The Circular Economy:

Plastic Waste Streams and BU's Reusable Container Program

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1: INTRODUCTION

Plastic waste contamination has reached every corner of our planet. It has been determined by leading scientists that plastic waste is reaching our oceans at the rate of a garbage truck per minute, and that by 2050, there will be more plastic waste than fish in our oceans[1]. Following World War II we have undergone a rapid transition from reusable to single-use plastics. Major investments in its development and use launched plastics into a number of new markets, making plastic the material of choice for a number of new applications, from cars and packaging to mobile phones and buildings. The packing sector alone accounted for 38.1% of all plastics consumed from 2001-2002[2]. Plastics continue to dominate the packaging market because it's cheap, lightweight, flexible, and easy to process. The resulting growth in the production of plastics is unmatched by any other man-made material to date[3]. Given the current state of recycling infrastructure worldwide, less than 9% of produced plastic is actually recycled[3]. Of the 8.3 billion tons of plastic waste that has been produced, over 79% has been discarded in landfills worldwide[3]. It is necessary that we confront the management and recovery of plastic waste in order to avoid the catastrophic invasion of plastic waste into our everyday lives.

ENVIRONMENTAL IMPACT OF PLASTIC WASTE

Plastic pollution is a pervasive and urgent issue that impacts human health, our oceans, and interconnecting ecosystems. The life cycle of plastic, beginning as a fossil fuel, emits greenhouse gasses in extraction and transport (9.5–10.5 million metric tons of CO2 equivalents (CO2e) were emitted in 2015), refining and manufacture (184.3–213.0 million metric tons of CO2e, as much as 45 million passenger vehicles driven, were emitted in 2015), and management / collection (global emissions from incineration totaled to 16 million metric tons of CO2e in 2015).[4] The projected growth of plastic consumption is predicted to reach 1.34 gigatons per year, which is equivalent to the emissions of more than 295 new 500-megawatt coal-fired power plants.[4] By the year 2050, the total emissions from the plastic lifecycle, with its predicted consumption growth, are expected to be over 56 gigatons.[4]

The development and mass production of modern polymers has resulted in a massive increase in the presence of highly durable plastic in our environment[5]. Of course, the rate at which

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[1] World Economic Forum. (2016). *New Plastics Economy: Rethinking the Future of Plastics*.

[2] Perugini, F., Mastellone, M. L., & Arena, U. (2005). *A Life Cycle Assessment of Mechanical and Feedstock Recycling Options for Management of Plastic Packaging Wastes.* Environmental Progress, *24* (2), 137–154.

[3] Geyer, R., Jambeck, J. R., & Law, K. L. (2017). *Production, Use, and Fate of All Plastics Ever Made.* Science Advances, *3*(7).

[4] Hamilton, L. A., Feit, S., & Labbe-Bellas, R. (2019). *Plastic & Climate: The Hidden Cost of A Plastic Planet.* Kistler & C. Muffett (Eds.), Center for International Environmental Law.

[5] Welden, N. A. (2020). *The Environmental Impacts of Plastic Pollution*. In T. M. Letcher (Ed.), Plastic Waste and Recycling (pp. 195–222). Academic Press.

plastic waste reaches the environment depends on the service life of the product, where single use plastics, in particular, pose a significant threat. The marine environment has arguably suffered the greatest environmental impact. The Great Pacific garbage patch now covers over 1.6 million square kilometers. Plastic deposits on this scale (in oceans and otherwise) are inevitably affecting natural systems, living organisms, and human health. The environmental and health effects of microplastics have also begun to infiltrate scientific literature. Microplastics are a result of the long-term breakdown of plastic waste. These plastic particles are easily transported and ingested by living creatures. The long term-health effects of microplastic buildup in biologic systems is currently being investigated. It is nearly impossible to remove plastic waste from the environment once it has been broken down to microplastic levels.

CHINA'S WASTE BAN

So, where does the "recycled" plastic actually go? Although your recycled trash is being picked up by or dropped off at municipal recycling centers, chances are it's not being recycled. Upwards of 270 million tons of recycled material is collected annually worldwide. Historically, about 60% of this recycled material was exported to China to be processed and reincorporated into new products. However, a once profitable business venture for China, collapsed due to the increasing percentage of contaminated and hazardous materials they were receiving. China would no longer remain the world's dumping ground. At the end of 2017, China enacted its National Sword Policy in which it shut its doors to imports of internationally sourced recycled materials[6]. The price of recycled materials plummeted, and the global recycling trade was suddenly turned on its head. China went from importing over 60% of global plastic waste in the first half of 2017, to importing less than 10% during that same period a year later[6]. G7 countries that typically relied on China to take their recycled materials were in desperate need of new countries willing to accept them, relying primarily on other Asian countries such as Malaysia, Thailand, and Vietnam to make up the difference (Figure 1).

FATE OF PLASTIC WASTE

The enactment of the National Sword Policy caused an unprecedented increase in the percentage of recycled materials that were either abandoned or discarded in landfills. In the United States alone, the percentage of recyclable plastics discarded in landfills increased by 23.2%[7]. Since exporting to China is off the table - we must find a way to deal with plastic domestically. Namely, we need to (1) increase demand for recycling plastics in the U.S. (i.e., create new recycled

[6] Hook, L., & Reed, J. (2018). *Why the World's Recycling System Stopped Working*. Financial Times.

[7] Vedantam, A., Suresh, N. C., Ajmal, K., & Shelly, M. (2022). *Impact of China's National Sword Policy on the U.S. Landfill and Plastics Recycling Industry*. Sustainability 2022, Vol. 14, Page 2456, 14(4), 2456.

materials markets), and (2) increase the quality of recycled plastic bales (i.e. better sorting infrastructure).

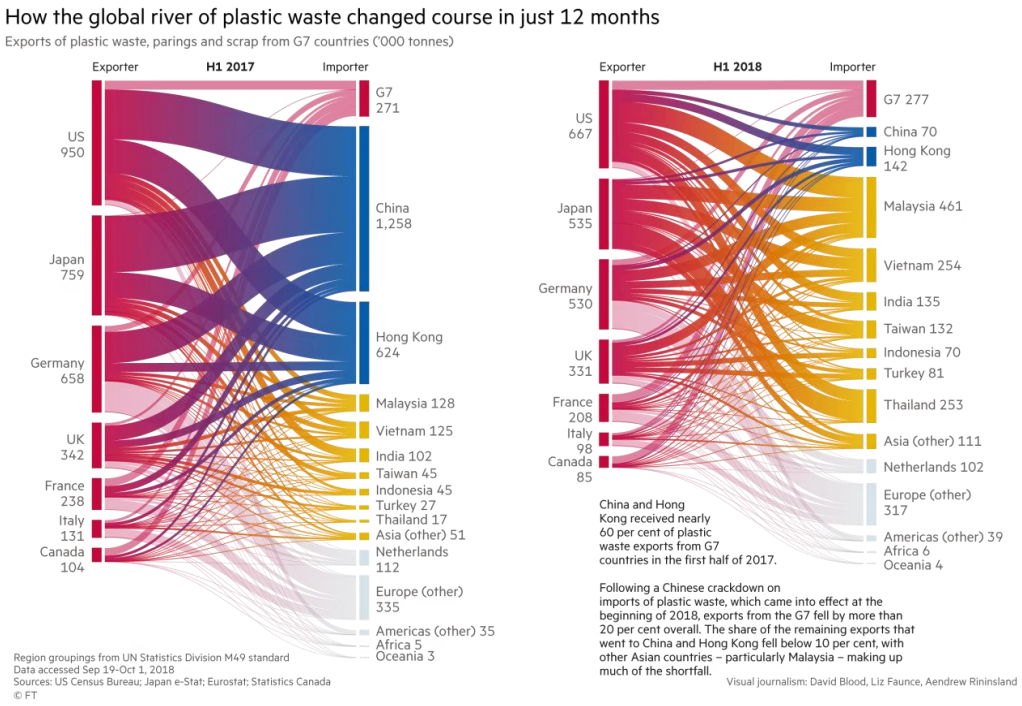


Figure 1: Transition of the international recycled materials trade following the enactment of China's National Sword policy at the end of 2017. Adapted from Hook & Reed, 2018.

