Do Students Understand Recycling?

Gauging Student Knowledge of and Attitudes towards Recycling
to Improve Recycling Education at Boston College

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Abstract

Although recycling bins are available throughout BC's campus and in every dining hall, it is unclear how well students understand recycling, how it works, or what happens to their waste if they do or do not recycle. Recycling is complex; municipal recyclables require machinery to be sorted and processed, and many paper and plastic recyclables are shipped overseas to be recycled elsewhere. To complicate matters further, in 2018 China implemented its National Sword policy, which banned 24 types of scrap imports, including paper and plastic. Following the ban, global recycling markets are demanding higher quality bales, which means less contamination, defined by the presence of unrecyclable, value-less, or heterogeneous material in otherwise sorted bales. Therefore, sorting recyclables correctly is now more important than ever to ensure that recyclables are effectively recycled and not discarded by already strained materials recovery facilities (MRFs). However, previous literature has shown that recycling behavior is contingent on recycling knowledge and attitudes. We measured Boston College students' knowledge and attitudes by surveying 125 undergraduates using an online survey platform. We not only asked their agreement levels with certain statements related to recycling processes and practices, but we also measured their ability to sort 22 objects commonly found on campus. Because dining hall managers and MRF operators reported high levels of contamination, we predicted that students would sort with considerable error and would have poor understanding of recycling processes. While we cannot measure an exact contamination rate from the sorting results of only 22 items, students sorted items better than anticipated. Additionally, students have fair to good understanding of recycling processes. These results indicate that high contamination rates at Boston College is not due to lack of knowledge of recycling processes, or what is and is not recyclable. Therefore we suggest educational and recycling marketing strategies to improve recycling rates at Boston College based on our findings.

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Introduction

Although recycling bins are available throughout BC's campus and in every dining hall, it is unclear how well students understand recycling, how it works, or what happens to their waste if they do or do not recycle. Even though it is practiced as a common habit, recycling can be a complex concept. Paper, plastic, metal and glass materials in a municipal stream require machinery at materials recovery facilities (MRFs) to sort these materials and weed out contaminants. Additionally, most paper and plastic recyclables are shipped overseas to be recycled in China or other Southeast Asian countries.[1] For example, the United States has sent approximately 80% of its plastic recyclables to China and Hong Kong since the early 2000s.[2] However, global recycling systems were sent into disarray in 2018 when China implemented their National Sword policy and banned the import of 24 different types of scrap, including the common PET (No. 1) and PE (No. 2), as well as PVC (No. 3) and PS (No. 6).[3] It also set a strict contamination rate at 0.5%. Now, with the United States' former primary recycler out of operation, and new importing countries demanding higher quality materials, cities and MRFs are challenged with delegating recyclables elsewhere and meeting higher quality standards. In other words, less contamination and proper sorting has become more critical than ever for effective recycling.

In order to improve recycling effectiveness after China's newly introduced National Sword policy, municipal and state-wide recycling educational initiatives have been implemented. The Massachusetts Department of Environmental Protection (MassDEP) has launched initiatives such as RecycleSmart[4] for citizens and Recycling IQ kits and grants[5] for municipalities, both specifically directed to reduce contamination.[6] The City of Boston has implemented similar programming, called Recycle Right, to encourage individuals to recycle correctly.[7] This is because MRFs can be forced to dispose of hauls that are too contaminated, or must pay more in processing and sorting costs to meet new contamination standards.[8] However, municipal and state governments have been equipped with information regarding recycling knowledge of residents. In 2015, Massachusetts Department of Environmental Protection conducted a survey related to recycling knowledge and attitudes.[9] They found that 94% of residents always or mostly recycle, and that 54% of residents said that if they were not sure if an item was recyclable, they would put it in the recycling bin with the expectation that it would be sorted out by the MRF. These results indicated a need for education on the impact of contamination and importance of

proper sorting. Additionally, these results showed that even well-intentioned recycling without proper knowledge can result in contamination of recycling streams.

Contamination of the recycling stream is also an issue on the Boston College (BC) campus. The recycling stream at BC is purportedly highly contaminated with materials that are not recyclable in a municipal stream, which results in significantly less effective recycling. Boston College Dining (BC Dining) managers and facilities employees, as well as plant operators at BC's MRF, Save that Stuff, have estimated that BC's waste streams can reach up to 50% contamination.[10] At Boston College, all waste bins have signage describing what can and cannot be recycled, yet contamination remains a key issue that hinders recycling effectiveness.

Previous research reveals that there are many factors that influence recycling behavior and contamination levels. A meta-analysis conducted by Hines et al. identifies knowledge of issues, knowledge of action strategies, locus of control, attitudes, verbal commitment, and sense of responsibility as the factors most strongly associated with environmentally sustainable behavior.[11] Similarly, research by Schultz and Oskamp highlights the strong predictive correlational relationship between attitudes and behaviors.[12] Their analysis shows that individuals who care more about environmentalism and sustainability are more likely to make extra effort to recycle. This research also supports the idea that individuals will recycle more often if it is more accessible and easy to do. Lastly, research by Kang et al. looked specifically at attitudes in terms of science and the relationship to sustainable behavior.[13] Using a model they created themselves, they found that how much students value societal understandings of science has an immediate impact on their beliefs regarding sustainability. The research of Hines et al., Shultz and Oskamp, and Kang all indicate that attitudes can predict recycling behavior. This literature indicates that if students know more about, believe it is environmentally beneficial and have pro-environmental value sets, and understand the science and facts surrounding waste, they may be more inclined to recycle or practice sustainable habits, like reusing.

Beyond attitudes, Oke recognizes that other factors affect recycling behavior.[14] These factors include demographics, situational context, and institutional factors like incentives and education. Oke found that an engaging combination of attitudes and the listed factors is necessary to increase workplace recycling behavior. These results highlight the importance of education campaigns that provide information on recycling practices and processes in a method tailored to their audience. We believe that these results translate to college campuses because, as

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institutions, college campuses share more similarities with offices than houses. Ensuring the success of waste management programs requires an understanding of the factors that contribute to recycling behavior and factors unique to that population.

