Waste·Way

Indoor Waste Management User Experience

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Abstract

Wherever people go in this day and age garbage will surely follow, it's true that some of this waste is able to be recycled and reused, but a lot of it ends up in a landfill. A large contributor to this problem is the waste management systems in public places such as campuses and shopping centres. it is in these facilities that the problem arises, waste isn't being properly sorted, both by the user and by the facility. After copious amounts of research, benchmarking and user observations several major problems within this system became visible, allowing for the ideation of solutions that could potentially simplify improve potentially overcome these problems. With a focus on making the act of sorting and recycling waste into an immersive user experience, the goal is to improve the wayfinding, form factor, and interaction points of a standard waste collection receptacle.

The overall goal is to reduce the amount of waste that ends up in a landfill through the redesign of the entire indoor public space waste management system. A focus on an alternative to the standard Waste Management bin receptacle will be explored primarily. As well as a secondary focus on streamlining and re-evaluating the network as a whole, to reduce strenuous labour and unneeded complicating steps in the process.

Acknowledgements

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1 Problem Definition

How may we mitigate solid waste management in indoor public spaces?

In this age everyone seems concerned about the environment, one of the bigger aspects of this concern is related to solid waste and where it ends up. The weight of this responsibility is currently spread across a very wide range of people and places. The aim of this Thesis proposal is to reduce the overall amount of recyclable waste from public indoor spaces that is ending up in the landfill.

The goal would be to come up with a solution that considers full-bodied human interaction design and ergonomics, one that focuses on improving the overall experience and outcome of creating, sorting, and recycling solid waste in these public spaces. By completing user research and interviews to find specific challenges in the field, the ideation and development processes will have a solid foundation of experience and insights to build off. This will be coupled with referencing and studying the use of current solutions to locate pain points and potential Improvements.

All this analysis will be used to create a solution that considers full-bodied human interaction design and ergonomics, one that focuses on improving the overall experience and outcome of creating, sorting, and recycling solid waste in these public spaces.

Needs Statement 1 (before research)

The user needs to dispose of waste in a public place.

Needs Statement 2 (after benchmarking)

The user needs a straightforward way to dispose of waste in an indoor public space, with proper signage end good organization to allow ease of use.

Needs Statement 3 (after benchmarking / linking human needs)

The user needs a waste management system that will work based on the intuitions built into the human psyche, allowing straightforward wayfinding and no strenuous thoughts.

This system is traditionally a straightforward and boring one, human beings like to build behaviors on good feelings so a social and reward esteem-based aspect should be implemented to increase the quality of use.

These aspects can come together to create a waste management system that for the user feels more like an Interactive and rewarding experience.

Interviews:

Claudia Marsales
Senior Manager, Waste & Environmental Management
Communicated via email and Zoom
Shared knowledge based on 30+ years of experience.

Safa Al-Haji
Sustainability Manager
Communicated via email

Shared experience in waste managment

Secondary Research:

Articles, books, and surveys were all thoughtfully searched through and cunsulted in order to find key pain-points and areas of interest pertaining to this topic.

Interview Takeaways:

- Lack of interest or care from consumers
- Proper recycling is hard to follow daily
- No standardization across municipalities, a big complication
- People need to be educated more on how it works
- The different types of plastics that can be recycled or can't be
- Everyone's interested but dont want to sit and learn more about it
- Some malls have manual sorters that sort it all at the end of the night
- Educating students/staff on sorting waste effectively
- Inaccessible and/or hard to understand signage
- Open-top bins that can accept all types of waste
- Users should understand the bigger picture behind their actions
- A can is thrown in the garbage, costs the emissions used to create a new can
- Single-user actions matter, sorting properly every time is how we make change

Secondary Research Takeaways:

- Customers are the most important part, they're responsible for disposing of and sorting of solid waste.
- The more organized, straight forward, and thoughtful the waste management solution is the better the results will be
- 10% of the total waste generated is municipal waste..
- Poor waste management can negatively affect the health and wellbeing of people and the climate.
- Companies that embrace sustainability as one of their core values are the most significant contributors to positive environmental change.
- Landfill over usage could be reduced at the source in these large buildings with better organization.
- Investing in waste management yields positive results seen in the decrease of the output of landfill waste.
- Collecting data on waste is imperative to prevent the unnecessary buildup of landfill waste

1.2 Rationale & Significance

The only way to learn is to be willing to search for answers, however for a topic as broad and with as many touch-points as this, it's more like searching for questions. A good solution can only be good if it's backed by the right evidence and data. So that's why the utmost care was put into planning research and getting useful data to hopefully lead to some insightful questions. Questions that will help to find pain points and eventually evolve into complex solutions

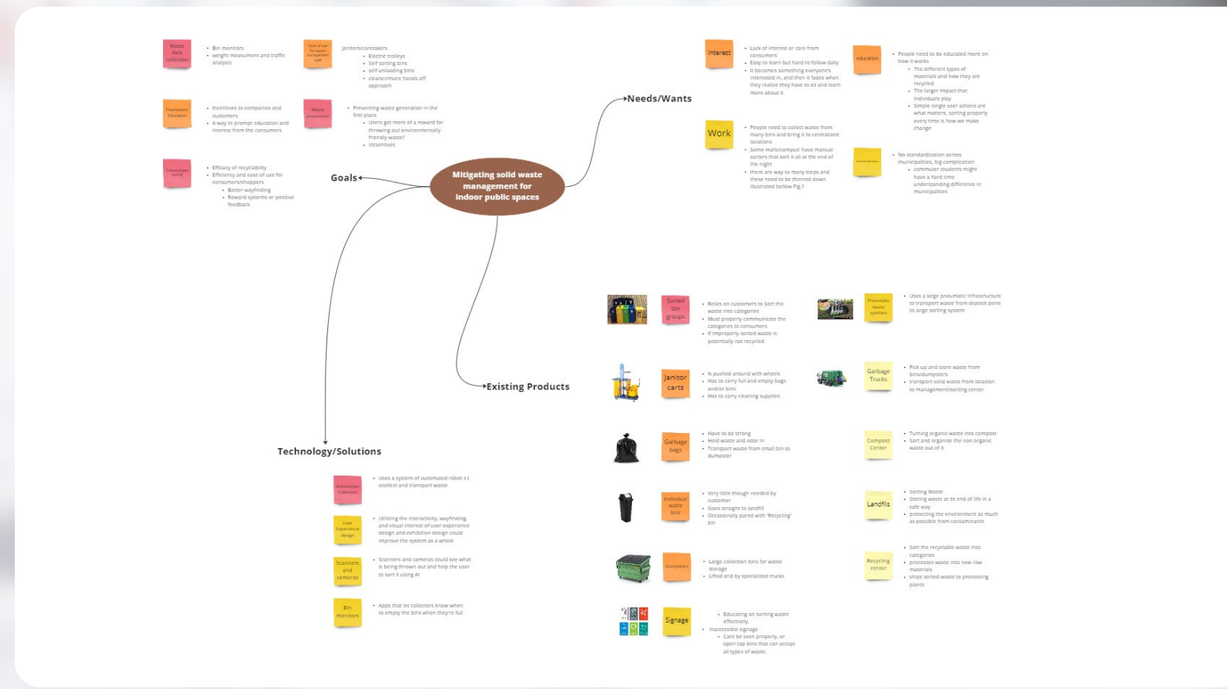
The most important information that needs to be determined through this research is:

- What are the biggest pain points for a user throwing out waste?
- What are the biggest pain points for a janitorial staff interacting with the waste bins?
- How can the waste management network or system be reduced or simplified in complexity?

These questions was answered through interviews with; fast food workers, Waste Management specialists, and garbage bin users(students and Mall shoppers).
As well as consulting secondary research such as articles, surveys, bucks, and websites and finally through first-hand primary observation and study users interacting with existing solutions and ergonomic prototype mock-ups.

1.3 Background / History /Social Context

Lots of factors affect this topic from users to environments to existing products and solutions, some examples of these factors are laid out below in a mind map.



Chapter 2

Research

2.1 User Research

With the goal being to properly enrich and improve a user's experience, one must first understand what problems challenges and pain points the user faces. Through numerous sources of primary and secondary research the pain points, needs, wants, and behaviour of the primary user has been understood and cataloged.

2.1.1 User Profile – Persona

The User Profile explains the demographics and behaviours of the target user allowing the project to focus and more efficiently solve problems. A demographics profile was determined by second-hand research, as well as drawing on user surveys, user interviews, and user observations.

The primary user is consumers/waste bin users, they are comprised of the majority of the population, meaning their gender is essentially 50f-50m (50.36% women compared to 49.64% men).

User:

Primary:	Consumers / Waste bin users
Secondary:	Custodian / Caretaker
Tertiary:	Shopping center owner

Culture / Ethnicity source

European	52.5%
North American	22.9%
Asian	19.3%
North American Indigenous	6.1%
African	3.8%
Latin, Central and South American	2.5%
Other	8.4%

Target Persona #1
Name: Wade Watson
Age: 24
Job: Fast food employee
Income: $33,500
Education: Collage student
Location: Toronto, ON
Mall Frequency: Once a week
Duration: 1 ½ hours

Profile
Wade Watson is 24, working as a fast food employee while he Gets his college education. His income currently is $33,500

Habits
Wade often shops at the mall with his friends as a social outing or by himself out of necessity.

Use Behavior
While shopping on campus or at the mall he often purchases consumables that produce waste. He finds numerous difficulties and annoyances while sorting waste into the proper bins.

Interaction points
Products (bags, boxes, cups, napkins etc..),
Garbage bin lid, bin foot petal, Hand sanitizer, etc..

Persona #2 Custodian

Name: Jane Johnston
Age: 37
Job: Janitorial staff
Income: $30,000
Education: High-school graduate
Relationship: Taken
Location: Newmarket, ON
Duration: 1 ½ hours

Profile
Victoria Price is 37 and works as a Custodian/ Janitorial staff at a mall complex. Her income currently is $30,000

Job
While cleaning and maintaining the mall she is also taken with employing and replacing the bags in the garbage bins.

Interaction points
Cart
Transports and stores cleaning supplies
Takes full garbage bags to compactor
Cleaning supplies

Use Behavior
While doing her tasks she finds numerous difficulties and annoyances trying to remove replace and transport the waste bags back to the compactor waste into the proper bins.

2.1.2 Current User Practice

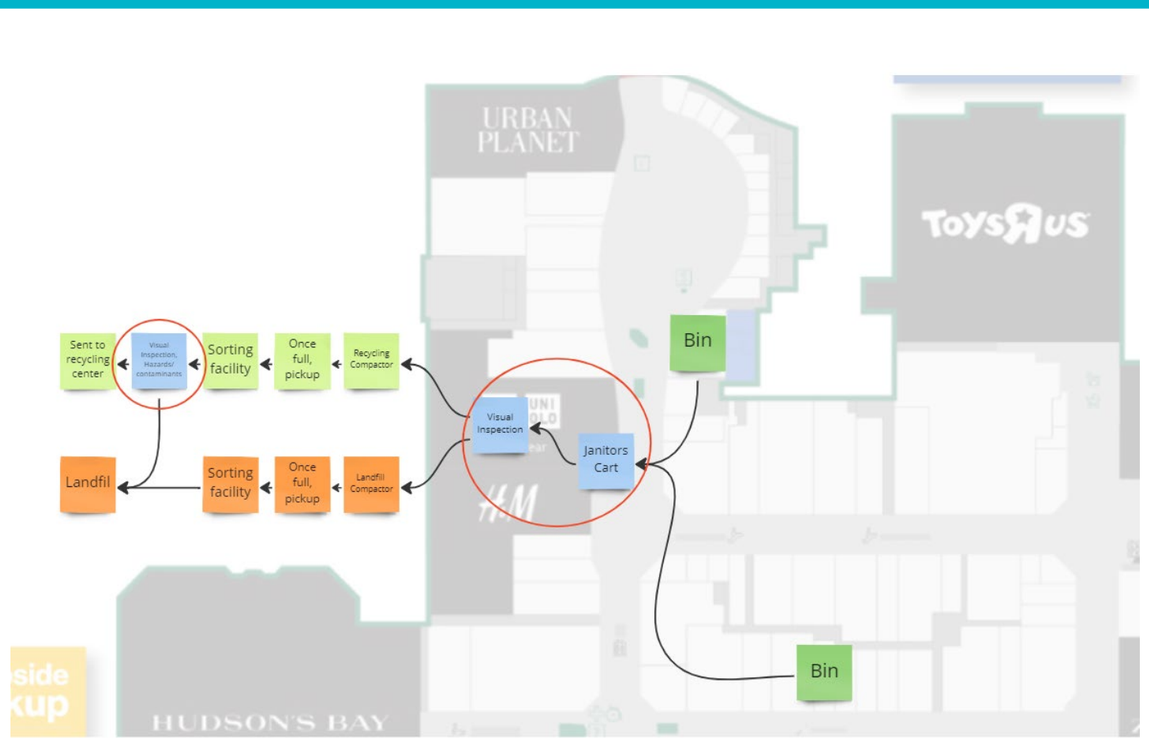
The current system for Waste Management in public indoor spaces is relatively complex with 12 different nodes of interaction minimum. This interaction diagram is later graphically in the image below and it's comprised of the following parts.

Bins
- Main consumer interaction point

Janitors cart
- Purpose is to take waste from Bins to a compactor
 Can be combined with the bin

Visual inspection
- Visually inspect and sort through waste with their hands
- Sorting can be done better at the bin stage

Compactor
- Collects and compacts waste for midterm storage
- Waste could be compacted ahead of time



2.1.3 User Observation - Activity Mapping

In the following research activity a video of a waste management system being explained Was transcribed and coded to try and isolate the pain points and needs that they were experiencing and equally importantly, the solutions they found.

Source:
“Reducing Waste- NSCC Burridge- "Leaders By Example"" - Youtube

Method:
Video was coded with the following codes:
Solution to a problem
Pain Point that needs solving

Speaker 2: *[00:00:48]* First of all, we have templates here. If anyone has a problem with the garbage, they can look. It's all individual paper, recyclables, garbage, refundable and organics. And in here we have this in English and French. One of our main problems we had starting out this process was coffee cups. The coffee cup would come and was done. Into the paper bin, thus contaminating the paper. One solution that we went with was planning to sign up with which coffee and coffee cups? We've put it in a different container. So does eliminating the contamination of other garbage recyclables. And as well we have the green then have. Compost and there are leakproof bags and they are all compostable. It's a fact of life that nothing is perfect. So I have an area where I do the double sorting and the bag for bag. I resort to double time all the recyclables, the organics, the paper products and put them in the individual bags here. Every bag is weighed and recorded on a spreadsheet.

Speaker 1: *[00:02:09]* From the sorting station. The food waste goes into our recycle bin, sort of a compostable base on the outside, and once the compost is completed, we will be putting the cart portion through these bags here where we're growing our vegetable. The

Summary:

Better wayfinding/signage helps to elevate the struggles of sorted waste, however, the staff at this building is still hand-sorting waste post collection.

Improving the system as a whole is important to improve this hassle. There is multiple areas that could benefit from this, to reduce physical labour and tedious mental work.

Bins are usually sorted into specific groups mostly paper recyclables landfill, waste, organics, etc.. cross-contamination is a big problem as it could take recyclables no longer recyclable.

This building has to manually sort through all of its waste and so do some malls on campuses as well. This company found a way to skip the landfill/shipping by using their own waste as compost for growing food.

2.1.4 User Observation – Human Factors of existing products

Ergonomics plays a huge factor in the success or failure of many product designs, especially those at a human scale such as the one in this thesis project. The ergonomic factors for garbage bins and waste management touch-points were evaluated to ensure the sizing is accurate and comfortable for all potential users. This physical ergonomic study was conducted alongside a way-finding user observation as well.

The hope was that this ergonomic study would provide evidence of usability or lack thereof and ultimately provide data that will help to produce a viable scale and placement for user touch points to move forward with.

There are lots of factors to consider in an ergonomic study, especially in systems as complex as this one, but the following points are what the focus of observations will be on.

- Access to the top opening at different user heights, insuring the angle and size is user friendly to all who need to use it
- Legibility of signage for different user heights, making sure signage is at an appropriate and viable height
- The path that users take when throwing out waste
    - What hand motions and directions are they using?
    - What direction are they walking to/from while interacting with it?
    - What are they looking at? What are they looking for?
- How long are they there for? What's taking up most of their time?

The user observation study proved that several interaction points are most likely to be utilized for the final Direction. These interaction points are signage, which plays an important role as a visual interaction point and is the first place that users will look when they don't know where to throw their waste. The opening of the bin is the primary physical interaction point and is where all the waste passes through while entering the bin. And lastly, the call to action would be in the form of a QR code scannable interface that is linked with an accompanying app or service.

In summation, a lot was taken away from this user observation and ergonomics study, and real hard evidence was acquired that will be used to base all future ideations and developments around. This project will not have any arbitrary features as everything will be evidence-based and research-driven.

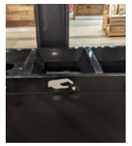
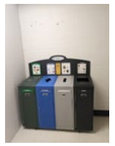
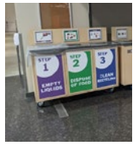
User Observation Notes:

- Always a brief pause before picking up into throwing their waste into the bin
- People need reassurance they look in the bins and at the signage for information and confirmation that they are in the right
- Contradicting information is confusing, like paper can go in recycling so why is there a paper bin, unless each recyclable has its own bin don't have a recyclable thing in a separate bin
- If people have more than one item they can get lazy and put them both in the same bin because why would you separate them that's a lot of work
- If confused they will default to the waste bin
- Composite materials are either going in the wrong bin or the waste bin
- Interestingly users will look at signage after throwing waste out (reassurance)
- often one-handed
- will look in the bin to see if the waste matches the rest
- better to be shorter or clear so people can look in
- most people throw out waste on the way past, some stop to read
- There is a cup option but because it is smaller and hard to see they put in waste
- lots of people put plastic cups in the landfill bin
- 1 out of 150 people scanned the QR code (possibly wasn't visible or 'worthwhile' enough)
- Hierarchy is a friend but also an enemy
- you want the signage to be first but then nobody sees the call to action qr code
- The height is a little high for 1st-percentile
- Users don't want to stop and read they want to walk through it
- Users have to lift their hands from their side up to the bin

Top 4 Takeaways

- People use signage and visual cues for reassurance
- If confused or in a rush they default to the ‘Waste bin’
- Users would prefer to pass by and not to stop
- People often don't know what bin an item belongs in
- Composite materials, dirty recycling, ect..

2.1.5 User Observation – Safety and Health of existing products

Benchmarked products						

Health and safety takeaways:

The only inherent safety and health considerations of all existing Benchmark products are that they keep waste out of human reach. Some of these existing products do this more or less effectively and the different shapes and sizes of holes exist not only to guide the user as to what to place in the bin but also to prevent them from reaching in and taking anything out.

Another factor that should be considered is touch points. It's safe to say that everyone using this bin is throwing out an unwanted item, these unwanted items are often dirty or contaminated with food waste or microbes and the users that are interacting with these bins are holding that item in their hands. This means that any touch points for the bins will pose a health and contamination risk for diseases and dirt.

2.2 Product Research

In a similar manner to how user research was conducted to gain a better sense of the user interactions and pain points, product benchmarking was done to try and understand what products exist in the market. It's imperative to know these products' strengths and where they fall short in order to ensure that the proposed design is able to negate these weaknesses and capitalize on the strengths.

2.2.1 Benchmarking – Benefits and Features of Existing Products

Existing Solutions - Full Waste management process

The waste management system has lots of different touchpoints and as such it is important to list and categorize all of these touchpoints in order to see where the biggest challenges and opportunities lie.

Existing Solutions - Bins/signage

Existing waste collection receptacles are all relatively similar in design featuring an opening in the top to put garbage, signage and basic wayfinding above the opening, and some sort of removable storage on the inside.

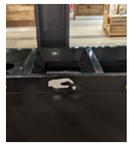
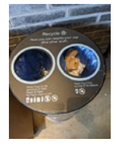
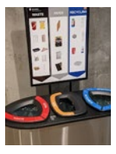
Data collected from online reviews and advertisements on existing garbage bin receptacles were placed into Excel and sorted alphabetically, this led to the most important categories being discovered, and frequency was then tabulated.

Features:	Frequency:
Colour coding	7
Modular	4
Signage	3
Lid	3

Benefits:	Frequency:
Efficient	8
Durable	5
Simple	3
Adaptable	2

2.2 Benchmarking – Functionality of Existing Products

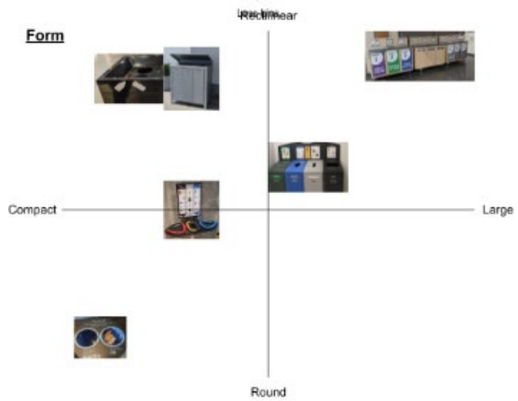
Identify Existing product solutions and their functionalities.
Types of Product solution

Types of Product solution	 Sorted bin groups	 Janitor carts	 Garbage bags	 Dumpsters	 Signage	 Garbage Trucks
Use	Allows users to sort waste into bins	Lets Caretakers pick up waste bins and transport it to larger storage	Goes within the bins and is replaced by caretakers upon removal	Dumpsters are the larger capacity storage bins that are used to hold waste long term	Signage informs users where to put their waste.	Transfers waste from dumpster or compactor to waste management facility
	Very Frequent	Often	Very Frequent	Not often	Very Frequent	Often
Types of Product solution						
Notes	Only a simple graphic, not easy to understand the limits of what is allowed in the bin	Contradicting information, (users are meant to throw out their cups and take their lids elsewhere?) bad wayfinding	Good signage, organization, and colour coding, Wayfinding is obvious and not too complicated	Good signage, organization. Colour coding is odd and not following the standard Wayfinding is obvious and not too complicated	Good signage, great organization, and colour coding, too many options, can confuse users	Simple, just a word, not language accessible, No colour use No pictures or icons

Based on Benchmarking of various bins there seem to be no good examples of products that are able to communicate good wayfinding without being very simple in form. this could be due to the fact that having a more complex shape and form could distract the user's attention away from wayfinding making it appear less effective. there are no examples of finding that are designed purposefully where the form implies and strengthens the functionality.

2.2.3 Benchmarking – Aesthetics and Semantic Profile of Existing Products

Interface
Wayfinding methods and quantity of bins seem to be the two most commonly fluctuating interface factors, here they are plotted on a chart against each other.



Takeaways

It seems that the more bins there are in a unit the better and more robust the wayfinding needs to be, this isn't always a good thing, as too many choices can distract and overwhelm users, and too much wayfinding is often confusing and contradicting. There is a sweet spot that balances bins and wayfinding to allow users the simplest yet most efficient sorting method.

Aesthetics

Next the same grouping of bins plotted on a graph to visually represent the form of the object. The two axes were. compact and large. versus round and rectilinear.

Design Take-aways:

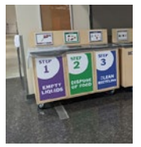
Shape

- Often Square/ angled boxes lined up next to each other
- Single standalone bins are often cylindrical
- Some have a panel behind that shows images of accepted waste
- Round bins are usually smaller scale

Communication/wayfinding

- Photos and images of accepted waste
- Icons implying what can/can't be thrown out
- Words sating what can/can't be thrown out

2.2.4 Benchmarking – Materials and Manufacturing of Existing Products

Benchmarked product						
Materials	Sheet metal bin with removable lid Uses Plastic garbage bags	Recycled plastic construction, sliding removable bins Uses Plastic garbage bags	Sheet metal bin with Plastic removable lid Uses Plastic garbage bags	Wood box with metal lids and hinging door on front Uses Plastic garbage bags	Sheet metal bin with sliding removable drawers Uses Plastic garbage bags	Sheet metal bin with heavy removable lid Uses Plastic garbage bags

It can be seen that all existing waste management receptacle solutions use a garbage bag in order to transport waste from location to location as well as keeping the inside of the bins clean. This isn't ideal as they are a plastic disposable product and that itself is contributing to landfill waste buildup.

As for materials and manufacturing, these bins are made to be as affordable as possible, usually out of recycled metals or plastics manufactured into thin shells that hold and protect the bags within.

2.2.5 Benchmarking – Sustainability of Existing Products

The effectiveness of these products in the sustainability category almost entirely relates to how effectively they can separate and organize the waste categories. If a bin can effectively keep the recycling uncontaminated and the organics out of the landfill then the materials and manufacturing prosses of the bins will no longer matter.

The materials and manufacturing aspects play a part as well, it's without a doubt better to use recycled/recyclable materials when making bins for mass production. As well as considering the manufacturing process and that amount of carbon production it entails.

2.3 Summary of Chapter 2

Before the Aesthetics and functionality of a product or even to be considered the user must be fully analyzed and understood. Empathy in design is of the utmost importance, making something look and sound great is easy, but it's impossible to design a user-friendly, ergonomic, and functional product if you aren't able to understand and empathize with the end user. That's why such care was taken to gather as much data as possible on the user both in and out of the environment of use. The findings prove that the subconscious plays a huge role in decision-making and is able to do so in a very short amount of time. This means that the proposed solution will have to solve this problem and help make the process of throwing out waste simpler and more intuitive.

Existing products are all based on the exact same foundation, a box with a hole in the top and some words and pictures nearby. This works too visually to look like the problem is being solved however it doesn't do a lot to actually encourage proper Recycling. It seems as though a product that not only had good wayfinding but also had an aesthetic form that led into the wayfinding and strengthened it would benefit the user in many ways compared to the existing products on the market.

Goals to eliminate pain-points

- Eliminate confusion caused by contradicting information
- Make the task of separating and sorting items not feel like a task
- Optimize design for a one handed walk-through experience
- Utilize graphics to inspire confidence and reassurance in their decisions
- Change the default option in peoples minds, deter them from using landfill bin make it obvious where things go; Composite materials, dirty recycling, cups, ect..

Chapter 3

Analysis

3.1 Needs Analysis

When it comes to researching especially for product projects of this scale gathering the data is only half of the battle. The other and arguably more critical half of it is the analysis section. this is where all of the previously collected data is compiled and understood to determine the next steps.

3.1.1 Needs/Benefits Not Met by Current Products

All current products rely on users to do the mental sorting and often the waste Disposal by hand. none of them try to play two users' psychological processes or intuitions. Also, as mentioned in previous chapters none of the existing products are visually aesthetic.

3.1.2 Latent Needs

Latent needs are a type of need that the user is unaware of they kind of operate in the self-conscious or as one of the unperceived types of interactions. The latent needs 4 Waste Management bin users are sown in the table.

The tabulated latent needs are based on Maslow's hierarchy of needs, one of the most popular and well-known organizational methods for human needs. the most important needs that this project addresses are physiological and security needs for cleanliness, As well as control over waste management and environmental damage.

Put another way the important things needed to be focused on are: Keeping areas of human interaction clean from garbage and keeping harmful waste away from users. Secondly, instilling control and convenience in a user's interaction with a waste management receptacle. Lastly, how can we do all of this in a way that not only is better for the environment but it makes the user feel like they're doing good for the environment as well. These are all needs that must be met by the proposed final product and they will be considered at every step of the way.

3.1.3 Categorization of Needs

Dividing the needs of the user into three different categories immediate needs latent needs and wishes / wants, Is an effective way to visually see what the end product needs to focus on in terms of what the users actually need.

Product- garbage bin				
Needs	Benefits and Underlying Needs	Level of importance		
Basic Needs Physiological				
Food, water, shelter	Keeps shelter clean and garbage free			High
Pleasure, gratification (sensory, compulsive responses)	user feels good knowing they are disposing of waste properly		Moderate	High
Security Safety, securing resources				
keeps user safe from harmful; waste	keeps the user safe from harmful; waste/deseses			High
Securing resources	Recycles resources. these are used by everyone			High
Control over environment (tasks)	keeps the user safe from harmful; waste/deseses	Slight		
"Convenience Ease of Use"	wayfinding makes the sorting task easier		Moderate	
"Long Term Security/ Stability of Group Health/care/education of children"	Recycles resources. these are used by everyone, keeps the user safe from harmful; waste/deseses			High
Environmental sustainability	sorts and recycles waste to better save the environment			High
Social Belonging Effort / resources to belong to a 'tribe'				
Behavior cues for social interaction of group	user usees it because everyone else does and its the right thing to do	Slight		
Peer Pressure	user usees it because everyone else does and its the right thing to do	Slight		
Esteem Personal influence in 'tribe'				
Social Recognition	helps the user be more environmentally consious	Slight		
Self-Actualization				
Intrinsic pleasure	helps users feel like they're doing something to help fight climate change and environmental damage	Slight		
Emotional	helps users feel like they're doing something to help fight climate change and environmental damage, makes user feel good when they recycle		Moderate	

3.2 Analysis – Usability

After funny and so much information about users and products separately it is of crucial importance to combine the two of them and get information of their interactions together. There are many different ways to visually organize information, That being said, the usability analysis was laid out in a user Journey map and a user experience map.