2. DEALING WITH PLASTIC WASTE

The following section details different ways of dealing with plastic waste, including (but not limited to) traditional curbside recycling, chemical recycling, deposit return systems, and reusable container programs.

TRADITIONAL CURBSIDE RECYCLING

It has been estimated that just 9% of globally produced plastic has been recycled[3]. It is shocking to learn that such a small percentage of plastic is actually recycled, given such a massive recycling infrastructure in countries like the United States. So where is the recycling system going wrong? The biggest issue with the current recycling infrastructure is that it's often obscure and misleading - a black box of sorts. It should be considered that citizens aren't as informed about recycling as they should be.

It is common knowledge that plastics are broken down into 6 different types. The following is a list of international labeling numbers:

1 PET (polyethylene terephthalate) - water and beverage bottles
2 HDPE (high-density polyethylene) - shampoo bottles, milk bottles, freezer bags
3 PVC (polyvinyl chloride)
4 LDPE (low-density polyethylene) - plastic bags, food packaging
5 PP (polypropylene) - bottle caps, plastic bags
6 PS (polystyrene) - plastic cups, cutlery

The recycling system relies on the fact that people understand the different types of plastic waste, and that they are able to properly sort and dispose of their materials. Even if plastic waste is sorted correctly, it is often the case that plastic materials are contaminated by food waste, electronics, batteries, glass, or are mixed with other types of (unrecyclable) plastic., which renders a large amount of collected plastic materials unrecyclable.

Due to China's National Sword Policy, municipal recycling is becoming less and less profitable - and many municipalities have abandoned their recycling programs. To solve this problem, we must create a market for recycled plastic and increase demand for recycled materials domestically, while simultaneously increasing the quality of recycled materials collected.

CHEMICAL RECYCLING

Non-recycled plastics (NRP) can be converted into hydrocarbon fuels through a process called pyrolysis. In this process, the plastics are heated to approximately 430-550°C, and this is done without oxygen to avoid the oxidation of hydrocarbons and make the fuel more resistant to higher temperatures. Depending on the pyrolysis system and the molecular composition of the plastic feedstock, gas, liquid fuel, and char can form in different proportions.[8] Analyses have shown that pyrolysis scenarios reduce GHG emissions and consumption of fossil fuel resources compared to scenarios like material recovery, hydrocracking, landfilling, and combustion[8].

Several life-cycle analysis studies have found that recycling in order to replace the extraction and refining to make new plastic is the most environmentally friendly method of handling waste.[9] However, not all plastic can be recycled (only plastics 1, 2, and 5 are universally recyclable), and other plastics that are low-quality are rejected from recycling facilities for being difficult to process.[10] An alternative option to handling these plastics, landfilling, emits 253 grams of carbon dioxide for every kilogram of plastic from landfill emissions and management.[11]

[8] Benavides, P. T., Sun, P., Han, J., Dunn, J. B., & Wang, M. (2017). *Life-Cycle Analysis of Fuels from Post-Use Non-Recycled Plastics.* Fuel, 203, 11–22.

[9] Lazarevic, D., Aoustin, E., Buclet, N., & Brandt, N. (2010). *Plastic Waste Management in the Context of a European Recycling Society: Comparing Results and Uncertainties in a Life Cycle Perspective.* Resources, Conservation and Recycling

[10] Hite, J. (2019). *We Can't Recycle Our Way Out of the Plastic Pollution Problem.* Conservation Law Foundation.

[11] Eriksson, O., & Finnveden, G. (2009). *Plastic Waste as a Fuel: CO2 Neutral or Not?* Energy & Environmental Science

Incineration will leave almost no carbon for landfills, but it produces the most greenhouse gasses compared to landfilling and pyrolysis.

Pyrolysis products include ultra-low sulfur diesel fuel (ULSD), hydrogen fuel, char, and syngas. These products resulted in lower impacts abiotic depletion, acidification, eutrophication, ozone layer depletion, photochemical oxidant formation and cumulative non-renewable energy demand impact categories than landfilling/incineration waste management methods.[12] Pyrolysis for energy-generation purposes can have varied environmental impacts depending on the avoided emissions from heat and power supply. Compared to the municipal solid waste incineration option, the use of plastic pyrolysis is more energy - and emissions-saving[9]. Additionally, it saves the resources needed to make new plastic. With a high electricity-to-heat ratio, plastic pyrolysis can have a net negative contribution of greenhouse gasses if it replaces enough oil extraction and refining[11].

DEPOSIT RETURN SYSTEMS

Deposit return systems (DRS) provide one of the most successful models for increasing recycling rates - providing a monetary incentive to prevent littering and promote recycling. Say a consumer purchases a 12-pack of carbonated soda. When the consumer brings their empty bottles back to the store (or to the nearest container return location), they will receive 10 cents per bottle. These systems rely on "Bottle Bills" which set the price of the container deposit and determine which types of materials can be returned. These systems also increase the quality of recycled materials. What sets these systems apart from traditional curbside recycling, is that the plastic materials are already separated upon collection. These systems create opportunities for innovation in recycled materials markets by providing a steady stream of high quality recycled materials.

Another benefit of a DRS system is that they help to facilitate the transition to reusables by shifting consumer behavior. If we could shift consumer behavior and get people used to returning their containers, we might be able to build out the infrastructure necessary to make reuse possible. The transition from recycling to reuse is the ultimate goal for dealing with plastic waste. If we can get enough people to care about recycling, then reuse becomes the next logical step to creating a more circular economy.

REUSABLE CONTAINERS

Obviously, reusable containers have a greater environmental benefit compared to traditional (and DRS) recycling alone - they eliminate the need for materials sorting, transportation, processing, and delivery. The use of reusable water bottles has increased

[12] Iribarren, D., Dufour, J., & Serrano, D. P. (2012). *Preliminary Assessment of Plastic Waste Valorization via Sequential Pyrolysis and Catalytic Reforming.* Journal of Material Cycles and Waste Management

dramatically over the past decade. This shift in consumer behavior can be expanded to new markets such as take-out, to-go coffee, and leftovers in restaurants; this is however, a daunting logistical challenge. Implementing reusable containers on a large scale would require massive investment in infrastructure, and as noted, a fundamental change in consumer behavior. It is typically the case that reusable container programs are most effective for small scale uses, such as college campuses and individual restaurant chains. There is considerable evidence that these types of programs reduce annual food packaging costs, reduce food waste, and reduce GHG emissions.