To improve recycling at BC, it is critical to acquire data on the recycling knowledge and attitudes of BC students for several reasons. First, contamination is not measured, only observed by eye, which further necessitates more data on the actual recycling habits and knowledge of students. It is of interest for decision-makers on waste at BC to assess the student body's understanding of and attitudes toward recyclability and recycling processes in order to deduce strategies that educate them on how to recycle correctly and reduce contamination. Second, as outlined above, previous research has shown that attitudes and knowledge directly predict environmentally sustainable behavior, including recycling.[15] If students know more about how recycling works, the literature reveals that they may be more inclined to recycle. Finally, as the 2015 MassDEP survey reveals, data on recycling knowledge and attitudes is critical to understanding how to improve recycling rates and effectiveness –from our findings we can suggest educational best practices tailored to the Boston College student body.

Research Questions & Hypotheses

In this study, we aim to survey how well students understand recycling, including what is recyclable and other salient elements of the recycling process and practices, in order to deduce best practices for improving recycling effectiveness. Our research goals are twofold: 1) assessing student knowledge and attitudes about recycling and 2) recommending educational strategies to improve recycling rates and reduce contamination.

Our first question is, **1) What do students know about recycling?** We used a survey distributed to BC students to measure recycling knowledge and attitudes. Firstly, we measured student knowledge of recycling processes. Recycling processes include the end-of-life sorting and processing of recycled materials, and the export of recyclables internationally. This is the part of recycling that students indirectly engage with, and what happens beyond their immediate control. Secondly, we measured knowledge of and attitudes towards recycling practices. Recycling practices entails consumption decisions, attitudes towards recycling, and whether BC students know how to sort materials correctly, into either compost, recycling or trash. This is the

part of recycling that students directly engage with, including what they consume and how they dispose of it.

Our second question is, **2) What are the best educational strategies for improving recycling rates and effectiveness?** In the discussion section, we will use our survey findings, comparative information gathered from Santa Clara University, and existing literature to make recommendations for educational initiatives and strategies to improve recycling effectiveness at Boston College.

Due to high contamination rates at BC, we hypothesize that **1)** students are confused about the recyclability of common items, do not understand what happens when they recycle items, and do not know where or how their discarded materials are recycled. Additionally, also due to high contamination rates at BC, we hypothesize that **2)** students have poor attitudes towards recycling, in that they do not believe recycling is environmentally beneficial or do not believe it is important to recycle correctly. Lastly, we hypothesize that **3)** students who have a better understanding of recycling processes will sort waste items more accurately. This assumption is based on previous research that has shown that knowledge of issues and appreciation for science are correlated with pro-environmental behavior.[16]

Methods

In order to measure recycling knowledge, we developed a survey study conducted online using REDCap. The results of the survey informed our recommendations for educational strategies to improve recycling effectiveness.

Measuring Recycling Knowledge: Survey Design & Data Analysis

The survey measured the recycling knowledge of Boston College students, and was divided into four sections: I) Demographics (Appendix A), II) Recycling Processes (Appendix B), III) Recycling Practices - Sorting Knowledge (Appendix C), and IV) Recycling Practices (Appendix D).

Section I, Demographics, asked for class year, gender identification, and whether a student had involvement in a sustainability group on campus. Respondents who are involved in at least one sustainability organization on campus cannot make up more than 30% of the

respondents, because this group of students is likely to have a better knowledge of recycling than the general student body, and could skew the results.

In both Section II, Recycling Processes, and Section IV, Recycling Practices, students were asked to respond to statements like, *I have a good understanding of what is and is not recyclable,* using the options: "Strongly Agree," "Agree," "Neutral," "Disagree," or "Strongly Disagree." In order to quantify agreement level, we assigned an agreement score to each statement from -2 to 2. A "Strongly Agree" would receive a score of 2, an "Agree" response would receive a 1, "Neutral" would receive a 0, "Disagree" would receive a -1, and "Strongly Disagree" would receive a -2. We took the inverse of the negative statement scores to standardize the agreement levels of both the positive and negative statements. We then averaged each respondents' agreement scores within each category. For example, if a respondent answered "Strongly Agree" for the positive statement, and received an agreement score of 2, and "Disagree" for the negative statement, and received a score of -1 inverted to 1, they received an agreement score of 1.5 for that category. The final agreement score corresponded to how much each respondent agreed with a positive statement in each category. Agreement scores were averaged to generate a representative agreement level for each category from the sample of 124 respondents.

The Recycling Processes section surveyed students' knowledge of the end-of-life processes involved in recycling, including the sorting and processing done at materials recovery facilities, the export of recyclables internationally, and finally the items that recycled goods become in their end-of-life. We measured knowledge of processes since knowledge can inform students' decisions to recycle and how they recycle.[17] Additionally, this section also measured how students perceive the issue of contamination, which has become a salient issue in recycling effectiveness in light of recent changes to global recycling markets which now demand higher quality materials with less contamination. In sum, it is important to measure students' understanding of recycling processes because it can have consequences on their recycling decisions and behavior.

This section included a list of 14 statements. Each statement corresponds to one overarching category: 1) perceived understanding of what can be recycled, 2) the salience of contamination, 3) the international trading of recyclables, 4) the end-of-life use of recycled materials, and 5) the difference between reusing and recycling. We included both positive and

negative statements for each category to better control for any bias generated from the wording of the statements. For example, to measure the perceived understanding of what can be recycled, respondents were asked to respond to both the positive statement, *I have a good understanding of what is and is not recyclable*, as well as the negative statement, *I do not have a good understanding of what is and is not recyclable*. Some categories corresponded with more than two statements in order to further control for wording if the category was particularly complex or salient. For example, the theme of contamination had five corresponding statements, three positive and two negative.

Section IV, Recycling Practices, was very similar to the setup of the Recycling Processes section. This section surveyed students' knowledge of consumer best practices, such as which materials have lower environmental footprints, as well as sorting knowledge, such as which items go in the recycling, trash and compost. Respondents were presented with 18 statements, which were also positive and negative, and corresponded to 8 categories: 1) personal impact, 2) environmental impact, 3) single-use plastics, 4) convenience, 5) ocean plastics, 6) options in the dining hall, 7) effect of location on recycling behavior, and 8) sorting. The method of data analysis for this section was the same as the Recycling Processes section.

