Engineering Strategies & Practice

University of Toronto
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APS112 & APS113
Conceptual Design Specifications (CDS)

Project #	098	Date	April 5, 2021

Project Title	Waste Management
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Please check off which components you are submitting for your assignment.
CDS submitted as a PDF to Quercus with the following components:

- ✓ Cover Page
- ✓ Executive Summary
- ✓ Introduction
- ✓ Problem Statement
- ✓ Service Environment
- ✓ Stakeholders
- ✓ Detailed Requirements (FOCs)
- ✓ Alternative Designs
- ✓ Proposed Conceptual Design
- ✓ Measures of Success
- ✓ Conclusion
- ✓ Reference list
- ✓ Appendices

Executive Summary

Improper waste management by residents within condominiums is a common issue. This not only damages the environment but also costs efforts and money to repair and maintain the system. The team's client, Maria Eggonidis, wants the team to design a solution to increase the number of residents following the waste management system and to avoid damages to garbage chutes on individual floors. Currently, there is a gap in lack of guidance and knowledge towards residents on how to waste manage. This project will only scope the individual chutes and recycling room on the main floor within a single condominium.

This design will operate in both physical and virtual environments and should operate all year round. Physically, the design should work in a range of temperatures of the building. The living things that interact with the design are children, adults, seniors, and domestic animals.

The City of Toronto and the Condominium Management Regulatory Authority of Ontario (CMRAO) are two key stakeholders who provide regulations for the condo and are affected by or interested in the design. Next, the document's detailed requirement section will outline the functions, objectives, and constraints for the design. To satisfy the gap and need, the primary function of the design is to increase the number of residents properly using the designated waste management system. Two secondary functions are listed in the document.

The team used a brainstorming, multi-voting, and modified design tool inspired by the graphical design tool to generate ideas and select three alternative designs. The three alternative designs were as follows. Providing new tenants with emails and welcome kits that give information and instructions on using the chutes; placing waste storage bins in each residence; and providing instructional material and a Condo program.

The final proposed design of Instructional material on each floor was chosen based on its ability to surpass the other designs in completing the objectives of our project—both allowing for a low-costing and effective design for disposing of waste.

The proposed conceptual design of instructional material and a Condo program includes four components. First, by providing posters of instructions on the specific items to be put in each chute and the size to be compacted, residents will have guidance on how to waste manage properly. Second, residents are encouraged to report others when they see improper waste management and incentives to follow instructions by providing prizes for the winning floor that manages waste the best. Third, to solve the problem of new tenants constantly moving in, the landlords are instructed to attach the waste managing posters and other essential door keys and information to tenants when moving in. Lastly, to emphasize the importance of waste management towards residents, posters will be present throughout the condominium, including poster boards, emails, elevator screens, and monitors.

To further demonstrate the choice of our proposed design, we have outlined a three-week testing plan to reinforce our solution. After the testing, the team prototypes the solution to demonstrate the result of our design.

This document must be approved by the Engineering Manager and the Teaching Assistant before shared to the client for a debrief.

1.0 Introduction

Our client Maria Eggonidis is looking for a solution to improve the condominium residents' waste management system. Currently, the lack of guidance about recycling is a significant problem for residents. This document outlines the service environment, functions, objectives of the design, and constraints. The team is assigned to create a proposed conceptual design based on these functions, objectives, and constraints, which is also included in this document, along with the alternative designs and the design's measures of success.

2.0 Problem Statement

Improperly recycled waste will increase the operating costs of buildings and harms the environment[1]. An effective recycling program will reduce the cost of waste management by up to 25%[2]. This improper recycling of waste is a common problem that all condos in today's community must address[3]. One of the main reasons condominiums cannot recycle waste effectively is the change in new tenants; some may not be informed of the waste management system's utilization. They do not feel that it is their responsibility to follow the procedure strictly[4][5]. Form the client statement, about 30% of residents in the condo do not recycle their waste properly. The design needs to maximize the number of residents that follow the waste management system and minimize damages to garbage chutes in individual floors. Lack of guidance and information on the waste management system usage to all residents brings up the gap. This project's scope is the improvement of the waste management system of a single condominium, where the design only focuses on the proper use of individual chutes and recycling room on the main floor. Regardless, the waste management system itself should not be modified.