3. REUSABLE CONTAINER PROGRAMS

Reusable container programs are not uncommon among universities. In order to get a sense of the benefits and obstacles of reusable container programs, several sustainability and dining representatives from different universities were interviewed about their programs. Their insights will help inform how Boston University can introduce and organize their program. Brandeis University, Vanderbilt University, and Ohio University were interviewed. The following questions were asked:

1. *How does your program work? Is the program mandatory?*
2. *What are the most successful aspects and if you could change something, what would you change?*
3. *Was the system impacted by COVID and how was it handled?*
4. *How necessary is it to have in-person cashiers?*
5. *Ratio of disposable containers to reusable ones? How do you measure the success of the program?*
6. *What incentivizes students to use the program?*
7. *How did you raise awareness of the program?*

CASE STUDY 1: BRANDEIS UNIVERSITY

Brandeis was chosen because of its proximity to Boston University and its familiarity with Massachusetts universities' dining programs. Mary Fischer, the Associate Director of Sustainability Programs at Brandeis University, was interviewed.

As a smaller school, Brandeis has only two dining halls. They use the "all-you-can-eat" model similar to Boston University dining halls. When students swipe in to access the dining hall, there are staff with clean containers near where the students leave dirty dishes. Program participants can trade in their dirty food containers for a new container or a plastic coin that can be used to get a new container at a later time. This system requires in-person cashiers for the container transactions, and it is only applicable to a dining hall model. Additionally, there is no

way to measure how many containers are in circulation, though Fischers estimated that there are around 1000. Their system is voluntary, and students pay a non-refundable deposit of $4 for every new container. **Students join the program because the reusable containers are the only way for them to be able to carry their food out of the dining hall.** According to Fischer, the program gains the most awareness when students see other students carrying their food around campus in the green containers and dropping them off in the dining halls. Brandeis dining and sustainability also uses social media to promote the program.

Brandeis also has retail locations that use their own apps to order ahead of time, but this system is difficult to alter in order to accommodate a reusable container program. Thus, as a pilot program, Fischer recommended introducing the containers through the BU dining halls. Another consideration that should be taken with the retail locations is the willingness of the staff to handle the additional dishwashing of the used containers. Fischer emphasized that the staff's preferences should be taken seriously, as additional dishwashing greatly impacts the labor that goes into their jobs.

Surveying the GSU staff's willingness to accept increased dishwashing and figuring out ways to compensate them for the additional work, are important steps that should be taken before implementing the program. Another consideration is the compatibility of GSU foods and the containers. An issue that Brandeis has had is their sub and sandwich station foods not fitting into the reusable containers, so students are less incentivized to use them. Additionally, "messier" foods like soup deter students from using the containers for fear that they will leak. Getting a sense of what foods are most commonly ordered at the GSU and ensuring that they are compatible to be carried in the reusable containers is a good way to predict whether or not the program will actually be convenient and attractive for students.

Fischer also proposed a "reusable-to-stay" option that could greatly reduce disposable packaging waste in the GSU and other retail locations. Many students order their GSU food through Grubhub and eat it in the GSU itself. Rather than using disposable containers, they can be using the reusable plates, cutlery, and cups that the GSU already has. A "for here/to-go" option while ordering on the app can avoid creating food packaging waste for the students who order ahead but still eat at the GSU. Perhaps even a price incentive (making the to-go option cost more) can further push students to use reusable packaging.

CASE STUDY 2: VANDERBILT UNIVERSITY

As a part of the Sustainability Tracking, Assessment & Rating System (STARS), Vanderbilt University is a successful example of a university prioritizing sustainability and implementing a reusable container program. Suzanne Heron, the sustainability coordinator of campus dining, was interviewed.

Vanderbilt initiated a pilot program for its reusable container program in one of its residence halls in Fall 2019. It started at just one location, and the program was optional. Much like Brandeis, Vanderbilt has in-person cashiers that trade used containers for either a new container or a carabiner that acts as a voucher for a container at a later time. Heron said that the program was quite successful, as the pilot alone had between 275 and 300 participants. The containers are dispersed free of charge; however, there is a $5 fee for lost containers.

Students are motivated to use the program because, like Brandeis, the containers are the only way to get the dining hall food to-go. Unfortunately, COVID-19 put a halt to this program and forced the university to use compostable take-out containers, but next semester (Fall 2022), the university plans to extend the program to other residence halls. Vanderbilt advertises the program to the residence halls using social media, signs, and physical examples of how the containers look. They also provide a contact in their advertising for students to reach out to if they have questions about the program.

One issue that Heron is anticipating is having to transport dirty containers to different locations as more than one residence hall is entered into the program. If one hall is much more popular than the others, then it might run out of the containers while the other halls have an excess. Perhaps students will choose to get containers from one of the halls and drop them off at another hall out of convenience. It will take more effort to track the stock of containers in each residence hall and find a method to replenish containers in the more populated dining halls. Heron suggested they might make it mandatory to return the container at the same hall that it was picked up, though she foresees unnecessary complications with this system.

When asked about how the dining hall staff felt about the additional responsibilities they would have with the reusable container program, Heron responded that no issues were voiced by the staff. Students are asked to wipe down or rinse their containers before returning them, so the staff does not have to deal with excessive food waste. Additionally, as hourly employees, Heron was reassured that the staff simply viewed the container transactions as just one of their responsibilities. She thinks high morale was prevalent because the impact and importance of the reusable container program was explained to the staff as well, so they are more inclined to be doing tasks that are for a good cause.

Spending time to educate the GSU staff on what their extra responsibilities will be and why they are impactful will make for a better introduction of the program. Heron was pleasantly surprised by how many people signed up for the pilot program. The on-campus student group Students Promoting Environmental Awareness and Responsibility (SPEAR) played an important role in raising awareness of the program and educating students on its importance.

At Boston University, student groups like the Environmental Student Organization (ESO) and Sustainable Oceans Alliance (SOA) can help promote the program and effectively communicate its positive environmental impact. **Heron's biggest takeaway is that students are more willing to be sustainable than one might assume, but they are drawn to convenience.** She encouraged us to keep the program as simple and convenient as possible: the carabiner token was a large success because students could simply clip them to their backpacks instead of having to keep track of a card that could easily be lost. If students find the cards difficult to keep track of, perhaps switching to a QR code keychain or carabiner would be easier for them.

Heron suggested additional people to reach out to:

- Virginia Institute of Technology: has a reusable container program that used barcodes and machines, but there were lots of technology issues.

- Ohio State University: has a successful reusable container program that helped inform Vanderbilt's system.

CASE STUDY 3: OHIO UNIVERSITY

Ohio University is well-known for the success of its reusable container program. Autumn Ryder, the Assistant Director of culinary services, and Frank Pazzanese, the Executive Director, were interviewed.

Ohio University also uses their containers in dining halls. Their retail locations have independent apps that have been a success and also have the flexibility to add a reusable container option to online ordering. The Culinary Services Development Community (CSDC) is an active student group that plays an important role in promoting the program; they highly encouraged the pilot program. Like Brandeis and Vanderbilt, Ohio University has in-person cashiers to handle container transactions, and also has a keychain that acts as a token voucher. Pazzanese insists that using the containers in the dining hall is not a financial burden because taking a meal to-go in the containers counts as a dining meal "swipe". Additionally, students are more likely to use several plates in an all-you-can-eat dining hall, so using only one reusable container in a "to-go swipe" means less dishes to wash per student.

In the pilot program, Ohio University had some issues with drying the reusable containers - because of their shape, they were not compatible with dish drying racks used for other dining hall dishes. The university had to buy specific bins, racking systems, and fans to dry the dishes. Boston University should check if the dishwashing areas have enough space for the reusable containers and see if existing dishwashing methods (particularly the drying process) work for the unique shape of the containers.

