tabled at The Arbor. When groups table, they often hand out fliers, the majority of which are disposed of almost immediately by the recipients. During the initial observational period, many groups were tableing at The Arbor as it was a time

where most student organizations were recruiting new members. The amount of students present and types of organizations present could have influenced the type of material disposed of.

The overall percentage of both landfill and compostable material sorted correctly at The Arbor increased between the initial and secondary observational periods. This can likely be attributed to the implementation of the newer and clearer signage.

Between the initial and secondary observational periods, there was a slight increase in the overall percentage of material sorted correctly at The Arbor. This 4% increase was notably smaller than the percentage increases recorded at both Coral Tree Café and Courtyard Café. There are several explanations for why The Arbor only experienced a minor increase in its overall percentage of material sorted correctly. First, as mentioned earlier, The Arbor has a significantly diverse waste stream, one that is more diverse than the waste streams at either of the two other eateries. The diversity of The Arbor's waste stream makes it difficult to design signage that incorporates a wide enough variety of materials and items. Secondly, unlike at the other two eateries, the open-top landfill receptacles at The Arbor were not removed from the area. These open-top landfill receptacles were still heavily utilized during the secondary observational period, meaning that many compostable and recyclable materials were still disposed of into a landfill receptacle. Lastly, The Arbor does not have a consistent customer base. Every day, thousands of different individuals pass through The Arbor, making it more difficult for The Arbor to establish a consistent customer base that is familiar with The Arbor's products. The larger and more diverse a customer base, the more difficult it is to establish familiarity with the products, a step which aids in the process of correctly sorting materials. A combination of these factors explains why there was only a slight increase in the total percentage of material sorted correct at The Arbor.

Coral Tree Café

Coral Tree Café, which is surrounded by both academic and administrative buildings, is mainly frequented by staff and faculty members and is primarily used for sit-down lunches and meetings. Thus, the data collected from Coral Tree Café reflects waste that was often thrown away by staff or faculty members who had just finished lunch.

The overall percentage of both landfill and compostable material sorted correctly at Coral Tree Café significantly increased. This again, is likely to have been caused by the implementation of the new signage. On top of this, while no formal studies were conducted on the effectiveness of the additional signage that was placed inside of Coral Tree Café (signage which indicated beneath each product as to which waste stream it should be disposed into), it is possible that this signage contributed to the increases in both of these percentages. Additionally, unlike at The Arbor, Coral Tree Café has a relatively consistent customer base, making it easier for individuals to familiarize themselves with the café's products. When individuals are more familiar with products, it becomes more likely that they will sort the products correctly. This is another factor that could have contributed to the two increases in percentages discussed above. The overall percentage of recyclable material sorted correctly at Coral Tree Café decreased by 1%, an almost negligible amount. Thus, the overall recycling rate at Coral Tree Café remained relatively stagnant and unchanged, which could have been likely attributed to the consistent customer base.

Coral Tree Café's relatively high overall percentage rate of compostable material sorted correctly is likely due to the café's high usage of compostable materials. The café uses compostable plates, napkins, utensils, bowls, clamshells, and cups. Coral Tree Café provides a higher amount of compostable materials than either of the two other eateries. This can be attributed to the café's lack of having a leased tenant and in turn, having a relatively consistent and controlled waste stream because of minimal diversity in their packaging and items sold at the eatery.

Because of this breadth of compostable materials, many individuals were able to dispose of their materials as a single unit. When items belonging to the same waste stream can be disposed of together it becomes easier for individuals to place these items into the correct waste streams. Thus, many individuals were able to dispose of all of their items into the compost receptacle as a single unit, which is likely to have contributed to Coral Tree Café's overall high percentage rate of compostable material sorted correctly.

Between the initial and secondary observational periods, Coral Tree Café experienced an 11% increase in its overall percentage of material sorted correctly. As mentioned earlier, much of this is due to the implementation of the new signage. However, the removal of the three open-top landfill receptacles also contributed to this increase in the percentage. By removing the bins, individuals who ate outside were then directed to utilize the recycling and compost units of the BigBelly Solar receptacles.

Courtyard Café

Courtyard Café, which is surrounded primarily by science-focused buildings, has a consistent customer base, many of which are graduate students who come to eat at the café for lunch. Thus, the data collected from Courtyard Café reflects waste that was often thrown away by graduate students. The café is also home to one leased tenant, Yoshinoya, a Japanese fast food chain. At the beginning of the academic school year, Yoshinoya was contracted to provide 100% compostable food packaging. However, during the initial observational period of the study, it was discovered that Yoshinoya was using several products that were not compostable, the main one being a plastic bowl made of polypropylene. In addition to this, Yoshinoya handed out plastic bags with every order. In between the initial and secondary observational periods, Yoshinoya was contacted about these issues and as a result, ceased to automatically hand out plastic bags with every order. They are still currently working on finding a compostable alternative to their plastic bowls.