3.0 Service Environment

Our client is the regional manager of a condominium located at 170 Fort York Boulevard, Toronto, Ontario, M5V 0E6. The design has been scoped to this single condominium in Toronto, and thus this section describes its service environment.

3.1 Physical Environment

This section describes the temperature in the condominium as well as its physical attributes that may affect the design. The condominium is a temperature-controlled environment and so it is assumed that its temperature will not be affected by Toronto's climate.

The following information in Table 1 was researched by the team and provided by the client.

Table 1:Physical Attributes of the Building

Attribute	Description
Temperature	• Temperature of the building is to be between 21°C and 26°C throughout the year according to the Toronto Municipal Code[5].
Building height	• 29 stories high
Waste management rooms	• Chute rooms are on every floor of the building. There are two chutes, one for garbage, and one for recycling and compost. The user must choose what kind of waste they are disposing of for the second chute(Figures 1 and 2) • Recycling room is on the ground floor**.** This room is to dispose of large recyclables(Figure 3). • Garbage, recycling, and compost storage room on ground floor. This waste storage room contains the "Tri-Sorter" system that is in place for the building. It sorts the waste into the three categories, garbage, recycling, and compost(Figure 4).
Notices	• On screens in every elevator(Figure 5). • On display board in the mail room(Figure 6).

Figure 1:Garbage chute in the chute room. the chute room.

Figure 2:Recycling and compost chute in

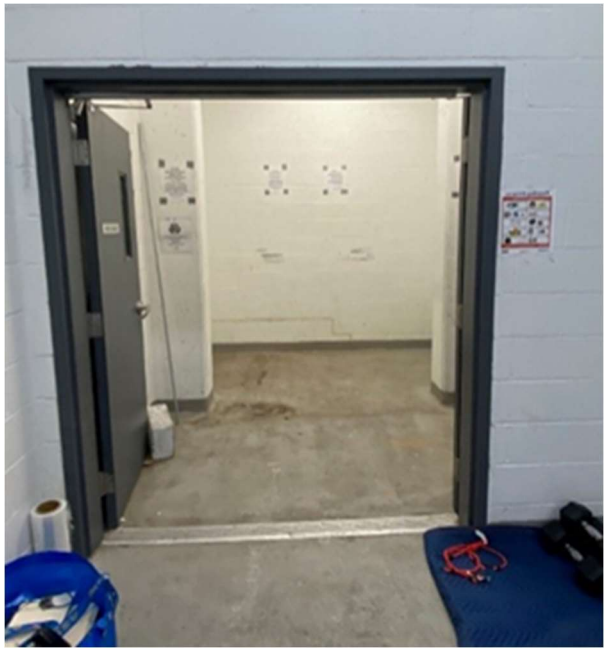

Figure 3:Recycling room for large recyclables.

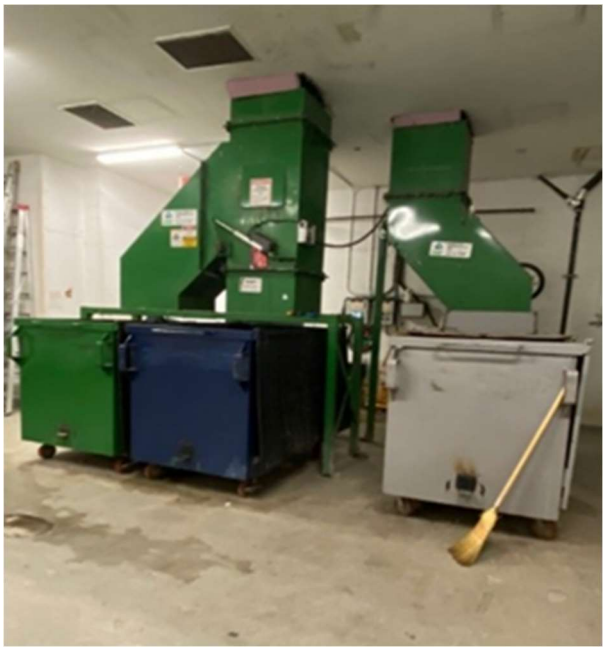

Figure 4:Garbage, recycling, and compost storage room with tri-sorter.