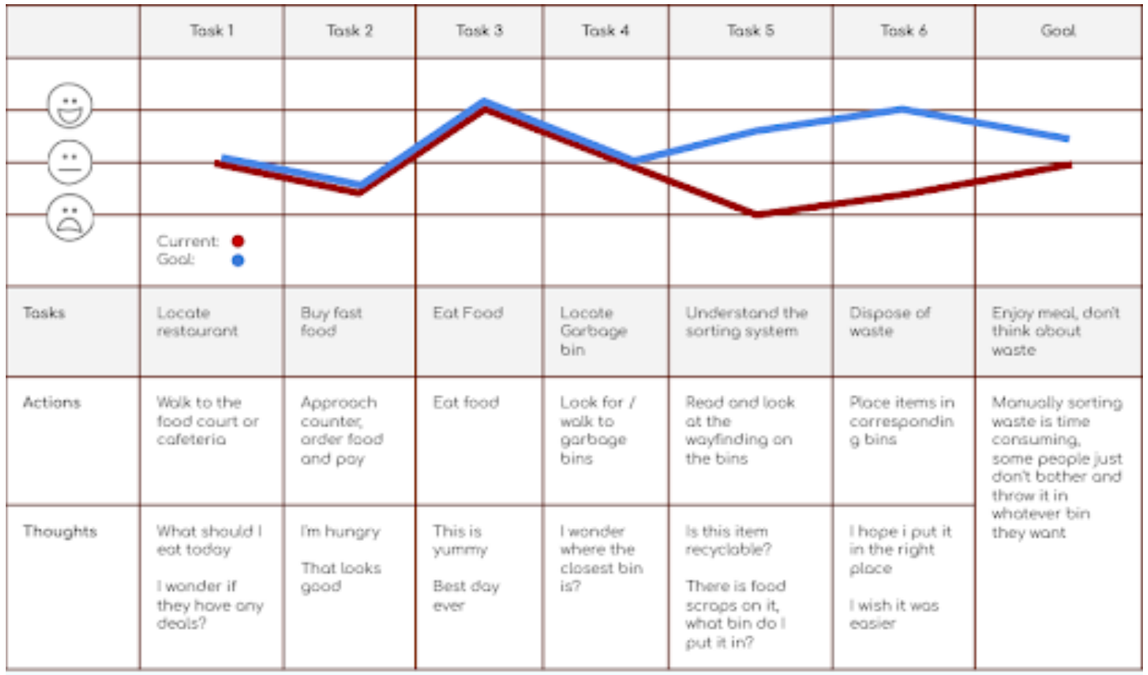
3.2.1 Journey Mapping

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Goal
Goals	Locate restaurant	Buy fast food	Eat Food	Locate Garbage bin	Understand the sorting system	Dispose of waste	Enjoy meal, don't think about waste
Actions	Walk to food court or cafeteria	Approach counter, order food and pay	Eat food	Look for and walk towards garbage bins	Read and look at the wayfinding on the bins	Place items in their corresponding bins	Manually sorting waste is time consuming, some people just don't bother and throw it in whatever bin they want
Thoughts	What should I eat today	I'm hungry that looks good	This is yummy	I wonder where the closest bin is?	Is this item recyclable?	I hope i put it in the right place	
Feelings							

This journey map shows the Journey of a user buying food and then disposing of the waste products in a public indoor space. I can be seen highlighted in green that task 3 of eating food is the point of delight, this means that it is the parts that the user does the task for and it's the part that feels the best for the user. and in contrast Task 5 of understanding the sorting system is the least enjoyable part and the primary pain point for this thesis topic. having to learn and understand how to properly sort waste for the first time is time-consuming and annoying for someone who is on the move and trying to get things done.

3.2.2 User Experience

The blue line on the above graph represents the Target or goal of this project and you red line represents the current user experience. with this, in mind, the goal of the project is to make the active understanding of the sorting system and disposal of waste not only more efficient and easy for the user but also more enjoyable. through aspects covered in Chapter 4, the user experience will be modified to favour enjoyment and usability over the standard models that choose to favour cost.



3.3 Analysis – Human Factors

The ergonomic factors for garbage bins and waste management touch-points were evaluated to ensure the sizing is accurate and comfortable for all potential users. This physical ergonomic study was conducted alongside a wayfinding user observation that was covered in chapter 2.1.4.

The purpose of the 1:1 is to find out what scale and measurements are most appropriate for human interaction touch points of a waste management system. This study will focus not only on the physical measurements but also on the positioning and effectiveness of the graphical wayfinding elements.

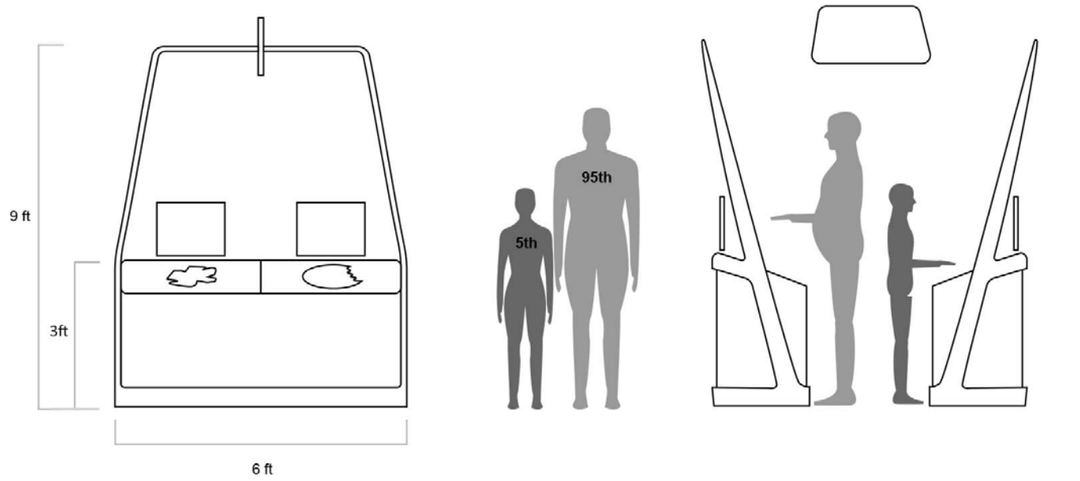
Evaluation process

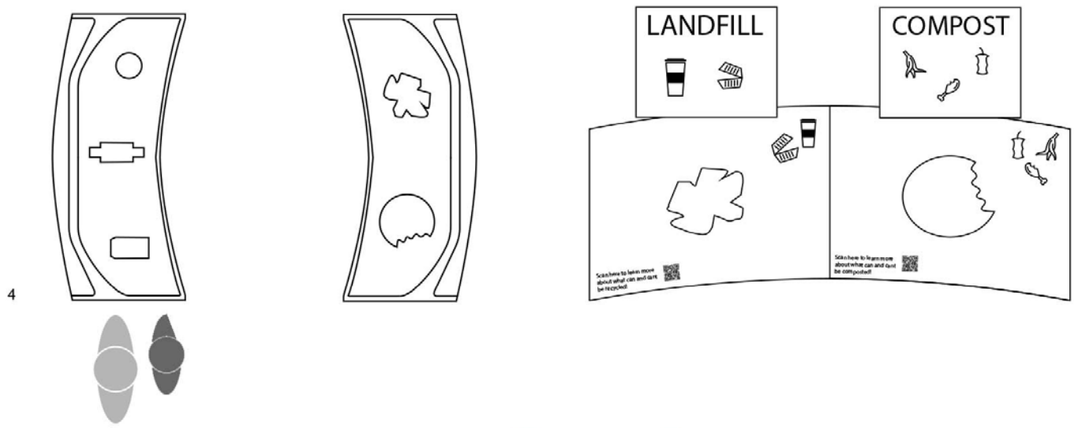
Signage plays an important visual interaction point and is the first place that users will look when they don't know where to throw their waste

- The height and opening of the bin is the primary physical interaction point as that is where all the waste will end up
- The third interaction point is the call to action which would be in the form of a QR code scannable interface linked with the accompanying app

Description of User Observation Environment Used in this Study
The product is a collection of waste management receptacles user is used to this but usually, in a basic rectangular form-factor, These would be placed throughout the building to allow users to access waste bins wherever they are In this study specifically, the environment was at Humber Collage North campus outside of the entrance to the Tim Hortons

3.3.1 Product Schematic – Configuration Diagram

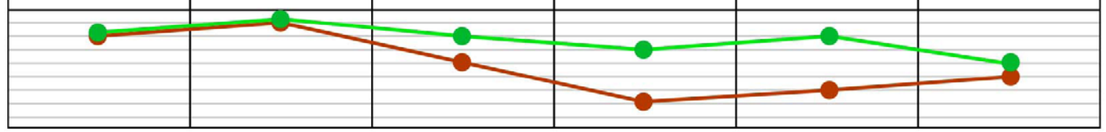




4

Discarding waste in public indoor spaces: **Current** **Proposed**

Buy Food	Eat	Locate Bin	Sort	Throwout	Leave
Find a resturant or store and purchase a consumable item	Consum purchased food either while sitting or while walking around	Find a suitable place to dicard the waste produced while eating	After finding the garbage bins, pick what bin is the proper bin to throw waste into	Place Waste items in the chosen bin	Continue on with day as planned



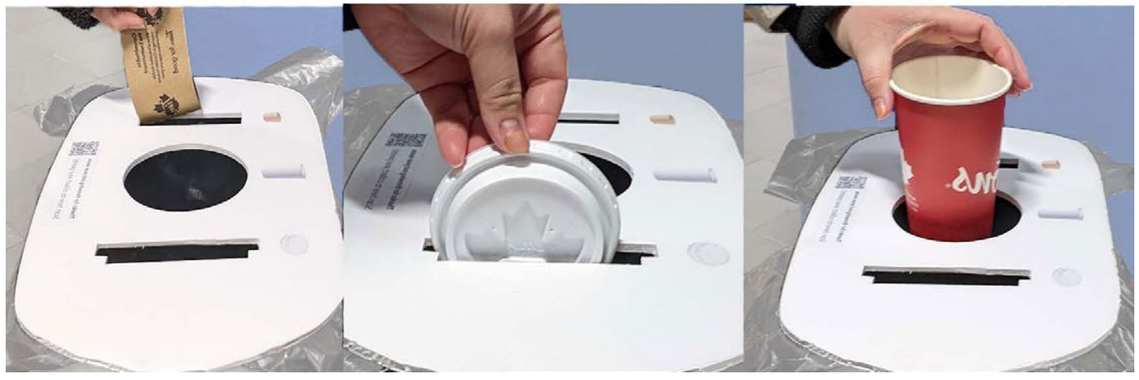
3.3.2 Ergonomic –1:1 Human Scale Study

The most important takeaway from this study is that users are (for the most part) in a rush or they at least prefer not to spend their time trying to understand how a bin works. Based on the roughly 150 users observed interacting with this bin, on average they only interacted with it for 3 seconds and more often than not after this a lot of time frame gave up and by default through their waste in the landfill bin. This is quite interesting because it offers an opportunity to change the status quo of waste management receptacles. Garbage bins are often rectangular in shape and, regardless of if they have a slanted top or not, always have a hole in the top with signage facing out to the user directly perpendicular to the depth of the bins. Users are often passing by parallel to the length of the bins and thus would have to stop and rotate their bodies 90 degrees in order to read the signage from the appropriate angle. As seen in figures 2 and 3 Users tend to dispose of waste with a single hand often holding onto a bag or personal device with the other. The combination of these two factors proved to be quite the opportunity for innovation from the floor plan wayfinding perspective as well as the physical shape and styling of the object.

The ergonomic scale model was separately tested with a 1st-percentile woman and a 95th-percentile man and both users found the signage and height of the bins adequate and usable. A minor but potentially impactful observation is that users often walk with their garbage at their waist side but upon approaching the bin lift their arm up either to the mid-torso or shoulder height in order to dispose of their waste. This is a symptom of the top-loading waste bin and would apply to any solution with the opening to the bin on the top at that height. it could serve as a minor pain point or it could simply be a mechanism of use. Continuing on the track of visual hierarchy another huge factor that it plays is attention span. As seen in figure 4 there was a call to action on each of the bins with a QR code and some text saying “Thank you for recycling, scan here to claim your reward”. During the roughly 3-hour observation window, only 1 person out of 150 took the time to scan the QR code.
This could be due to the fact that it was at the bottom left of the bin and wasn't very colourful or enticing, or potentially due to it just getting lost in the user's peripheral. A big part of human perception is filtering out stuff that isn't useful so it's in the best interest of the product to make these aspects of the bin more useful and more visually appealing such that users will see it immediately and understand what it wants you to do.

95th percentile Man (6’1”)

5th percentile Woman (4’9”)



3.4 Analysis – Aesthetics & Semantic Profile

The aesthetic and semantic profile of the proposed project will be aimed at letting the forum influence the usability and waste management collection as opposed to a simple box with signage.

This project will rebuild the aesthetics and interaction with this product from the ground up and let the form do a lot of the speaking and a lot of the wayfinding as opposed to relying on signage. This could be through symbolic forms or by having the shape of the object influence end play to the human instincts and phycology.

The shape will break the norm of a basic receptacle with an opening in the top and try to play more to a user experience design or exhibition design. some examples of images are below for material and overall shape aesthetics.

3.5 Analysis – Sustainability: Safety, Health and Environment

For the chosen approach to sustainability in this project the focuses are on reducing landfill waste and increasing the success of cyclical recycling and composting. These three main factors are the foundation of the design, meaning all aspects of the design are built off of these goals.

By improving recycling and composting landfill waste also increases in effectiveness, and when all three are achieved this means that fewer carbon emissions and greenhouse gases are emitted from collecting virgin resources and manufacturing new products from scratch, less harmful chemicals are leached into the environment, and less solid waste like plastics and up in natural habitats and the food chain. This affects the health and safety of wildlife and ecosystems globally but it would also indirectly lead back to humans through the food chain and drinking water.

Knowing all of this, this thesis project will utilize tactics like wayfinding info-graphics and psychology to guide and educate users on how to properly sort their solid waste. this knowledge will be used for the proposed product but it will also be retained in the user's active memory to then be applied to other less sophisticated waste management systems. Effectively offering a replacement product that does the job better and training the general population to use existing products more effectively.

3.6 Analysis – Innovation Opportunity

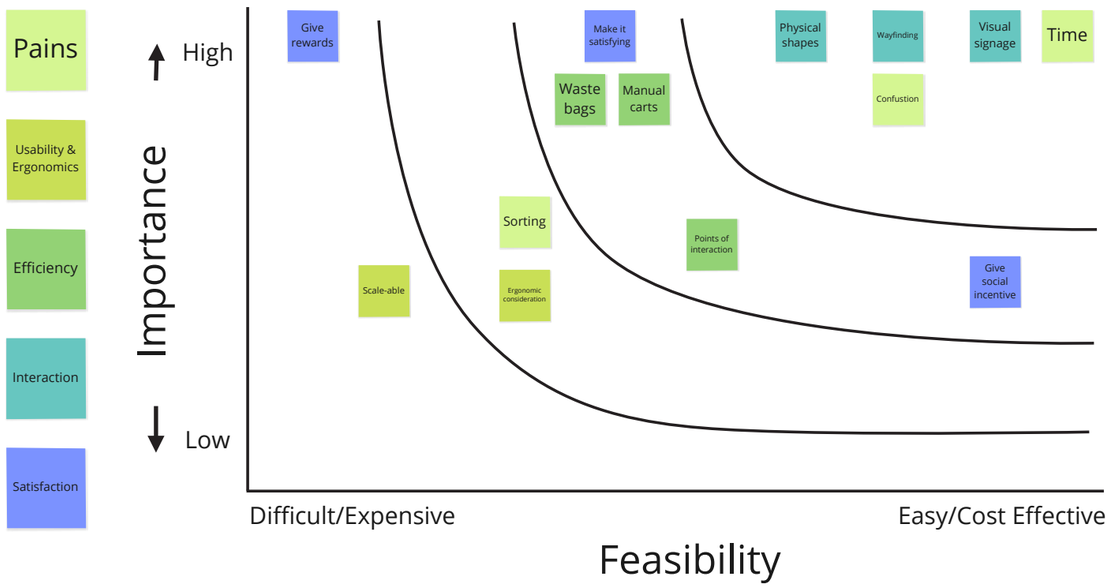
There is an astonishingly large number of variations when it comes to garbage bins, however, all of them have the same downfalls and cause the same problems. There are many factors to consider, whether that be wayfinding, signage, size, form, materials, or system network. The Innovation for this project will focus on the human interaction side primarily and secondarily focus on the product as a whole and how it interacts with the existing systems.

As seen in section 2.2.3 the more bins there are in a unit the better and more robust the wayfinding needs to be, this isn't always a good thing, as too much wayfinding is often confusing and contradicting. There is a sweet spot that this project hopes to achieve in order to make a product that isn't overwhelming and plays on the intuitions and instincts of the user rather than relying on their ability to think and solve complex problems.

3.6.1 Needs Analysis Diagram

Painpoints

- Sorting waste by hand is not ideal or scaleable and users would prefer another option
- Collecting waste bags is time consuming and not ergonomic or user friendly
- Users dont have alot of time to sort and understand their waste management signage
- Better wayfinding and sorting would eliminate the need for a sorting system down the line
- Visual signage and physical shapes are important and can be used to imply wayfinding
- From the janitors perspective having to disassemble bins and exchange bins is not ideal
- Potentially hazardous to have to touch and physically sort through waste
- Making the action of throwing out the waste satisfying is part of the solution.



3.6.2 Desirability, Feasibility & Viability

Desirability

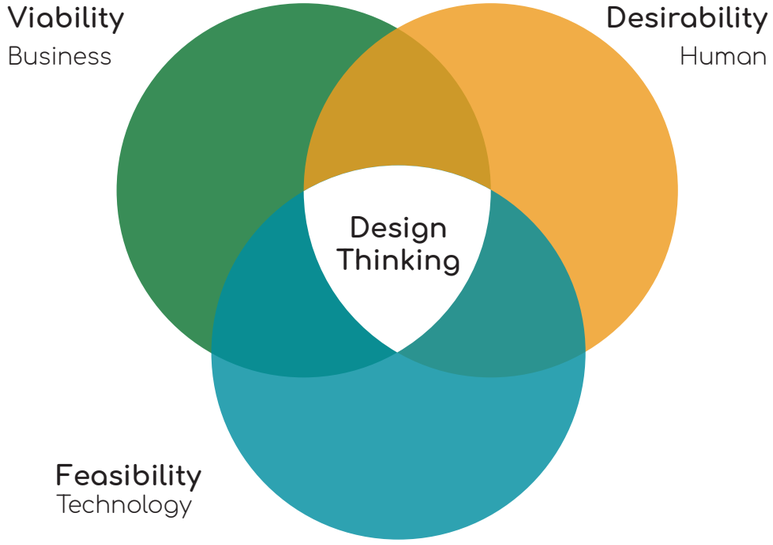
Users do not want to struggle or take time out of their day to learn how to properly recycle and I also don't want to be burdened with the question of if they recycle properly or about their impact on the environment is. a solution that solves these problems would improve user experience and increase the likelihood of proper Waste Management from the user's perspective.

Viability

There is a huge gap in the market for Waste Management experiences. All of the Benchmark products and researched existing Solutions are strictly utilitarian and ineffective. if a product was able to more efficiently and effectively sort waste and in doing so taught users how to properly recycle and Brace manage while reducing improper landfill disposal it would change a lot about the way waste is dealt with in public places.

Feasibility

The possibilities for this design are very exciting there are many ways that it could go. in terms of Technology there are many systems that this unit will most likely rely on, artificial intelligence is getting more and more complex every day and the ability to identify and sort waste through purely visual input is feasible today and will almost definitely be applicable in a consumer situation Within 5 to 10 years. In addition, a system of autonomous robots would be able to drive to and from bins emptying them when they're full And would greatly reduce the amount of strenuous labour placed on to janitorial staff when having to empty bins. With advances in 3D printing and additive manufacturing, it's easy to see how any shape possible could be implemented in this project. this could allow for recyclable/recycled materials to be shaped in two forms that will imply the function of the product.



3.7 Summary of Chapter 3 – Defining Design Brief

The future of this product will be based on and guided by the following 10 points, these points make up the design brief and will be considered where every decision moving forward.

- Mitigate the amount of recyclable waste wrongfully thrown in the landfill.
- Streamline the current indoor waste management network.
- Mitigate the amount of time needed to sort waste into the correct receptacle, letting users in a rush easily 'drive by' and not have to stop
- Educate users on how to properly recycle so they can apply that knowledge to less sophisticated systems.
- Bring an aspect of fun into the process of disposing of waste.
- Help users feel reassured that their actions are the correct ones, aim to eliminate all chances of users needing to guess.
- Physically or physiologically restrict users from wrongfully recycling. In other words, make it difficult for users to place items in the wrong bin.
- Play to users' instincts in order to eliminate the need for strenuous thinking while they understand how to properly sort waste.
- Reduce the amount of physical labour janitorial staff have to endure in order to empty the full bins.
- Use different psychological tricks to reward or teach users how to properly sort waste

Goals to eliminate painpoints

- Eliminate confusion caused by contradicting information
- Make the task of separating and sorting items not feel like a task
- Optimize design for a one handed walk-through experience
- Utilize graphics to inspire confidence and reassurance in their decisions
- Change the default option in peoples minds, deter them from using landfill bin
- Make it obvious where things go; Composite materials, dirty recycling, cups, ect..

Chapter 4

Design Development

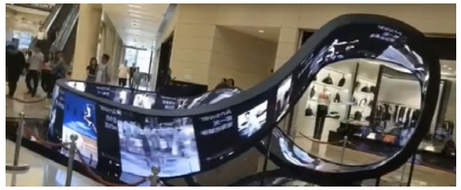
4.1 Initial Idea Generation

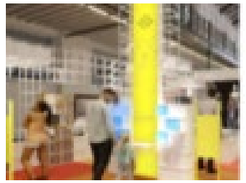
So the data has been collected and analyzed, now what? Now is the part all designers look forward to, coming up with concepts to solve the problems and pain points found in the research. Through multiple stages of ideation, planning, and development numerous concepts where created. These concepts were then slip apart changed recombined and refined to create the final selected direction.

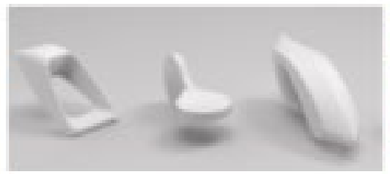
4.1.1 Aesthetics Approach & Semantic Profile

The Aesthetics and semantics are two important factors that need to be considered When approaching any design project. For this project in particular the Aesthetics are based primarily on user interaction and wayfinding. keeping the overall aesthetic simple elegant and functional, as well as incorporating he wayfinding into the aesthetics will help to let d wayfinding and Graphics do the talking. it would be nice to include some elements of bio-mimicry in the design as well as incorporating sustainable materials so that the solution doesn't go against the primary directive and end up in a landfill.

As for the semantic profile user interaction and wayfinding is at the top of the hierarchy of priority, the goal is to be able to simplify the experience for users and make it more straightforward as to which bin to throw what object into. the secondary priority is simplifying the overall Network or system of waste management and collection within an indoor space. this will hopefully lead to easier jobs for janitorial or caretaker staff as well as less money and time spent on what's important parts voice managing and more focused on the parts that matter.

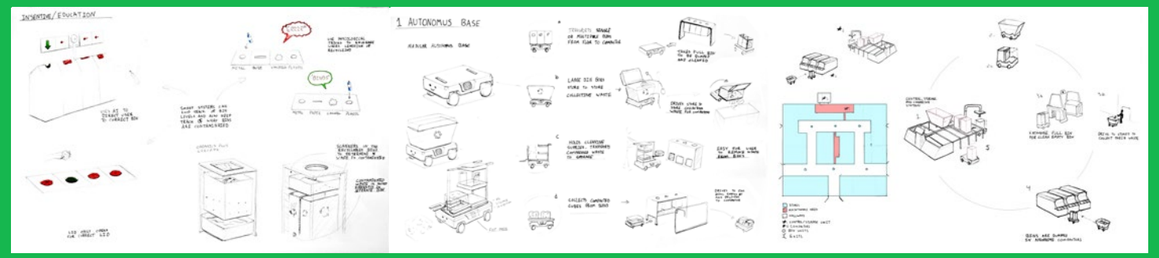


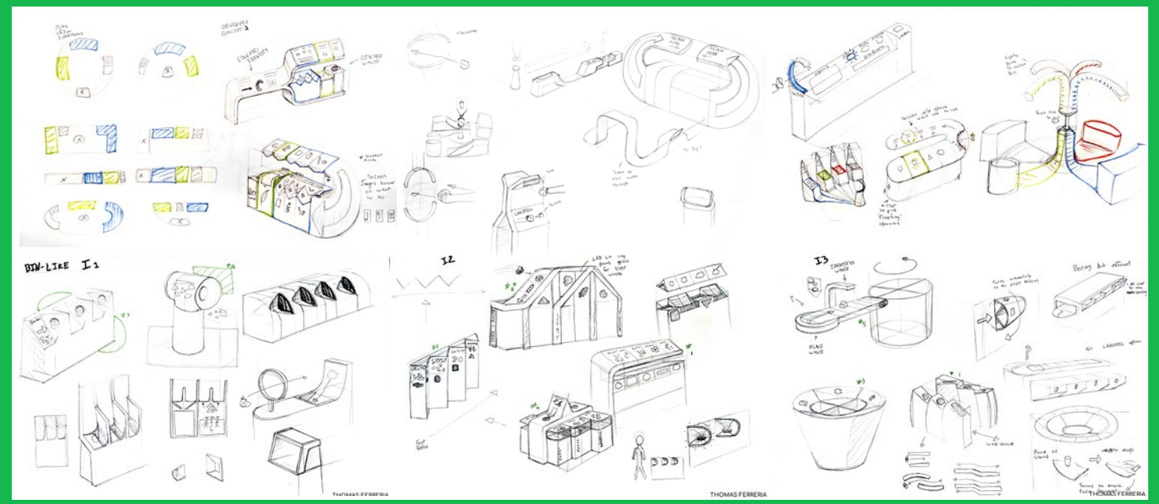


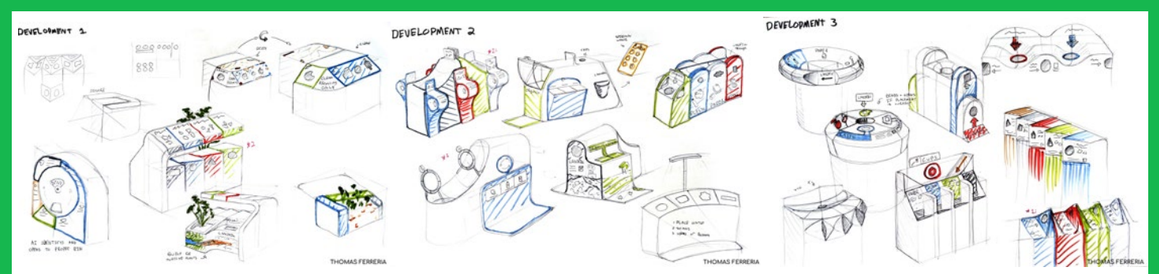


4.1.2 Ideation Sketches

Many potential ideas were explored in the Ideation phase, all of them are focussed on different layouts of bins and how the user can interact with them. There was lots of experimenting with different placement for the openings different styles and angles and shapes.