It is important to note that Yoshinoya uses a compostable clamshell which differs in appearance to the other compostable clamshells used by the University at Coral Tree Café. The compostable clamshells at Coral Tree Café are beige and paper-based, while the compostable clamshells used at Yoshinoya are black and PLA 7 plastic, making them less easily identifiable as compostable.

The overall percentage of recyclable material sorted correctly at Courtyard Café decreased between the initial and secondary observational periods. One possible explanation for why this occurred can be attributed to the significant decrease in the amount of plastic bags that were handed out at Yoshinoya. During the initial observational period, when Yoshinoya was handing out plastic bags to every customer, the majority of individuals grouped all of their items into the plastic bag before

throwing the bag away as a single unit. Most of these plastic bags were disposed of in either the landfill or recycling receptacles. Because of this, it was difficult to identify which materials were being disposed of into which waste streams and many materials went uncounted for. Once Yoshinoya altered their policy of handing out plastic bags, a significant decrease in the disposal of the filled plastic bags as a single unit was noted. This change in policy placed Yoshinoya customers into a new position where they were encouraged to sort their materials rather than throwing them away as a single unit inside of a plastic bag. The decrease in the overall percentage of recyclable material sorted correctly at Courtyard Café could be attributed to the fact that once individuals were encouraged to sort their materials, they were less knowledgeable about which products were recyclable than had previously been thought.

Additionally, there is another explanation for why the overall percentage of recyclable material sorted correctly at Courtyard Café decreased. By removing three of the four open-top landfill receptacles, more individuals were encouraged to utilize the BigBelly Solar receptacles, receptacles which many individuals are more unfamiliar with. The switch from using the open-top landfill receptacles to the BigBelly Solar receptacles potentially revealed many individuals' poor waste sorting practices.

The overall percentage of both landfill and compostable material sorted correctly at Courtyard Café increased between the initial and secondary observational periods. This can likely be attributed to a variety of factors, the main one being the implementation of the newer and clearer signage. In addition to this, the removal of three of the four open-top landfill receptacles encouraged individuals to utilize the recycling and compost units of the BigBelly Solar receptacles. Lastly, the discontinuation of Yoshinoya's policy of automatically handing out plastic bags with every order is likely to have been a factor in the increases in both of these percentages. During the initial observational period, most individuals who ate from Yoshinoya then disposed of all of their materials as a single unit, within the plastic bag, into either the landfill or recycling bin. Thus, the plastic bags were discouraging individuals from actually sorting their waste. By eliminating the plastic bags, individuals were encouraged to sort their items.

Disposal of PLA 7 Products

As the data reflects, after the new sign implementation there was an increase in the overall waste diversion and sorting rates. However, there was still noticeable confusion around certain items, many of which were made out of PLA 7 plastic.

The majority of noticeable confusion surrounded the plastic-like compostable products which were made out of PLA 7. The main materials involved in this confusion were the PLA 7 cups and PLA 7 containers, though there was additional confusion surrounding the PLA 7 utensils. Prior to the implementation of the new signage, PLA 7 cups and containers had a 25% correct sorting rate. It is important to note that during the initial observational period, the compost bin signage made no direct reference to PLA 7 materials. Thus, even those who did look at the bin signage still had difficulty sorting correctly, which reaffirmed the need for new signage to be developed.

The new compost signage explicitly included an image and description of the exact PLA 7 items utilized at the eateries with the hopes of increasing the correct sorting rates for these materials. Despite this significant change, the post-signage correct sorting rate for PLA 7 cups and containers only slightly increased by 6%, to an overall 31% correct sorting rate. This could be due to a combination of factors that have been identified.