During COVID, the dining halls only did carryout, but the reusable containers were still used. The university worked with the health department to ensure that all washing protocols were safe for the program to operate. Working with the health department to ensure that containers were adequately sanitized, promoted student participation. The program is voluntary, and students have to pay $5 to enter the program. Students who use the disposable containers pay an extra $0.50 for every container.

Making disposable containers more expensive and the reusable container fee less expensive will further incentivize students to join the program. In addition to this price incentive, Ryder said that students are motivated to purchase a reusable container because of Ohio University's student senate initiatives, housing and residence life connections, and marketing materials through the dining hall TV screens to educate the students.

Ryder and Pazzanese suggested strengthening the reusable container program through the dining halls before introducing them to dining locations. This way, there will be more student interest and support for establishing a program for the GSU and other retail locations. They also suggested that we look into potential issues with Aramark Dining (Boston University's supplier) and reach out to other schools who partner with Aramark Dining and have implemented reusable container programs.

CASE STUDY 4: STONEHILL COLLEGE

Mary Fischer from Stonehill College recommended we talk to Professor Cheryl Schnitzer from Stonehill College. Stonehill has had a very successful program (see appendix for their metrics) through the Choose2Reuse service, soon-to-be-named Reuzzi. Schnitzer is the Founder and CEO of Reuzzi LLC, an app that combines the QR code system of reusable container programs with an app that keeps track of the number of containers that a student checks out, created an intuitive "Container Pass" system (see appendix) that cashiers can quickly check, and also gives email and phone reminders for students to return their containers. Schnitzer kindly provided the metrics that indicate the success of the program: $85,737 saved by not buying disposable containers, 20% decrease in trash tonnage, and an 89% decrease in single use containers.

Boston University has bought QR codes through the Fill it Forward program, whose QR code system is not currently compatible with the Reuzzi system. However, Schnitzer emphasized that Reuzzi QR code stickers can be bought and put on the reusable containers that Boston University already has. An additional benefit to integrating with Reuzzi is that Schnitzer is planning to have conversations with Grubhub and similar apps to include a reusable container option in the online ordering process. In the appendix is Schnitzer's presentation and contact information. Fill it Forward, Boston University's app, does a lot of what Reuzzi does - particularly with giving metrics for how many containers are being used. However, the reminder aspect of the

Reuzzi app would be very beneficial for BU, as the main concern is that students are not returning the containers. The idea of sending email/text reminders is the most beneficial aspect of Reuzzi; Boston University should have talks with the Reuzzi developers to learn how to implement this or perhaps even combine systems.

4. REUSABLE CONTAINER PROGRAM AT BOSTON UNIVERSITY

BU Dining Services is currently looking for recommendations to improve and/or revamp the program to increase student participation. This information is taken directly from the Fill it Forward webpage found below, https://www.bu.edu/dining/fill-it-forward/.

OVERVIEW

Boston University kicked off its first reusable to-go container program, Fill it Forward, in Fall 2021. Not only does this program reduce plastic waste, but each time a student uses a reusable container, Boston University makes a charitable donation to organizations that address food and water access around the world. Students can redeem their reusable containers at three different dining halls across campus. Given that many students choose to order their food for pick-up through a Grubhub, Boston University is looking to expand the Fill it Forward to mobile ordering pickup and retail locations in the near future. The following section outlines the instructions for using the Fill it Forward as it currently exists.

1. Join the Fill it Forward program via Rhetty To-Go.
2. Download the Fill It Forward App and create an account. Use your BU email address for the account.
3. When you visit the dining hall to pick up your first order you will pay the $15 Fill it Forward deposit.
4. When you receive your first order you will also receive three rental code cards, enter the codes into the Fill it Forward App. All of the codes should be entered into the same account on the Fill it Forward App. Once you add the codes to the App follow the prompts and scan the Fill it Forward QR codes on the containers.

   ** If you did not receive a meal with three containers for your first order, enter the same number of codes as containers you received and save the remaining rental code card(s) for your next Rhetty To-Go order**

5. Enjoy your meal!
6. Empty and wipe out your container(s) with a paper napkin or paper towel. Return empty containers to the dish belt at Marciano Commons, Warren Towers, or West Campus. Use

the Fill It Forward App to scan the QR code on the return sign posted next to the dish belt or the QR code on the container (once for each container you are returning) to "check-in" the container(s).

If you don't return your container(s) and scan the barcode on the return sign, you will not be able to check out another container

7. When you place your next order, select Fill it Forward as your container choice and confirm that you do not have outstanding containers that need to be returned.
8. Open the Fill It Forward App and scan the Fill it Forward QR code on your reusable container(s) when you receive your order to check out your containers.
9. Stop by the cashier on your way out of the dining hall and show them your app to confirm you have checked-out the containers and don't have outstanding containers to return.

   If you do have outstanding containers you will need to pay an additional rental fee of $5 per container.

10. Repeat steps 5 - 9

Because of COVID, the Grubhub app was utilized at Boston University so that students could order their food ahead of time and for pickup and thus have limited cashier interactions. Post-COVID, the Grubhub app is still in use, and students are able to eat at the GSU again. Grubhub has an option to use a reusable container/a "for here" option; the problem is that there is no way to ensure that students return their containers because there is no physical person to check them in/out. Additionally, BU uses compostable disposable containers that are more expensive, so there is a massive potential to save money by switching to reusable containers.

COST / BENEFIT ANALYSIS

Below we have included a simplified cost-benefit analysis to determine the payback period of a reusable to-go container program at Boston University. Using data from various sources we have compiled information on the average size of the freshman class at Boston University[13], the cost of reusable containers[14], the cost of disposable containers[19], the number of school days per year at Boston University[15], the percentage of reusable containers lost or damaged each year[16], and the optimal student to container ratio for reusable containers[21] (Table 1). Using student survey

[13] Laskowsi, A. (2016). *Boston University Class of 2020*. BU Today.

[14] Raczka, A. (2022). Boston University Dining Services.

[15] Office of the University Registrar. (2022). *Official Academic Calendars.*

[16] G.E.T. Marketing. (2017). *What Does Implementing an Eco-Takeouts Reusable To-Go Program Cost Colleges and Universities?*

results we have also estimated the average number of BU dining meals purchased per student per day, and the number of containers required per meal (Table 1). Given this information we have calculated the initial investment and recurring annual costs associated with each type of to-go container.

	Disposable	Reusable
Cost Per Container	0.35	3.475
Freshman Class Size	3,200	3,200
Number of School Days / Year	222	222
Number of Meals / Day	1	1
Number of Meals / Year	222	222
Number of Containers / Meal	2	2
Student to Container Ratio	1:1	3:1
Containers Demanded By Freshman Class / Year	1,420,800	473,600
Initial Cost	$497,280	$1,645,760
Replacements Required / Year	N/A	10%
Recurring Annual Cost	$497,280	$164,576

Table 1: Metrics used for conducting our cost-benefit analysis.