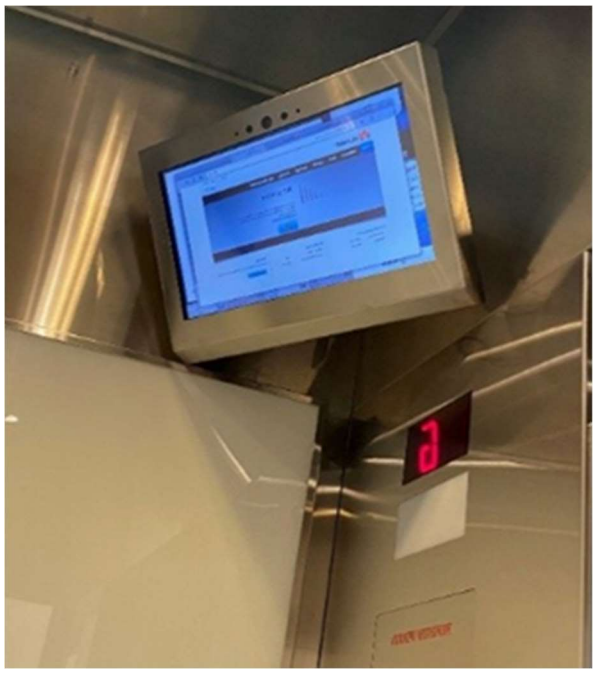

Figure 5:Digital message screens on an elevator.

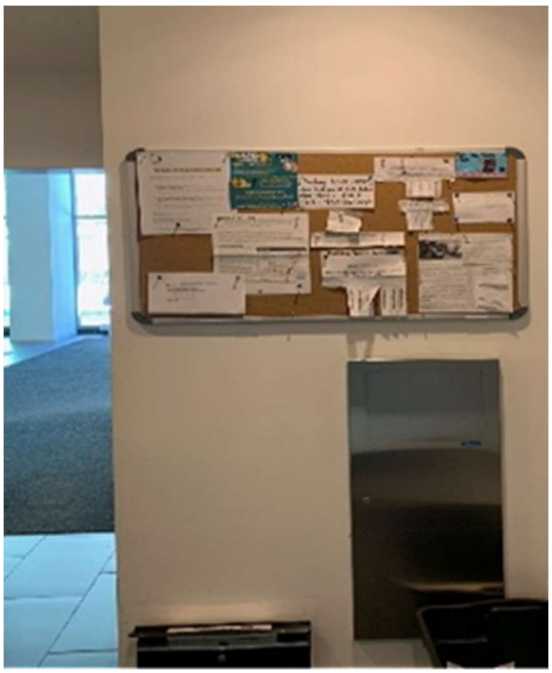

Figure 6:Message board in mail room.

3.2 Living Things

The only living things in the condominium are humans. Any other living things such as pets do not interact with the design, and so have no effect on it. Given the size of the building, an estimation of the number of residents yields approximately 700.

3.3 Virtual Environment

Since the design may have some virtual aspects, the electrical specifications are provided below.

- Electrical Supply
    - 120 volts alternating current
    - Frequency: 60 Hertz
- Internet Connection
    - There is no internet connection inside the elevator
    - The residence requires internet connection to accessing the portal for announcements of the condo.

4.0 Stakeholders

The stakeholders of the design are Miller Waste Systems, the Condominium Management Regulatory Authority of Ontario, the City of Toronto, and the Manufacture of Marketing Material. These stakeholders are listed in detail below in Table 2. The residents are users of the design but are not stakeholders. Thus, are not included in the stakeholder's chart below.

Table 2:Relevant Stakeholders of Waste Management System Implementation

Stakeholder	Design Impact
Miller Waste Systems	Miller Waste Systems[6] is the company responsible for collection and disposal of garbage and recycling from condo. Changes to the current waste disposal system in the condo could affect the process currently in place at the condo, resulting in them having to adapt.
The Condominium Management Regulatory Authority of Ontario (CMRAO)	The CMRAO [7] is a government-affiliated regulatory group responsible for providing regulation and oversight to the condos with rules and standards that the management must follow. Any design that is implemented must not violate these rules.
The City of Toronto	Any design implemented must adhere to rules and regulations created by the city of Toronto[8] regarding collection, garbage disposal, organics, and recycling in condo buildings.
Manufacturer of Marketing Material (BrandLume Inc.)	Any company that is responsible for the production of any of the marketing material in the condo will be impacted by a design that implements methods of marketing things to the residents of the building. In this case its BrandLume Inc.[14] which provides marketing materials to condos across Toronto.