Finally, Section III, Recycling Practices - Sorting, measured students' knowledge of how to properly sort items into the recycling bin, compost bin, and trash bin. Therefore, this section effectively measured students' perception of what is and is not recyclable. The respondents were prompted with 22 items commonly found on campus and/or in the Dining Halls and asked in which of the three bins they should go. A correct answer received a score of 2, and an incorrect answer received a score of -2. The average score for each item was calculated in order to measure the sample's ability to sort each item effectively. Additionally, the overall scores of the 22 items were averaged together to generate a score representing how well the sample is able to sort overall.

The survey was administered on the platform REDCap, and it was advertised on the sophomore, junior, and senior class Facebook groups, and was also distributed to professors' class listservs. The survey is attached in the appendix.

Educational Strategies

We have consolidated data and information on the educational initiatives and strategies to improve recycling used at Santa Clara University (SCU) for our recommendations on educational strategies. We use data on waste diversion from both BC and SCU to compare the success of their educational initiatives.

Results

Survey Demographics

While 149 respondents completed the initial Demographics portion of the survey, a number of responses were removed from the data analysis for incomplete survey responses, leaving 124 complete responses predominantly from the sophomore, junior and senior classes (**Figure 1**).

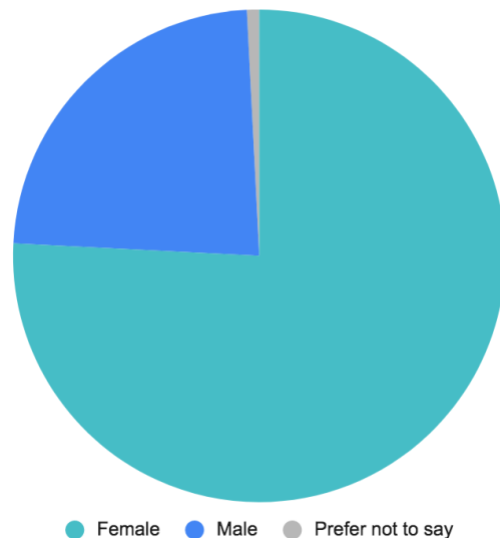**Figure 1**. Survey respondents by class year. n = 124.

Figure 2. Survey respondents by gender identification. n = 124.

The respondents were 75% female and 23% male, revealing a significant gender bias in survey respondents skewed towards women (**Figure 2**). This may be consistent with Swim et al.'s findings that because recycling is a pro-environmental behavior associated with femininity, men are less likely to engage in it and feel insecure when they do so.[18] However, there are other potential variables involved: perhaps women are generally more inclined to answer surveys, or perhaps women were more inclined to respond to this survey in particular because it was distributed by other women on the social media platform, Facebook.

A prerequisite of the survey was that not more than 30% of the respondents could belong to a sustainability group on campus. Students in sustainability groups tend to know more about how recycling works and how to recycle correctly, so having too many respondents belonging to these groups could skew results. However, only 14.9% of the respondents belonged to sustainability groups.

Recycling Processes

The respondents were asked for their level of agreement (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree) to both positive and negative statements related to the processes of recycling. We found no negative agreement scores, meaning that students generally agree with the statements in **Figure 3** (the average scores were ≥ 0).
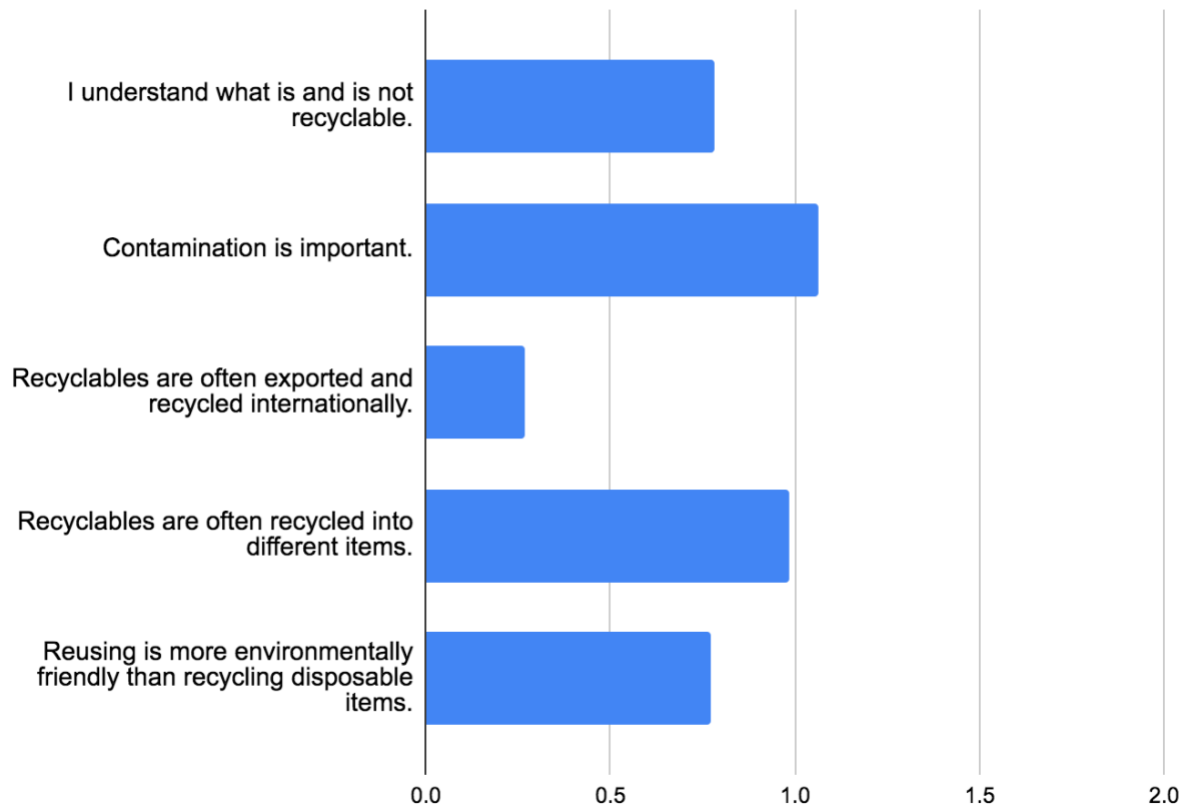
Figure 3. Agreement scores with statements related to recycling processes on a scale of -2 to 2. n = 95.