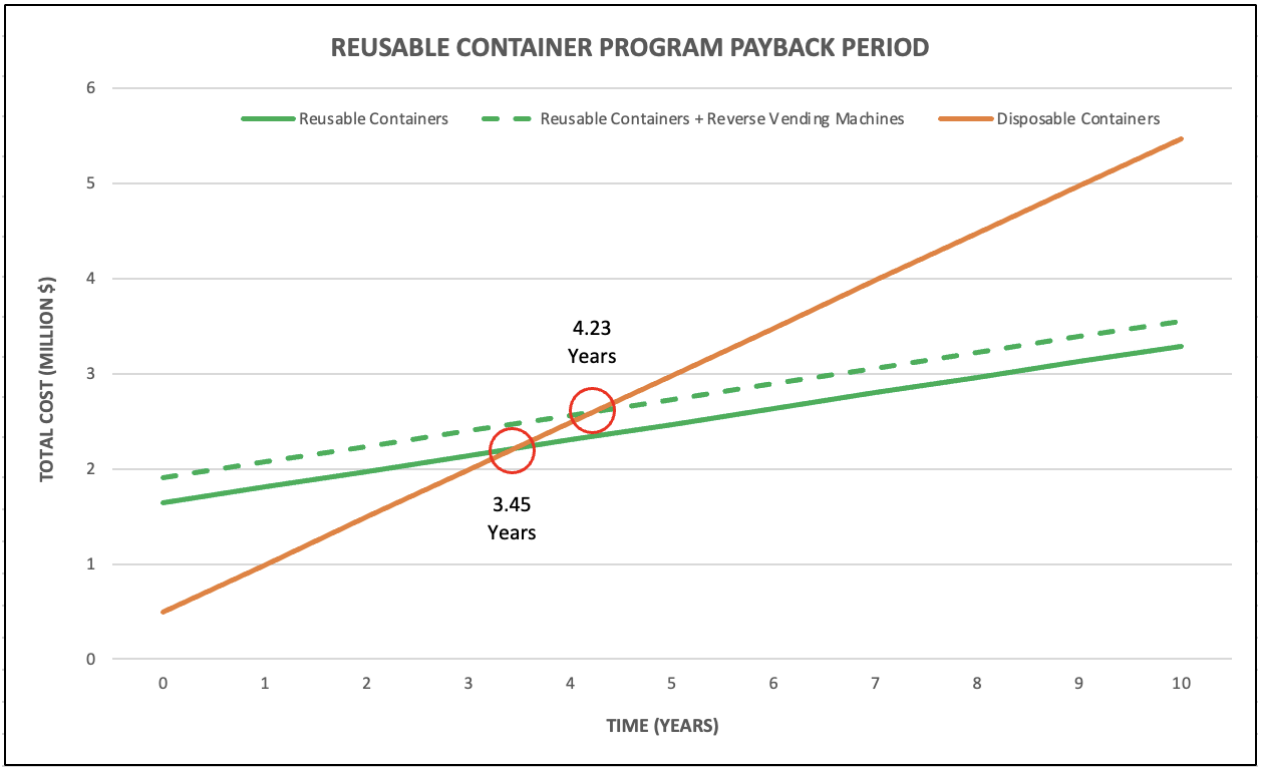
The initial investment in a reusable container program may seem significant; however, it has been proven by a number of universities across the country that these types of programs do in fact have a relatively short payback period (typically about 3.5 years) - as is the case for Boston University.

The initial cost of purchasing disposable containers (given our estimated demand) is $497,280, whereas the initial cost of purchasing reusable containers (given our estimated demand and optimal student to container ratio) is $1,645,760. The ongoing annual cost of purchasing disposable containers will remain constant at $497,280 each year, while the ongoing annual cost of purchasing reusable containers (given a replacement rate of 10% each year due to lost/damaged containers) will be $164,576. Using these estimations, we have calculated that the payback period of a reusable container program at Boston University is approximately 3.45 years (Graph 1).

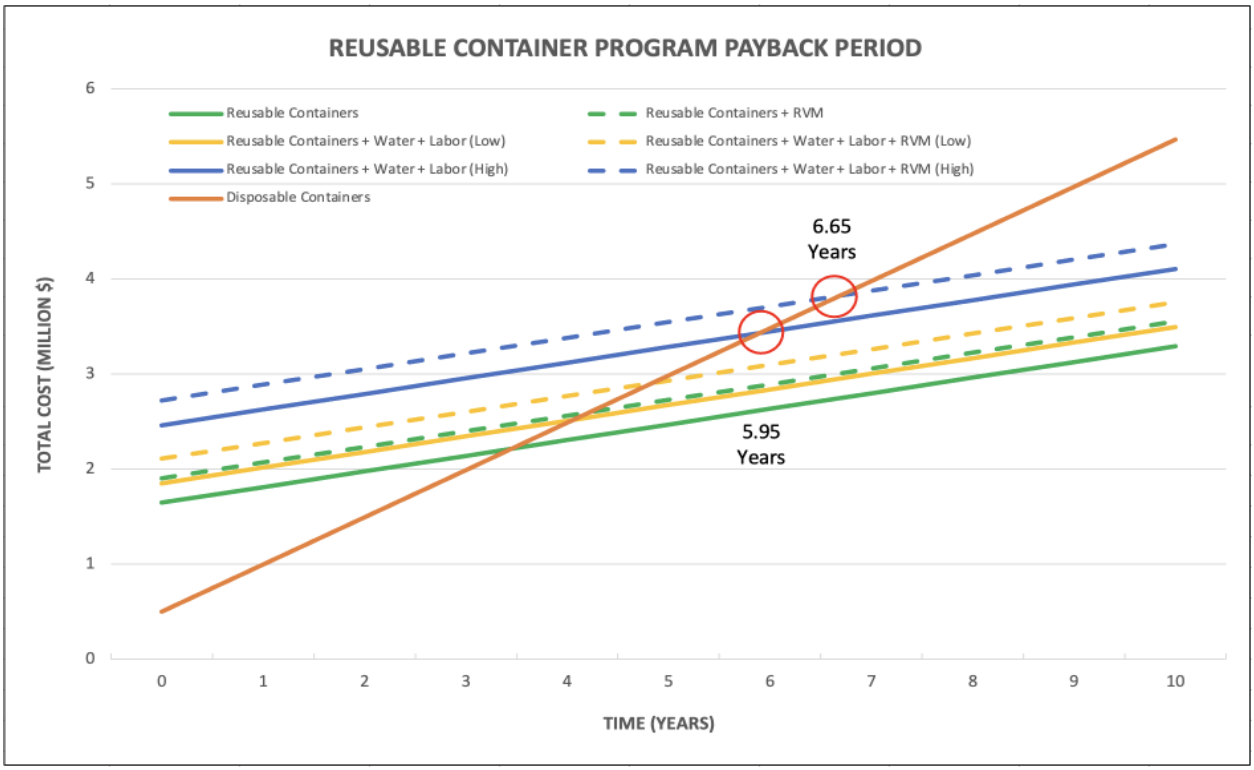
We have also considered an alternate situation where Boston University chooses to invest in 10 reverse vending machines to collect reusable containers, where the cost of each machine is $26,000. Given this scenario, the estimated payback period would increase to 4.23 years (Graph

1). By year 10 the reusable container program will have saved the university about $2,178,560, or $1,918,560 with the additional investment in reverse vending machines (Table 2).