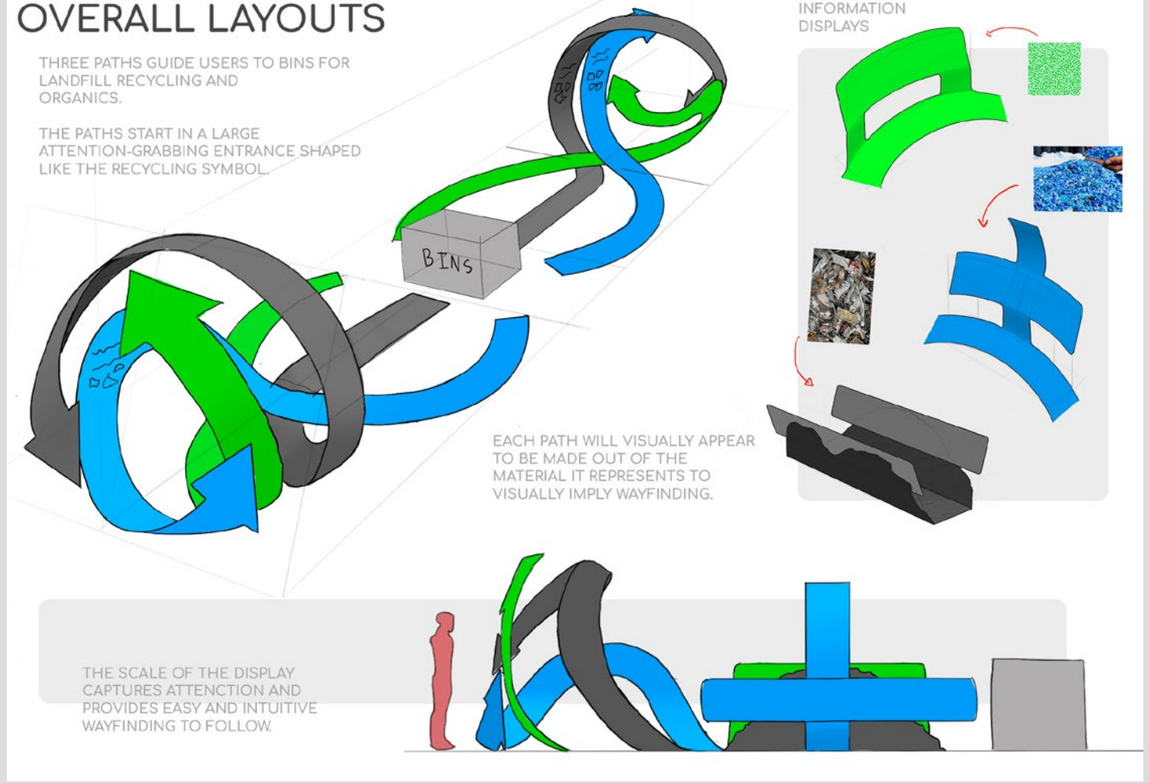
4.2 Concepts Exploration

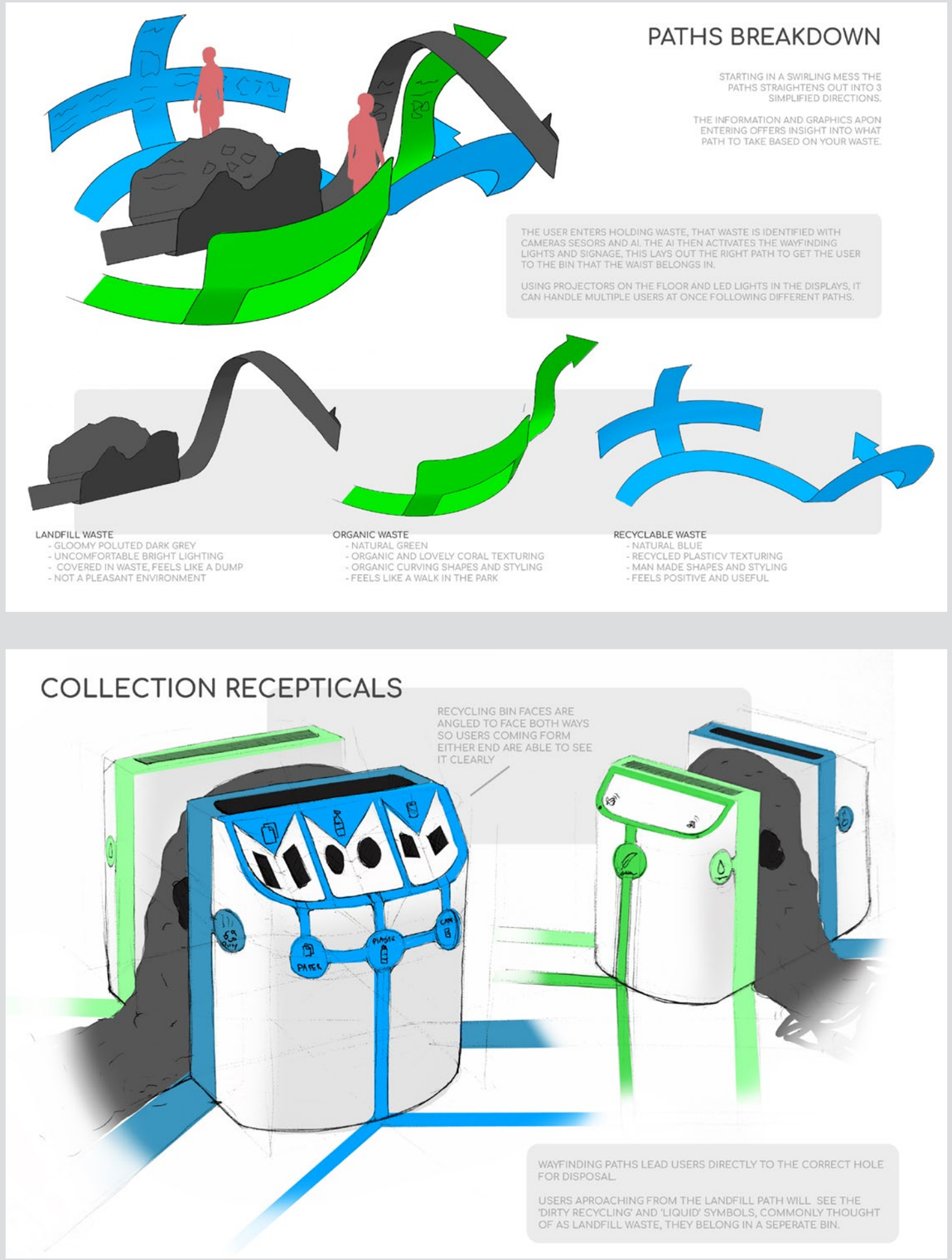
The ideation sketches from chapter 4.1.3 where chosen to be combined and developed further to get a set of much stronger ideation that will help lead to the final concept directions. Each concept focuses in very different ways on the opening into the bin the viewing angle of the wayfinding and opening for the bin as well as the mechanism for sorting whether that be manual or automatic.

- All concepts will be linked to a companion app that rewards users for recycling properly
- All concepts will use autonomous vehicles to remove and replace bins
- All concepts will use washable bins to replace disposable plastic bags
- All concepts will give visual and audio feedback when waste in properly/inproperly sorted

4.2.1 Concept One

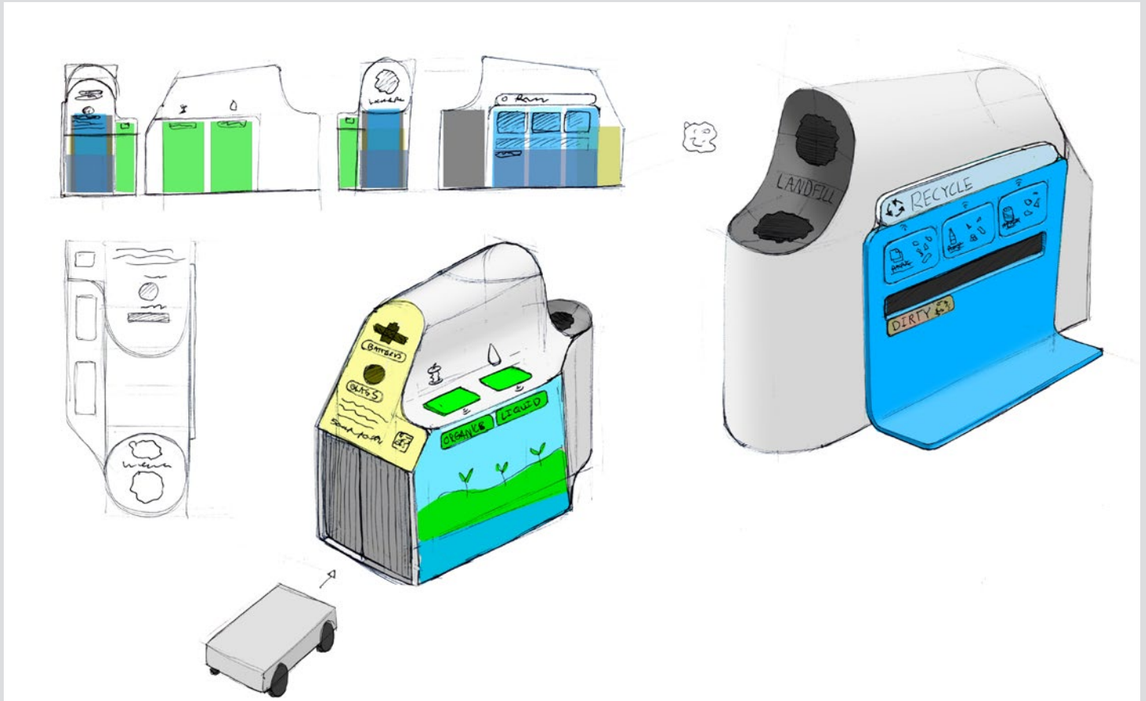
Overall exhibit entrance is shaped like the recycling symbol to draw attention and entice users in with a large twisting entrance each path then leads the user to a specific part of the bin guiding them on where to throw out their specific waste with signage along the way.





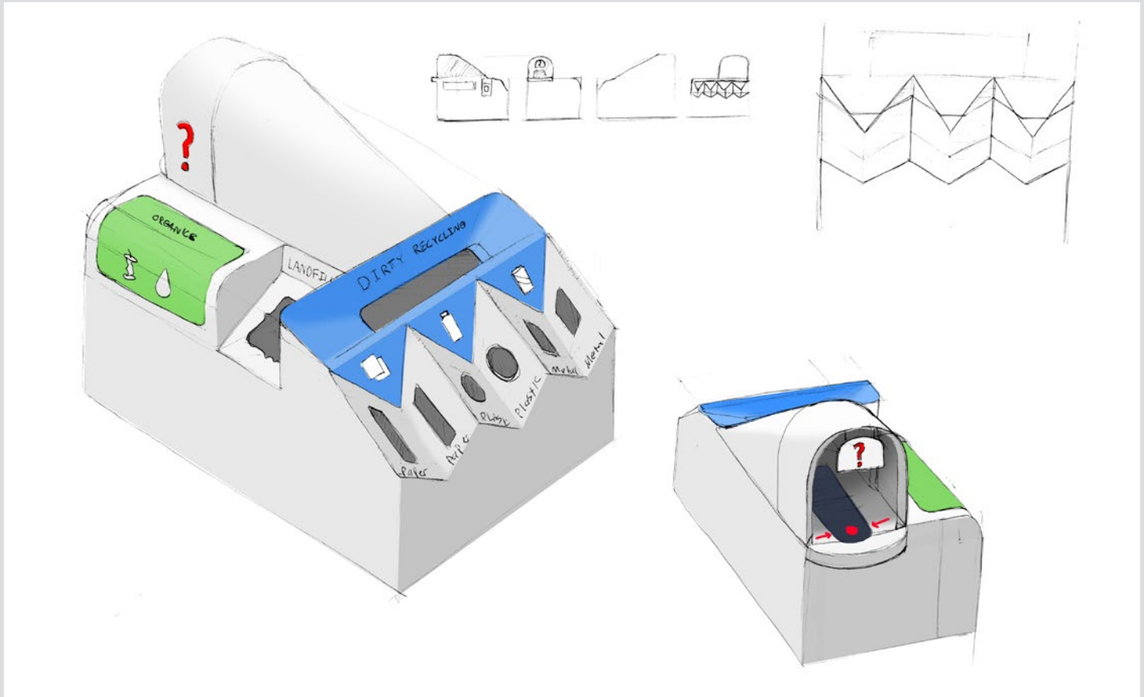
4.2.2 Concept Two

- Recycling is grouped all together with an option for dirty recycling underneath that encompasses all three sub recycling categories
- Landfill waste has two options of entry for the waste, this will encourage users to place landfill waste and it over the recycling as it's more enjoyable (could lead to users throwing recyclables into the landfill so different option should be considered)
- Options for E-Waste and glass waste are also available on the yellow section
- Liquids in Organics are placed next to each other but are actually one big bin this is to encourage proper sorting but accept the fact that some people are lazy and will not separate the two
- Overall different categories of waste are separated by distance and she has to help differentiate for the user
- Having different categories on different sides of the bin may result in some not being seen and us not being used



4.2.3 Concept Three

- AI Automatic sorting option for if users are confused or in too much of a rush to think about manually sorting. This works with a series of treadmills that push waste to the right bin
- Audio and light indicators throughout inform the user of where the waste should have been thrown out when automatically sorting so that they can do it manually next time
- Very effective and efficient interface for recycling, visible from most angles and very straightforward
- Dirty recycling is very hard to miss as it right above al other recycling
- Landfill opening is small and out of the way to encourage proper sorting first



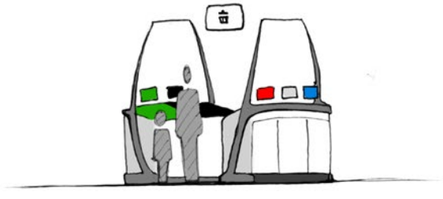
4.3 Concept Strategy

Countless different concept directions and many different types of solutions were explored but ultimately two were chosen to continue development. Out of these concepts, concept number two was the one that was decided as most effective at solving the problem and as such it was chosen as the final concept direction for this project.

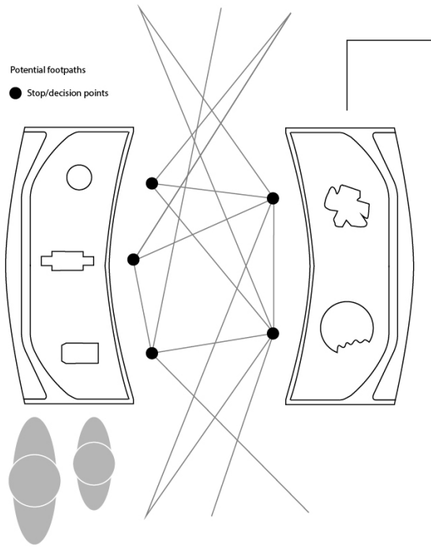
The configuration diagrams are important as they force designers to get a sence of human interaction scales for the concept. It's quite frequent for design students to develop a concept and make the proportions look perfect and aesthetic only to see that when modelled in cad the tires on your car are 5 feet tall.

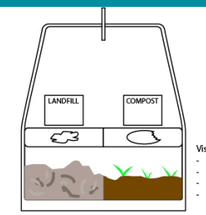
4.3.1 Concept Direction & Product Schematic One

Concept direction one was developed quite early in the ideation process and represents a standard bin unit with a focus on graphics and visual wayfinding Concepts from chapter 4.2.2 and 4.2.3 Elaborate on the details regarding the shape size layout openings and function of this concept Direction.



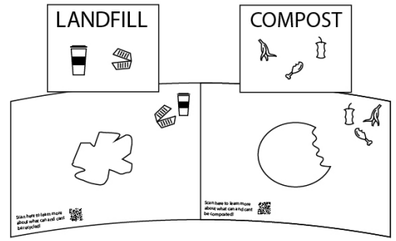
Wayfinding





Visual wayfinding:
- Words
- Images of accepted items
- Implied shape of items cutouts
- Imaging of the place teh items will end up

Interactive opertunities to:
- learn
- have fun
- help keep the world clean

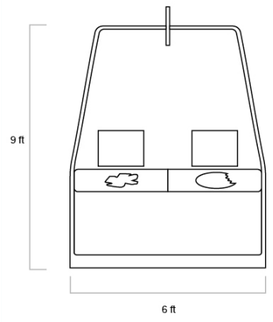


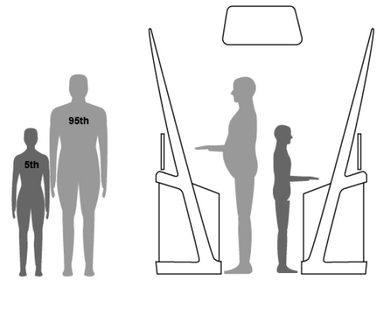
Discarding waste in public indoor spaces: Current Proposed

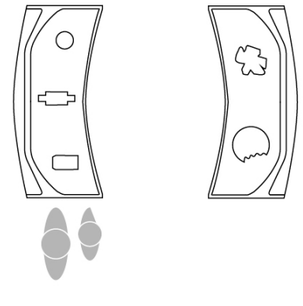
Buy Food	Eat	Locate Bin	Sort	Throwout	Leave
Find a resturant or store and purchase a consumable item	Consum purchased food either while sitting or while walking around	Find a suitable place to dicard the waste produced while eating	After finding the garbage bins, pick what bin is the proper bin to throw waste into	Place Waste items in the chosen bin	Continue on with day as planned

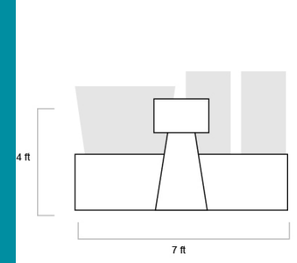
Thomas Ferreira

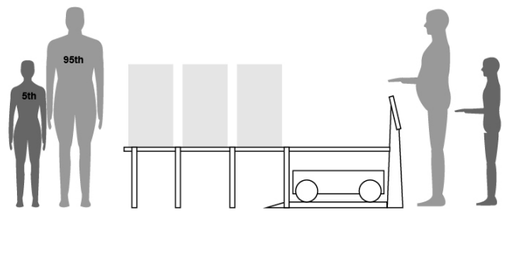
Touchpoints

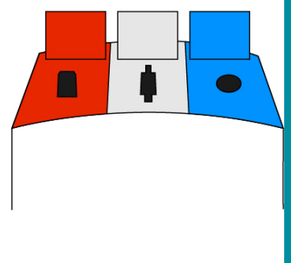






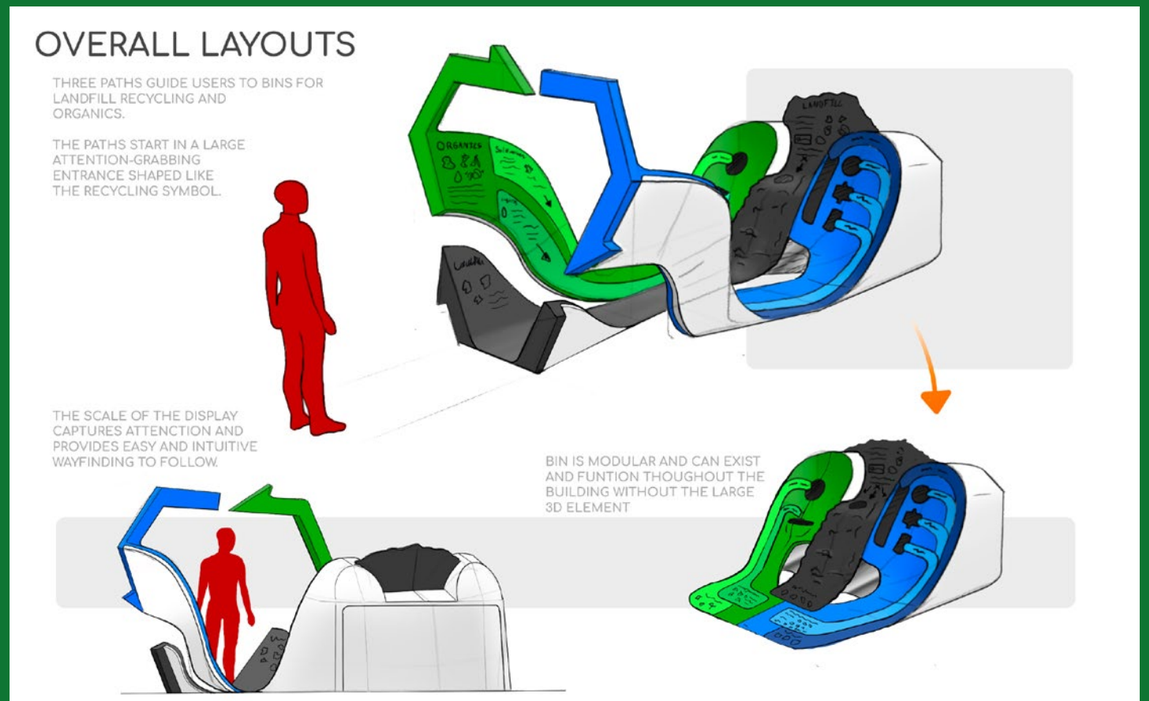


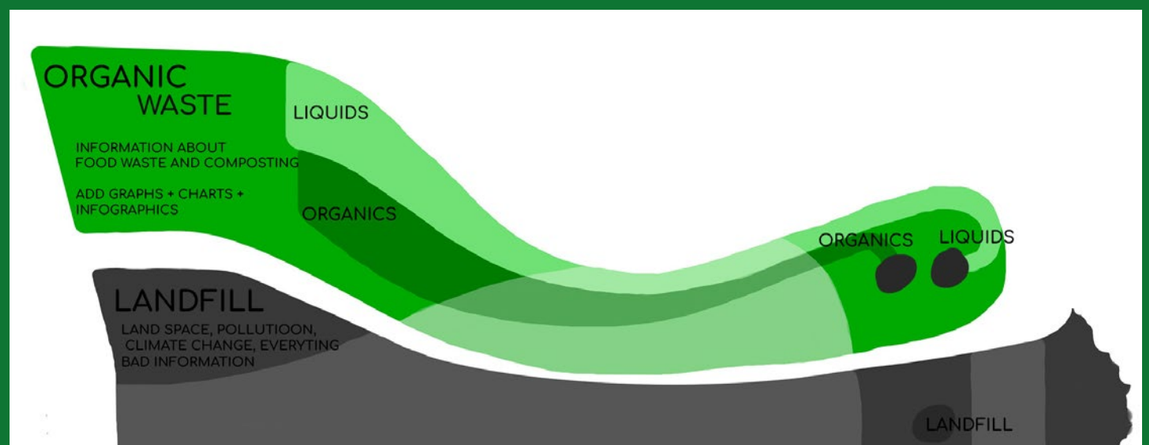


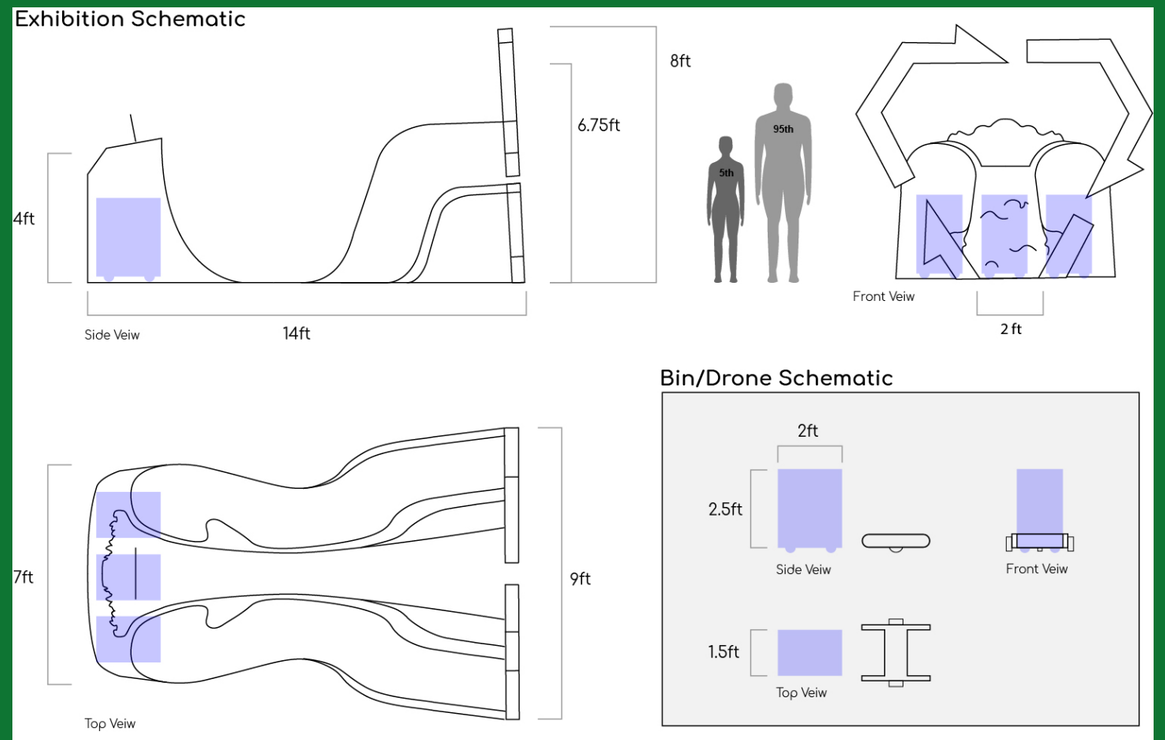


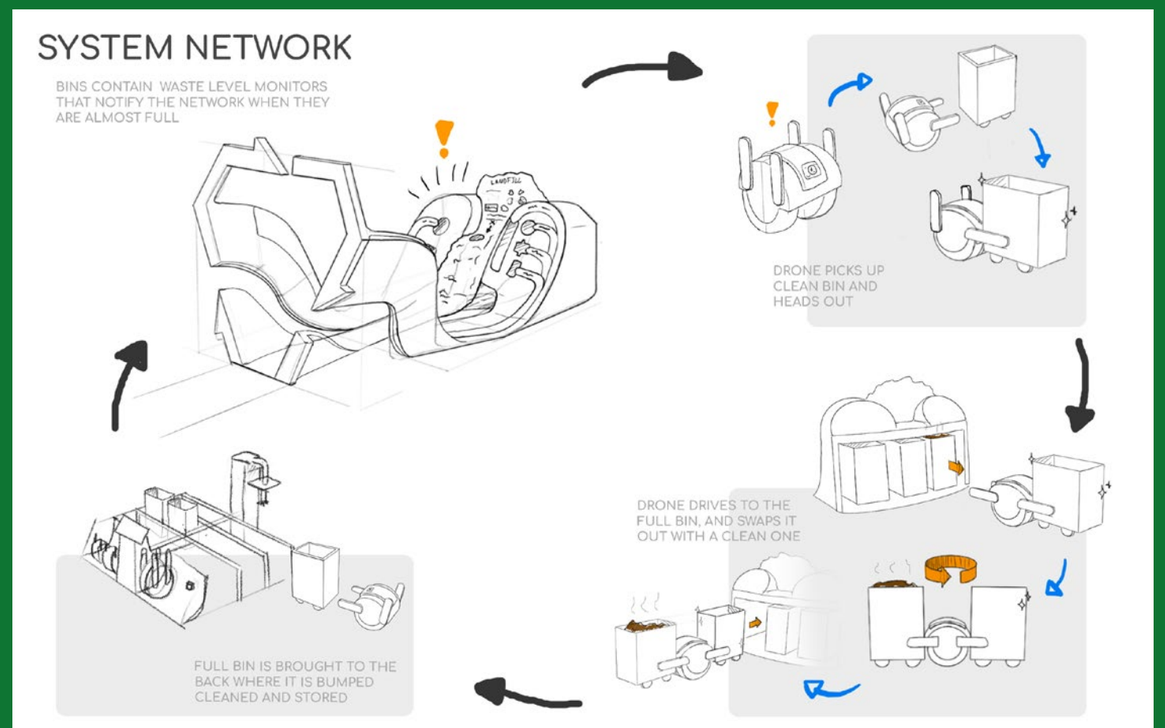
4.3.2 Concept Direction & Product Schematic Two

Concept direction two elaborates and refines details from chapter 4.2.1. It focuses on the exhibition display style large three-dimensional structure that not only grabs the attention of the user and draws them in, but also plays a huge part in the overall information communication and wayfinding of the concept.