5.0 Detailed Requirements

The detailed requirements section is separated into functions, objectives, and constraints.

5.1 Functions

The functions below indicate what the design should do to resolve the issue of lack of residents following the waste management at the condominium.

Primary:

- Increases the number of residents properly following the designated waste management system.

Secondary:

- Promoting and motivating residents to recycle.
- Informing residents on proper usage of the condominium waste system

5.2 Objectives

The objectives for the design are listed in order in Table 3. The order was determined using pairwise comparison(Appendix K). Objectives such as effective, low-cost, and simple are referenced from the client meeting the team attended.

Table 3:List of Objectives, Metrics, and Goals Ranked by Priority

Objectives	Metrics	Goal	Rank
Effective	Percentage of tenants that properly waste manage.	60-65% of the tenants dispose properly, the design aims to increase the percentage to above 90%.	1
Low-cost	Measured in CAD.	This design also has no specific numerical budget, the only limitation is the cost should be approved by Condo board.	2
Proper size	Measured in centimeters (cm)	Messages can be placed inside the elevator, the size of a letter(8.5’’x11’’)[9]	3
Simple	Number of users	This design should not require any technical assistance on each usage and can be done individually.	4

5.3 Constraints

The constraints of the design are minimal garbage system failure, manageable budget of implementation, and compliance with city rules, declarations, and by-laws. These constraints are listed in Table 4.

Table 4:Limits and Metrics of Design Constraints

Constraint	Limit/Metrics
Minimal garbage system failure	The garbage chutes located on each individual floor of the condo should experience a maximum amount of blockage or failure 3 times a month, where chutes should be repaired within 3 business days[10]
Manageable budget of implementation	The implementation of the final solution should not exceed a budget of $280 per floor (which is the estimated cost of seven repairs of the garbage chutes per month)[11]
Compliant by the city rules, declaration, and by-laws	The system of design should adhere to the codes and standards of the Condominium Act 1998 by the Condominium Authority of Toronto, specifically under section 89 to 90 regarding Repair and Maintenance, and section 136, regarding Enforcement, including charges and fines[12]

6.0 Alternative Designs

The alternative design section is separated into Idea Generation Process, Alternative Design Process, and Alternative Designs.

6.1 Idea Generation Process

The idea generation process the team has taken involves a team meeting using brainstorming method. This tool allows the team to generate maximum number of ideas in a given time. During brainstorming, the team's environment was an open-minded environment where each team member can perform at the best of their capabilities when generating ideas from different perspectives. The team also focused on full participation and limiting communication to create a space for the team to focus and help contribute to using the brainstorming method. In total, the

team had three brainstorming sessions and generated up to 62 ideas(Appendix A). After the brainstorming session was over, the team went through the ideas and removed any duplicate ideas, which narrowed the list to 42 ideas(Appendix B).

6.2 Alternative Design Process

For the alternative design process, the team used two design tools. The first design tool the team used was the multi-voting design tool. This tool allows the team to choose and remove ideas fairly by giving each team member several votes. After the multi-voting process(Appendix C), the team was left with 8 ideas. After, the team went through an editing process(Appendix D). Finally, the team used the second design tool. This tool was inspired by the graphical design tool, where the team compares ideas with the two most important objectives. The three ideas with the highest points that resulted in using the design tool were selected as the three alternative designs (Appendix E). During the alternative design process, the team faced a problem. The problem is that some ideas had an unrealistic price range that had to be removed and adjusted to meet realistic expectations. To meet the realistic expectations for cost range, the team adjusted their approach using a client statement from a client and team meeting.

6.3 Alternative Designs

Through the alternative design process, the team came up with 3 alternative designs.

Solution 1 - Emails and Welcome Kits

Description:

Condo management will email (Figure 7) information and instructions to new tenants regarding waste management and proper usage of the garbage chutes. A “Welcome Kit”(Figure 8 and Figure 9) with information on managing waste shall also be provided.

Function Relation:

This design will inform the new residents on the methods and systems for waste disposal currently in the building. More informed residents will lead to an increase in those following the designated waste system.

Objective Analysis:

The email (Figure 7) is easy to duplicate and quick to send. The welcome kit contains a reusable bag (Figure 8), which costs $1 and an information sheet (Figure 9) from the City of Toronto that can be downloaded and printed 22cm x 28cm for free.