It is important to consider that we have not factored in the additional labor / handling costs associated with reusable container programs. We calculated a low and high cost estimate for the additional labor / handling (Table 3) to illustrate that the additional costs will not have a significant impact on our estimated payback period (Graph 2). Similarly, we have not included the environmental benefits associated with a reusable container program - primarily, reduced greenhouse gas emissions, reduced food waste, and reduced plastic packaging waste. The environmental benefit associated with the reusable container program will far outweigh the additional labor / handling costs. After consulting Lexie Raczka (Sustainability Director, BU Dining Services), she noted that the starting wage of dining staff is higher than what was in the cost benefit analysis, but she cannot give the exact salary. Raczka also did an cost-benefit analysis herself and found that the program could pay for itself in a year, so our numbers reflect a higher estimation for a payback period.



Graph 1: This graph illustrates the payback period under two different scenarios, (1) that Boston University invests in reusable containers, and (2) that Boston University invests in reusable containers and 10 reverse vending machines. The payback period for scenario 1 is 3.45 years, whereas the payback period for scenario 2 is 4.23 years.



Graph 2: This graph illustrates the payback period under a scenario in which Boston University invests in reusable containers, with a low and high estimate for additional water and labor costs. Given our high estimate for additional labor / water costs associated with the reusable container program, the payback period is still less than 10 years.

	Reusable Containers	Reusable + Reverse Vending Machines
Cost Savings (Year 5)	$515,040	$255,040
Cost Savings (Year 10)	$2,178,560	$1,918,560
Cost Savings (Year 15)	$3,842,080	$3,582,080
Cost Savings (Year 20)	$5,505,600	$5,245,600

Table 2: This table portrays the estimated cost savings for our two investment scenarios over a 5, 10, 15, and 20 year time horizon.

	High Estimate	Low Estimate
Labor		
New Workers	100	20
Hours / Week	10	10
Weeks	52	52
Wage ($/hour)	$ 15.00	$ 15.00
Total	**$ 780,000.00**	**$ 156,000.00**

	High Estimate	Low Estimate
Water		
Cost / Wash	$ 0.50	$ 0.50
Washes / Day	200	50
Days	365	365
Total	**$ 36,500.00**	**$ 9,125.00**

Table 3: This table portrays the metrics used to calculate the high and low cost estimates for the additional labor / handling costs associated with a reusable containers program.

STUDENT SURVEY

We created a student survey to help gauge interest in the reusable to-go container program at Boston University and to address participation barriers and/or suggested improvements. Our main priority in circulating this survey was to reach Boston University students who (1) are on the student dining plan, and (2) do not have a particularly vested interest in sustainability.
While it was not required that survey participants had no interest in sustainability, we wanted to ensure that our survey results were representative of a large demographic - covering those who might not opt into the program based solely on its environmental benefit.

We collected a total of 60 student responses which are summarized below. The survey consisted of the following questions:

1. What year are you?
2. What is your major / minor?
3. Are you currently on a meal plan at Boston University?
4. How concerned are you about food packaging waste? (1 - not concerned at all, 10 - extremely concerned)
5. Have you ever participated in a reusable to-go container program?
6. Would you be interested in participating in a reusable to-go container program at Boston University?
7. Would you be willing to use an app to check-in / check-out your containers?
8. Would you be willing to put down a $15 refundable deposit?
9. How many times per week do you use a takeout / disposable container?
10. How many times per week do you "dine-in" at a Boston University dining hall using the for-here/plated option?
11. How many times per week do you order through Grubhub using your student account?

12. In your opinion, what would be the biggest obstacle to joining a reusable to-go container program?
    a. I have to download an app to keep track of my containers
    b. I have to check-in / check-out my containers manually using QR codes
    c. There is no special kiosk to return my containers
    d. I have to put down a refundable deposit
    e. I would rather just use a disposable container
13. In your opinion, what would be the second biggest obstacle to joining a reusable to-go container program?
    a. I have to download an app to keep track of my containers
    b. I have to check-in / check-out my containers manually using QR codes
    c. There is no special kiosk to return my containers
    d. I have to put down a refundable deposit
    e. I would rather just use a disposable container
14. In your opinion, what would be the third biggest obstacle to joining a reusable to-go container program?
    a. I have to download an app to keep track of my containers
    b. I have to check-in / check-out my containers manually using QR codes
    c. There is no special kiosk to return my containers
    d. I have to put down a refundable deposit
    e. I would rather just use a disposable container
15. What can we do to increase participation in the reusable to-go program? In other words, what would motivate you to sign up?

STUDENT SURVEY RESULTS

We found that 87.6% of surveyed students had not participated in a reusable to-go container program, but that 85% of them would be interested in participating in a reusable to-go container program at Boston University. We also found that 90% of surveyed students would be willing to use an app to check-in / check-out their containers and that 67% of students would be willing to put down a $15 refundable deposit. These results indicate that students are willing to participate in the program, but that the $15 dollar deposit is not favorable.

Unsurprisingly, 67% of the students surveyed used a disposable to-go container 2 - 5 times per week, 48% of students opted to “dine-in” less than 2 times per week, and 50% of surveyed students used Grubhub more than 3 times per week. These results indicate that students typically opt to use disposable containers instead of “dining-in” and that there is a bimodal distribution of students that choose to use Grubhub - either they Grubhub often, or very rarely. This emphasizes the importance of integrating the reusable container program with Grubhub and retail locations.

While 90% of surveyed students said that they would be willing to check-in / check-out their containers using an app - this action (using QR codes) was determined to be the first and second largest obstacle to participation. The third biggest obstacle noted was that students have to download a third party app to keep track of their containers. These results indicate that the use of a third party app to manually keep track of containers using QR codes is a major barrier to participation, and that some other method should be considered. While it is important to maintain metrics on program performance, if the ultimate goal is to reduce packaging waste - participation is more important than measuring the environmental benefit.

The survey concluded by asking the student participants to write out feedback and suggestions for implementing the reusable container program at Boston University. Out of the 32 feedback comments, 16 (50%) of the comments mentioned increasing advertising of the program to raise awareness of it. There is a sense that if the program was more well-known, more people would be interested in joining it. The next most common feedback addressed price incentives, particularly reducing the $15 deposit for entering the program and providing discounts on food for those who use the container. The high starting cost, though refundable, is a significant barrier to students joining the program. There is also the idea of "continuous returns," meaning that students want to feel like they are saving money throughout their time in the program through meal discounts or perhaps even avoiding disposable container fees.

5. SUGGESTIONS

The following suggestions are drawn from our cost/benefit analysis, student survey results, and stakeholder interviews about reusable to-go container programs at Brandeis University, Vanderbilt University, Ohio University, and Stonehill college.

MARKETING / PRIORITIZE STUDENT FEEDBACK

People are typically more inclined to participate in something that they feel they have had a "hand" in. Prioritizing student feedback will not only increase program participation, but also increase the number of students who are aware of the program. The student survey showed that not many people are currently in the reusable container program, but many of them would be interested in joining. This reveals a missing link of communication to let interested students kow about the program. Additionally, our number one response from students about how to improve the program is that we need to get the word out - many noted that they hadn't heard of the program before taking the survey. Aside from the obvious marketing strategies, posting fliers in dining halls, social media campaigns, etc, Boston University should get creative about how they spread the word. It would be particularly useful to target freshman and other incoming students. There are a number of student organizations at Boston University that have a vested interest in sustainability - reaching out to these organizations to participate in the program early on would also be beneficial for spreading awareness.

MANDATORY PARTICIPATION / PRICE INCENTIVES

It is also important to consider making the program mandatory and/or implementing an additional charge for using disposable containers. Students (and people in general) are surprisingly resilient. This has been proved over the past year as students have been required to participate in mandatory weekly COVID testing - all it takes is a slight behavioral adjustment. If the program was mandatory, students (particularly freshman) would quickly catch on and learn to consider the reusable container program a way of life. Furthermore, it could be marketed as a part of Boston University culture. Regardless, there should at the very least be a price incentive for students to take advantage of the reusable container program.