Firstly, it was noticed that many individuals disposed of their PLA 7 products without looking at either the material itself or at the bin signage. Specifically, many individuals disposed of their PLA 7 products into the recycling receptacle without looking at the material or signage. This could be due to the fact that (1) many individuals are still unfamiliar with knowing that PLA 7 is considered compostable at UCSB, (2) PLA 7 is a different material than other plastics, #1-7, (3) or the individuals were unaware that the materials in their hands were made of PLA 7. Because of its many plastic-like qualities, specifically in visual similarity, it is easy for PLA 7 to be mistaken as recyclable plastic. In the post-signage secondary observational period, PLA 7 cups and containers were disposed of into the recycling receptacle 44% of the time, into the landfill receptacle 25% of the time, and into the compost receptacle 31% of the time. Thus, the majority of PLA 7 cups and container were disposed of into the recycling receptacle, furthering the theory that most individuals incorrectly associate PLA 7 items with the recycling waste stream instead of with the compost waste stream. As was witnessed in this study, this association cannot be altered solely by creating newer signage. Additional strategies such as outside education, easier identifiable compostable products, and uniformity among compostable products are likely to be needed in order to effectively aid individuals in correctly sorting PLA 7 products.

The overall increase in the total percentage of material sorted correctly shows that the implementation of new signage had a positive influence in aiding individuals to correctly sort their waste. However, the decrease in recycling sorting rates at each of the eateries, combined with the fact that there is still much room for the overall total percentage of material sorted correctly to increase, indicates that the implementation of new signage by itself is not enough to create the significant change needed to aid the UCSB campus in reaching its waste management goals. Additional factors such as outside education, easier identifiable compostable and recyclable products, and uniformity among all products on campus are needed in order to aid individuals in correctly sorting their waste.

Additional Observations

It is important to mention that when an individual placed their item into the correct receptacle, it may not be directly attributed to the individual's knowledge of where the materials should be correctly placed. It cannot be assumed that there was a direct correlation between individuals' intentions and their actions when placing materials into the receptacles. While some individuals may have intentionally and knowingly placed their items into the correct receptacle, others may have gotten lucky with their decision. Regardless of whether or not one item was correctly sorted, this is not representative of an individual's comprehensive knowledge of correct waste sorting

practices. For example, one individual who placed a compostable bowl into the compost receptacle, then placed a Ziploc bag into the receptacle as well, thus suggesting that the individual's correct placement of the compostable bowl perhaps was more due to chance than to substantial knowledge.

In addition, it was also noted that most individuals who took the time to look at the bin signage often only looked at those signs which correlated with the bin that they were already heading towards, or ended up using. For example, an individual with a PLA 7 cup may immediately head to the recycling bin and glance at the recycling bin signage, yet fail to look at either the landfill or compost signs to get an overall understanding of where the item should be placed.

As noted, it is difficult to get individuals to actually read all of the signs. If individuals took the time to read the signs from top to bottom, it is projected that there would be close to a 100% sorting rate. Thus, additional educational components and strategies can be introduced in order to increase individual's sorting rates.

FUTURE RESEARCH

In addition to the sorting rate data, there were several other components of the research that could be expanded upon in future studies.

As noted earlier, one major pattern that was observed was determining whether looking at the bin signage corresponded to the correct placement of the material in the individual's hand. While this study focused more on the placement of materials, further research should be conducted that specifically focuses on whether or not individuals look at the signage and if this then leads to correct sorting practices. This study would help determine if there is a direct correlation between the signage and the sorting rates.

Another area for expansion would be in assessing the convenience factor of waste disposal. Observations revealed that individuals threw their trash away in the receptacle most convenient to where they were sitting, resulting in a higher use of the open trash cans due to their presence (APPENDIX VI). It was also noticed that individuals generally disposed of items into the bin that were in the direct path of where they were walking from, or where they were heading to. Many items disposed of in the open trash cans were actually compostable or recyclable. A study focusing on the convenience factor of personal waste disposal could yield valuable information on setting up an effective and efficient waste infrastructure.

An additional observation that could be expanded is exploring the correct sorting rate of individuals when they dispose of their waste as a unit or when they dispose of each item separately. This would be important to understand because entities that distribute a variety of packaging,

which are recyclable, landfill, or compostable, may be making it more difficult for individuals to properly sort their waste.

It would also be interesting to evaluate the influence on individuals when disposing of their waste when alone vs. in groups. Social pressures in a large group of individuals could influence the behavior of the rest of the group when it comes to waste disposal.

ACKNOWLEDGMENTS

There are a several organizations that made this research possible. UCSB's Facilities Management, along with Matthew O'Carroll, the Refuse, Recycling & Water Efficiency Manager, provided the student researchers with staff support and guidance throughout the project, including invaluable feedback on the development of the new signage. UCSB's The Green Initiative Fund (TGIF), granted R³C with the funding for two student researcher positions for the year. The Associated Students Recycling Program (ASR) assisted the student researchers in the informal waste audit and worked with them to finalize the new signage. Lastly, UCen dining, the campus-run dining facilities approved and supported the installation of the new signage at the campus eateries.