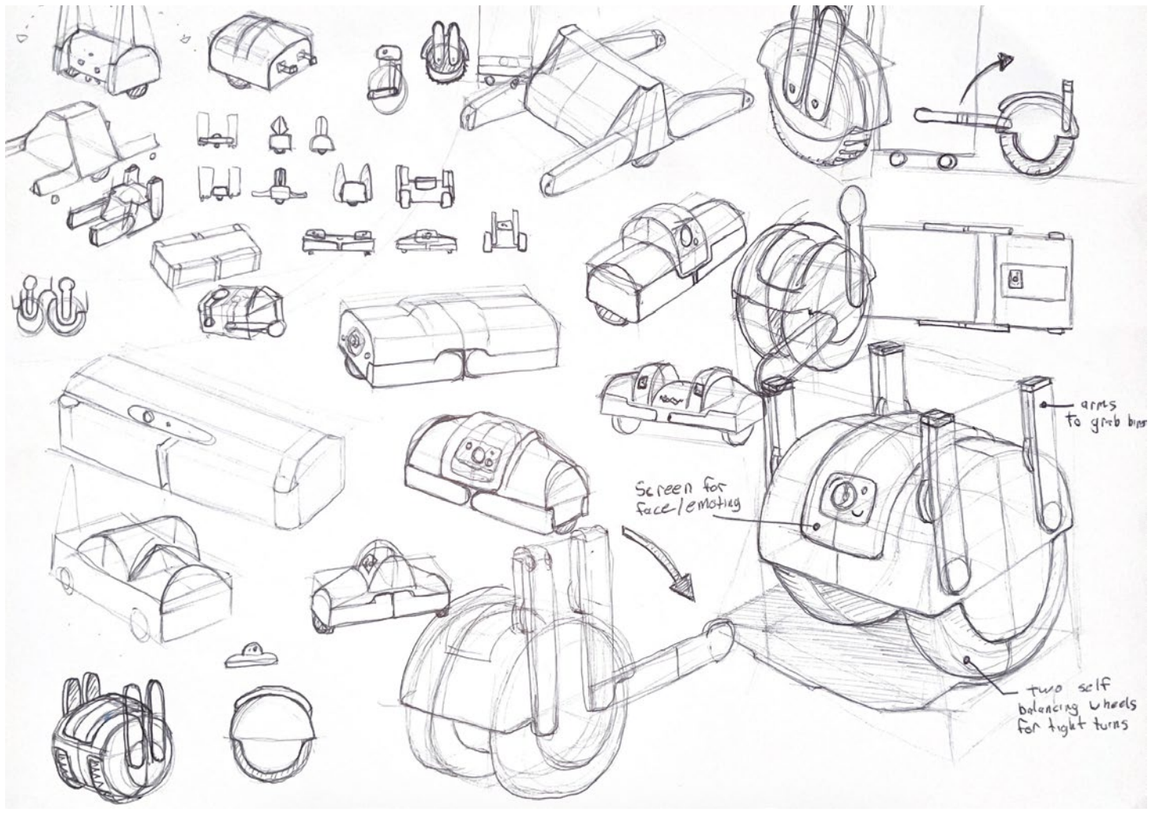


4.4 Concept Refinement & Validation

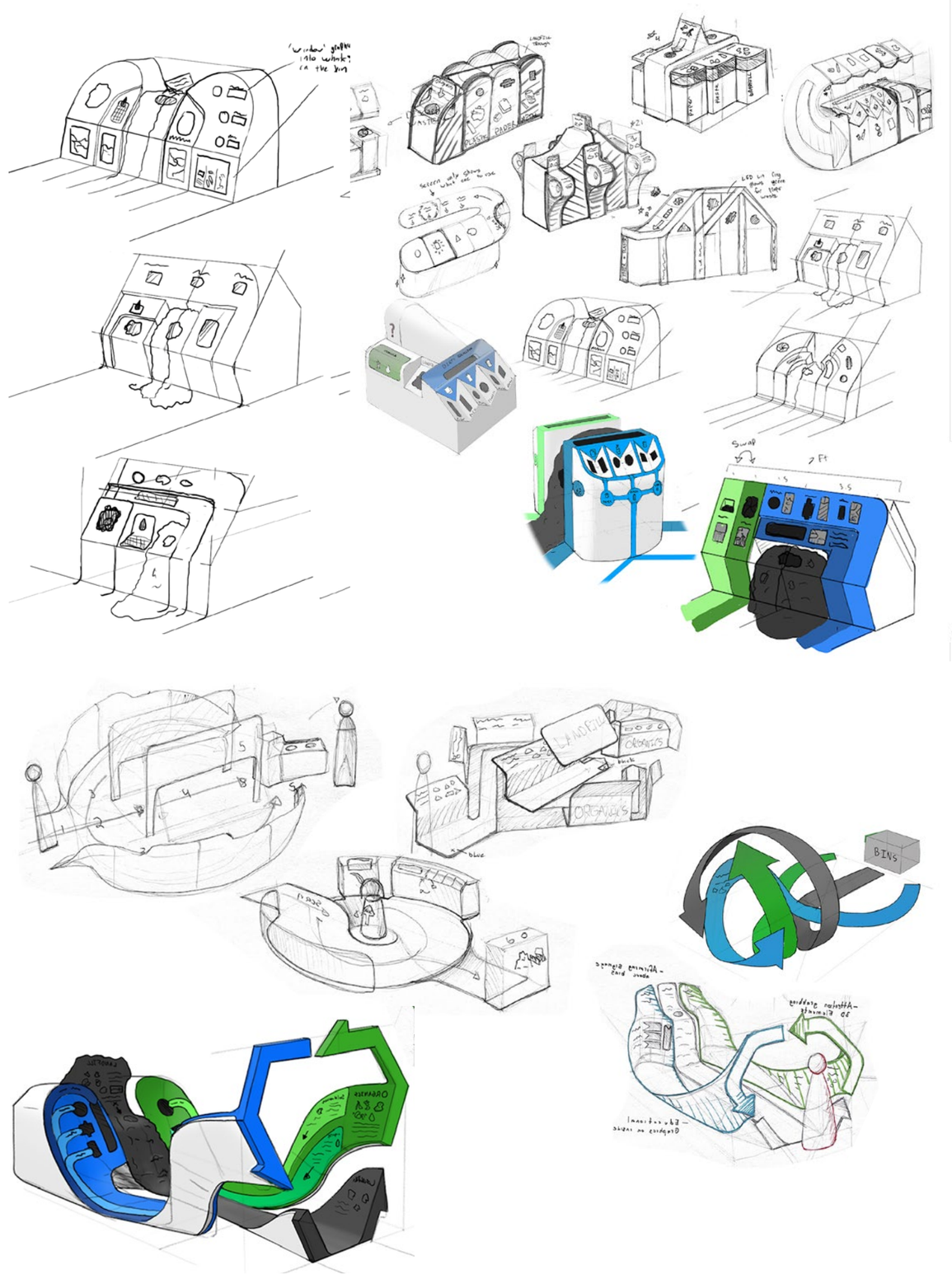
As perviously sstated, concept number two was chosen as the final concept direction for this project. this is due to the following resons:

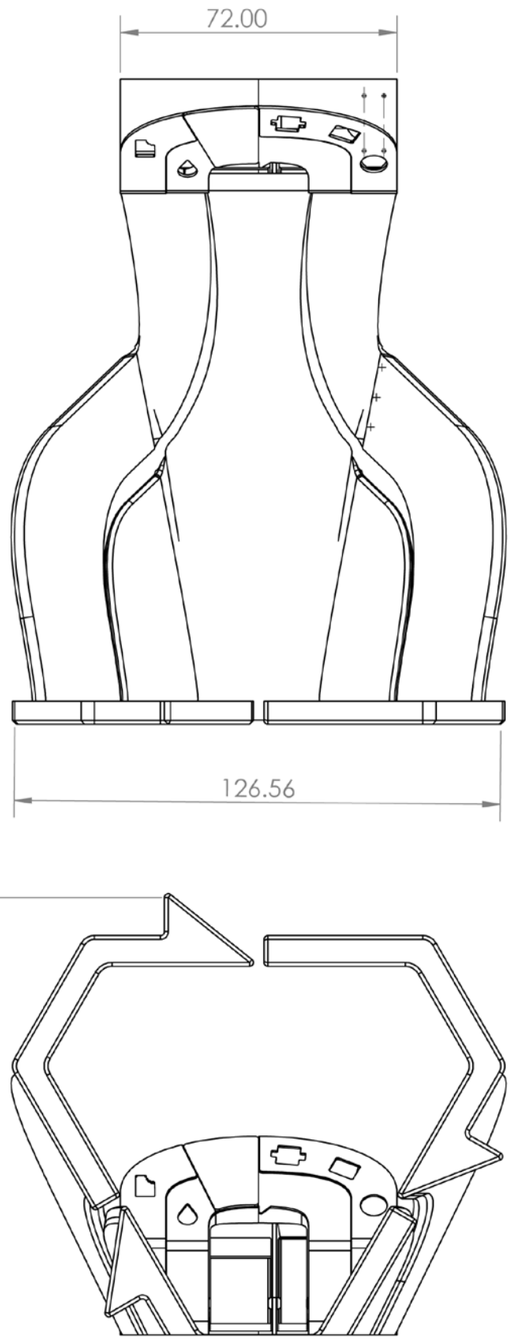
- Effective wayfinding promise
- Form following function, guiding users
- Potential for scalability (larger or smaller buildings and applications)
- Potential for improved system network
- Wow factor (its quite a large concept and sure to draw the users attention)

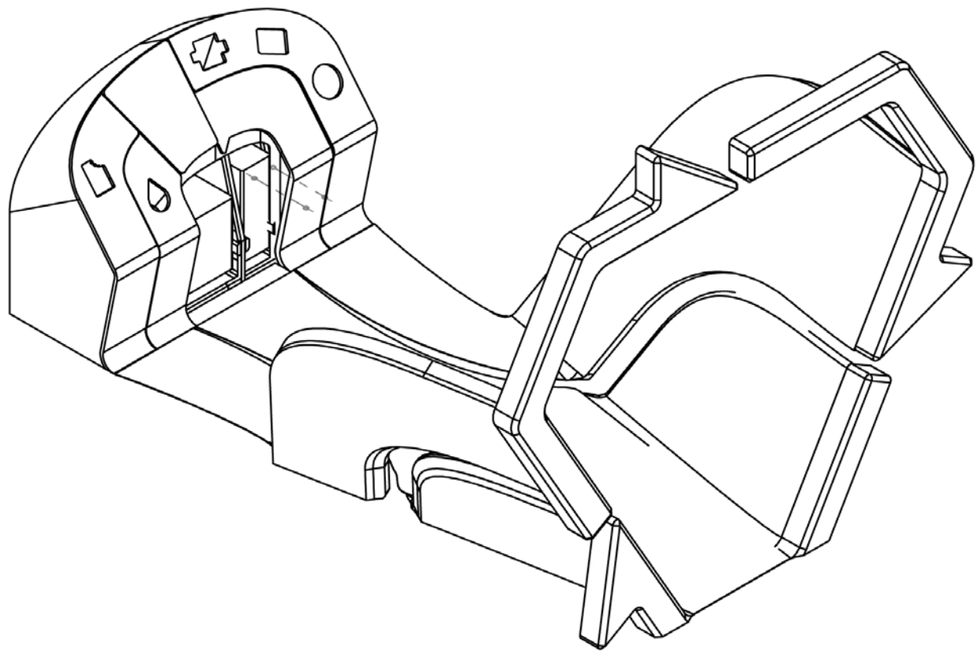
4.4.1 Design Refinement

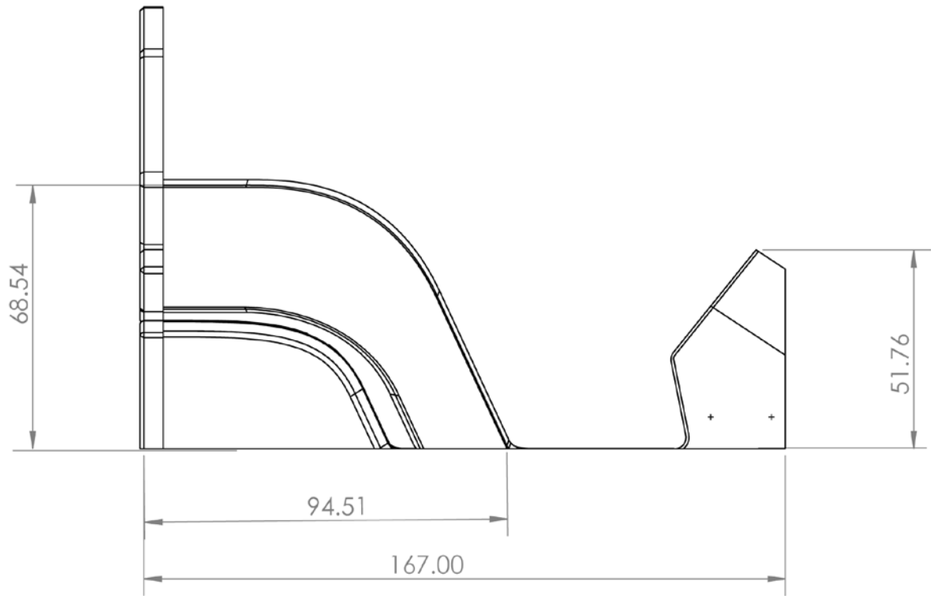


4.4.2 Detail Development





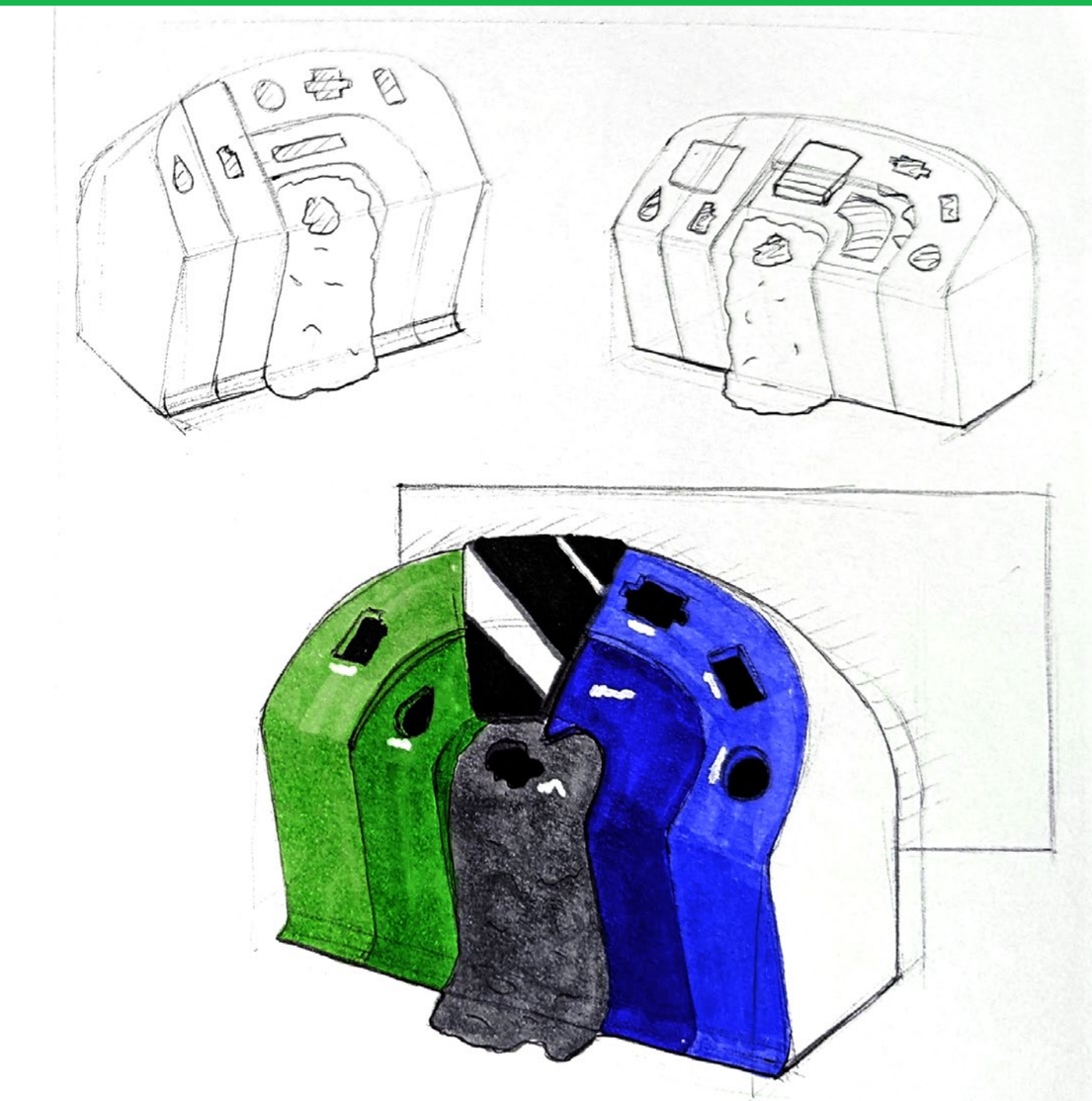




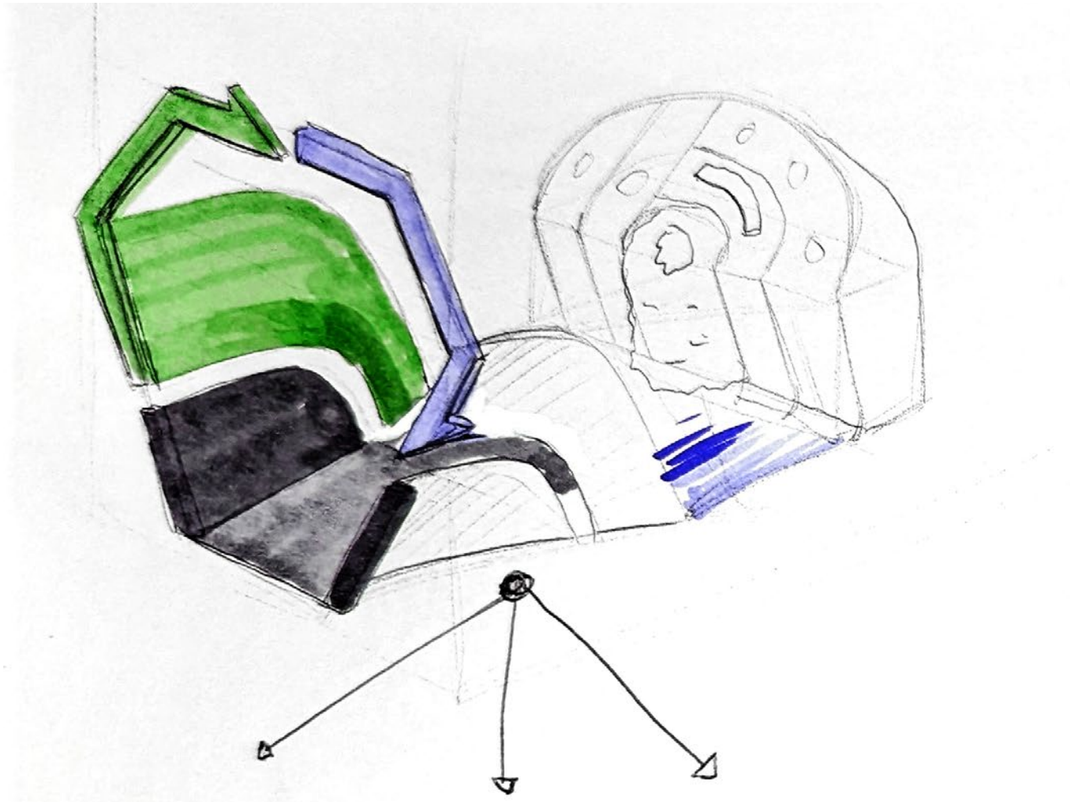
4.4.3 Refined Product Schematic & Key Ergonomic

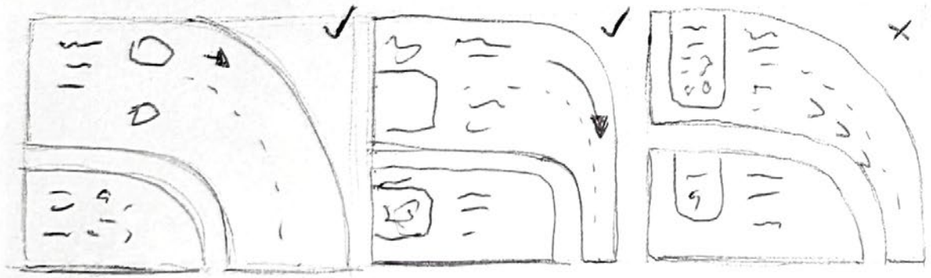
4.5.1 Design Finalization

Finalizing the design is all about the polish, not literally polishing any surfaces but more figuratively bringing all the details together and making it feel like a cohesive well thought out system. All elements of the design have to not only look and feel like they're part of the same system aesthetically, but they also have to function properly with respect to human factors. The f finalized design considers full-body human interaction, general accessibility, sustainable material choices, and overall aims at solving the problem set in chapters 1 - 3.

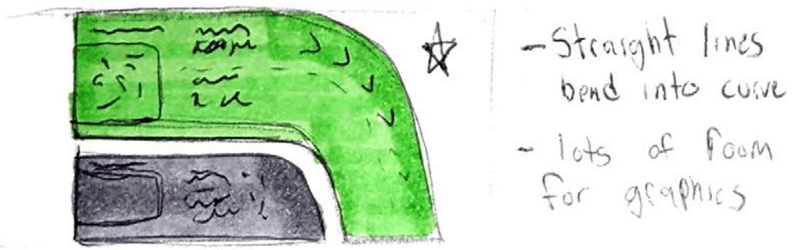


In order to make the user interaction as simple and straightforward as possible dozens of different bin layout combinations were ideated and this was the chosen final Direction the long arching scoops follow the path laid out by the graphic display panels and each one leads directly to the screen which guides users on which hole to put the waste in .

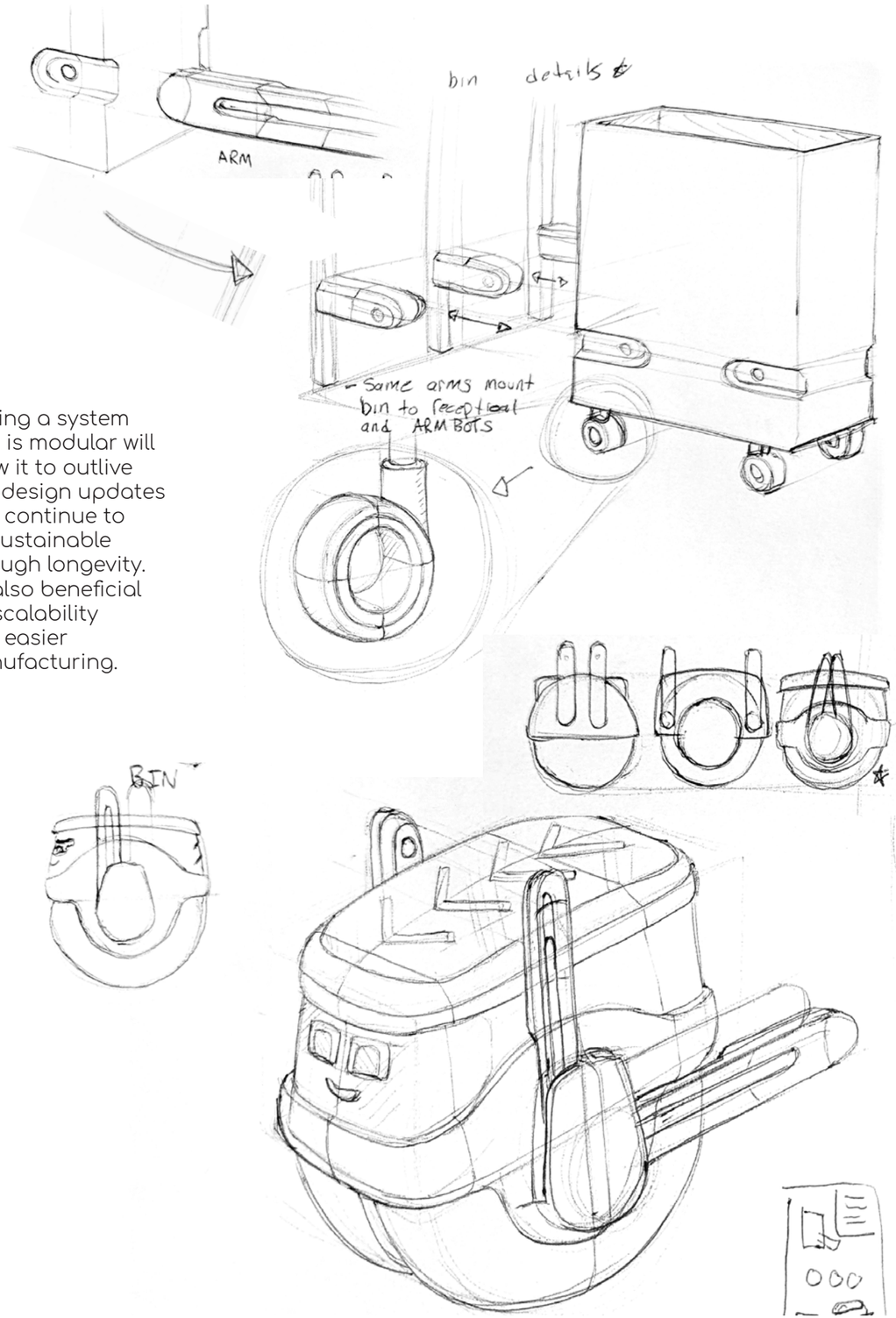


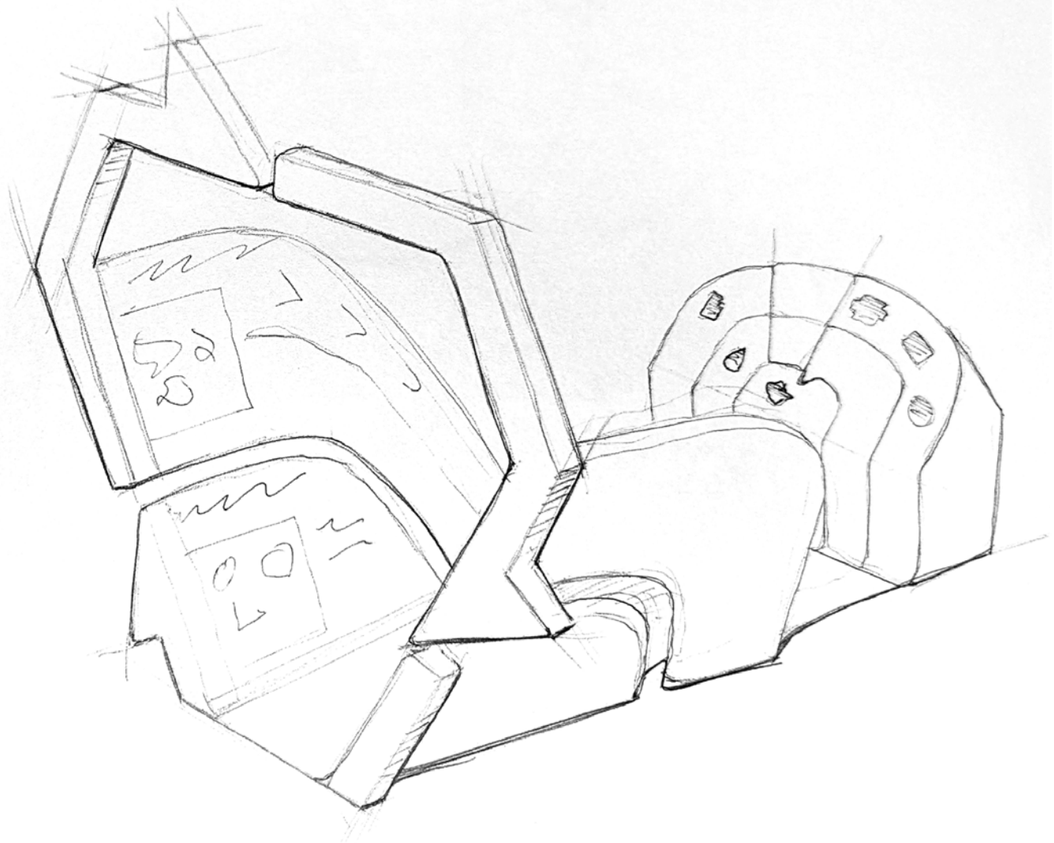


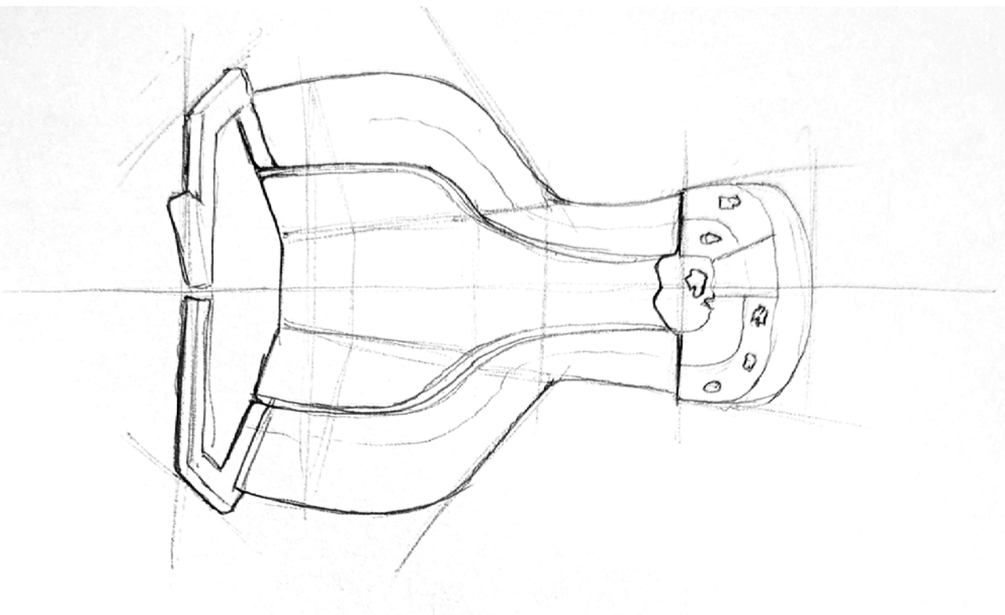
One of the most important parts of this concept is the graphic display that users interact with and that needed to be designed from the ground up as well in order to fit on the swooping screens



Having a system that is modular will allow it to outlive any design updates and continue to be sustainable through longevity. it's also beneficial for scalability and easier manufacturing.