INVEST IN TAKEBACK INFRASTRUCTURE

Another major student suggestion is that Boston University provides specialized areas to return student containers. Students feel that reverse vending machines would provide program marketing and create a more straightforward model for container check-in / check-out. This points towards an investment in takeback infrastructure, which unfortunately, does have a large upfront cost; however, we found in our cost / benefit analysis that these additional upfront costs are negligible given long term savings, increasing the payback period by less than a year. The additional benefit is that the vending machines market themselves: the large machines and intriguing automated aspect can spark the curiosity of students and help raise awareness of the program.

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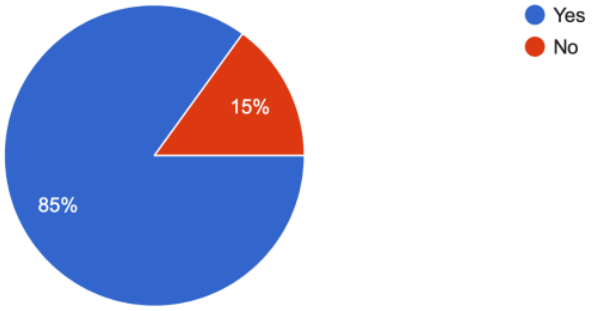
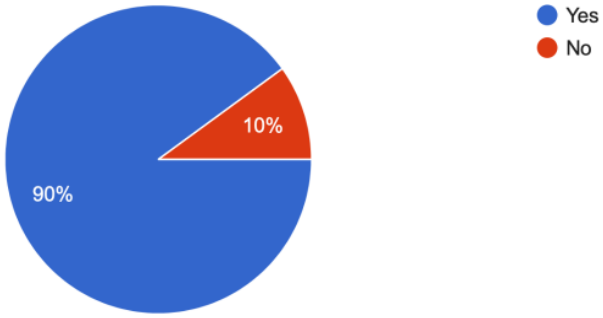
7. APPENDIX

SURVEY RESULTS

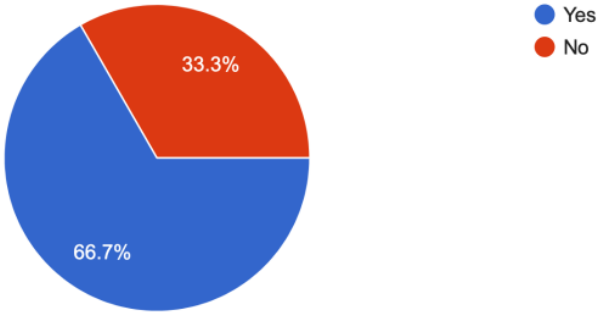
Would you be interested in participating in a reusable to-go container program at BU?
60 responses



Would you be willing to use an app to check-in / check-out your containers?
60 responses

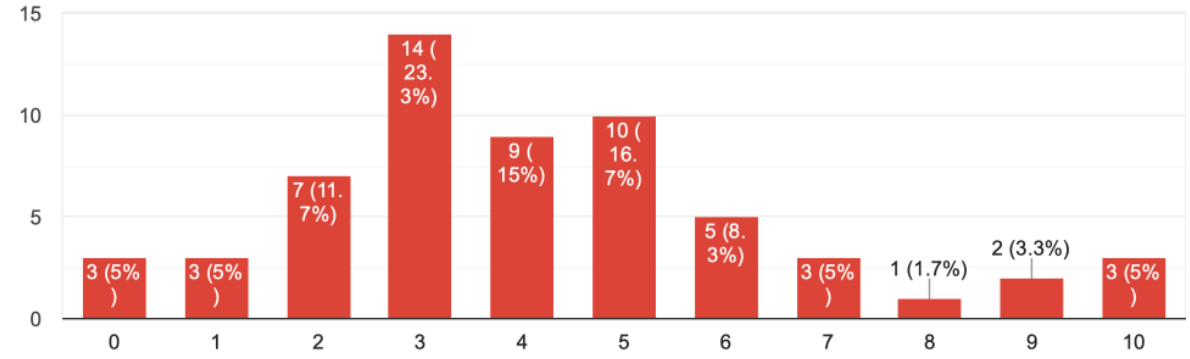


Would you be willing to put down a $15 refundable deposit?
60 responses



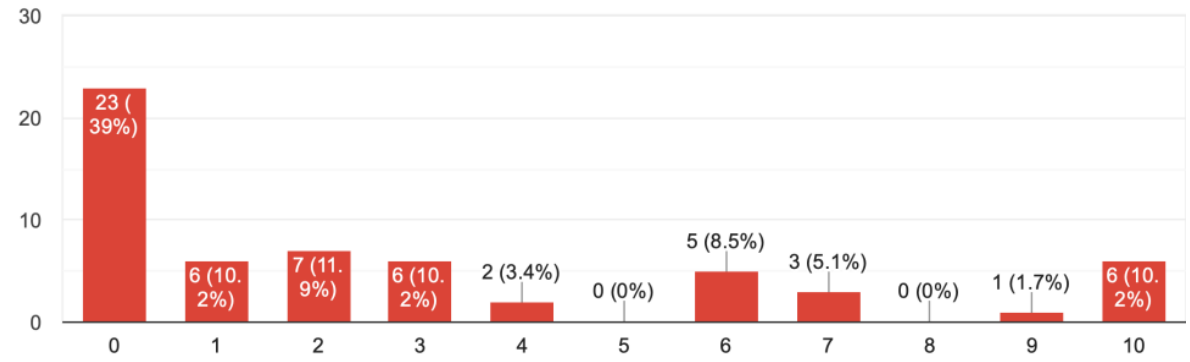
How many times per week do you use a takeout/disposable container?

60 responses



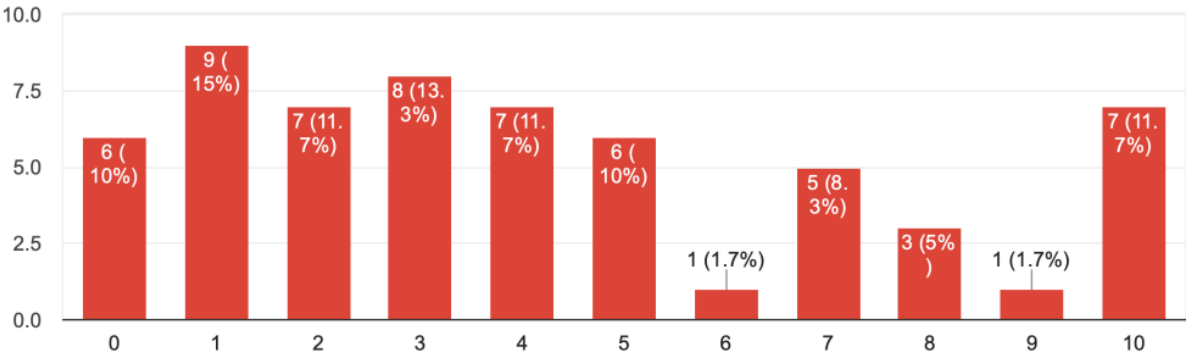
How many times per week do you "dine-in" at a BU dining hall using the for-here/plated option?