The average agreement score to the statement "I understand what is and is not recyclable" was 0.784 on a scale of -2 to 2, meaning that students generally agree that they understand how to recycle, but that there is still room for error. While the agreement score was still above 0 for the statement "Recyclables are often exported and recycled internationally," it was only 0.268. This indicates that students may not understand the global recycling trade very well.

Lastly, the statement with the highest agreement score in this section was "Contamination is important," with a score of 1.061. This statement was the average of five statements related to contamination. Specifically, the statement "If I am not sure if an item is recyclable or not, throwing it in the trash is better," received an agreement score of 0.758. These findings are surprising and important – in our discussion with BC Dining management, contamination came up as the biggest challenge concerning recycling, with contamination rates as high as 50%. However, from these results, students appear to understand the consequences of contaminating the recycling stream, and believe that contamination is important to effective recycling.

Sorting

In the sorting section of the survey, we asked students to place 22 waste items commonly found in the dining halls and on campus into either the trash bin, compost bin, or recycling bin. Overall, students scored a 0.785 on a scale of -2 to 2 on the sorting section (**Figure 4**. For answers to the sorting section, see **Appendix C**). Interestingly, the overall score on the sorting section is almost exactly equivalent to the score for the statement, "I understand what is and is not recyclable" (**Figure 3**). This means that students are good at judging themselves on how to recycle, and understand their own abilities and limitations well. As predicted, there was a positive correlation between knowledge of recycling processes and scores on the sorting quiz. The Pearson correlation coefficient of 0.3843 means that students who know more about recycling processes generally sort their waste into the proper bins, and sort their waste better than students who know less about recycling processes.
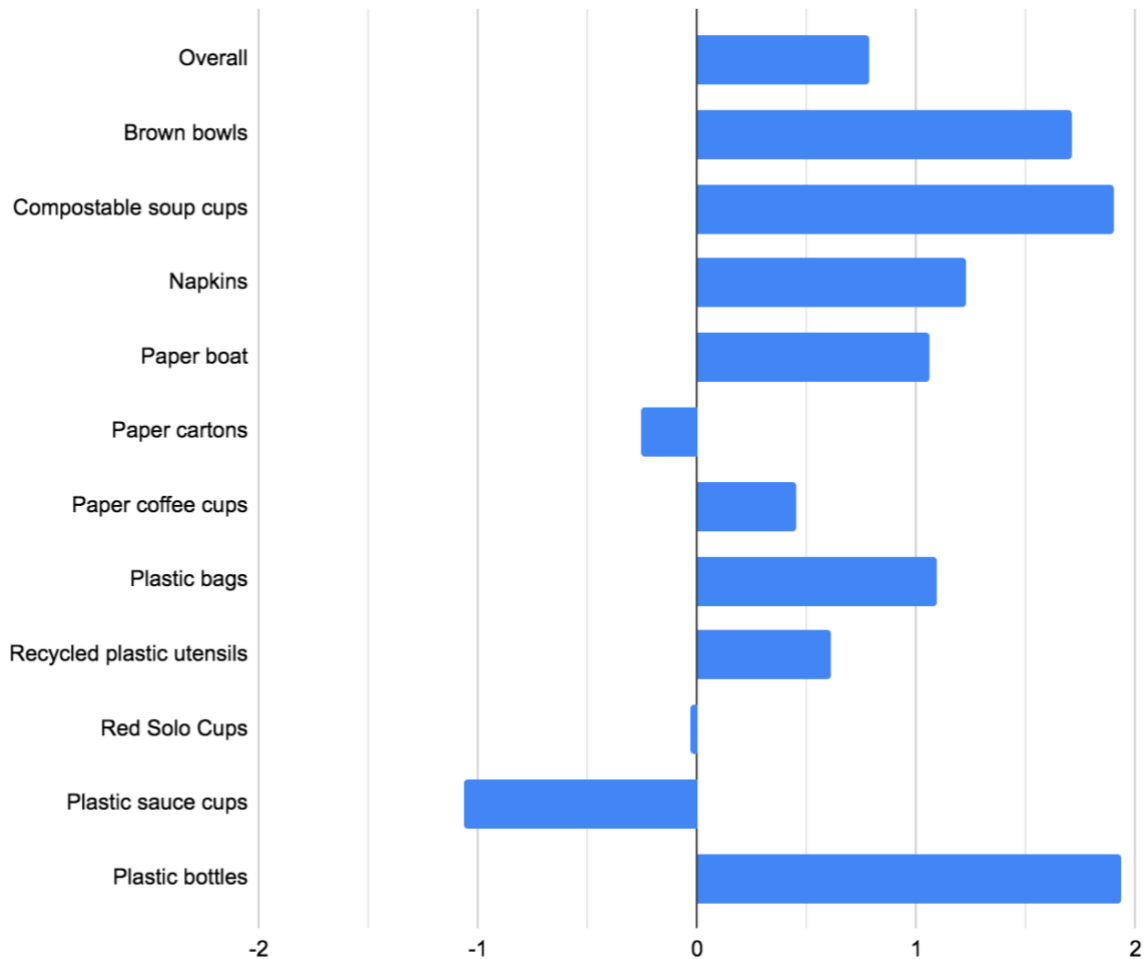
Figure 4. Average scores for the sorting of waste items commonly found in the dining halls and on campus. A score of -2 means that students never sort items correctly, while a score of 2 means that students always sort items correctly. n = 124.

The results indicate that students sorted all items correctly, albeit some better than others, with the exception of three items: paper cartons, Red Solo Cups, and plastic sauce cups. These items are all deceptive when it comes to sorting. While all made out of materials that are recyclable – paper or plastic – there are specific characteristics about these items that make them not recyclable. First, while paper cartons were considered municipally recyclable in the recent past, the state of Massachusetts made updates to their list of acceptable recyclable items in 2018 as a result of the National Sword policy.[19] Therefore cartons are no longer recyclable in Boston and most other MA municipalities. The survey result for sorting paper cartons indicates that students do not understand the concept of recycling changes after National Sword very well.