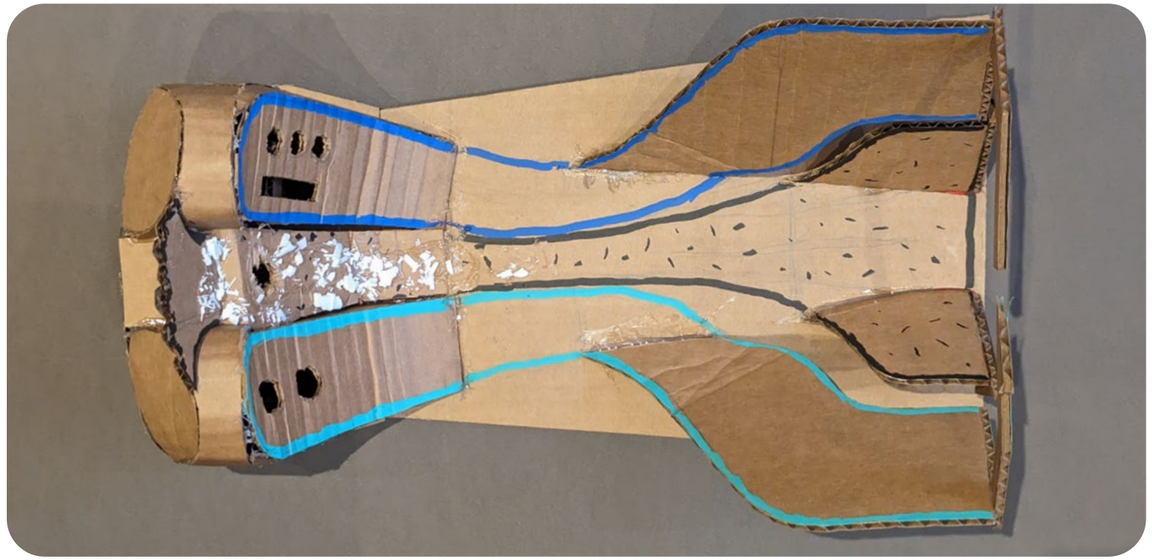


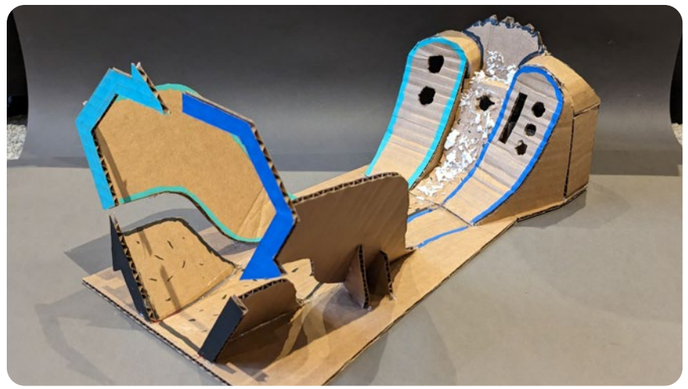


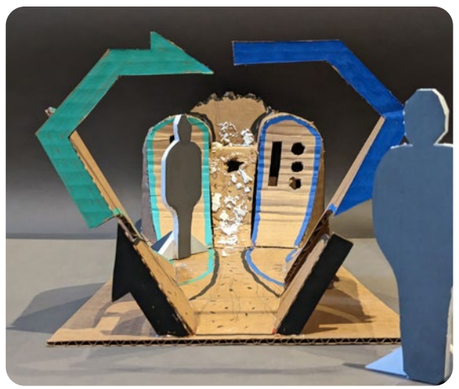


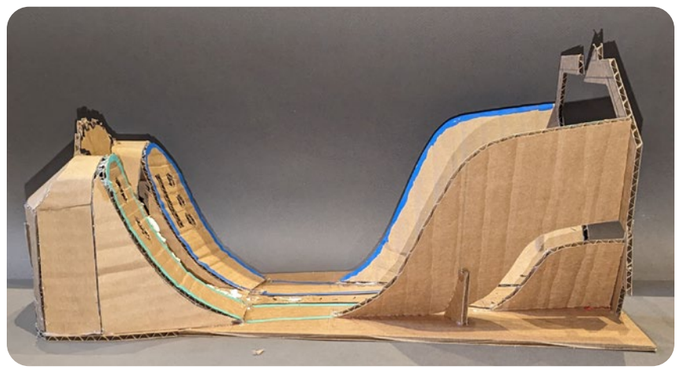
4.5.2 Physical Study Models

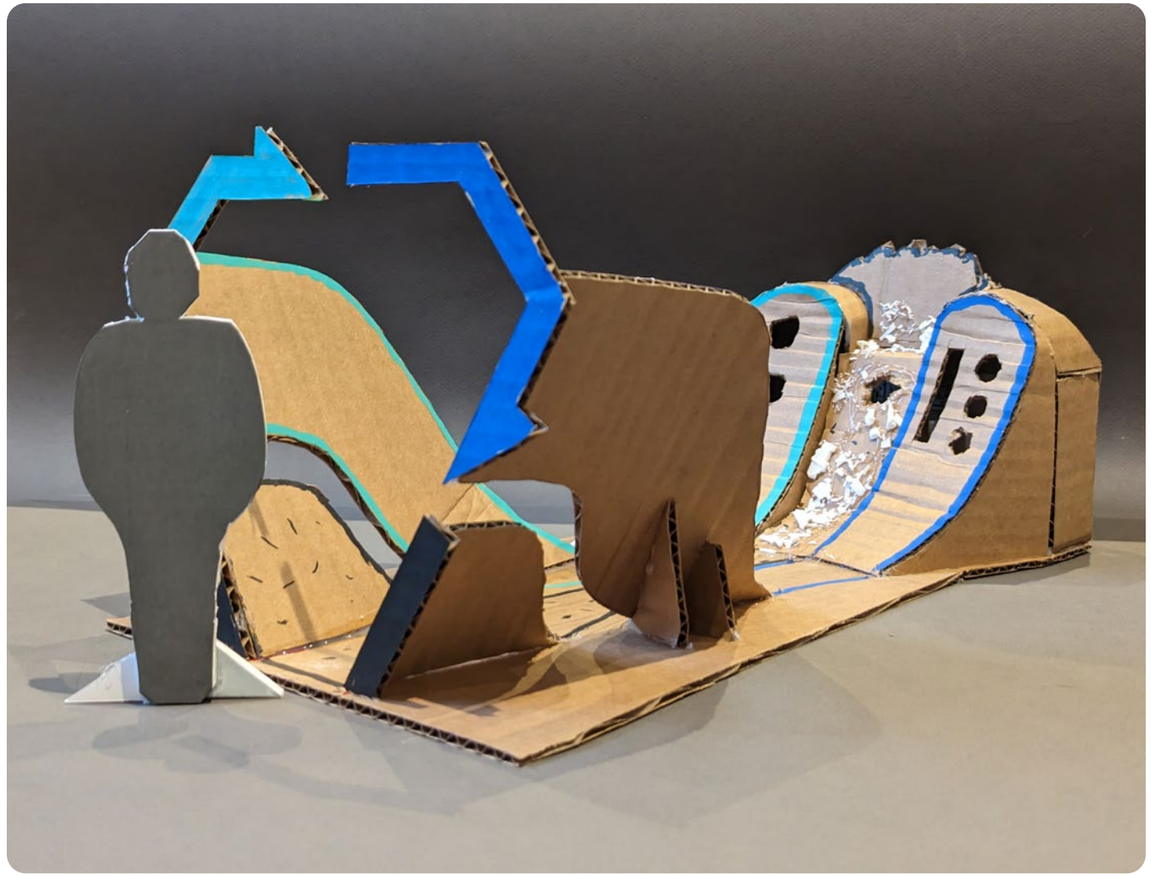
The physical study model was done at an earlier stage of development than the 4.5.1 design finalization and this was to test a lot of the fundamentals of the idea as well as get an accurate sense of scale.

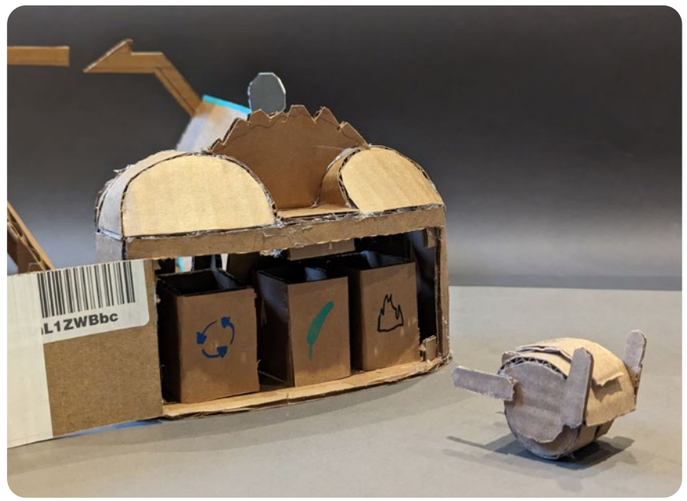


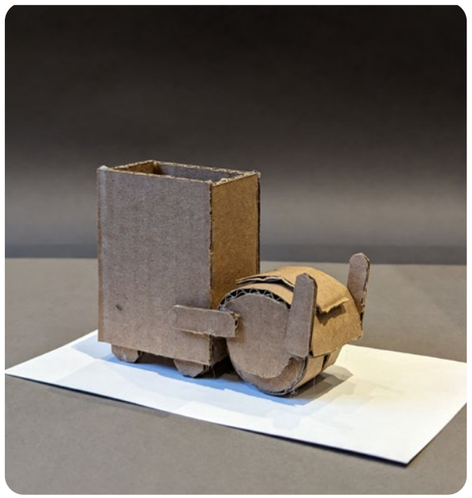












4.6 Design Resolution

Human interaction

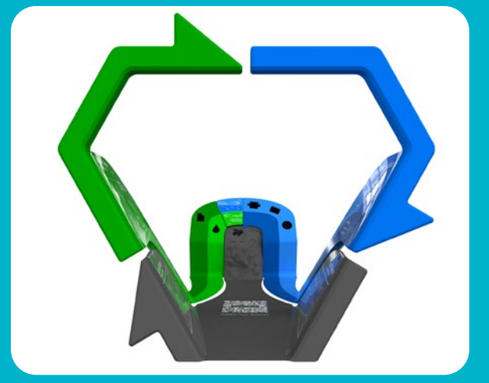
- The main display is physically large enough to accommodate people of all sizes both through the entrance seeing the graphics and interacting with the receptacles.
- The companion app automatically syncs the user's data to the display.
- Janitorial staff no longer have to carry heavy and hazardous waste out of the bins and replace the bags, instead, the autonomous armbots do all the lifting and the bins are bag-less to prevent unnecessary waste.
- The display uses numerous psychological tricks to ensure the user throws the waste into the proper receptacle. (Sound dampening barrier near the graphics to entice users to read, visual arrows blinking towards the path, a light Illuminating around the proper hole, a screen on the bin with another arrow pointing at the correct hole, an auditory feedback upon throwing out the object, points awarded in the app)

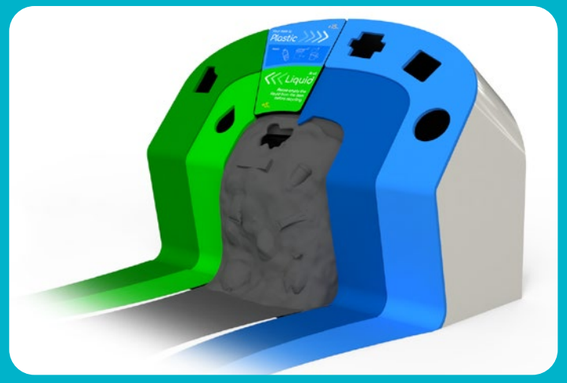
Functionality

- Upon entering the display
  - The user's phone will automatically be synced if they have the app installed (if they don't they will be prompted to install the app).
  - The Main display entrance contains screens that display graphics data and information to simultaneously guide the users to the right bin and educate them.
  - When the user's app is synced the screens will stop displaying the standard educational statistics and start displaying the users specific data with encouraging messages.
- The whole building is connected through a system that allows the bins to communicate with the autonomous armbots, this means that whenever it been is reaching its maximum capacity the armbots will be dispatched to replace the full bin with a clean one.
- Once the bin is picked up it will be bringing to the compactor where it will be emptied and then brought to the storage unit where it will be cleaned and stored until needed.

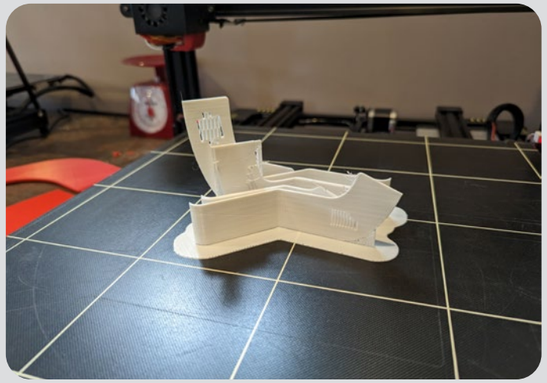
Aesthetic Approach

- All elements of the system are based on the same aesthetic profile, soft curves and straight lines, bright colours and clean neutrals, the overall vibe is friendly but professional.
- All elements of the concept are made from sustainable sourced materials
  - The main unit is constructed based on an aluminum frame with hemp-based structural paneling and a recycled textile sound dampening barrier.
  - The armbot's frame and body are also made from aluminum
  - All other visual components are made from recycled plastic.

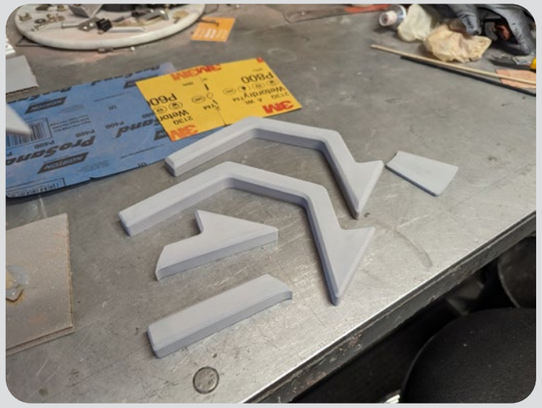




4.8 Physical Model Fabrication



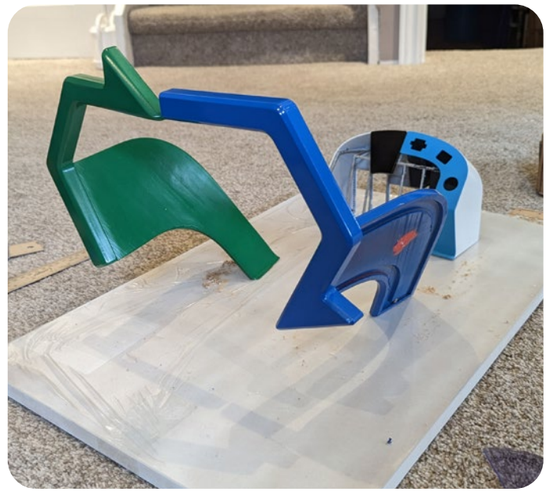
All parts were modeled in CAD and 3D Printed at 1:10th scale. The exhibit was printed in PLA and the bot was made of resin.

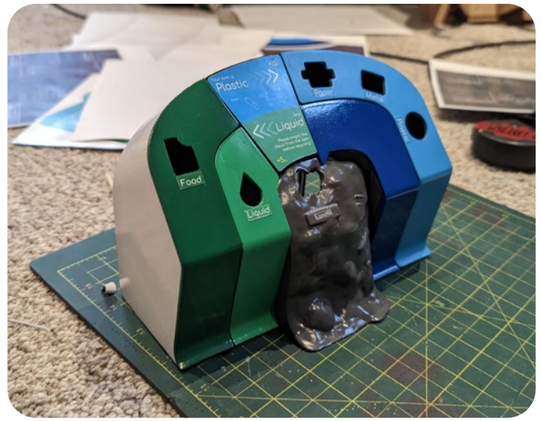


Once all parts were printed they were filled and sanded a number of times with body filler, filler primer, and glazing putty.

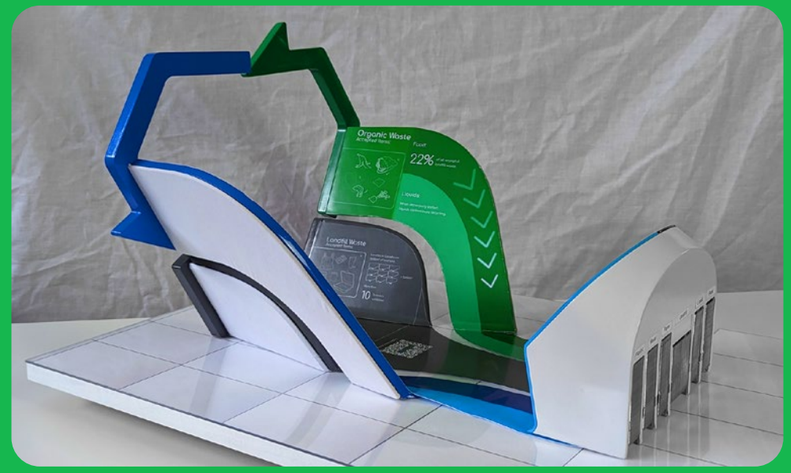
After the finish was nice and smooth the parts were all individually spray painted.

Graphics were printed on glossy sticker paper and attached where needed.



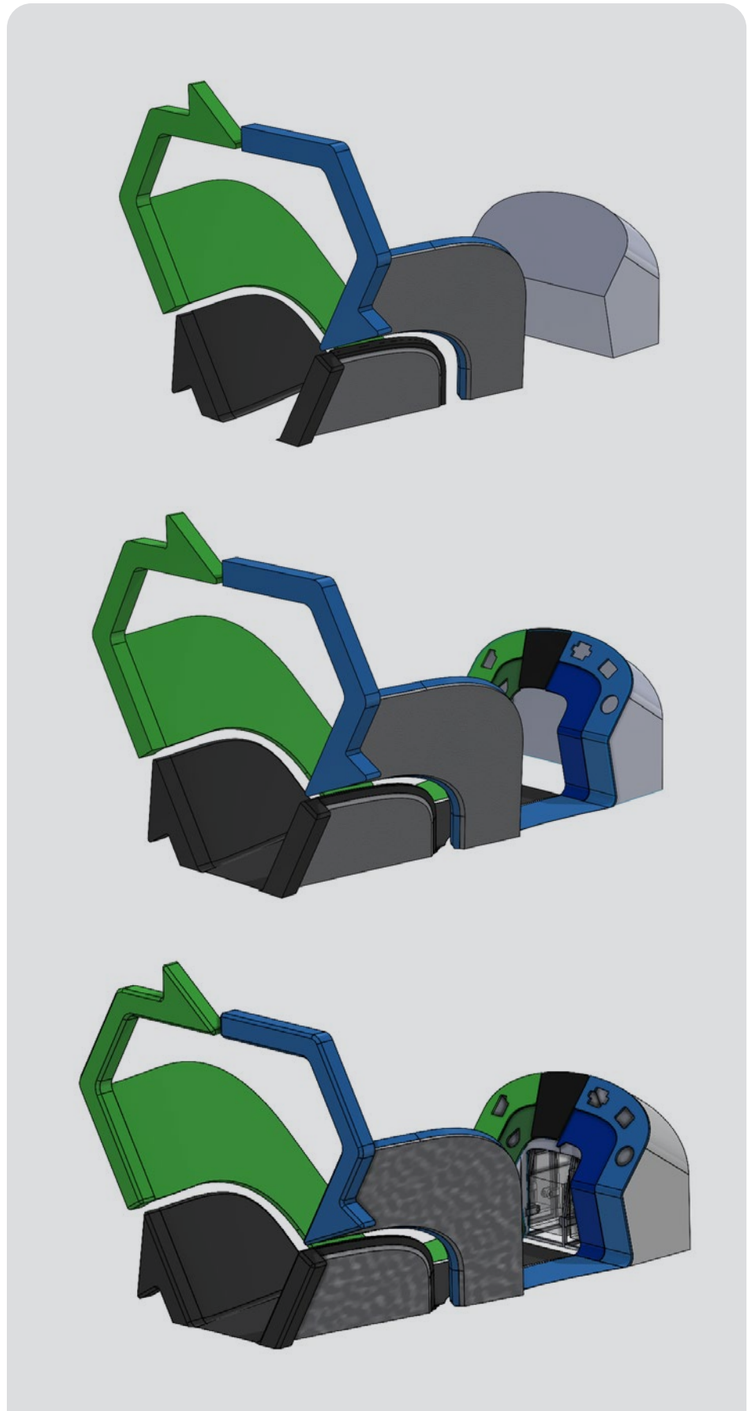


Final assembly was completed leaving the finished model above.

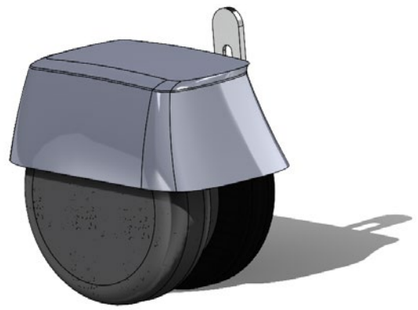


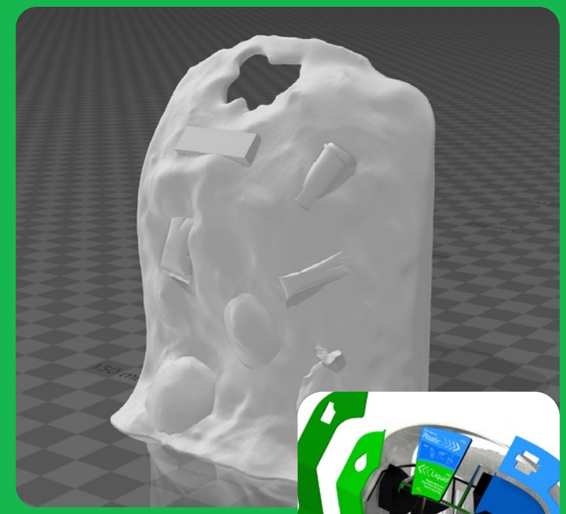
4.7 CAD Development

During the 3D CAD modeling and development phase of this project, several key outcomes and learnings were discovered that will inform the design decisions and finalization of the product. Through the development of accurate and detailed 3D models, it was possible to test and refine the design to ensure optimal functionality. Additionally, the use of CAD software allowed for easy and consistent scale and and ergonomic factors. Overall, this process has resulted in a more efficient and effective development process, leading to a higher quality and more successful final product.

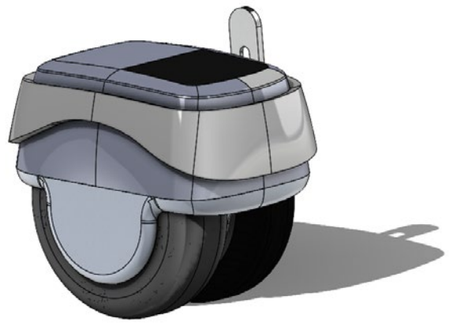


The modelling process for the main exhibit consisted of blocking out large General shapes and then cutting away and adding in specific shapes and details in order to get the desired finished look.

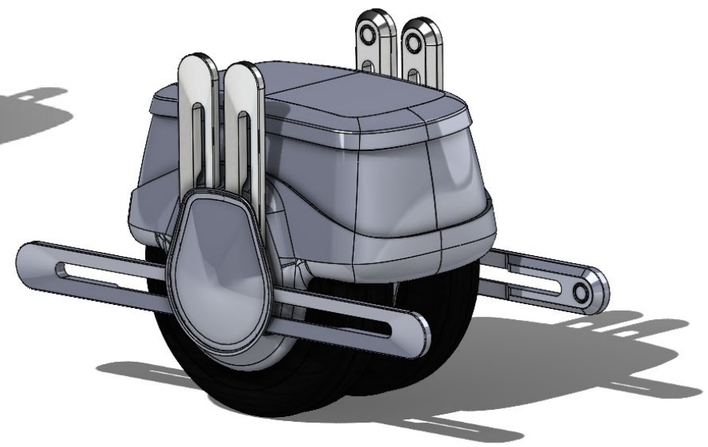




The pile of garbage in the center of the bin cluster Was a unique feature and due to its organic lumpy appearance could not be modeled in SolidWorks like the rest of the model. due to this, it was modeled in a combination of VR Gravity Sketch as well as using Meshmixer to add in details and chunks of trash.



The development process for the arm bots was relatively similar to that of the exhibit slowly blocking out General shapes and then cutting and extruding and filleting to add details and precise shapes.



Chapter 5

FINAL DESIGN

5.1 Design Summary

The final design is a highly ergonomic and user-centric waste management system that is designed to reduce the amount of recyclable waste that ends up in landfills from public indoor spaces. It features a system that is clearly labeled, accessible, self guiding and color-coded to make it easy for users to sort their waste. The bins are also designed to be easily removed and exchanged, removing the need for plastic bags and improving the lives of janitorial staff.

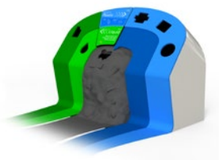
The waste management system has been designed to be highly sustainable, using materials that are both durable, recycled, and recyclable. The bins are made from recycled plastic and are designed to be easily disassembled for recycling at the end of their lifespan.

Overall, the benefits of this waste management system are significant. By making it easy for users to sort their waste, the system helps to reduce the amount of recyclable waste that ends up in landfills, which is better for the environment and encourages a circular material economy. Additionally, the system is highly user-friendly, which improves the overall experience of sorting and recycling solid waste in public spaces. Finally, the system is highly sustainable and cost-effective, which makes it a smart investment for public spaces of all sizes.

5.2 Design Criteria Met

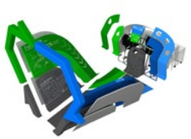
Enhancement of human lifestyle:
This Waste Management product is designed to improve the overall experience of sorting and recycling the solid waste in public spaces. Making the process of waste disposal more efficient has a positive impact on the daily lives of users, making it more convenient for them to recycle and reducing the amount of waste that ends up in landfills.

Ergonomics and human factors:
Waste-way was designed with ergonomics and human factors in mind, meaning how people interact with the product and how it affects their physical and cognitive behaviour were considered in every aspect of the design. The intention is to reduce the physical strain on users, making it easier for them to sort and dispose of waste, while also considering the psychological factors influencing how people approach recycling.

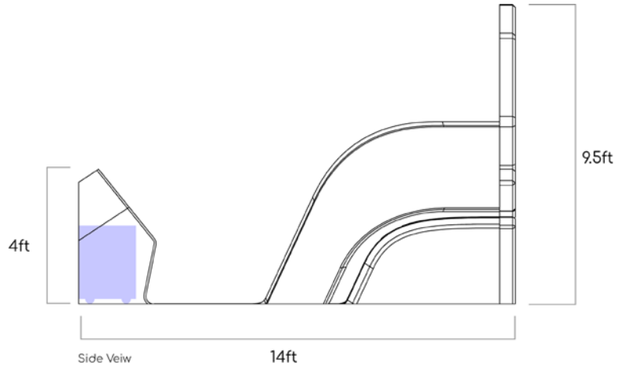


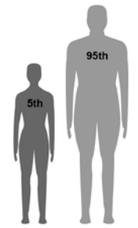
Sustainability and social responsibility:
Waste-way seeks to reduce the environmental impact of waste disposal while promoting social and economic benefits. Reducing the amount of recyclable waste that ends up in landfills helps to conserve natural resources and reduce greenhouse gas emissions.

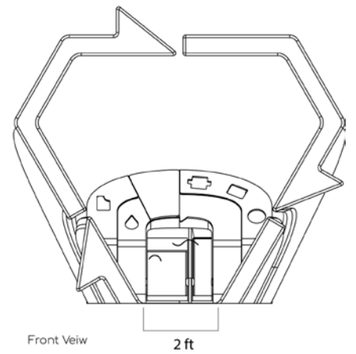
Human Interaction and User-centric Design:
The design of the product is tailored to the needs and preferences of users. The goal was to create a positive user experience and to make waste disposal more intuitive and enjoyable. Waste-way is user-friendly, with clear signage and instructions, as well as interactive features that make it more engaging for users.

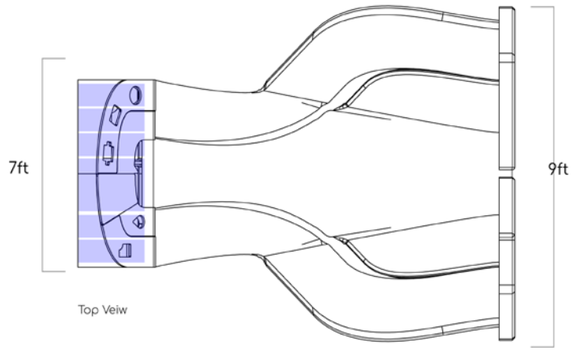


5.2.1 Full Bodied Interaction Design

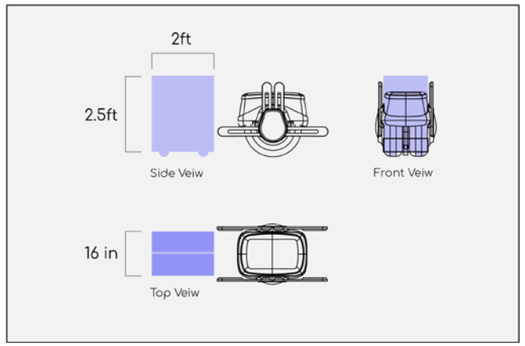








Bin/Drone Schematic



5.2.2. Materials, Processes and Technology

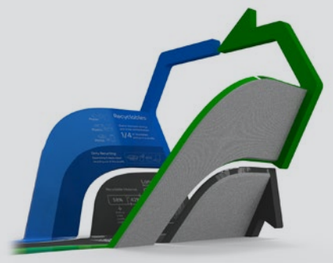
The final design solution was carefully crafted to utilize sustainable materials and manufacturing processes. The main materials used are recycled and recyclable helping the product commit to cyclical recycling and a circular economy in two ways. The three main chosen materials are: hemp based panels, aluminum, and Recycled PET.

The majority of the large display was built from hemp-based panels, a highly sustainable material with a low carbon footprint. Overall, the material and manufacturing process selection for this final design adheres to a sustainable and environmentally conscious approach, minimizing its impact on the environment while still maintaining durability and functionality. When the product has lived its full life and is ready for decommission the panels are easily removed and can be composted or recycled further.

The structural frames for all parts were constructed out of aluminum, which is known for its lightweight and sturdy properties. What its more well known for is its infinite recyclability, meaning it can be melted down over and over without loosing strength. These properties not only make the product easy to transport but also ensures that it can hold strong for as long as its needed to..

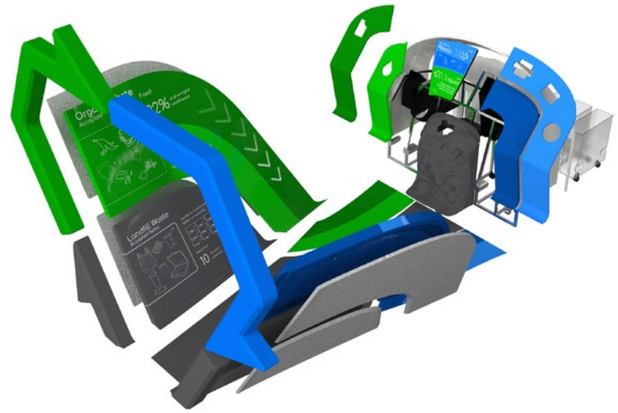
Recycled PET was chosen as the main material for the Armbots and bins, as it is highly durable and can withstand frequent use. Additionally, PET is highly recyclable and used in countless products from water-bottles to packaging material, making it an ideal choice for a project focused on sustainability.