59 responses



How many times per week do you order through Grubhub using your student account?

60 responses



In your opinion, what would be the biggest obstacle to joining a reusable to-go container program?

60 responses

In your opinion, what would be the second biggest obstacle to joining a reusable to-go container program?

60 responses

In your opinion, what would be the third biggest obstacle to joining a reusable to-go container program?

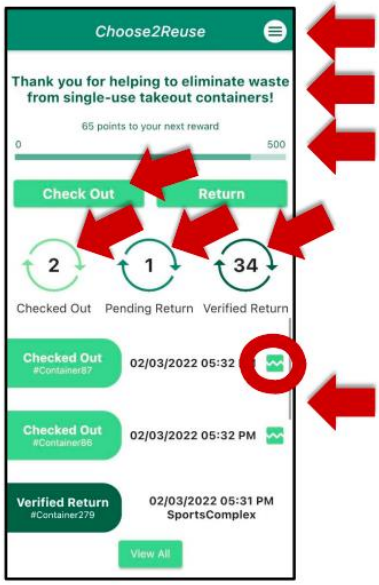
58 responses

REUZZI PROGRAM PRESENTATION

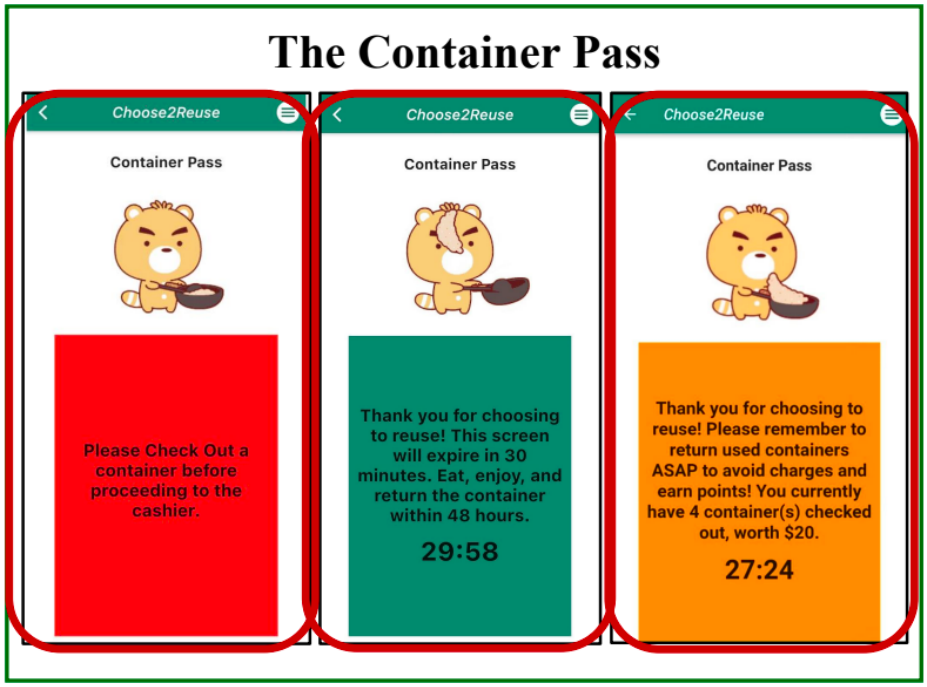
Stonehill's Success Story with Reusable Containers

CHOOSE 2 REUSE was born!

How does CHOOSE 2 REUSE work?



The Container Pass



Stonehill Choose2Reuse Savings

Pre-Choose2Reuse	With Choose2Reuse	Annual Savings
Cost $95,337	Cost $9,600	$85,737!

ADDITIONAL SAVINGS WITH Choose2Reuse:

- After the first year when containers are reused
- Students save money
- Trash tonnage decreased 20%
- Institution labor reduced
- Environmental and health benefits
- More savings anticipated by integrating with Bite app and other retail dining locations

The CHOOSE2REUSE Website

www.choose2reuse.org Admin Login

Transactions | Locations | Users | Containers | Balances

cschnitzer Toggle Limit

Export Table

Want to Choose Columns?

Email	QR Code	Status All	Status Update Time	Location QR Code	Description
cschnitzer@stonehill.edu	Container1	Verified Return	2021-07-20 11:37:34	RocheCommons	None
cschnitzer@stonehill.edu	Container1	Verified Return	2021-07-20 11:38:44	RocheCommons	None
cschnitzer@stonehill.edu	Container1	Verified Return	2021-07-21 12:30:11	RocheCommons	None

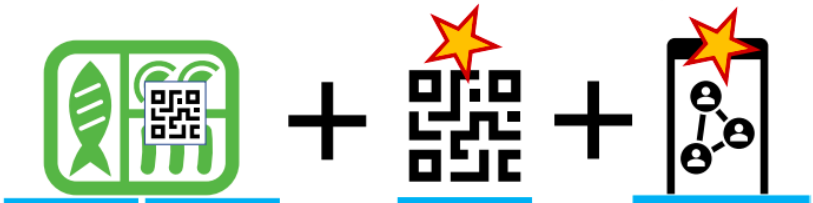
What are Folks Saying about CHOOSE2REUSE?

"Before Choose2Reuse, students were making a lot of trash having lunch or dinner in the servery and then throwing out single-use containers…it made no sense. And, it was a full-time job taking out the trash."
—Donlie Wood, Dining Services Supervisor

"I think the app is very user-friendly and easy to operate. The QR codes always work on the containers and drop off locations. Keep up the great work!"
—Ben Simmons '23

"As a busy student athlete, I was worried that this would take too much time. It didn't and I hope people start utilizing the containers to make Stonehill less wasteful!"
—Alexa Adinolfi '23

What is the Cost of CHOOSE2REUSE ?



Price per Container	Price per Label	Price per QR Code	Monthly Service Fee
$2.20	$1.00	$1.75	$292

Total Cost First Year (Initial Setup): **$8,450/first year***

Total Cost After the First Year (Maintenance): **$3,748/year**

*MassDEP Reduce, Reuse, Repair Micro-Grant provides $5,000!

The Cost of the CHOOSE2REUSE Service

Quantity of QR Codes	Price per QR Code	Maintain (Monthly)	C2R Cost Year 1	C2R Cost Years 2+
1 – 500	2.00	**$167**	$3,000	$2,050
501 – 1,000	1.75	**$292**	$5,250	$3,588
1,001 – 5,000	1.50	**$1,250**	$22,500	$15,375
5,001 – 10,000	1.25	**$2,083**	$37,500	$25,625

This is the cost of the Choose2Reuse Service only; the Institution would also be responsible for purchasing reusable containers and labels (as explained on previous slide).

Why is CHOOSE 2 REUSE the leader?

- Environmental and Health Benefits
- Improved Bottom Line
- Aligns with Our Values
- Leadership and Ease
- Convenient, Data-Driven, Scalable, Accessible
- Like a Library Book, Protect Investment
- User Accountability Closes the Loop
- Students are Demanding Change

Timeline for CHOOSE 2 REUSE Service

May 1, 2022
Sign agreement

Aug. 15, 2022
Ready for BU

July 1, 2022
Order QR Codes and
begin monthly service fee

CHOOSE 2 REUSE

For financial gains and environmental benefits in your dining operations

Cheryl Schnitzer, Ph.D.
cschnitzer@reuzzi.com
508-963-8712

BOSTON UNIVERSITY

Mobile app to track takeout food containers using QR Codes