Constraints:

Management emailing residents and handing out material of waste is legal under condo by-laws[11]. The meagre cost of $1 for the Welcome Kit does not exceed $280/floor.

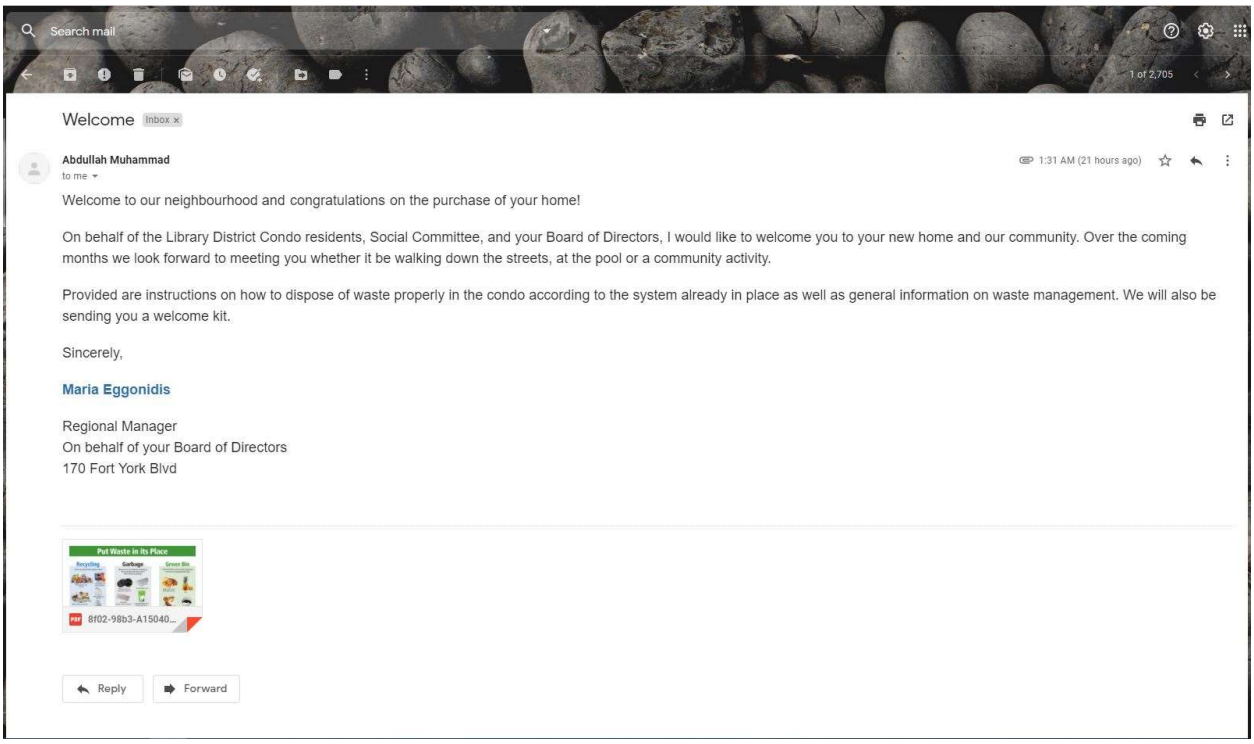

Figure 7:Email Sent to Tenants

Figure 8:Reusable Bag[12]

Figure 9:City of Toronto Information Sheet[13]

Solution 2 - Storage Bins

Description:

Moderate-sized waste storage bins(Figure 10) are placed in each residence. There are labels and information on the bins that help differentiate them, and the waste is collected weekly by Condo Employees.

Function Relation:
The bins will make it easier for residents to differentiate and sort their waste. Making sorting easier will motivate and promote residents to recycle, thus increasing recycling in the condo.

Figure 10:Waste Bins[14]

Objective Analysis:

Three bins (recycling, garbage, organic) are needed for each unit. Each bin costs approx. 8 CAD. No technical assistance required.

Constraints:

Providing residents with bins falls under Condo By-Laws[11] and would cost only $24 per unit, which is manageable.

Solution 3 - Instructional Material and Condo Program

Description:

On poster boards, elevator monitors, emails, and in all chute rooms, posters with instruction and information on recycling, sorting, and the condo's chute system will be posted. Residents can report misuse of chutes to management, resulting in fines for offenders. A small gift card will be given each month to the best recycler on the floor. The landlord will be provided instructions that they must pass on to their tenants.