APPENDICES

APPENDIX I



BigBelly Solar Receptacles (recycling, landfill, and compost)



Open-top Landfill Receptacle



Bertha Cluster

APPENDIX II

Behavioral Economics of Waste Management/ Separation: Recording Sheet #1

Study: _____ Recorder: _____ Location: _____
 Receptacle Type: _____ Date: _____ Start Time: _____ End Time: _____

Person	Material Type In Hand			Receptacle Material is Placed			Notes
	R	L	C	R	L	C	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							

Recording Sheet #1

Used to record: material type was in hand (recycling, landfill, compost, or miscellaneous), where the item was placed (recycling, landfill, compost), and specific material identification

Behavioral Economics of Waste Management/ Separation: Recording Sheet #2

Look for: body language; group of friends, if so, did friends recycle; look at signage; dispose out of convenience; etc.

Person	Notes
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	
33	
34	
35	

Recording Sheet #2

Used to record detailed notes regarding: gender, group type/size, whether they looked at signage, whether they looked at the material in hand, student status, and noteworthy interactions with the receptacle

compost

use this compost bin for:

all food waste
 vegetables / fruits
 dairy products
 meat
 seafood

compostable service ware
 (must be certified compostable)
 utensils
 clamshells
 plates
 cups

food soiled paper products
 soiled paper bags
 greasy pizza boxes
 paper to-go boxes
 waxed paper
 waxed cartons

used tissues, paper towels & napkins

compostable bags



Signage A

compost

ALL FOOD WASTE
 Vegetables & Fruits
 Dairy Products
 Teabags
 Meat

COMPOSTABLE SERVICEWARE
 (must be labeled compostable)
 Compostable Utensils
 Clamshells & Plates
 Coffee Cups & Lids
 Bowls

PLA 7 PRODUCTS
 Drinking Cups
 Containers

SOILED PAPER PRODUCTS
 Sandwich Paper
 Paper Bags
 Pizza Boxes
 Paper Towels

NAPKINS



Signage C

landfill



use this garbage bin for:

styrofoam
 cups
 plates
 containers
 packaging materials...

dirty plastic
 dirty grocery bags
 candy wrapper
 dirty Ziploc[®] Text Box
 chips & snack bags...

dirty food containers
 condiment packages
 straws
 cellophane wrap...

used tissues & paper towels

food scraps
 fruit peels
 unfinished food...



Signage A

landfill



WRAPPERS
 Condiment Packets
 Candy Wrappers
 Snack Bags

MISCELLANEOUS
 Wax Cartons
 Tape

STYROFOAM



Signage C

recycling

use this commingled bin to recycle:

metal
aluminum cans
tin foil
paper clips
staples ...

plastic (#1-#7)
clean food containers
plates
bottles
coffee lids

paper
news papers
magazines ...

cardboard
packaging materials
coffee sleeves
boxes...

glass
bottles
jars...

clean plastic film
plastic bags
shrink/stretch wrap...





Signage A

recycling

PLASTICS #1-#6
Plastic Utensils
Yogurt Cups
Saran Wrap
Bottles
Straws
Bags

METAL
Cans
Foil

GLASS
Bottles

PAPER
Newspaper
Cardboard
Magazines
Flyers





Signage C

Please help with recycling & composting efforts

**Sort your waste at the
BigBelly™ receptacle located
to your left**



Thank you!



Additional Variables Applied

Door Signage at Courtyard Café

compost

**Please dispose of
these items at the
compost bin outside**



landfill

**Please dispose of
these items at the
landfill bin outside**



recycling

**Please dispose of
these items at the
recycling bin outside**



Additional Variables

Materials Signage Placed Underneath Various Products at Coral Tree Café

**Please sort your waste
at the BigBelly™
receptacle outside**



Thank you!



Additional Variables Applied

Signage Placed at the Cash Registers at The Arbor

APPENDIX V

When entering the data, we made sure to count an individual as “1” regardless of how many items they threw away. This enabled us to gather two different types of data: 1) the overall number of people that we observed, and 2) the overall number of materials that were disposed of.

Pre-Signage Data	
Total People	638
Total Materials	1218
Properly Sorted Material	
Recycling	157
Landfill	53
Compost	378
Total:	588
% sorted correctly:	48%

Post-Signage Data	
Total People	661
Total Materials	1221
Properly Sorted Material	
Recycling	148
Landfill	72
Compost	490
Total:	710
% sorted correctly:	58%

Overall between the first phase and the second phase of our research, we observed a positive increase in the sorting rate from 48% to 58%, or a 10% increase.