Second, respondents also sorted Red Solo Cups incorrectly. Although they are made out of plastic, Red Solo Cups are not recyclable because they are made out of Polystyrene (PS, No. 6), which is not considered a recyclable plastic polymer. Only polymer Nos. 1, 2 and clear No. 5 are able to be recycled consistently in municipal streams. RecycleSmart MA indicates on their website that Red Solo Cups are not accepted because they are "simply not made of high-value plastic."[20] The concept tested here – polymer type and recyclability – is fairly nuanced, and the negative sorting result for Red Solo Cups indicate that students may not understand this concept.

Finally, the respondents incorrectly sorted plastic sauce cups the most. Most respondents placed these items in the recycling bin, when they are not recyclable due to their size. They are made out of PET (No. 1) plastic, a highly recyclable polymer, but are too small to be recycled. Shape affects the recyclability of other items as well, such as clamshells, trays, utensils, and more.[21] The poor score on the plastic sauce cups of -1.065 indicates that students understand the concept of shape and recyclability very poorly.

The items that were best sorted are items that are highly visible in sorting signs and advertisements, both at BC and in general. For example, the plastic orange juice bottle was almost perfectly sorted correctly into the recycling bin with a score of 1.935 on a scale of -2 to 2. Plastic bottles are repeatedly advertised as highly recyclable in general messaging on recycling (see **Figure 5**). Additionally, eleven states in the U.S., including Massachusetts, have container deposit laws, in which citizens receive 5-10 cents for returning bottles for recycling. This may increase the visibility of plastic bottles as a recyclable item.

Figure 5. Recycling guidelines from Massachusetts Department of Environmental Protection (MassDEP).

Other items that were well sorted were the brown compostable bowls and the compostable soup cups. These are also items that are highly visible and advertised as compostable. The dining halls which use the brown compostable burrito bowls (labeled "brown bowls" in **Figure 4**) have signs indicating that they are compostable placed in high traffic areas, such as serving lines (see **Figure 6**). The compostable soup cups do not have specific signage, but do say "100% compostable" on the side (**Figure 7**).

Figure 6. Signage in BC Dining halls which commonly use the brown burrito bowl. Note that yellow is the color associated with compost bins.

Figure 7. Compostable soup cup container.

We calculated the total percentage of items sorted correctly, and found that 69.5% of the items were sorted correctly throughout all 125 responses (**Figure 8**). This means that only 30.5% of tested items were sorted incorrectly. However, these items could have been sorted incorrectly and gone into the trash instead of the compost or recycling bins, which would pose no contamination to those bins.

Therefore, in order to better estimate sorting behavior for items that are more likely to become contaminants, we calculated the total percentage of correct sorting responses only for the 7 items that were meant to go into the trash can out of our sample of 22 (**Figure 9**). These items were the plastic utensil, Red Solo Cup, plastic bag, plastic sauce cup, paper coffee cup, paper carton, and paper boat. If these items were incorrectly sorted, they would contaminate either the compost or recycling bins, and therefore be more problematic than items that were incorrectly sorted into the trash. We found that respondents indicated that these items should go into the trash bin, and therefore correctly sorted them, only 56.4% of the time. The percentage of items sorted incorrectly and therefore potential contaminants of the compost and recycling bins, 43.6%, by no means offers an estimated contamination rate for BC as a whole. There are also considerations of mass and volume of contaminants, and there are plenty of other materials besides these 7 that may be contaminants. However, this percentage indicates that BC Dining's estimate of 50% contamination may be a bit high, but not outlandish.
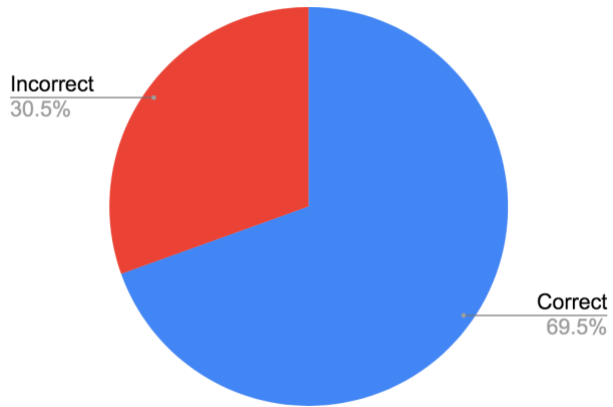
Figure 8. Total correct and incorrect sorting responses out of the 22 items.

Figure 9. Total correct and incorrect sorting responses for the 7 items that were meant to go in the trash bin.