The final most abundant material is the Recycled textiles used to make the sound dampening barriers on the outside of the swoops. It's made from recycled clothing and fabrics giving these materials a second life they previously would not have been able to obtain.

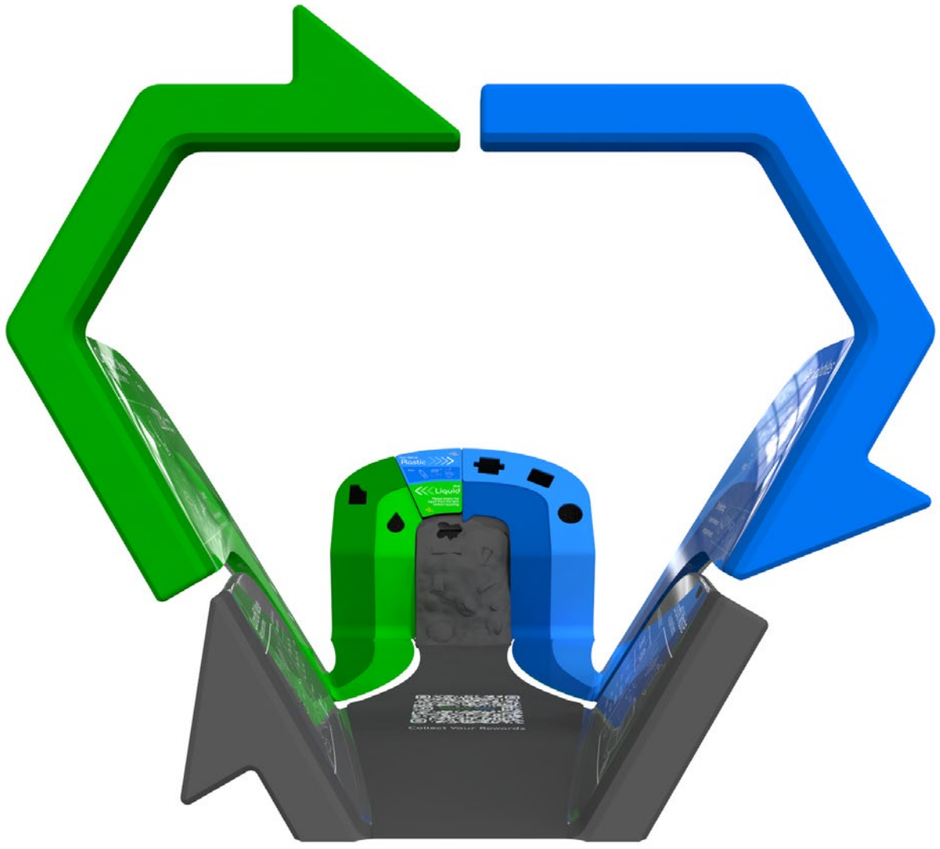


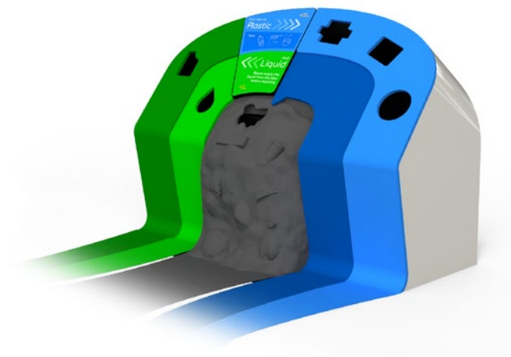
5.2.3 Design Implementation

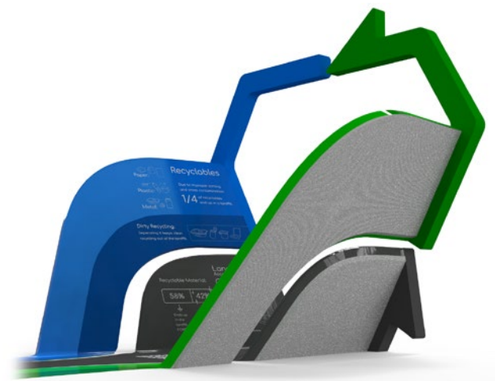
Qty	Description	Material
2	Entrance top arrow	Hemp panel
1	Landfill arrow point	Hemp panel
1	Landfill arrow tail	Hemp panel
2	Sound dampening sheet large	Recycled textiles
2	Sound dampening sheet small	Recycled textiles
1	Swoop housing large L	Hemp panel
1	Swoop housing large R	Hemp panel
1	Swoop housing small L	Hemp panel
1	Swoop housing small R	Hemp panel
5	Screens	. . .
1	Exhibit frame	Aluminum
1	Bin frame	Aluminum
5	Thin bins	Recycled PET
1	Thick bin	Recycled PET
1	Bin main body	Hemp panel
1	Food face	Hemp panel
1	Liquid face	Hemp panel
1	Recycling face	Hemp panel
1	Dirty recycling face	Hemp panel
1	Landfill bin	Recycled PET
5	Bin chutes for waste	Recycled PET
1	Floor stickers	Recyclable sticker
1	Bot internals	. . .
1	Bot frame	Aluminum
1	Bot housing	Recycled PET
4	Bot arms	Aluminum

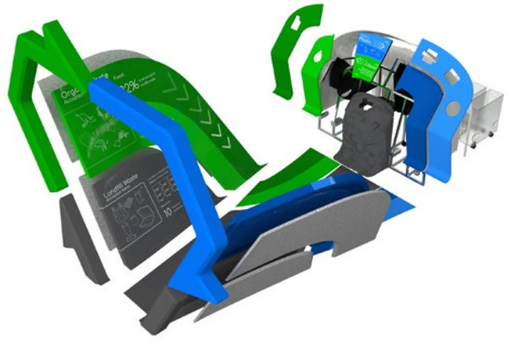


5.3 Final CAD Rendering

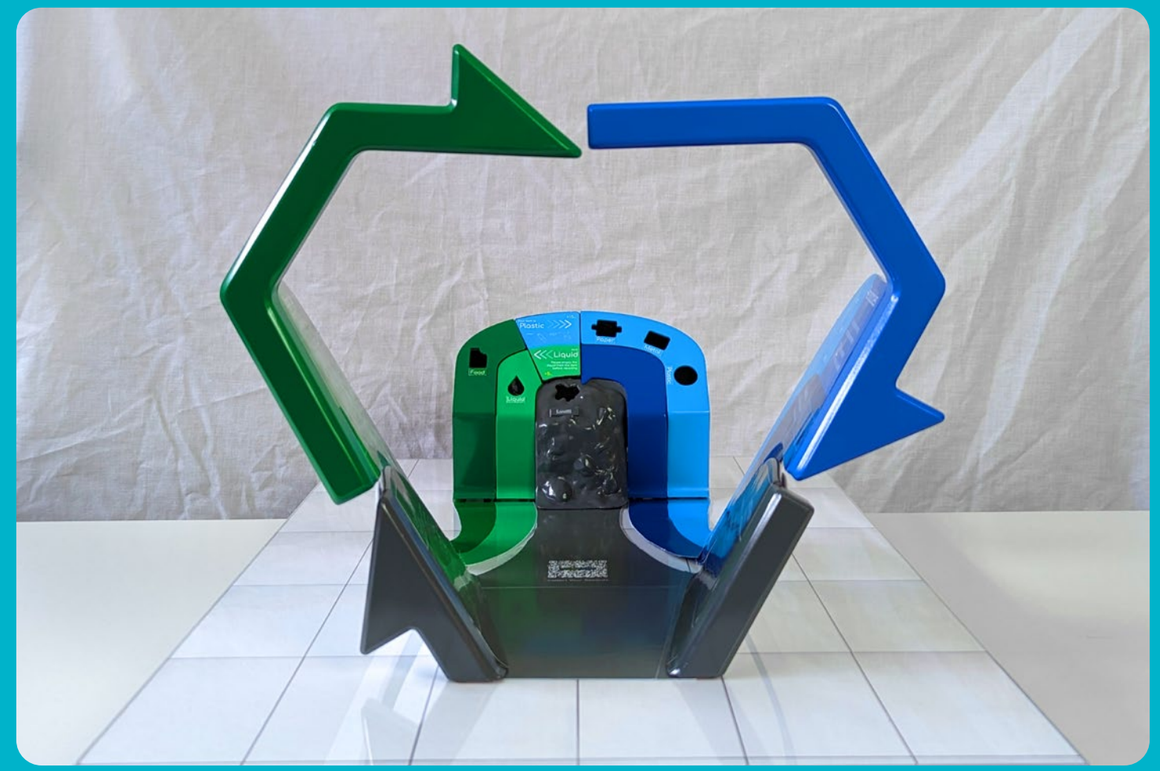


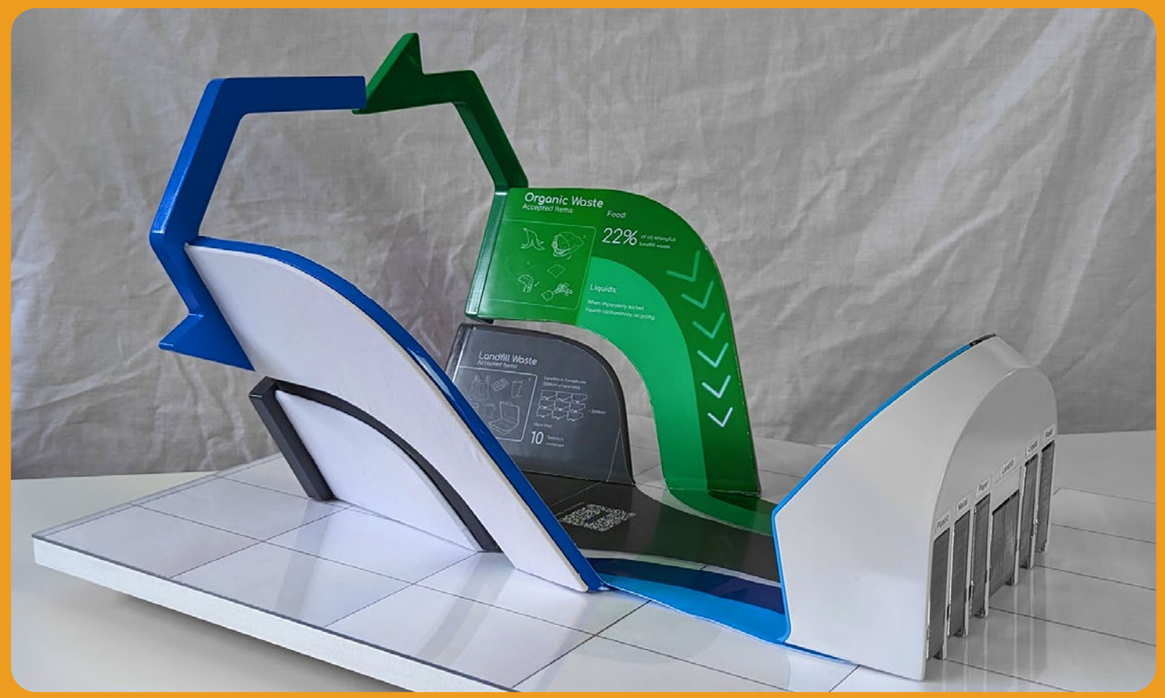




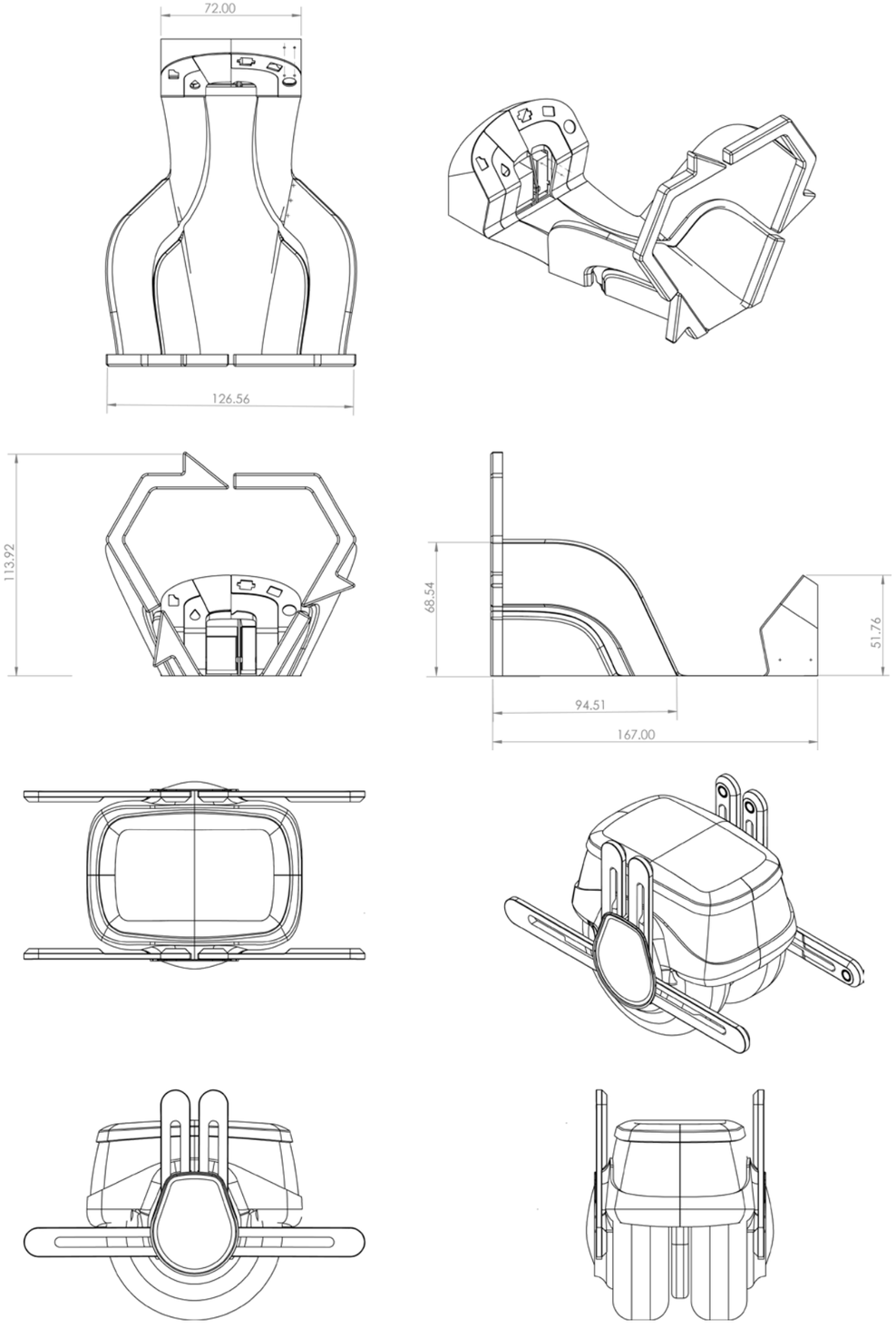


5.4 Physical Model





5.5 Technical Drawings



5.6 Sustainability

This project is first and foremost a sustainability project, the overall goal is to improve the effectiveness of recycling and composting while simultaneously reducing unnecessary and wrongful landfill waste in public spaces.

Materials:

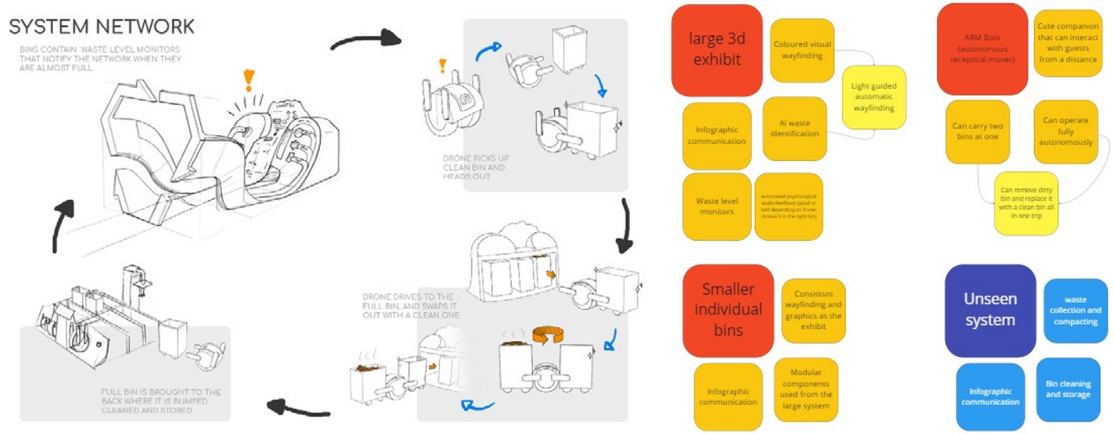
The large wayfinding 3D element and the housing for the bins are made from a sturdy aluminum frame with hemp-based bio panels as a more sustainable alternative to plywood and that would be covered with a graphic wood-based adhesive sheet on the inside and a tightly woven cotton acoustic panel on the outside. The actual bins that hold the waist will be made out of 100% recycled plastic. As for the ARM-bots, they have an aluminum frame with recycled plastic panelling and are designed in a way to be easy to disassemble and break down into recyclable parts.

Business model:

As previously mentioned the system's goal is to teach users how to properly recycle and compost waste. it does this through an exhibit-style walk-through feature that visually graphically and automatically guides users to the correct bin to dispose of whatever waste they may be holding. this is done through clever psychological tricks as well as visual graphic wayfinding and lastly through a smart system that can identify what item the user is holding and light up a path to the corresponding hole that the team goes in. This interaction exhibit contains three categories of waste disposal: (compost landfill and recycling) which are further broken down into solid organics, liquid organics, landfill dirty recycling, paper, plastic, and metal. All these bins help to ensure that there's no cross-contamination that would result in recyclable or compostable objects ending up in the landfill bin. Once an individual bin is almost full the system sends a signal to the ARM bots to come and exchange the full bin for a clean one. These bins are able to avoid the use of a plastic bag through The use of a complimentary pressure washing nozzle that removes all internal contamination once the bin has been emptied into its respective compactor.

Network:

All of the previously mentioned stages of the business model can be seen in the diagram below and they all add up to a system that is designed with the express purpose of ensuring proper waste organization and Disposal through A rework of the existing indoor cells with a solid waste management system as well as modifying the users' interaction with solid waste disposal at the source.



Chapter 6

CONCLUSION

CONCLUSION

Waste-Way is a sustainable solution designed to minimize the amount of recyclable waste that ends up in landfills. Through eight months of user research, interviews, and benchmarking, this project has been designed to promote shared responsibility in managing solid waste while taking into account the importance of human interaction and user-centric design. This product aims to forge a path to a more sustainable future by providing a practical solution that minimizes the negative impact of solid waste on the environment.

APPENDIX

APPENDIX

REFERENCES
Appendix - A Discovery
Appendix - B Contextual Research (User)
Appendix - C Field Research (Product)
Appendix - D Result Analysis
Appendix - E CAD Development Include CAD images not in main body of content Winter
Appendix - F Physical Model Photograph
Appendix - G Technical Drawings
Appendix - H Bill of Materials Info/Data
Appendix - I Sustainability Info/Data
Appendix - J Approval Forms & Plans
Appendix - K Advisor Meetings &Agreement Forms
Appendix - L Other Supportive Raw Data
Appendix - M Topic Specific Data

References:

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APPENDIX - A Discovery

a thorough research was conducted on the topic and several key articles were sourced and selected. The required content of the articles such as abstract, introduction, and conclusion sections were carefully reviewed and highlighted to extract the relevant information. This allowed for a comprehensive understanding of the topic and helped in making informed decisions regarding the design and development of the final product.

Objective
To perform a fast, preliminary search on a possible thesis topic.

Thesis Topic
How may we improve solid waste management in shopping centers?

Background:
The main problem with traditional waste management in buildings Is flawed in the way that they sort and organize the waste. They usually have smaller accessible trash bins throughout the building that consumers manually place their garbage into. These are usually sorted into 'recycling' 'compost' and 'garbage' but there are many variations on this. The fact that there is no standard organization as well as some products containing multiple materials leads to confusion and often disregard of the sorting system by the consumer. If this problem was solved it would lead to less waste going into landfills.

Needs Statement:
The primary user would be the individual who is throwing out their waste. The secondary user would be the individual(s) who collect the garbage and bring it to larger waste receptacles. The tertiary user in this case could be the waste collection/ management company or the retail establishment owners.

How is this need being addressed currently?
This problem is currently being addressed by a system of collection receptacles. Thes smaller bins are dispersed around the property and collected by a staff member who compiles the garbage into the bags in a cart and then brings all the waste to the appropriate larger outdoor dumpster.

Step 1: Topic Area Inquiry

Search #1: Scholarly search (peer-reviewed)

Search Engine: Humber Library

Keywords Used in Search: "review retail mall waste management"

APA Citation:
Baharum, & Pitt, M. (2010). Retail shopping centre recycling initiatives. Journal of Retail & Leisure Property, 9(3), 201–210. https://doi.org/10.1057/rlp.2010.10

Abstract
There is growing pressure on retailing businesses to act responsibly and comprehensively to manage their waste in a sustainable way. In addition, the practical importance of meeting waste directives and environmental credentials has made most businesses value facilities management services to business. Despite Fuller's and Pitt's observations concerning shopping centre waste management trends, little attempt has been made to investigate the existing solid waste recycling from the UK shopping centre sector. Most previous research on waste minimisation through recycling relates to municipal buildings, commercial office buildings, medical facilities, hotels, educational buildings and industrial buildings. Few studies from other sectors have developed critical success factors (CSFs) for waste management and recycling initiatives. Therefore, this article sets out to identify those primary factors that are considered to be of critical importance to the successful implementation of recycling initiatives in UK retail shopping centres. The article establishes how these factors can be determined and validated in accordance with current perspectives. This article reviews the relative importance of CSFs associated with shopping centres solid waste recycling initiatives in the United Kingdom. By doing so, factoring analysis is used to classify a relatively small number of factor groupings that can be used to represent the relationship among a set of many interrelated variables. This technique is significant to explore the groupings that might exist among the CSFs with regard to UK retail shopping centre solid waste recycling initiatives. [PUBLICATION ABSTRACT]

Introduction
Experience suggests that sustainability derives its greatest power and affects organisations when it is deeply embraced as a set of core values that genuinely integrate economic prosperity, environmental stewardship and social responsibility: profit, planet and people. The etiquette towards sustainable solid waste management and recycling becomes a necessary part in every business (Agenda21, 1992; DETR, 1999; DETR, 2000; DEFRA, 2008), so as to enable the realisation of financial saving and competitiveness (Envirowise, 1998; Phillips et al , 2006). The earlier over-reliance on landfill has also caused many countries to face shortages of landfill sites. Throughout Europe and the United States, there is an over-reliance on the disposing of waste to landfill. However, in many developing countries, conditions for waste disposal are still basic.
Whereas waste disposal creates the potential causes of various negative impacts on health and the environment, including emissions to air, surface water and groundwater, however, it is entirely dependant on how it is managed. For Henstock (1976), the value of waste is both economic and social. He describes the value of waste should depend entirely on its ability to be recycled. Hence, managing waste in a sustainable way, optimising recycling and limiting the generation of waste materials forms a core part of the UK government policy to protect the environment.

CONCLUSIONS
Recycling initiatives from the shopping centre sector has been reviewed to identify the research problems and gaps. Recycling techniques are expected to lead to cost improvements in service efficiency and performance levels. Having highlighted the challenges and issues that face FMs in the course of managing solid waste recycling initiatives, and delivering the services, the principal factors identified are seen as indicators to the existing problems. Perhaps this could subsequently lead to FM

knowledge in recycling innovation (Baharum and Pitt, 2009) and improved services interaction between shopping centre establishments, service providers and their recycling partners. Perhaps this will facilitate the efficiency of this service operation and may overcome the shortcomings in meeting the waste framework directive expectations.

Summary
1. There is lots of research on solid waste management effects in other types of buildings, these articles would share potentially important insights into this topic as well
2. Companies that are environmentally conscious and embrace sustainability as one of their core values are the most significant contributors to positive environmental change
3. Landfills are overused and relied too heavily upon, there are ways to solve the waste management issues without as many or as big landfills
4. Landfill over usage could be reduced at the source in these large buildings with better organization
5. Waste has social and environmental value depending on its ability to be recycled

Search #1: Secular search (non-peer reviewed)

Search Engine: Google

Keywords Used in Search: "review retail mall waste management"

APA Citation:
Reporter, S. (2021, September 10). How can malls, retailers improve waste management? Singapore business review. Retrieved September 10, 2022, from https://sbr.com.sg/retail/news/how-can-malls-retailers-improve-waste-management

Article:
How can malls, retailers improve waste management? Lendlease and WWF-Singapore recommend using technology and encouraging wider participation of customers and tenants.
Mall operators should take advantage of technology for better waste management and encourage the participation of tenants and customers in reducing wastes, according to a study by Lendlease and World Wide Fund for Nature-Singapore.
Lack of data on waste and reduction targets is the key barrier in improving waste reduction, they said.
The Circularity in Retail: Tackling the Waste Problem Report also analysed waste data from three of Lendlease retail malls in Singapore between 2019 and 2020, and waste data collected by an automated waste data QR code system at Paya Lebar Quarter in 2020, finding their average recycling rate at almost 29%, 2.5 times more than Singapore's average recycling rate of 11.4%. It is driven by efficient waste segregation, waste data monitoring, and clear communication of waste management obligations to tenants, they said.
The study found that malls should leverage technology to improve waste management and segregation practices in malls, by digitising waste collection data to trace waste generated by retail category, allowing them to set measurable targets.
Join Singapore Business Review community. It also said that installing food waste monitoring systems for food and beverage (F&B) tenants to digitally measure and monitor wastes going into the bins during the preparation of food can also help reduce food waste.
The study also recommended the installation of bin level monitors to give more time for housekeeping staff to support recycling efforts, electric trolleys for door-to-door collection to make "recyclables less strenuous" and sink grinders to process food waste.
Mall operators also play a critical role in encouraging participation of tenants and customers In waste management initiatives such as encouraging F&B establishment customers to bring their own reusable containers or bags by providing discounts or introducing a points system as a reward for shoppers, they said.

Summary
1. Customers are the most important part because they are responsible for purchasing disposing of and sorting of the solid waste
2. Collecting data on where waste comes from and how it's sorted is imperative to prevent the unnecessary buildup of landfill waste
3. Caretaker improvements
4. Bin level monitors help mitigate wasted time by the caretaking staff, letting them know when to empty out the bins at an optimal time instead of them needing to check on a regular schedule.
5. Electric trolleys help caretakers reduce the amount of physical labour and stresses of moving all that weight around my hand
6. Another factor to this could potentially come in the form of a system to assist in lifting and moving the bags of waste
7. Clear communication of waste management strategies, good waste segregation, and data collection are all factors that increase the recycling rates and the efficacy of waste management

Step 2: Major Challenges / Issues

Search #1: Scholarly search (peer-reviewed)

Search Engine: Google Scholar

Keywords Used in Search: "issues in retail mall waste management"

APA Citation:
Pitt, Michael. (2005). Trends in shopping centre waste management. Facilities. 23. 522-533. 10.1108/02632770510618480.

Abstract:
Purpose
The paper is intended to examine the performance of a group of UK shopping centres in regard to waste production and disposal over periods of two, three and four years.
Design/methodology/approach
The method adopted is the collection and analysis of data relating to waste production and disposal. The data was collected by and obtained from individual

shopping centres before analysis.
Findings
The sector as a whole did not show a decreasing level of waste production although some individual centres did perform well. In general, as one might expect, the more professional the approach to waste management, the better were the results.
Research limitations/implications
More data was available for the shorter periods analysed as many centres have only just started recording waste data. The project could be usefully revisited in five years.
Practical implications
The paper shows that investing in waste management does produce positive results. The effect of the landfill tax is not certain but additional incentives may be necessary to drive an industry wide improvement.
Originality/value
The paper represents a new and an independent review of performance in the shopping centre sector.