The following charts provide a specific look at the recycling, landfill, and compost sorting rates. The correct sorting rates are highlighted in blue:

Pre-Signage Data:

Recycling Placed in:		%
Recycling	157	66%
Landfill	68	29%
Compost	12	5%
Total:	237	

Landfill Placed in:		%
Recycling	20	22%
Landfill	53	59%
Compost	17	19%
Total:	90	

Compost Placed in:		%
Recycling	137	16%
Landfill	341	40%
Compost	378	44%
Total:	856	

Post-Signage Data:

Recycling Placed in:		%
Recycling	148	58%
Landfill	86	33%
Compost	23	9%
Total:	257	

Landfill Placed in:		%
Recycling	17	17%
Landfill	72	71%
Compost	13	13%
Total:	102	

Compost Placed in:		%
Recycling	122	14%
Landfill	239	28%
Compost	490	58%
Total:	851	

The following charts provide a look at the general material make-up of the bins in terms of recycling, landfill, and compost:

Pre-Signage Data:

Recycling Bin Make Up		%
Recycling	157	50%
Landfill	20	6%
Compost	137	44%
Total:	314	
Landfill Bin Make Up		%
Recycling	68	15%
Landfill	53	11%
Compost	341	74%
Total:	462	

Compost Bin Make Up		%
Recycling	12	9%
Landfill	17	13%
Compost	103	78%
Total:	132	

Post-Signage Data:

Recycling Bin Make Up		%
Recycling	148	52%
Landfill	17	6%
Compost	122	43%
Total:	287	

Landfill Bin Make Up		%
Recycling	86	22%
Landfill	72	18%
Compost	239	60%
Total:	397	

Compost Bin Make Up		%
Recycling	23	4%
Landfill	13	2%
Compost	490	93%
Total:	526	

The following charts represent the various sorting rates of certain stand-out items. The correct sorting rates are highlighted in blue:

Recyclable Materials Sorting Rate

Pre-Signage Data:

Paper		%
Recycling	13	87%
Landfill	1	7%
Compost	1	7%
Total:	15	

Post-Signage Data:

Paper		%
Recycling	17	77%
Landfill	3	14%
Compost	2	9%
Total:	22	

Saran Wrap		%
Recycling	2	14%
Landfill	12	86%
Compost	0	0%
Total:	14	

Saran Wrap		%
Recycling	4	12%
Landfill	25	76%
Compost	4	12%
Total:	33	

Plastic Bottles		%
Recycling	43	91%
Landfill	4	9%
Compost	0	0%
Total:	47	

Plastic Bottles		%
Recycling	40	87%
Landfill	5	11%
Compost	1	2%
Total:	46	

Sushi Container		%
Recycling	2	22%
Landfill	4	44%
Compost	3	33%
Total:	9	

Sushi Container		%
Recycling	3	14%
Landfill	17	77%
Compost	2	9%
Total:	22	

Landfill Materials Sorting Rate

Pre-Signage Data:

Wrappers*		%
Recycling	4	11%
Landfill	26	70%
Compost	7	19%
Total:	37	

Post-Signage Data:

Wrappers*		%
Recycling	7	20%
Landfill	28	80%
Compost	0	0%
Total:	35	

Condiment Packet		%
Recycling	3	25%
Landfill	6	50%
Compost	3	25%
Total:	12	

Condiment Packet		%
Recycling	3	19%
Landfill	11	69%
Compost	2	13%
Total:	16	

Compostable Materials Sorting Rate

Pre-Signage Data:

PLA 7 Cups		%
Recycling	23	39%
Landfill	24	41%
Compost	12	20%
Total:	59	

Post-Signage Data:

PLA 7 Cups		%
Recycling	24	50%
Landfill	8	17%
Compost	16	33%
Total:	48	

Compostable Plates		%
Recycling	4	5%
Landfill	33	40%
Compost	46	55%
Total:	83	

Compostable Plates		%
Recycling	4	6%
Landfill	17	24%
Compost	49	70%
Total:	70	

Compostable Utensils		%
Recycling	20	19%
Landfill	36	34%
Compost	49	47%
Total:	105	

Compostable Utensils		%
Recycling	35	23%
Landfill	37	25%
Compost	78	52%
Total:	150	