Recycling Practices

In the recycling practices survey, students were asked to rank their agreement, from Strongly Disagree to Strongly Agree, with statements assessing their recycling practices and attitudes. We also assessed related pro-environmental behavior, like reuse and usage of single-use plastic. The results indicate that most students assess their recycling practices and correct sorting behavior as important as well as beneficial for the environment, with scores between Agree and Strongly Agree (**Figure 10**). Specifically, the average score for "It is good to recycle as much as possible" was 1.427, "It is good for the environment to recycle" was 1.463, and "I think it is important to sort waste into correct bins" was 1.602. These scores show that students are in agreement regarding the importance and impact of recycling behavior.
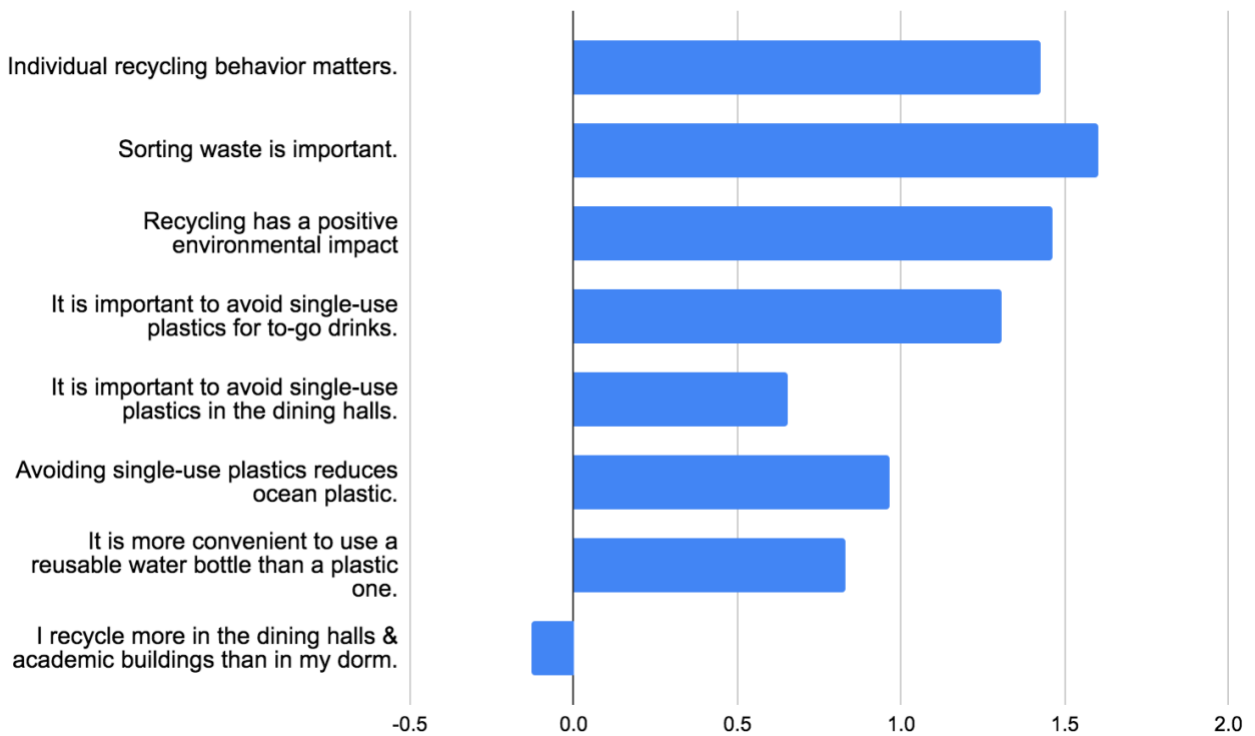
Figure 10. Agreement scores with statements related to recycling practices on a scale of -2 to 2. n = 123.

The data also show that students believe it is important to minimize the usage of single-use plastics. Students' scores indicate that they agree it is important to avoid single-use plastics or disposables for to-go drinks. The average agreement score for the statement "It is important to avoid using disposable coffee or drink cups" was 1.370. Similarly, in response to the statement "It is important to avoid using plastic straws," the average score was 1.248. These results indicate that students view avoiding single-use plastic to-go drinks and plastic straws as almost equally important.

To assess behavior related to convenience, we asked students to rank their level of agreement with the statement "It is more convenient to use a plastic water bottle than to use a reusable one." The average score was 0.8293. This result indicates that students tend to agree that using a reusable water bottle is more convenient than using a plastic water bottle. In comparison to the results for plastic in terms of to-go drinks, this trend toward agreement is weaker.

We asked students to rate their level of agreement with two statements regarding how their behavior impacts the amount of plastic in the ocean. These statements were "Refusing a

plastic straw in the United States helps to reduce ocean plastic," and "Using a reusable coffee cup in the United States helps to reduce ocean plastic," with an average score of 0.965. This score indicates a trend toward agreement with these statements. In the United States, single-use plastics generally do not end up in the ocean unless they are disposed of as litter. Consequently, these results indicate that students do not understand the impact of their single-use plastic usage at the end of life.

Because most signage about recycling and proper waste sorting at Boston College is in dining halls, we were interested in students' behavior in dining halls on campus. We asked students to rate their level of agreement with the statements "I would be interested in using BC Dining's reusable container program, Green2Go, because it is good for the environment" and "I use reusable metal silverware in the dining halls whenever I can, because it is good for the environment." The average agreement score was 0.65, which indicates a trend toward agreement with these statements. To compare behavior in dining halls, where there is substantial signage, with behavior in dorms, we asked students to rate their level of agreement with the statement "I recycle more often on campus in dining halls and academic buildings than I do in my dorm." The average score was -0.13, which shows a trend toward disagreement, meaning that students trend toward recycling more in their dorms than in dining halls or academic buildings. This result does not align with our predictions. One confound possibly affecting this result is the fact that students do not sort their own waste in Lower Dining Hall. In general, the students who eat most frequently in this particular dining hall are sophomores, juniors, and seniors; those same grade levels made up the majority of our survey respondents.

Discussion

Survey Results

Our findings deviated from our first hypothesis that Boston College students have a poor understanding of recycling processes and what is and is not recyclable. Students tended to understand recycling processes relatively well, having high agreement scores (≥ 1) with statements related to the importance of contamination and the diverse end-of-life of recyclables (**Figure 3**). However, students seemed to

not agree very strongly with the statement, "Recyclables are often exported and recycled internationally," (score of 0.268 on scale of -2 to 2), indicating that they do not understand that recycling is a global market. The international nature of recycling has implications on how it is recycled and under what conditions – recyclables shipped and recycled in Southeast Asia can have negative ethical and environmental implications.[22] Students may not be aware of these nuances and considerations, and future research should investigate how awareness of the international nature of recycling influences recycling attitudes and behavior.

Additionally, our findings from the recycling practices survey section indicate that students generally believe that recycling is important and environmentally beneficial, which deviates from our second hypothesis. Previous literature reveals that people who appreciate and value the environment are more inclined to engage in recycling.[23] Therefore, from our findings, decision makers at BC can deduce that BC students are likely to recycle or compost, to the best of their ability, at a high rate.

Lastly, the Pearson correlation coefficient of 0.3843 between students' knowledge of recycling processes and their sorting behavior indicates that students who understand recycling processes are more likely to sort waste correctly, which confirmed our third hypothesis. This finding has implications for waste decision-makers at BC and other institutions: educating the student body will lead to better knowledge of recycling process and lower rates of contamination.

Educational Strategies

From our survey results, as well as other university recycling programs and the existing literature, we offer BC waste decision-makers suggestions of best educational strategies that may improve recycling rates and effectiveness.

1) **Increase visibility of common items.**

According to the sorting knowledge section of the survey, the best-sorted items (plastic bottles, compostable brown bowls and compostable soup cups) are highly visible to students. This means that their sorting designation (compost, trash, or recycling) is repeatedly advertised. Plastic bottles are repeatedly advertised as recyclable in state-wide campaigns like RecycleSmart MA, and also have a container deposit, which makes them a highly visible recyclable item. The brown bowls have specific signage indicating that

they are compostable in high traffic dining hall areas, and the soup cups are labeled compostable on the packaging. Although there are signs above bins indicating what is and is not recyclable, they are general and may be too detailed for students to read or notice.