(Full PDF was requested for more information from author)

Summary:
1. some conters can do well individually, unless the solution is available system wide the overall sector wont improve as quickly
2. The more organized, professional, straight forward, and thoughtful the waste management solution is the better the results will be
3. Investing in waste management yields positive results seen in the decrease of the output of landfill waste.
4. Landfil tax is a factor but weather or not itis confirmed to be effective is up for debate.
5. Other methods could very likely do better than this at solving the problem of reducing landfil waste.
6. This tax means that large wealthy companies could theoretically pollute all the want as they have the funds to pay the tax off, but smaller businesses have to invest in better waste management as it may be harder for them to pay off the taxes

Search #2: Scholarly search (peer-reviewed)

Search Engine: Google

Keywords Used in Search: "review retail mall waste management"

APA Citation:
Didier, B. (2015, June). Understanding waste management: Policy challenges and opportunities: Think tank: European parliament. Think Tank | European Parliament. Retrieved September 18, 2022, from https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2015)559493

Article:
Five tonnes of waste per capita are generated every year in the European Union (EU), mostly from the construction and mining sectors, with municipal waste accounting for roughly 10% of the total. Although wide differences remain between Member States, recent trends in the treatment of municipal waste show a shift away from landfilling and an increase in the proportion of waste recycled. Management of waste can have adverse effects on the environment, climate and human health.
EU waste policy is built on a thematic strategy, a series of overarching directives, legal acts applying to specific waste streams, legal acts on specific installations, and implementing acts defining when specific materials leave the waste regime after treatment. Various targets set out in EU legislation (in particular as regards recycling of houshold waste and landfilling of biodegradable waste) are being implemented at varying speed across Member States, regions and municipalities. Regional and local policies have a significant influence on waste recycling rates. Despite this legislation, illegal waste shipments remain a concern.
Waste management requires facing a number of challenging issues, for instance, balancing objectives between promoting recycling and protecting consumers against harmful chemical substances in recycled materials; insufficient data collection; quality aspects related to recycling; energy recovery of waste; and waste prevention. The opportunities relate mainly to a shift towards a more circular economy, with benefits for the environment and human health, as well as the economy. The European Parliament has consistently called for policies in line with the hierarch of waste prevention and management options, and moving towards a more circular economy.

Summary:
1. Most waste is generated by construction and mining projects
2. 10% of the total waste generated each year comes from Municipal waste management
3. Poor waste management can negatively effect the health and well being of human, climate and environmental health.
4. Theres lots of factors that challenge the waste management sector
5. Promoting recycling
6. Protecting consumers against harmful chemical substances
7. Insufficient data collection
8. Quality aspects related to recycling
9. Energy recovery of waste
10. Waste prevention

Possible thesis focus:
1. Waste data collection
2. Bin monitors
3. Recyclability
4. Landfil waste
5. Promoting proper waste management and recycling
6. Incentives to companies and customers
7. Ensuring propper sorting and efficacy of recyclability
8. Communication and ease of use for janitors/caretakers
9. Efficiency and ease of use for consumers/shoppers

Interviews:

Claudia Marsales - Senior Manager, Waste & Environmental Management

Communicated via email and Zoom
Shared knowledge on waste management based on 30+ years of experience

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022 & WINTER 2023

INFORMATION LETTER

Conditions of Participation

- ✔ I understand that I am free to withdraw from the study at any time without any consequences.
- ✔ I understand that my participation in this study is confidential. (i.e. the researcher will know but will not disclose my identity)
- ✔ My identity will be masked.
- ✔ I understand that the data from this study may be published.

☑ **I have read the information presented above and I understand this agreement. I voluntarily agree to take part in this study.**

Claudia Marsales		November 7, 2022
Participant's Name	Participant's Signature	Date

Project Information

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: 289-338-1978

Email: Thomas.ferreira@gmail.com

My supervisor is:

Prof. Catherine Chong, **catherine.chong@humber.ca**

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022 & WINTER 2023

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: Mitigating solid-waste management in public indoor spaces

Investigator: Thomas Ferreira / 289-338-1978 / Thomasr.ferreira@gmail.com

Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, Claudia Marsales (First Name/Last Name), have carefully read the Information Letter for the project Mitigating solid-waste management in public indoor spaces, led by Thomas Ferreira. A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Thomas Ferreira at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording and note taking on conversations surrounding this topic, and that my name and title may be associated with the information I provide.

Consent for Publication: Add a (X) mark in one of the columns for each activity

ACTIVITY		YES	NO
Publication	I give consent for publication in the Humber Library Digital Repository which is an open access portal available to the public	☑	☐
Review	I give consent for review by the Professor	☑	☐

Privacy

All data gathered is stored anonymously and kept confidential. Only the principle investigator /researcher, « insert student Name here » and Prof. Catherine Chong or Prof. Frederick Matovu may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

I also understand that I may decline or withdraw from participation at any time, without negative consequences.

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca** or « insert student Name /Phone Number /Email Address ».

Verification of having read the Informed Consent Form:

☑ I have read the Informed Consent Form.

My signature below verifies that I have read this document and give consent to the use of the data from questionnaires and interviews in research report, publications (if any) and presentations with the proviso that my identity will not be disclosed. I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Click or tap here to enter text. Claudia Marsales		Click to enter a date. November 7, 2022
Participant's Name	Participant's Signature	Date

Claudia
are ripe for improvement from a design aspect?

Thomas Ferreira
Definitely. Do you mind if I record this video? Just for my own reference? I can delete? Oh, that's fine. Okay, perfect. Thank you. Just because it's easier not to have to take notes. So just a couple housekeeping things. Do you consent to being mentioned in the research? Like with your name and title next to the potential? Yeah, answers to the question about consent. Okay, perfect. And then following the interview, I have just a consent form I'm required to send you. So I can send that your way and get you to sign up for me, that'd be great. Okay, perfect. Let's get started. I don't want to take up too much of your time, I do have a class closer to 12. So it won't be that long of an interview. But to get started, I guess how or why did you get started in this field?

Claudia
Well, so I've worked in waste management for over 30 years, working on initially establishment of landfills in Ontario. And then when blue box recycling started in the 80s, I worked on some of the initial implementation of blue box systems in Ontario, that worked for the city of Markham for 20 years now, actively involved in both public space recycling, zero waste, textile recycling with our we designed a new container for that. So I've been actively involved in diversion initiatives for 30 years. So I have a I have a fairly good understanding of, of the systems.

Thomas Ferreira
Yeah, sure. Out of all those things that you mentioned, which one do you think you spend the most time doing or like is the biggest impact on waste management?

Claudia
Well, it would be the curbside program has the largest impact. And it's, it's interesting, because somebody designed like a little box, and back in the 80s, and said, Why don't we give this little box to people, and they could put their newspapers in, they can put their cans in because initially, it was only like newspaper papers, cans. So the box was actually designed to hold newspapers. And because at the time, the most common item in the household that was very recyclable, was your newspaper, and people got delivered to their homes. 123 in Toronto, possibly four papers. Every day, it's kind of hard to imagine that there was that much newspaper out there. But a Toronto household or a Markham household would get a could get a Toronto Star, a Globe and Mail the national close. I mean, we're talking volumes of newsprint. So that blue box was actually designed to have the folded newspapers in it.

Thomas Ferreira
That's really interesting. I didn't know that. Yeah,

Claudia
that's why it's an open square because people would twined so you'd save your newsprint, you put twine around it, and you could just place it in the blue box. And that's why it was sized in that direction. There was a huge push to recycle newsprint. So now evolving over the years, the curbside program still has blue boxes. We still use the same box, but we don't have any newsprint anymore. There's very little newsprint, everything is online. So now that now the container has to hold what the new product is, which are little plastic containers. So little plastic containers, whether it's a water bottle, or maybe your lemonade drink, you know, maybe your cereal box. It's extremely lightweight. And so the result of using this blue box open box for this kind of material has been really problematic because it's just they just become basically open litter bins in the communities. And so what has happened is the bloob ox, through numerous studies, is the culprit for most community litter, because it was never designed to hold water bottles and all these little yogurt containers that are very lightweight, it was designed for heavy newsprint. So there's a real opportunity, I think, from a design perspective, to improve the blue box to reflect modern day recycling. Now, there have been attempts to put a lid on the box. So you can get a blue box, and it has a lid that you can clip that clips on. But the problem is with the collection process, the lid become airborne. Because they're detached from the box, they basically become a Frisbee in in our kind of weather and they blow away or they get thrown in the truck. So the lid, the lid that has is available is really quite useless. So from a design perspective, it's very poor. Now we came up with something at Markham, which was actually quite innovative, and it was actually a net. So it would clip the net would clip to one side of the blue box and you stretched it over. And it was like a is actually made it a fishing net what fishermen use, and so has a stretchability. And then you could clip it and that kept all the products in the box. But that had a design fault in that residents would pile stuff on top of the net, so there'd be material in the box, but then instead of unclipping it, they would just throw the material on top of the net. So we found that both

physical plastic lid, and then a flexible net lid wasn't the design solution. So we continue to look for a better recycling container for the curbside. So that's one because that's, that's the most amount of material. And from a design perspective, some kind of covered, easily attached lid, almost like the green bit. So where it's a little mini cart has an attached lid that you can flip over to empty is would probably be a much better container. But we haven't seen that introduced anywhere at this point. But I would suggest a solution is almost like a blue, a mini blue cart with a attached lid and a clip that so that drivers can just clip it dump it and put it back. So the blue box is an excellent example of a of a container that was designed for a specific purpose. And now that purpose has changed here we have a container you know. So but so that's you know, one area, you know, obviously curbside but once you have a curbside program then you have to look at solutions for the changing lifestyle. So you have to look at solutions for people who live in condos. Yeah, right. So there are you know, there's there haven't been any good design solutions for people who live in in condos. And then the other is of course public space because the idea is you your cycle at home. If you go out you you should have an opportunity to also recycle and that has been the biggest I think design failure in the waste management industry is that no one yet has designed a container that can you hang on a second? Of course. Hello. Hi, how are you? Oh fine. Sounds to sound sick. Sorry about that, that staff person has got COVID Yeah, no worries. So, you know, has been, it has been an absolute dismal failure, all the public space containers are just badly designed, not functional for the purpose and not user friendly for the, for the people that that use them. And that that includes any kind of containers in the parks. And that includes the containers that private companies have put in place, or just are just horrendous content, right, horrendous containers, that that really, you know, you know, the more thought should have put into the, to the design and user friendliness and function of them. For

Thomas Ferreira
sure. And that's, that's hopefully what I what I plan on eating and solving with this project. What do you piggybacking on that? What do you think are the most the biggest flaws in the indoor outdoor public space? Waste Management? And how do you think we could maybe incorporate a solution that would solve those problems in public spaces, but could also be applied to the whole chain of waste management? Maybe?

Claudia
So so a couple of things mean, there was a great container that was designed in the US, which I thought had possibilities, and it was an I don't know if you're familiar with the big belly?

Thomas Ferreira
I don't think I've heard of it. No. Yeah.

Claudia
Okay. So it very interesting concept that came out of Boston. And we actually have some big bellies in Markham that we were piloting the concept is it's a closed container with a with a solar panel on the lid, so it's a flat top with the solar panel. And then there's the solar energy runs software in the in the container that operates a column of compaction mechanism mechanism. So it will compact down the material so you can get more into the container. And it sends a signal that the container is filling and then a signal when the container is full.

Thomas Ferreira
Right. Okay. All right.

Claudia
This is a great idea. But the flaws are? Well, the container itself, I think, is moving in the right direction, which is like a smart container. Yeah. Right. The people who have to deal with it aren't smart. What we found is, they didn't want to go online. So in their day to day job, they didn't want to go online and see what containers needed emptying they just wanted to go empty the container.

Thomas Ferreira
Right? Honestly, like the people that are meant to empty it out and take the waste to a different location.

Claudia
That's right. They didn't want to check now I do think that has changed. This was several years ago, I think with the with the advent of Uber and you know, ordering a lot more online. Maybe that philosophies changed a bit, but I do see the future as almost artificial intelligence with these containers that use solar power because they're outside to squish down the material so you get added volume and then send signals to a phone that says because like a yellow light, it's it's going to need emptying or or a red light, you know it's full, and that the sensors then would help develop routes in order to empty, empty the containers, that is really the future. Now, what would improve that container. And what we found through our public space studies is that there's a lot of germaphobic out there. And they don't want to touch handles of things. And even amongst our own staff in our buildings, they don't want to open lids at all. So I think something, a sensor, where you wave your hand, the it open, the flap opens, you can deposit your material. And the whole container is run off of the solar panel, which is the lid of the container. So you would wave your head lid opens, you put your material in, lid closes, you don't have to touch anything. And then it sends signals to the operator, that you don't need to come to this bin, it's not full, this bin or it's full, you need to service this bin. So we that's the direction, we need to move into make all of these containers not only for not only from a carbon reduction aspect of just driving around emptying containers that don't need emptying because it's on a route. But just the idea that you can get more, you don't need a bigger container, you can compact the it can actually operate a mini little squisher inside. And what would really be what would really be the icing on the cake in these containers is if they talked so, and I and I've seen this whole idea that we were even if the container just said thank you. That would be that would really mean we found that these kinds of things are real drivers for utilizing the contain or or you know, even if it says something like, thank you, I'm for recyclables only, like just giving them a message is key that that component could be tied in with this kind of, you know, smart garbage container.

Thomas Ferreira
Yeah, for sure. That's, that's thank you so much. That's very insightful. We had been talking, I've talked to a couple other people and my professors as well. And the consensus seems to be making that interaction more rewarding for the user. Because I know a lot of that did like a user study as well. And a lot of the users that are throwing out their waste in these bins just don't want to do like they're they're in a rush. They're lazy, they don't want to have to read or they don't want to learn. So anyway, we can make that process more straightforward. More like welcoming, friendly, even like if they were speaking, as you mentioned, it's a psychological tricks, and that could help the concept grow as well. Perfect. I that was really insightful. I'm learning a lot from all these interviews. And I think you are what you've told me so far has has helped a lot. I'm wondering how you think that sort of application could apply to a more specifically indoor environment? I don't know how much experience you have. With like shopping centers or campuses or like how the waste management works there.

Claudia
Well, I don't think I think I think this Oh, yeah. Cuz indoor because you wouldn't have the battery power the soul or maybe?

Thomas Ferreira
Yeah, that would be one of the only differences aside. Yeah, that may be different as well.

Claudia
Yeah. So we did try some containers that were battery operated inside. And so it was a total failure. Oh, no, we used big and oh D batteries. I think they were like each each one. So the idea was to have the, you wave your hand over it and the lid would open because there were so many germaphobic folks in the office. But it just it just burned through batteries. you'd almost have to plug it in, so you'd have to you'd have to make Get. So the concept is still good, but not battery driven, it would actually have to be plugged in. And it would have to be energy efficient. So it would have to meet the requirements for energy efficiency. But it can be the similar qualities can

be achieved through a plugin container, where you could, where you could wave your hand the lid would open, that was particularly important on the organic side. So the for the food side, putting your food in to On The Green, people didn't want to touch the lid, you couldn't leave the lid open, because you would end up with fruit flies and odors. So you know, some kind of plugin container where you could, could almost have the same capabilities as the big belly, but it's just not run on solar. Right? You know, and then, you know, because overfilling is such a problem on these things. And that's where I think that that the being able to speak is so once once the container is like, full something like I'm full, please do get give some kind of instruction it's, it's kind of hard you have to kind of understand what your what your volumes are because the prop I have a great photo, which if I find it, I'll send it to you. I have a photo of an absolute overflowing Tim Hortons. Like Tim Hortons, put those by the drive thru, right, the three, just spewing in the materials all over the grass. Like it's a classic example of like, poorly, this poor design, we're just kind of spews out, once it once it's sort of overloaded, and then not understanding, you know, the kind of generation and how often you need to, you know, to service that container. I mean, it's just, it's this picture just tells 1000 words. So we need to look at design that that provides more capacity, almost provides instructions to people, even if it's like a button. So you press a button, a blue button, and it says I take water bottles, I take coffee cups, I take that, like that constantly messaging back and forth. And I think we're there I think we're there with with the technology. Now, one thing you should know is these containers are extremely expensive. So just just the container, whether it's at a college, or whether it's in a park, public space containers are extremely expensive for $5,000 Really, for a container. We we purchased the big bellies with all of that technology, they were $4,000 so it's not it this is a realm where you're talking one containers $20,000 in one container is $1,000 Let's buy the $1,000 Shitty container for actually the the the software and the technology is not expensive. It's well within the reach of budgets for Cadillac, Fairview, you know, University of Toronto, you know, is a lot of value for money in there. And of course, there's also the reverse, which I like, which I haven't tried yet are the other reverse vending machines, because that gets back to the idea of you get a reward. So I put my bottle in the vending machine, right and I get a deposit and that is actually coming to Ontario. So for indoor, I like the idea of reverse vending machines. And I still think you can go smart containers, but you need they need to be electric plugin. To be a source batteries won't work. And they need to be energy efficient. Because people say why are you losing using electricity? You're kind of counter message in more I don't know, do Thomas Where do you live?

Thomas Ferreira
I lived slightly north of Newmarket. Oh, okay.

Claudia
Yes. So in Markham, we did a whole textile program and we put smart containers for textiles in Markham. And what we were testing is sensors inside these bins for volume detection and that are pilot on these new sensors that you can put into these bins in order to not not only improve capacity, but improved service. The sensor is is is going to be huge in the future. So these sensors actually helped our service providers like diabetes Canada and Salvation Army, not waste time going to bin because it wasn't anywhere near full, the center would tell them it was only at x volume in the container. So I think that that smart containers, whether it's through sensors that can actually calculate through, exactly it does, but it sort of it can calculate the volume component inside the container is, is going to be a future. important component, I think,

Thomas Ferreira
for sure. Yeah. And this project is set, like the timeline we're supposed to be aiming for is like 1015 years in the future. So all these technologies you mentioning, should be able to be implemented at probably even cheaper prices than they are today. Plus, like a couple of newer technologies, hopefully as well.

Claudia
No, I absolutely like that, you could this big belly technology, how to so you could go to a website, you can see all the locate, got locations, for your big valleys, you could click on the dot, and it would say, emptied July 19, but whatever time and you could click on each one and see their fill levels. So the idea was, the collectors would come in in the morning, check their check the bins, and then develop their routes, in accordance with the with the with the with the necessity of going to that bit or this bin or that bin. But it was a total failure. When we checked the website, they had our operations people had never logged in. Just wanted to get in their truck and do their route. Right. So it's, it's, it's designed plus buy in, right. But I'm hopeful on the buy in, because COVID made us become right more, if you want this, you can order it. So I think we've been long way. But that is the future the future should be. So in Toronto, there's like 5000 public space, then you should be able to go on a computer check when they were last emptied. What the Fill levels are designed, print out your days route based on on that information. That is a that is the future. That's what I see as the future. And then I also see in the public's face inside, like capture using artificial intelligence and interaction like using it almost as an education piece. Also where you can press a button and say, your pay your water bottles today are turning into.

Thomas Ferreira
Right. Yeah.

Claudia
Yeah, I bought us just as an aside, I bought a sweater the other day at Winners. And on the label was a little bottle and the whole sweater had been made out of plastic water bottles.

Thomas Ferreira
That's awesome. Right?

Claudia
So people can sort of see the linkage. Yeah. And I think when something taught when it's interactive, it also helps if people think they're being watched

Thomas Ferreira
to true.

Claudia
Better. Yeah, whether they're being watched. Yeah. And you almost want to put cameras on this. So what other something else I'm working on. Just briefly, I don't know, if y'all don't have much time. I'll try and do this very briefly. So everybody knows that in an apartment building. recycling rates are very poor. So most people, I don't

know, if you if you lived through your students, my son was living downtown in a condo and you walk down the hallway, and they had trice orders. So they had like a green button, a blue button and then a garbage button and you'd press it and put your materials down. But even with that technology, diversion rates are very poor. And part of that is because no one's being held accountable.

Thomas Ferreira
Right. Nobody knows who you are the one messing up. Nobody cares.

Claudia
That's right. And the other interesting point, from a design perspective is nobody He likes to wait the four seconds for the thing to move over because it's a shot at the bottom moves. So if you press blue, it moves over to blue. People didn't like to wait for those few seconds. So what we what we have found, we think that it's going to go where you have to have an ID. So the thing would be you would have a fob. So your unit 601. And you have to Bob and be tracked. So that I saw if your unit 601. And I get it, I get it, I can look up what, what you what you buttons, you press to deposit, if you only ever pressed garbage, then I know unit 601 Isn't recycling. And then I can target you to do better and say, you know, you have to separate your materials, blah, blah, blah. So we think in apartment buildings need a total redesign, in order to put accountability into the individual use of the system. I found it very interesting. In my son's condo, they tracked you all the time, like they tracked where you put your bike, they tracked where you park, they tracked like what doors you use, they you know, but they didn't track your garbage at all. So literally, my son could put everything down the garbage, nobody cared. But they tracked the pool, they tracked the gym, they knew if you're going to the gym, and now we need to put that same technology in because people do better if they if there's some kind of built in accountability.

Thomas Ferreira
Right. Yeah, that's that's a really good point. I will make sure to take note of that. Thank you. We have so just under five minutes left before the Zoom times out because I do not have the do you think you could briefly touch on you mentioned like the different types of sorting, there's like recycling waste. And organics usually, could you touch on like how those are looking to evolve and like how recycling is broken up. And why different municipalities and cities may do it differently than others.

Claudia
So the good news, Thomas is that in the past, that's how it was in the past. So in the future, and you may have to do a little bit of research on this, it's very easy as what's on there. So individual product, responsibility has come to Ontario, it actually starts in 2023, where all the producers are now responsible for the blue. And that's where there's a lot of opportunity because now that Loblaws, Coke and Pepsi are totally in charge of the blue box program in Ontario. I would think there'll be looking for some innovation. And so what what will be it will be the same program across Ontario, run by producers. So your blue container in front of your home won't say new market or Aurora it's gonna say recycle Ontario, probably. And it's everyone whether you're a new market, Aurora, Markham Toronto, we all going to recycle the same thing. So that is actually coming. That's good to hear, too. So it starts in 20, July 1 2023. Toronto is the first to go. And then lon Ottawa, London. Markham goes along with the rest of York in 2025. But it's becoming a provincial. So it's moving from a municipal system to a provincial system. All the same items. And this will make it a lot easier. Also for public space recycling. Because it it won't matter that you're a college in Oakville or a college and trucks. It's all going to be the same. Right? All the same rules except all the same materials.

Thomas Ferreira
Okay, that's that's perfect. Actually, that's really good because that was one of the main pain points was like nobody knew what can be recycled were like what bin things went in because in their municipality is different, right? So that's

Claudia
exactly it's been a huge problem. So now, every so effective, effective January 1 2026. All of Ontario will be under what's known that as the common collection system.

Thomas Ferreira
Okay, cool. That's awesome. I love that helps, and it lines up with the timeline of the project to

Claudia
go. And they, they're going to need new containers. Because, as I said, the same blue box, they're gonna find they don't like the blue with me, I have to manage the blue box now, the producers will they have to pick up, they're going to change things. So this is, this is actually quite awkward, awkward, there's lots of opportunity, because they also have to pay for the container. Now, municipalities won't be paying for these containers, it will be people like Loblaws, and Coke and Pepsi, looking for better containers. So it's it is it is kind of going to be a bit of a new world out there. Because as I say, the blue box has just been a really poor, poor container for outside in Ontario. Yeah. They're also the province is the producers. So calling the producers, they're also responsible for public space recycling. So they, they they were required by the Ministry of the Environment to take over the blue box. And they were required by the Ministry of the Environment to take over public space recycling. So there's also opportunity under that new law, the blue box new blue box law, to improve all of these containers, because it will be the producers making decisions not not, you know, municipalities where we really don't know anything actually mean, we really don't I mean, we couldn't design a better box if we try so, but it's the producers, that's their business, right? For sure. better customer service. Yeah, your focus.

Thomas Ferreira
Awesome. I really appreciate you taking the time looks like we have less than a minute. Do you think you'd be available or willing to meet like once or twice more maybe throughout the duration of the project?

Claudia
Oh, yeah. No, just send me an email. I'm always happy to help students. I just hope I've been helpful.

Thomas Ferreira
More than helpful. You have opened so many doors that I never considered before. So I'm very thankful for your insights today.

Safa Al-Haji:
Humber college sustainability Manager

Do you consent to the mention of your name and title next to these interview questions in the research document, or do you wish to remain anonymous?
Yes I consent.

1. 1. What does the life of a piece of garbage look like at Humber? Beginning when it's thrown into the sorting bin what happens to it? So, we work with a company called WasteCO. So our custodial staff have the job of taking that full bag of garbage from the sorting bin, to the compactors. Their trained to take a look at the bag, and review the level of contamination, if it can be used as recycling, they will throw it into the recycling compactor, however if it is completely garbage or has been over contaminated, they know to dispose of it into the garbage compactor. Humbers facilities team, is who calls on WasteCO to pick up loads of garbage, or any stream, once it's full. Their truck will come to empty out the compactor. Now our piece of waste is being transported to a sorting facility. There, the diligent staff members at WasteCO will physically take a look at the bag, and have to see if it has any hazardous waste (PPE, needles, blood, etc). if it doesn't have any hazardous waste, they will open the bag and sort it out, and if it does, then unfortunately that bag ends up in the landfill. Now if they do find unrecyclable or unusable items in that bag, it does end up in landfill.
2. 2. What do you believe are the top challenges or issues facing the area of waste management today? I believe it's the lack of interest in the environment, and the large effect that missorting has on our current environment. Waste Management is an easy thing to learn, but a hard concept to follow especially since, another challenge is municipalities all operate differently in terms of waste management. Humber College and City of Toronto, have completely different sorting rules, even though, Humber is in the region of Toronto. This aspect overcomplicates it, even our commuter students might have a hard time understanding why they can throw paper towels in the organics bin at home, but not at Humber. These are all the reasons that I've been contracted to Humber through my company Best Service Pros, it's my and our coordinators job to figure out how to combat this issue, and what's next.
3. 3. In recent years, what are the top trends facing the area of waste management? I believe there has been an increase in interest in the waste management area, but not enough to spur real change or education around the matter. I believe people still need more education on what's allowed and not in each municipality, and explaining it a bit more would be great for the general public. A lot of the time, we see international students, or commuter students coming froma further area in Canada, that don't realize organics is something that can actually be composted, or know the different types of plastics that can be recycled or cant be. I think it does become something everyone's interested in, and then it fades when they realize they have to sit and learn more about it.
4. 4. How is the waste management process different at a campus compared to other places? (like malls, or airports So, our company actually works with a few malls as well, and something that I found interesting is that some of the malls actually have internal sorters that take all the bags at the end of the night, and completely sort through it. While at Humber, we don't have that. Another item that I found interesting is that at Humber or any other college/university, we always find that they care a lot about their signage, and educating students/staff on sorting waste effectively, while at malls, their bins usually have inaccessible signage that cant be seen properly, or open top bins that can accept all types of waste. There's quite difference when you take a deep dive, some are in favor of malls and other in post-secondary.

5. Is there anything we didn't cover that you think is important for me to consider moving forward?
I think I'd like to end this with saying to always understand the bigger picture behind your actions, when you throw away your coke can into the garbage, you just costed us greenhouse gas emissions to create a whole new aluminum can to drink from. Your single actions are what spur everything, even if you are a small fish in this large world, you can teach who ever sees you doing the right thing, sort it out and do your part.

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE 2022

Certificate of Completion

This document certifies that

Thomas Ferreira

successfully completed the Course on Research Ethics based on the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2: CORE 2022)

Certificate # 0000832111 **7 July, 2022**

APPENDIX - B Contextual Research (User)

Ch 3.1. Analysis- User Needs

User needs were examined from three perspectives: benefits of similar products and latent needs. From this, a table categorizing needs and wants are generated, which is then followed by a needs statement.

Ch 3.1.1 Needs / Benefits Not Met by Current Products

Two existing products in the market were compared and contrasted to identify benefits that are common and some that may not be met by current products.

the products that are being looked at are public space waste management bins.

Needs Statement for a New Product

Two Products: Waste management bins

Rubbermaid® Recycling & Trash Can, 92 Gallon, Black/Blue/Red/Yellow
https://www.globalindustrial.ca/

Waste Watcher® 4 Piece 92 Gallon Recycling Bin Set
https://www.wayfair.ca/facilities-maintenance/pdp/busch-systems-waste-watcher-4-piece-92-gallon-recycling-bin-set-bsty1075.html?piid=23207965

Benefits and Features- from Promotional Literature

Benefits	Features
Efficient	Comes with sign frame
Durable	Modular design
Simple	venting channels
Adaptable	Easy-to-grip handles

Ch 3.1.2 Latent Needs

Latent needs are unknown. The user is unaware of them. One type of latent needs is Fundamental Human Needs.
Benefits with Needs (using Mazlow's Hierarchy of Human Needs) are linked in the table below.

LINKING BENEFITS WITH NEEDS

Product- garbage bin				
Needs	Benefits and Underlying Needs	Level of importance		
Basic Needs *Physiological*				
Food, water, shelter	Keeps shelter clean and garbage free			*High*
Pleasure, gratification *(sensory, compulsive responses)*	user feels good knowing they are disposing of waste properly		*Moderate*	*High*
Security *Safety, securing resources*				
keeps user safe from harmful; waste	keeps the user safe from harmful; waste/deseses			*High*
State, Group, Individual	n/a			
Securing resources *Optimization of limited resources (cost effectiveness)* • *Value* • *Accumulation of resources (wealth)*	Recycles resources. these are used by everyone			*High*
Control over environment (tasks)	keeps the user safe from harmful; waste/deseses	Slight		
Convenience *Ease of Use*	wayfinding makes the sorting task easier		*Moderate*	
Long Term Security/Stability of Group *Health/care/education of children*	Recycles resources. these are used by everyone, keeps the user safe from harmful; waste/deseses			*High*
Environmental sustainability	sorts and recycles waste to better save the environment			*High*
Social Belonging *Effort / resources to belong to a 'tribe'*				
Fear of Abandonment	N/A			
Fear of the enemy	N/A			
Tribal Identity	N/A			
Behavior cues for survival *(copying behaviors... safe to eat, learned skills)*	N/A			
Behavior cues for social interaction of group *(copying behaviors... Interaction cues, play, have fun)*	user usees it because everyone else does and its the right thing to do	Slight		
Peer Pressure	user usees it because everyone else does and its the right thing to do	Slight		
Social Expectation *(social covenant (gift))*	N/A			
Esteem *Personal influence in 'tribe'*				
Social Status'The elite have it...I want to be like them'	N/A			
Social Recognition	helps the user be more environmentally consious	Slight		
Sexual attractiveness	N/A			
Self-Actualization 'Higher order' Functions/Needs *Needs that are pre-dominantly 'outer cortex'*				

Intrinsic pleasure	helps users feel like they're doing something to help fight climate change and environmental damage	Slight		
Creative endeavours	N/A			
Experiential (extrinsic)	N/A			
Experiential (intrinsic)	N/A			
Emotional	helps users feel like they're doing something to help fight climate change and environmental damage, makes user feel good when they recycle		*Moderate*	

Needs Statement

Summarizing the results from the Table.