Napkins		%
Recycling	26	13%
Landfill	79	40%
Compost	92	47%
Total:	197	

Napkins		%
Recycling	14	10%
Landfill	41	30%
Compost	80	59%
Total:	135	

PLA 7 Containers		%
Recycling	7	23%
Landfill	13	43%
Compost	10	33%
Total:	30	

PLA 7 containers		%
Recycling	14	36%
Landfill	14	36%
Compost	11	28%
Total:	39	

Compostable Bowl		%
Recycling	8	13%
Landfill	18	28%
Compost	38	59%
Total:	64	

Compostable Bowl		%
Recycling	2	3%
Landfill	24	30%
Compost	54	68%
Total:	80	

Food scraps		%
Recycling	0	0%
Landfill	24	31%
Compost	53	69%
Total:	77	

Food Scraps		%
Recycling	3	4%
Landfill	14	19%
Compost	55	76%
Total:	72	

PLA 7 Cups and Containers		%
Recycling	30	34%
Landfill	37	42%
Compost	22	25%
Total:	89	

PLA 7 Cups and Containers		%
Recycling	38	44%
Landfill	22	25%
Compost	27	31%
Total:	87	

Yoshinoya Clamshell**		%
Recycling	1	8%
Landfill	4	33%
Compost	7	58%
Total:	12	

Yoshinoya Clamshell**		%
Recycling	4	9%
Landfill	15	33%
Compost	26	58%
Total:	45	

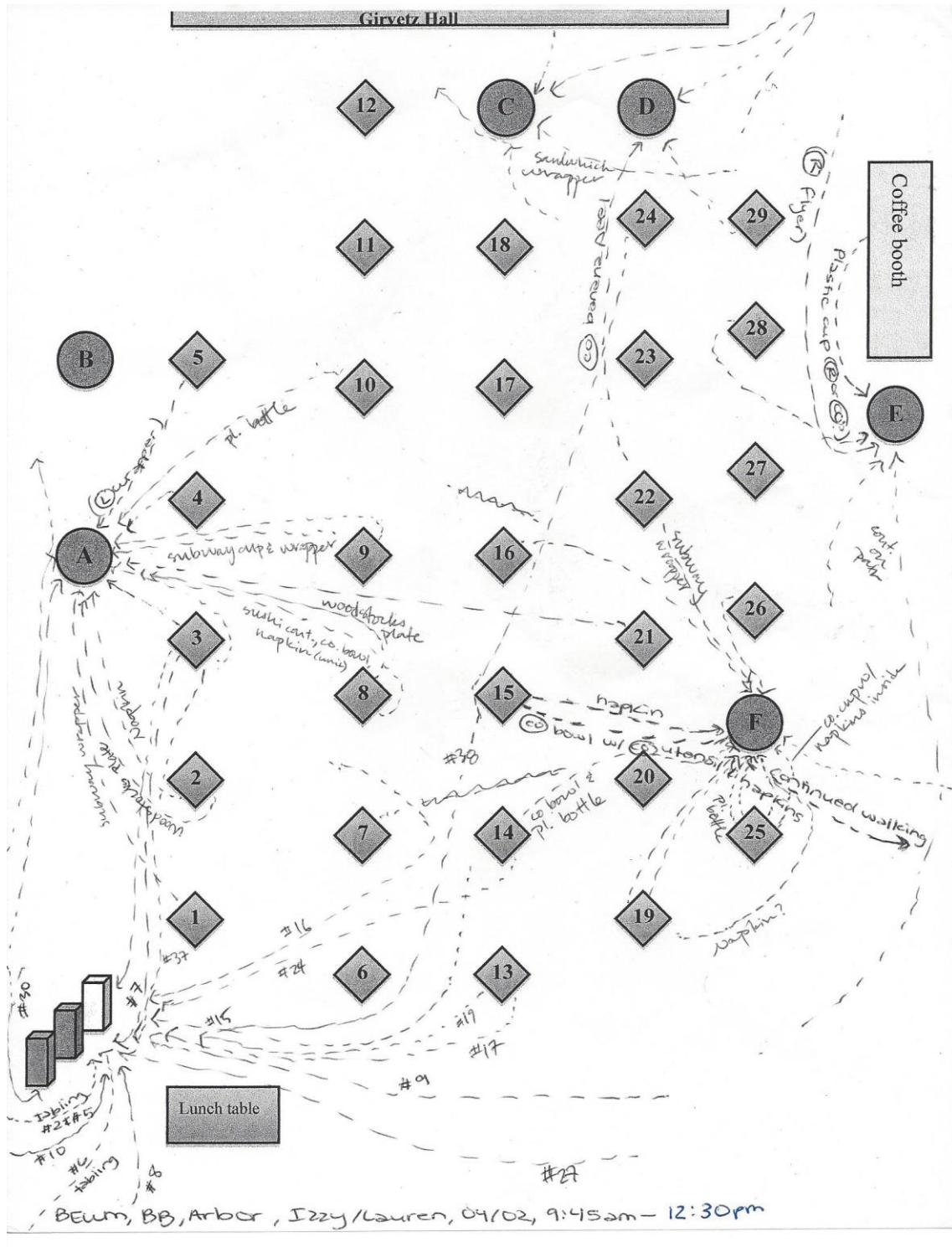
Compostable Coffee Cup		%
Recycling	11	34%
Landfill	10	31%
Compost	11	34%
Total:	32	