2) **Increase accuracy of messaging.**

Santa Clara University (SCU), a mid-sized (5,400 undergraduates and 3,000 post-graduates), Jesuit university, has a diversion rate of 71% as of 2019 (**Figure 11**). The Boston College diversion rate is approximately 40%, which is considerably lower. A key difference between the two institutions is the accuracy and quality of recycling messaging. Santa Clara's sustainability website details what gets sorted into the compost, recycling and trash bins.[24] The website also has instructions for dealing with e-waste, light bulbs, and batteries, and reuse options for hard-to-recycle material. The BC sustainability website does not disclose waste diversion data (**Figure 11**), and contains inaccurate sorting information.[25] For example, the website instructs BC community members to recycle plastics #1-7, but not all plastic polymers are recyclable in BC's stream.[26] Improving the accuracy and thoroughness of the website, or increasing access to other materials or reuse options, may improve recycling or diversion rates at BC.
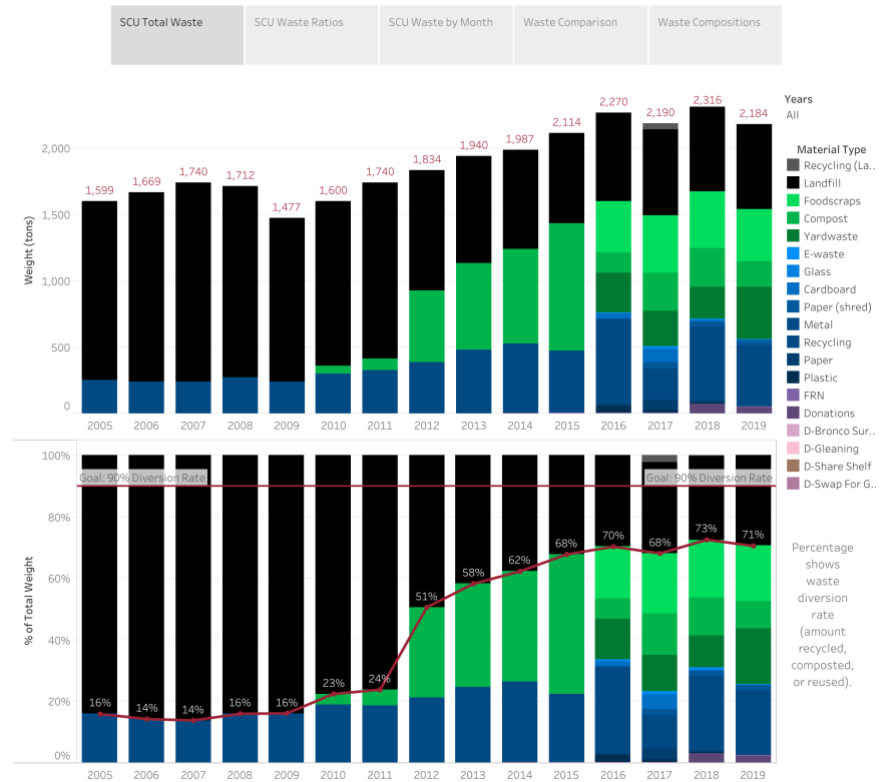
Figure 11. Santa Clara's waste diversion data. Publicly available at:
https://public.tableau.com/profile/scu.center.for.sustainability#!/vizhome/SCUWaste/SCUWaste.
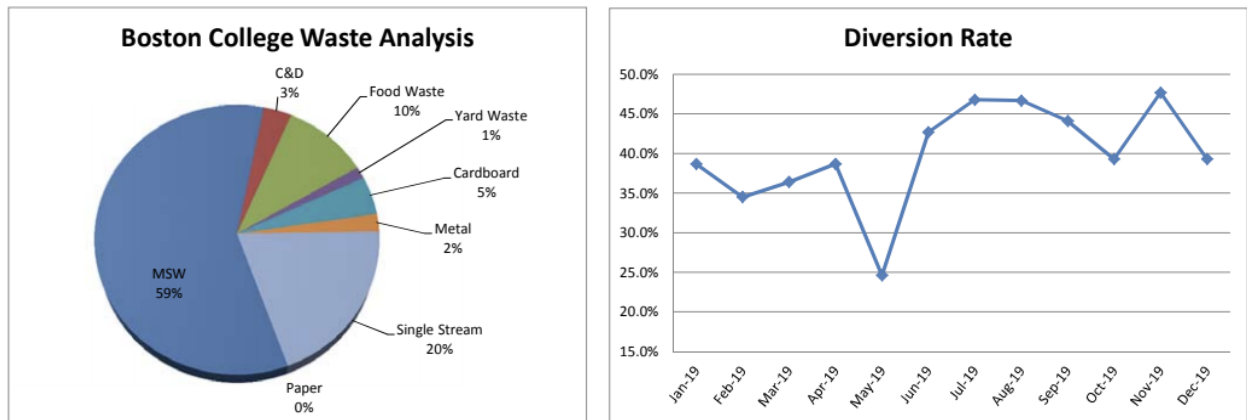
Figure 12. Boston College's waste diversion data, generated by Save that Stuff. Acquired from Boston College Dining Services.

3) **Establish a student eco-reps program.**

Research on eco-reps programs implemented at Tufts University, and almost thirty other universities which modeled their programs based on Tufts', indicates the success of peer-led programs.[27] We suggest implementation of a similar program at Boston College. This

program would use peer influence to improve recycling education and awareness through student conversations, social media campaigns and on-campus events.[28] Based on the success of similar programs, this program will increase recycling knowledge and improve recycling practices.

4) **Integrate sustainability lessons into programming for incoming students.**
At Boston College, Orientation and Welcome Week aim to teach incoming students about life at BC. Part of the programming involves teaching students about the culture, traditions, practices and expectations at BC. Part of the expectations that should be communicated to incoming students are how to properly sort items into trash, recycling or compost bins. Additional expectations beyond the scope of this paper are minimizing water and electricity usage and utilizing Boston College and public transportation options. Educating students on sustainability and recycling early in their BC careers will highlight its importance, develop positive attitudes towards recycling and reuse, and increase knowledge.