Benefits of both

- People's environment and shelter are clean and garbage free
- Make users feel good for disposing of waste properly
- Make users feel like they are doing something to fight climate change and environmental damage
- keeps resources in the cycle by recycling
- Keeps the user safe from harmful diseases

Benefits of Each

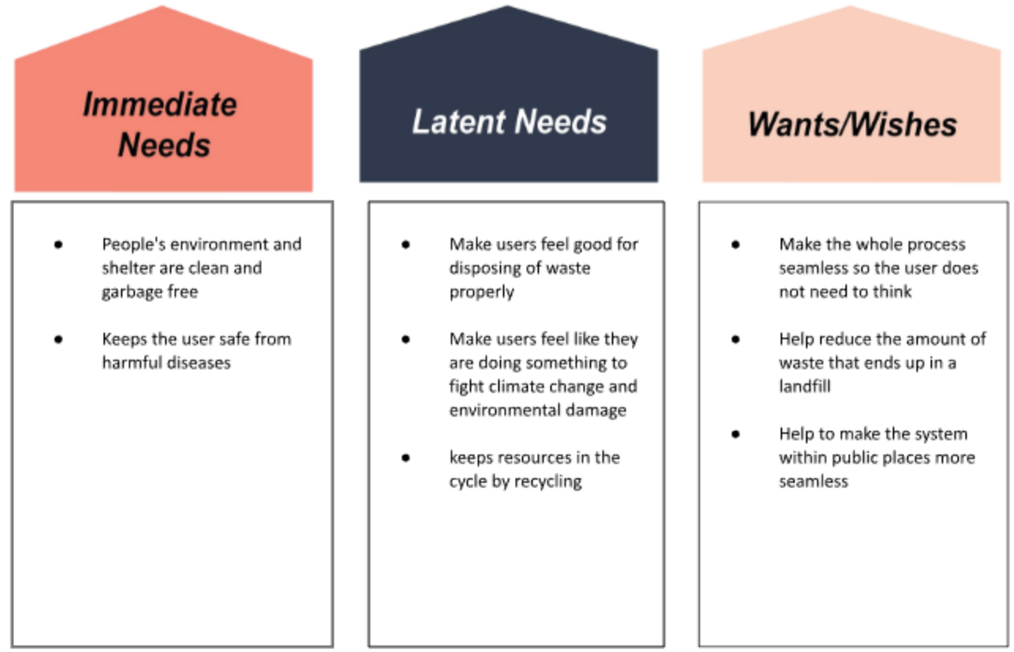
Product A: Rubbermaid® Recycling & Trash Can

- Modular design
  - 7 colours
  - 4 lid options
  - 10 Waste stream labels
- Snap-in Connector
- Bag Cinches
- Hinged lid inserts
- venting channels

Product B: Waste Watcher® 4 Piece 92 Gallon Recycling Bin Set

- Comes with sign frame
- Easy-to-grip handles
- Easy-to-read labels
- Easy-to-read signage
- Lightweight

Ch 3.1.3 Categorization of Needs



Ch 3.1.4 Needs Statement

Needs Statement 1 (before research)

The user needs to dispose of waste in a public place.

Needs Statement 2 (after benchmarking)

The user needs a straightforward way to dispose of waste in an indoor public space, with proper signage end good organization to allow ease of use.

Needs Statement 3 (after benchmarking **AND** linking with fundamental human needs)

The user needs a waste management system that will work based on the intuitions built into the human psyche, allowing straightforward wayfinding and no strenuous thoughts.

this system is traditionally a straightforward and boring one, human beings like to build behaviours on good feelings so a social and reward esteem-based aspect should be implemented to increase the quality of use.

These aspects can come together to create a waste management system that for the user feels more like an Interactive and rewarding experience.

APPENDIX - C Field Research (Product)

2.2.1 Benchmarking – Benefits and Features of Existing Products

Existing Solutions - Full Waste management process

Sorted bin groups

- Relies on customers to Sort the waste into categories
- Must properly communicate the categories to consumers
- If improperly sorted waste is potentially not recycled

Pneumatic waste system

- Uses a large pneumatic infrastructure to transport waste from deposit point to large sorting system

Janitor carts

- Is pushed around with wheels
- Has to carry full and empty bags and/or bins
- Has to carry cleaning supplies

Garbage Trucks

- Pick up and store waste from bins/dumpsters
- transport solid waste from location to management/sorting center

Garbage bags

- Have to be strong
- Hold waste and odor in
- Transport waste from small bin to dumpster

Bin monitors

- Apps that let collectors know when to empty the bins when they're full

Individual waste bins

- Very little though needed by customer
- Goes straight to landfill
- Occasionally pared with 'Recycling' bin

Compost Center

- Turning organic waste into compost
- Sort and organize the non organic waste out of it

Dumpsters

- Large collection bins for waste storage
- Lifted and by specialized trucks

Landfils

- Sorting Waste
- Storing waste at its end of life in a safe way
- protecting the environment as much as possible from contaminants

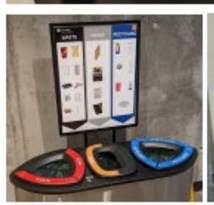
Signage

- Educating on sorting waste effectively,
- Inaccessible signage
  - Cant be seen properly, or open top bins that can accept all types of waste.

Recycling center

- Sort the recyclable waste into categories
- processes waste into new raw materials
- ships sorted waste to processing plants

Existing Solutions - Bins/signage



Product one:

Rubbermaid® Recycling & Trash Can, 92 Gallon, Black/Blue/Red/Yellow

https://www.globalindustrial.ca/

An **adaptable recycling** solution offers a front-of-house look with back-of-house functionality. **Intuitive lid openings** help patrons and staff **sort recyclables** more **effectively**. Provide better **waste stream** visibility by selecting a **colour** and waste stream **label** for your facility's needs. Hinging **lid** inserts are optimized to fit any size **recyclable**. **Simple** and **durable** execution. Components **snap** in place without the use of **hardware**.

Features:

1. Modular design
   a. 7 colours
   b. 4 lid options
   c. 10 Waste stream labels
2. Snap-in Connector
3. Bag Cinches
4. Hinged lid inserts
5. venting channels

Product two:

Waste Watcher® 4 Piece 92 Gallon Recycling Bin Set

https://www.wayfair.ca/facilities-maintenance/pdp/busch-systems-waste-watcher-4-piece-92-gallon-recycling-bin-set-bsty1075.html?piid=23207965

Perfect for in an **office** or **school** environment, the **Waste** Watcher Series containers are versatile, **customizable** bins designed to **streamline recycling** and waste **collection**.

Trusted capacilities make this bin a customer favourite, Reduce servicing with various **capacity** options, Reduce **containimation** with a mobile, connected station.

Features:

1. Comes with sign frame
2. Easy-to-grip handles
3. Easy-to-read labels
4. Easy-to-read signage
5. Lightweight

Data collected from Online reviews and advertisements was placed into Excel and sorted alphabetically, this led to the most important categories being discovered, and frequency was then tabulated

	A	B	C	D	E
1	**Features**			**Benifits**	
2	Colour	10 Waste stream labels		Less contamination	Adapts to environments
3	Modular	Bag Cinches		Durable	Better Lid
4	Sign	Bag vents		Simple	Comes with sign frame
5	Lid	Colour		Adapts to environments	Durable
6	lightweight	Colour Options		Comes with sign frame	Durable construction
7	Connecting	Colour options		Easy-to-grip handles	Easy-to-grip handles
8	hynging lid	color		Simple design	Easy-to-read labels
9	Waste stream signs	Connecting		Easy-to-read signage	Easy-to-read signage
10	no hardwear	Conection points		Lightweight	Efficent use
11	Colour options	Durable		Efficient	Efficently sorts waste
12	Four lid options	Differnt colours avalable		Durable construction	Efficient
13	Mdular system	Features		Easy-to-read labels	Good system
14	10 Waste stream labels	Four lid options		Versitile	Intuitive use
15	Snap-in Connector	Hinged lid inserts		Good system	Less contamination
16	Durable	hynging lid		Signage in good	Lightweight

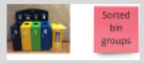
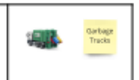
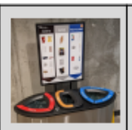
Features:	**Frequency**
Colour Coding	7
Modular	4
Signage	3
Lid	3

Benefits	**Frequency**
Efficient	8
Durable	5
Simple	3
Adaptable	2

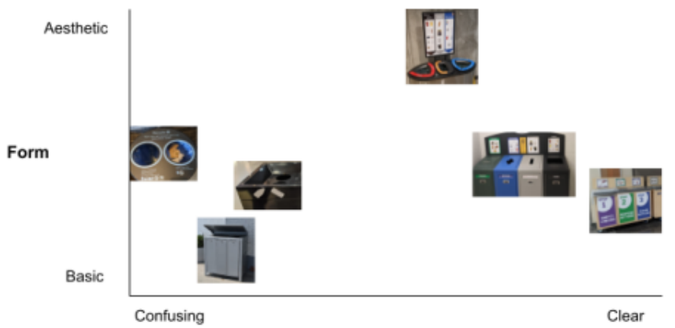
2.2.2 Benchmarking – Functionality of Existing Products

Objective:

Identify Existing product solutions and their functionalities.

Types of Product solution						
Use	Allows users to sort waste into bins	Lets Caretakers pick up waste from bins and transport it to larger storage	Goes within the bins and is replaced by caretakers upon removal	Dumpsters are the larger capacity storage bins that are used to hold waste long term	Signage informs users where to put their waste.	Transfers waste from dumpster or compactor to waste management facility
User interactions	Very Frequent	Often	Very frequent	Not often	Very Frequent	Often
Variations of bins						
Notes	Only a simple graphic, not easy to understand the limits of what is allowed in the bin	Contradicting information, (users are meant to throw out their cups and then take their lids elsewhere?) bad wayfinding (holes look the same but have different functions)	Good signage, organization, and colour coding, Wayfinding is obvious and not too complicated	Good signage, organization. Colour coding is odd and not following the standard Wayfinding is obvious and not too complicated	Good signage, great organization, and colour coding, too many options, can confuse users	Simple, just a word, not language accessible, No colour use No pictures or icons

Functionality



Takeaways:

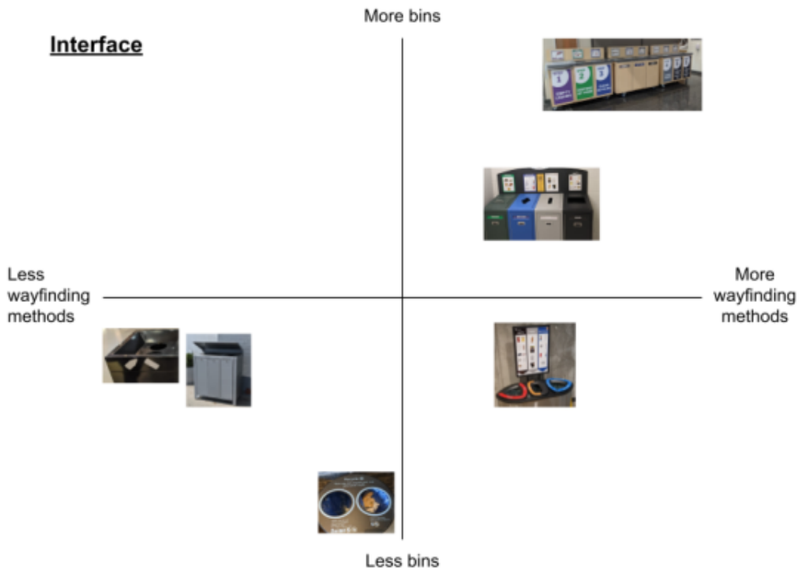
There seem to be no good examples of products that are able to communicate good wayfinding without being very simple in form.

There is a gap in existing products for aesthetic and exciting products that communicate and sort waste effectivly

2.2.3 Benchmarking – Aesthetics and Semantic Profile of Existing Products

Interface

Wayfinding methods and quantity of bins seems to be the two most commonly fluctuating interface factors.



Takeaways

It seems that the more bins there are in a unit the better and more robust the wayfinding needs to be, this isnt always a good thing, as to many choices can distract and overwhelm users, and to much wayfinding is often confusing and contradicting. There is a sweet spot that balances bins and wayfinding to allow users the simplest yet most efficient sorting method.

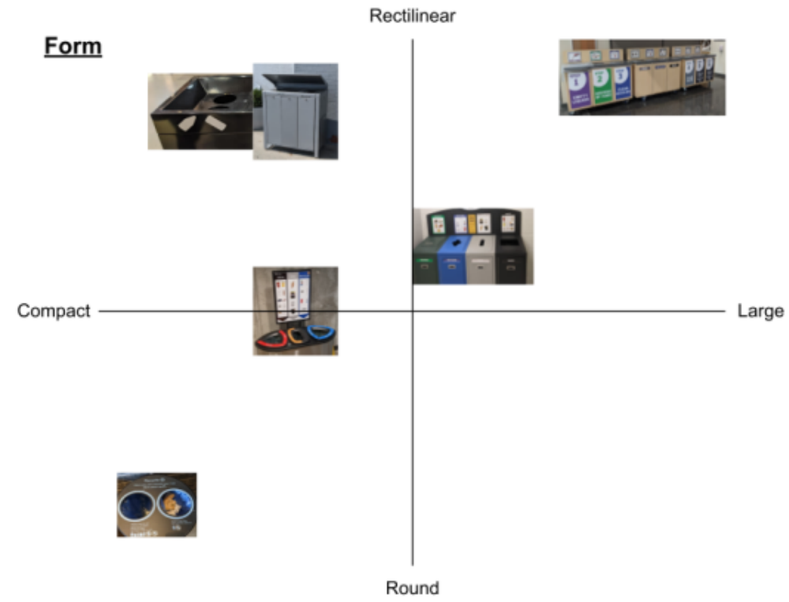
Colour for wayfinding (if used)

- Black means waste
- Blue means recycle
- White or grey means paper
- Green means organics

Aestetics

Objective (1 sentence) & Method (1 sentence) Not done / Done

Images or Graph not done / unsat / sat / good / exceed expectations



Design Take-aways

Shape

- Often Square/ angled boxes lined up next to each other
- Single standalone bins are often cylindrical
- Some have a panel behind that shows images of accepted waste
- Round bins are usually smaller scale

Communication/wayfinding

- Photos and images of accepted waste
- Icons implying what can/can't be thrown out
- Words sating what can/can't be thrown out

2.2.4 Benchmarking – Materials and Manufacturing of Existing Products

						
Materials	Sheet metal bin with heavy removable lid Uses Plastic garbage bags	Sheet metal bin with removable lid Uses Plastic garbage bags	Recylced plastic construction, sliding removable bins Uses Plastic garbage bags	Sheet metal bin with Plastic removable lid Uses Plastic garbage bags	Wood box with metal lids and hinging door on front Uses Plastic garbage bags	Sheet metal bin with sliding removable drawers Uses Plastic garbage bags

2.2.5 Benchmarking – Sustainability of Existing Products

The effectiveness of these products in the sustainability category almost entirely relates to how effectively they can separate and organize the waste time categories. The materials and manufacturing aspects play a part as well but the majority of this product's carbon footprint will be dictated by the waste that it helps to sort and recycle.

APPENDIX - D Result Analysis

- 10% of the total waste generated each year comes from Municipal waste management
- Poor waste management can negatively affect the health and well being of human, climate and environmental health.
- Though some counters can do well individually, unless the solution is available system wide the overall sector wont improve as quickly
- The more organized, professional, straight forward, and thoughtful the waste management solution is the better the results will be
- Investing in waste management yields positive results seen in the decrease of the output of landfill waste.
- Companies that are environmentally conscious and embrace sustainability as one of their core values are the most significant contributors to positive environmental change
- Landfills are overused and relied too heavily upon, there are ways to solve the waste management issues without as many or as big landfills
- Landfill over usage could be reduced at the source in these large buildings with better organization
- Waste has social and environmental value depending on its ability to be recycled
- Customers are the most important part because they are responsible for purchasing disposing of and sorting of the solid waste
- Collecting data on where waste comes from and how it's sorted is imperative to prevent the unnecessary buildup of landfill waste

APPENDIX - E CAD Development

All images regarding Solidworks model development can be found in sections 4 and 5

APPENDIX - F Physical Model Photograph

All images regarding physical model development can be found in sections 4 and 5

APPENDIX - G Technical Drawings

All technical drawings can be found in section 5

APPENDIX - H Bill of Materials Info/Data

Bill of Materials can be found in section 5.2.3

Indoor Waste Management Experience: Sustainability report

By Thomas Ferreira

Bachelor of Industrial Design
Faculty of Applied Sciences & Technology
Humber Institute of Technology and Advanced Learning

Supervisors: Catherine Chong and Fredrick Matovu

Introduction:

This report is an abridged version of all the sustainable research and forethought that went into this thesis project. It will touch on all aspects of sustainability from materials and manufacturing to the system network and overall environmental effects. This report will also touch on the health and safety aspects of the project with a particular focus on human and environmental wellbeing.

Literature Review:

Throughout the research process several sources were found on sustainable alternatives to standard materials. The most prominent in use for this project will be Biopannels, an eco-friendly and sustainable hemp-based plywood panel replacement. These panels were designed to replace plywood panels in recreational vehicles and as such are made with movement and weight bearing in mind. Another material that will be utilized in this concept is acoustic-dampening sound panels made from recycled textiles. The standard materials used to make acoustic panelling are woven polyester or polyurethane acoustic foam. Neither of these is fully recyclable or biodegradable and due to this a suitable replacement needed to be found. The last material touched on in the report was aluminum, aluminum is well known as one of the most infinitely recyclable resources on earth. This means that recycling old aluminum into new products can save 95% of the energy when compared to making it from virgin materials.

References:

Stacey, M. (2017, December). Aluminium and life cycle thinking - international aluminium institute. Aluminium Recyclability and Recycling Towards Sustainable Cities . Retrieved February 3, 2023, from https://international-aluminium.org/wp-content/uploads/2017/12/Aluminium-Life-Cycle-Thinking-TSC-3.pdf

Biopanels. INCA. (2023, January 10). Retrieved February 3, 2023, from https://incarenewtech.com/biopanels/

Najib, N. N., Briga-Sá, A., Awwad, E., Dissanayake, D. G. K., Dissanayake, G., Dahlbo, H., Tojo, N., Jayasinghe, I. H., Wang, Y., & Reis, J. M. L. dos. (2020, July 18). An environmentally friendly sound insulation material from post-industrial textile waste and natural rubber. Journal of Building Engineering. Retrieved February 3, 2023, from https://www.sciencedirect.com/science/article/abs/pii/S2352710220312997

Benchmarked product						
Materials	Sheet metal bin with removable lid Uses Plastic garbage bags	Recycled plastic construction, sliding removable bins Uses Plastic garbage bags	Sheet metal bin with Plastic removable lid Uses Plastic garbage bags	Wood box with metal lids and hinging door on front Uses Plastic garbage bags	Sheet metal bin with sliding removable drawers Uses Plastic garbage bags	Sheet metal bin with heavy removable lid Uses Plastic garbage bags

It can be seen that all existing waste management receptacle solutions use a garbage bag in order to transport waste from location to location as well as keeping the inside of the bins clean. This isn't ideal as they are a plastic disposable product and that itself is contributing to landfill waste buildup.

As for materials and manufacturing, these bins are made to be as affordable as possible, usually out of recycled metals or plastics manufactured into thin shells that hold and protect the bags within.

2.2.5 Benchmarking – Sustainability of Existing Products

The effectiveness of these products in the sustainability category almost entirely relates to how effectively they can separate and organize the waste categories. If a bin can effectively keep the recycling uncontaminated and the organics out of the landfill then the materials and manufacturing prosses of the bins will no longer matter.

The materials and manufacturing aspects play a part as well, it's without a doubt better to use recycled/recyclable materials when making bins for mass production. as well as considering the manufacturing process and that amount of carbon production it entails.

For the chosen approach to sustainability in this project the focuses are on reducing landfill waste and increasing the success of cyclical recycling and composting. These three main factors are the foundation of the design, meaning all aspects of the design are built off of these goals.

By improving recycling and composting landfill waste also increases in effectiveness, and when all three are achieved this means that fewer carbon emissions and greenhouse gases are emitted from collecting virgin resources and manufacturing new products from scratch, less harmful chemicals are leached into the environment, and less solid waste like plastics and up in naturalhabitats and the food chain. This affects the health and safety of wildlife and ecosystems globally but it would also indirectly lead back to humans through the food chain and drinking water.

Knowing all of this, this thesis project will utilize tacticslike wayfinding infographics and psychology to guide and educate users on how to properly sort their solid waste. this knowledge will be used for the proposed product but it will also be retained in the user's active memory to then be applied to other less sophisticated waste management systems. Effectively offering a replacement product that does the job better and training the general population to use existing products more effectively.

This project is first and foremost a sustainability project, the overall goal is to improve the effectiveness of recycling and composting while simultaneously reducing unnecessary and wrongful landfill waste in public spaces.

Materials:

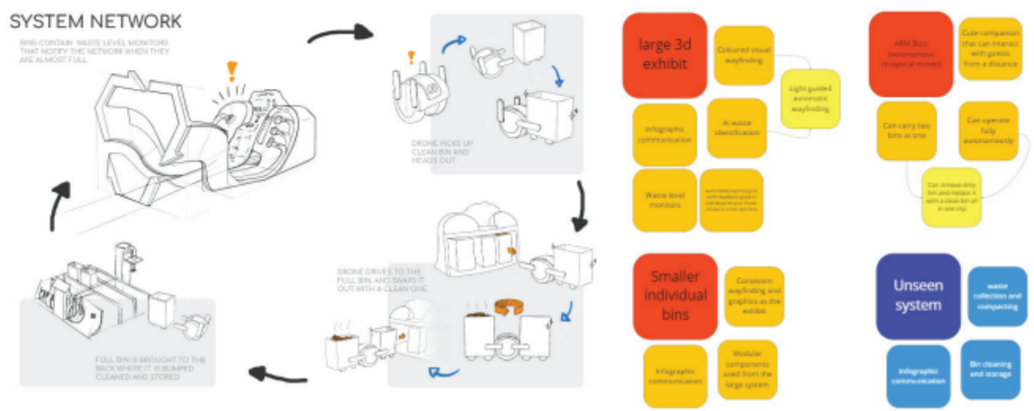
The large wayfinding 3D element and the housing for the bins are made from a sturdy aluminum frame with hemp-based bio panels as a more sustainable alternative to plywood and that would be covered with a graphic wood-based adhesive sheet on the inside and a tightly woven cotton acoustic panel on the outside. The actual bins that hold the waist will be made out of 100% recycled plastic. As for the ARM bots, they have an aluminum frame with recycled plastic panelling and are designed in a way to be easy to disassemble and break down into recyclable parts.

Business model:

As previously mentioned the system's goal is to teach users how to properly recycle and compost waste. it does this through an exhibit-style walk-through feature that visually graphically and automatically guides users to the correct bin to dispose of whatever waste they may be holding. this is done through clever psychological tricks as well as visual graphic wayfinding and lastly through a smart system that can identify what item the user is holding and light up a path to the corresponding hole that the team goes in. This interaction exhibit contains three categories of waste disposal: (compost landfill and recycling) which are further broken down into solid organics, liquid organics, landfill dirty recycling, paper, plastic, and metal. All these bins help to ensure that there's no cross-contamination that would result in recyclable or compostable objects ending up in the landfill bin. Once an individual bin is almost full the system sends a signal to the ARM bots to come and exchange the full bin for a clean one. These bins are able to avoid the use of a plastic bag through The use of a complimentary pressure washing nozzle that removes all internal contamination once the bin has been emptied into its respective compactor.

Network:

All of the previously mentioned stages of the business model can be seen in the diagram below and they all add up to a system that is designed with the express purpose of ensuring proper waste organization and Disposal through A rework of the existing indoor cells with a solid waste management system as well as modifying the users' interaction with solid waste disposal at the source.



IDSN 4002
SENIOR LEVEL THESIS ONE

Humber ITAL / Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022
Catherine Chong / Frederic Matovu

THESIS TOPIC APPROVAL:

Student Name:	Thomas Ferreira
Topic Title:	How may we mitigate solid waste management in indoor public spaces?

TOPIC DESCRIPTIVE SUMMARY (PRELIMINARY ABSTRACT)

In this age everyone seems concerned about the environment, one of the bigger aspects of this concern is related to solid waste and where it ends up. The weight of this responsibility is currently spread across a very wide range of people and places. The aim of this proposal is to reduce the overall amount of waste from public indoor spaces that is ending up in the landfill. The goal would be to come up with a solution that considers full-bodied human interaction design and ergonomics, one that focuses on improving the overall experience and outcome of creating, sorting, and recycling solid waste in these public spaces. By completing user research and interviews to find specific challenges in the field, the ideation and development processes will have a solid foundation of experience and insights to build off. This will be coupled with referencing and studying the use of current solutions to locate pain points and potential improvements. All this analysis will be used to create a solution that considers full-bodied human interaction design and ergonomics, one that focuses on improving the overall experience and outcome of creating, sorting, and recycling solid waste in these public spaces.

Student Signature(s):	Ferreira
Date:	24/09/2022

Instructor Signature(s):	Catherine Chong
Date:	29 / 09 / 2022

APPENDIX - K Advisor Meetings & Agreement Forms

IDSN 4502
SENIOR LEVEL THESIS TWO

Humber ITAL / Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / WINTER 2023
Catherine Chong / Fredric Matovu

CRITICAL MILESTONES: APPROVAL FOR CAD DEVELOPMENT & MODEL FABRICATION

Student Name:	Thomas Ferreira
Approved Thesis Title:	Indoor Waste Management Experience

THESIS PROJECT – DESIGN APPROVAL FORM

Design is reviewed and approved to proceed for the following:	[X] **CAD Design and Development Phase**
Comment:	Continue design refinement in CAD development, need to iron out detailing and product's features, pay attention to surfacing, components and assembly methods for design feasibility. Viable holistic design thinking in conjunction with considerations into sustainability aspects. CAD development must be at least 75% complete for review before approval for fabrication.

Design is reviewed and approved to proceed for the following:	[X] **Model Fabrication Including Rapid Prototyping / 3D Printing and Model Building Phase**
Comment:	Waiting for CAD development review (as of Feb-21). Good progress with CAD, design completed, fabrication of model can begin.

Instructor Signature(s):	Catherine Chong F.K. Matovu
Date:	07 March 2023

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022 & WINTER 2023

INFORMATION LETTER

Conditions of Participation

- ✔ I understand that I am free to withdraw from the study at any time without any consequences.
- ✔ I understand that my participation in this study is confidential. (i.e. the researcher will know but will not disclose my identity)
- ✔ My identity will be masked.
- ✔ I understand that the data from this study may be published.

☑ **I have read the information presented above and I understand this agreement. I voluntarily agree to take part in this study.**

Claudia Marsales	Claudia	November 7, 2022
Participant's Name	Participant's Signature	Date

Project Information

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: 289-338-1978

Email: Thomas.ferreira@gmail.com

My supervisor is:

Prof. Catherine Chong, **catherine.chong@humber.ca**

APPENDIX - L Other Supportive Raw Data

All relevant supportive raw data is included in the main report body

APPENDIX - M Topic Specific Data

All relevant topic specific data is included in the main report body

HUMBER
Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / FALL 2022 & WINTER 2023

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: Mitigating solid-waste management in public indoor spaces

Investigator: Thomas Ferreira / 289-338-1978 / Thomasr.ferreira@gmail.com

Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, Claudia Marsales (First Name/Last Name), have carefully read the Information Letter for the project Mitigating solid-waste management in public indoor spaces, led by Thomas Ferreira. A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Thomas Ferreira at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording and note taking on conversations surrounding this topic, and that my name and title may be associated with the information I provide.

Consent for Publication: Add a (X) mark in one of the columns for each activity

ACTIVITY		YES	NO
Publication	I give consent for publication in the Humber Library Digital Repository which is an open access portal available to the public	☑	☐
Review	I give consent for review by the Professor	☑	☐

Privacy

All data gathered is stored anonymously and kept confidential. Only the principle investigator /researcher, « insert student Name here » and Prof. Catherine Chong or Prof. Frederick Matovu may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

I also understand that I may decline or withdraw from participation at any time, without negative consequences.

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca** or « insert student Name /Phone Number /Email Address ».

Verification of having read the Informed Consent Form:

☑ I have read the Informed Consent Form.

My signature below verifies that I have read this document and give consent to the use of the data from questionnaires and interviews in research report, publications (if any) and presentations with the proviso that my identity will not be disclosed. I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

Click or tap here to enter text.		Click to enter a date.
Claudia Marsales		November 7, 2022
Participant's Name	Participant's Signature	Date