Compostable Coffee Cup		%
Recycling	7	23%
Landfill	8	27%
Compost	15	50%
Total:	30	

*Wrappers: we used this heading to refer to food wrappers that belong in the landfill such as chip bags, granola bar wrappers, candy bar wrappers, etc.

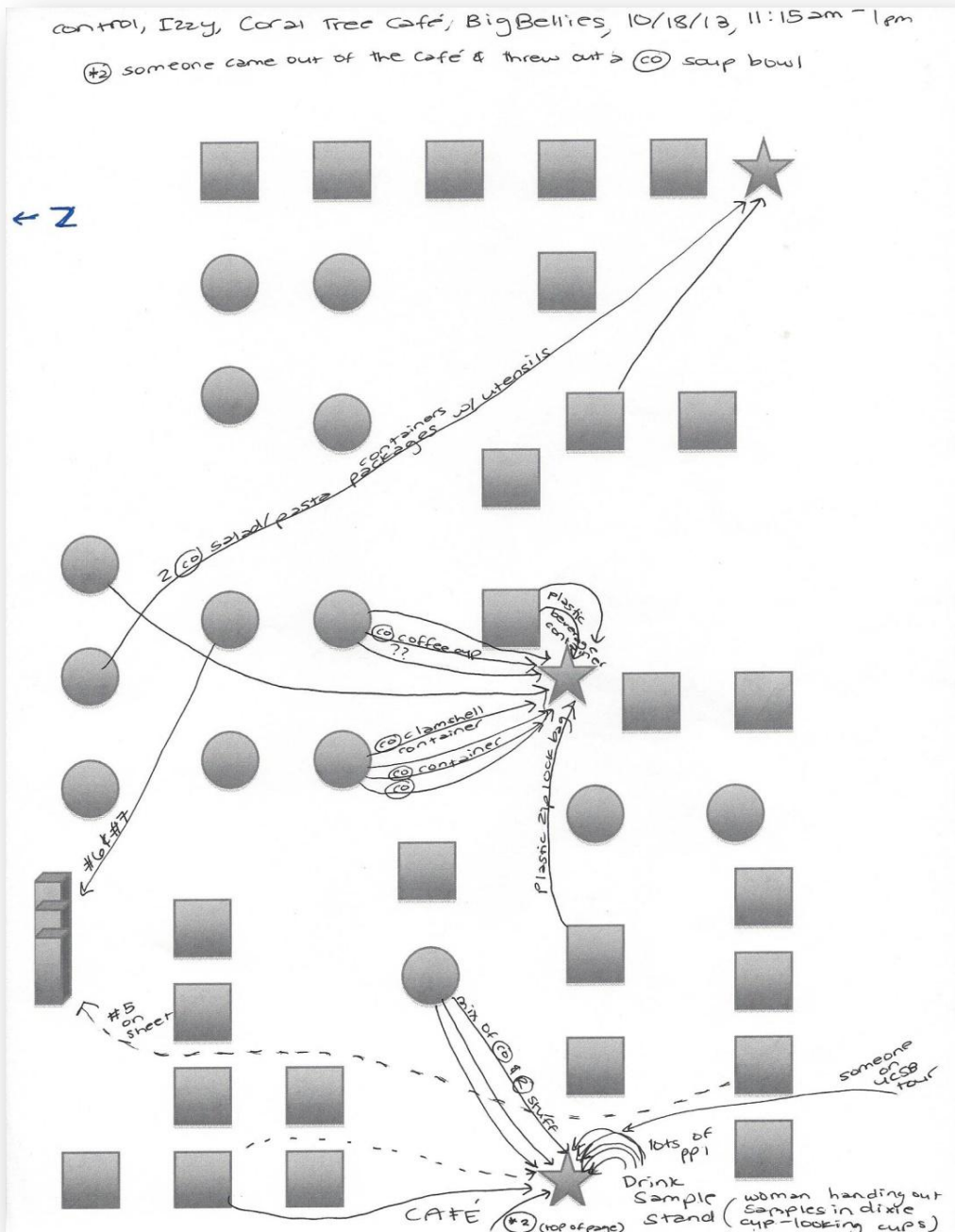
**Yoshinoya Clamshell: Yoshinoya is an eatery in the Courtyard Café that provided black compostable clamshells which differed from the campus-provided brown compostable clamshells