Challenges and Limitations

There are challenges that inherently limit the effectiveness of our suggested educational strategies, and may require more rigorous and institutional action to overcome. Firstly, recycling markets are subject to change, and public education may not be able to realistically keep up. For example, most students sorted the paper carton into the recycling bin most likely because this item is both made out of a commonly recognized "recyclable" material (paper), but also because it has been accepted by municipal recycling programs in the past. National Sword has changed recycling markets, and therefore the items able to be recycled, and markets may continue to change for years to come. Therefore, instead of continuously re-training students, decision-makers seeking to improve recycling rates and decrease contamination may consider standardizing products offered in dining halls and on campus. Eliminating common offenders of contamination and finding clearer alternatives will be more effective than education.

A key limitation of this study is that it only measures self-reported recycling behavior, not actual behavior. For example, students agreed with the statement "It is important to avoid single-use plastics in the dining halls" with a high agreement level of 1.309 on a scale of -2 to 2, but we did not measure how they actually behave. Do students act on their reported beliefs? If

not, what convinces them to do so? These are questions that have important ramifications for sustainable consumption, and are worth examination in future work.

Another limitation is that all responses were voluntary and there was no compensation for participating. Although the number of respondents in an environmental group on campus was below our threshold, there may still have been a response bias causing more students to voluntarily participate because of their personal interest in the subject matter. Although this may have swayed our sample to appear more knowledgeable about recycling and sorting than the general student body, we have no way to quantify this possible effect with our collected data.

A final limitation is that only 22 items were surveyed in the sorting section of the survey. These items may not be a comprehensive representation of BC's waste stream. An opportunity for further study is to conduct a waste audit, detailing the nature of BC's waste stream. From the audit, the most commonly used items could be identified. Students' sorting behaviors of those items would offer a more accurate representation of BC's true contamination rate.

Conclusion

Based on the high levels of contamination in recycling bins at Boston College, we predicted that students would have poor understanding of and negative attitudes towards recycling processes and practices. Contrary to our hypotheses, students demonstrated understanding of recycling processes and positive attitudes towards recycling in general. . However, our hypothesis that students with a better understanding of recycling processes would sort more effectively was confirmed. In the sorting section of our survey, the results revealed that items with clear, visible signage at BC and in general were disposed of most accurately. Building on these promising results, we have provided recommendations for education campaigns to increase recycling rates and reduce contamination for all recyclable items at Boston College.

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Appendices

A. Demographics
1. What is your class year?
2. What is your gender identification?
3. Are you involved in a sustainability group on campus?
   a. No
   b. EcoPledge
   c. Real Food
   d. Climate Justice
   e. UGBC Environment Committee
   f. Bike BC
   g. BC Dining or Office of Sustainability interns
   h. Other:

B. Recycling Processes
4. Likert Scale (1 to 7 ranging from strongly disagree to strongly agree)
   a. Original statements
      i. I have a good understanding of what is and is not recyclable.
      ii. It matters if there are a few things in the recycling bin that are not recyclable.
      iii. If there are too many non-recyclable items in the recycling bin, it will take longer for the non-recyclable items to be sorted out.
      iv. Most of what I put into the recycling bin gets recycled domestically.
      v. When I recycle an item, it is reused to create the same item it was before.
      vi. If I am not sure if an item is recyclable or not, throwing it in the recycling bin is better for the environment.
      vii. Using reusable items consistently is more environmentally friendly than recycling disposable items.
   b. Opposite statements
      i. I do not have a good understanding of what is and is not recyclable.
      ii. It does not matter if there are some things in the recycling bin that are not recyclable, since they are all sorted.
      iii. If there are too many non-recyclable items in the recycling bin, the entire bin will be sent to a landfill or incinerator.
      iv. Most of what I put into the recycling bin does not get recycled domestically.

v. When I recycle an item, it is not reused to create the same item it was before. Instead, it is reused to create a different item that it was before.

vi. If I am not sure if an item is recyclable or not, throwing it in the trash bin is better.

vii. Using reusable items consistently is as environmentally friendly as recycling disposable items.

C. Sorting Knowledge

Does this item go in the trash bin, compost bin, or recycling bin?*

*Note: only pictures were shown in this survey. The item label and sorting answer were added for clarification.

a. **Paper boat**: trash bin.

b. **Recycled plastic utensil**: trash bin.

c. **Compostable soup cup**: compost bin.

d. **Napkin**: compost bin.

e. **Red Solo Cup**: trash bin.

f. **Paper coffee cup**: trash bin..

g. **Brown bowl**: compost bin.

h. **Plastic bag**: trash bin.

i. **Paper carton**: trash bin.

j. **Plastic bottle**: recycling bin.

k. **Plastic sauce cup**: trash bin.

D. Recycling Practices
5. Likert scale (1 to 7 ranging from strongly disagree to strongly agree)
    a. Original statements:
        i.   It is good to recycle as much as possible.
        ii. It is good for the environment to recycle.
        iii. It is important to avoid using plastic straws.
        iv. It is important to avoid using disposable coffee or drink cups.
        v.   It is more convenient to use a plastic water bottle than to use a reusable one.
        vi. Refusing a plastic straw in the United States helps to reduce ocean plastic.
        vii. Using a reusable coffee cup in the United States helps to reduce ocean plastic.
        viii. I would be interested in using BC Dining's reusable container program, Green2Go, because it is good for the environment.
        ix. I use Green2Go even though I think people will judge me.
        x.   I use reusable metal silverware in the dining halls whenever I can, because it is good for the environment.
        xi. I recycle more often on campus in dining halls and academic buildings than I do in my dorm.
        xii. I think it is important to sort waste into correct bins.
    c. Opposite statements
        i.   Recycling as much as possible does not matter.
        ii. Recycling does not help the environment.
        iii. Avoiding plastic straws does not matter.
        iv. Avoiding disposable coffee or drink cups does not matter.
        v.   It is not more convenient to use a plastic water bottle than to use a reusable one.
        vi. I do not use Green2Go because I think people will judge me.
        vii. Refusing a plastic straw in the United States does not help to reduce ocean plastic.

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