APPENDIX VI



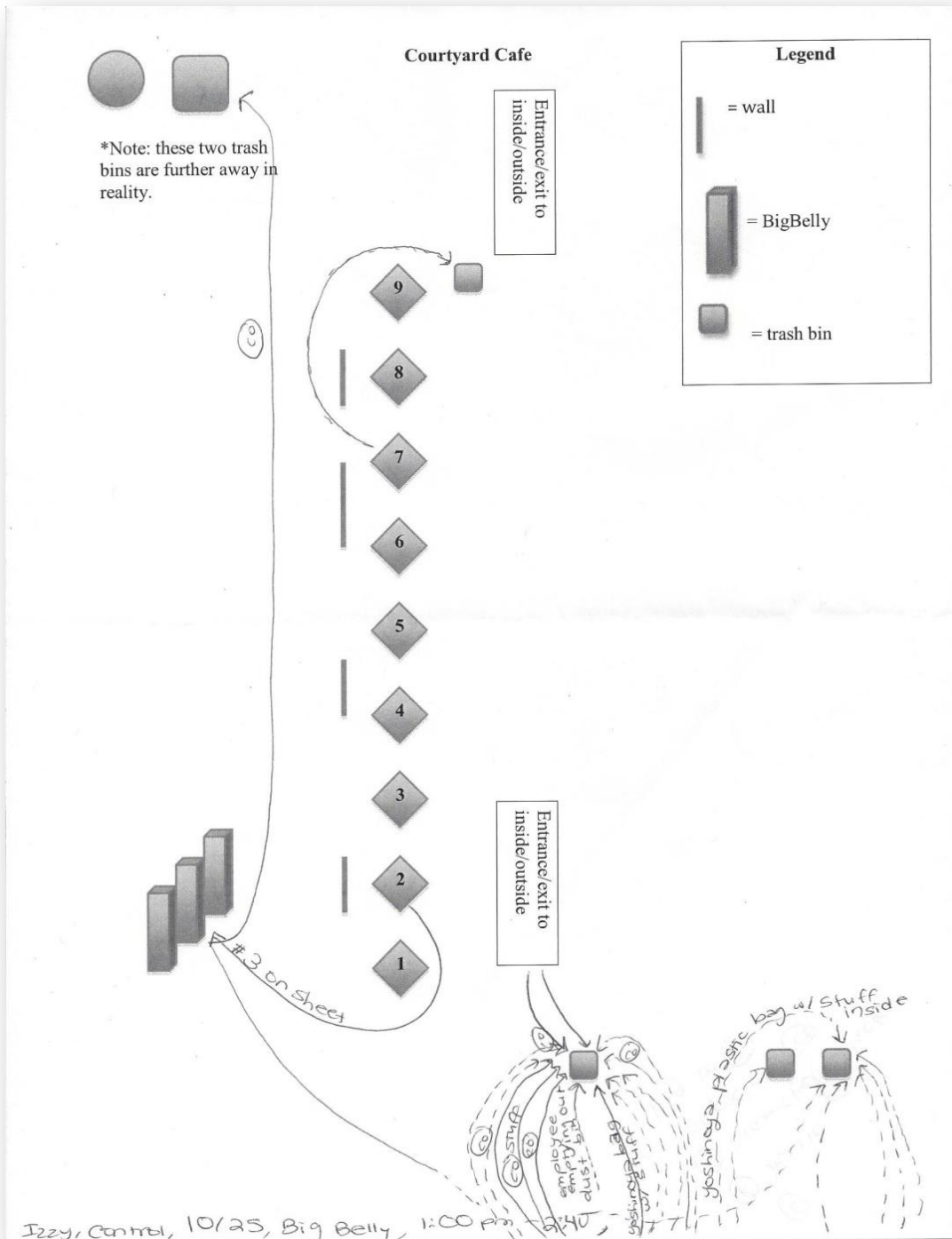
The Arbor, April 2, 2014

9:45 am - 12:30 pm



Coral Tree Café, October 18, 2013

11:15 am - 1 pm



Courtyard Café, October 25, 2013

1:00 pm - 2:40 pm