Function Relation:

There are numerous ways that residents are being educated about waste management through this design. The prizes, as well as the reporting method, help motivate residents to manage their waste properly.

Objective Analysis:

The prizes cost $5-$10 per floor. The materials are proper size. The design requires no technical assistance.

Constraints:

A condo can post information posters in chutes, elevators, message rooms and hallways according to by-laws[11] and can field reports and complaints about other residents and provide fines.

7.0 Proposed Conceptual Design

As determined by the Pugh method of idea selection process shown in Appendix F, the team proposes the final conceptual design, **Instructional Material and Condo Program**, consisting of four components. First is to provide instructions and pictures of specific items in each garbage chute on all floor chute rooms and the size of the object that needs to be compacted to bring to the main room. All instructions are apparent to see. The poster would be designed to show pictures of the major components in each chute bin, directing less time for the residents to read, with a specific identification of the minimum size of the item that should be compacted. This design would then be manufactured and printed by the stakeholder BrandLume Inc and put

beside every single chute bin for all floors within the condominium. This solves the central gap of the problem by guiding waste management procedures.

Second is that residents are encouraged to report others when they see misuse of chutes and have contests between floors on the best waste managing floors with winning prizes. This component addresses personal diligence in their waste managing actions. Residents are encouraged to phone in when they see usage of the chutes improperly by others, and the reported resident, upon confirmation, would face a small fine (the same amount as the cleaning fee, which the client has already implemented.) In addition, having an incentive would also increase the motivation in people to properly waste manage. A small gift card of $5-$10 can be given to individual residents of a floor with the best waste managing procedures every month. This can be determined by the least amount of garbage chute failures or the organization's overall cleanliness and observations.

Third, the condominium can provide printouts of the posters and instructions on waste management to all landlords, instruct them to attach the information, and all the contracts and door keys to be given to every new tenant moving in, ensuring that new tenants have access to the information. This component addresses the problem of new tenants moving in and being unaware of the waste management system.

Lastly, all poster boards, emails, elevator monitors, and screens will include waste managing information. This ensures that all residents can access the information repetitively in multiple places and realize the seriousness of improper waste managing behaviours.

8.0 Measures of Success

To demonstrate why our solution is best fit the design's objectives and constraints, we will develop a three-week plan to testing the solution and collecting data that will further reinforces the validity of our selected solution:

Week	Course of action
Week 1 (Apr.05–Apr.11)	We will survey our team member's family asking them what type of information sources they would pay more attention to. • Collect data from at least 20 people. • This survey will question them about choosing one of the following information sources to gain information about waste management. (Email, Poster, video played on elevator monitor,

	etc.)(Appendix G) • Using the data that we collected, we can decide the percentage of information we deliver to each resident.
Week 2 (Apr.12–Apr.18)	We will be collecting data about our solution by creating surveys. Specifically, we will develop surveys that ask a question about the poster on the garbage chute room, the email sent to the residents, and the video plays on the elevator screen. • For the poster, we will ask about the type of content they will pay more attention to (Appendix H). • For the email, we will create a survey asking about the content they prefer to see about waste management. (Appendix I) • For the video, we have run a survey asking the type of video and length of the video. • These data collected will teach us on how to design a message delivery solution that exhibits objective 1(effective)
Week 3 (Apr.19–Apr.25)	For this week, we will **prototype** using the data we collected last week. • Based on the data collected, we decided to design a poster that indicates the recycled waste, organic waste, and the usage of the chute. (Figures 11 and 12) • We will test this prototype by printing it and use it at home to test its effectiveness. • We will also **simulate** when we put the poster onto the actual chute room. (Appendix J) • This week should tell us more about why our chosen solution exhibits all our objectives (effective, low-cost, proper size, and simple) • At the end of our testing, our data should demonstrate why our chosen solution is the most optimal that fits the objectives and constraints.

Figure 11:Poster about recycle and organic waste, design by Yifei Wang

Figure 12:Poster that inform the residents about the size of the chute, design by Yifei Wang

Please see Appendix J for more details about the prototypes

9.0 Conclusion

The team utilized sections from 2.0 to 5.0 to complete the idea generation and alternative design process. The team generated 62 ideas during the idea generation process. After the alternative design process, the team could eliminate ideas down to three alternative designs before selecting the proposed conceptual design. The proposed conceptual design the team will recommend to the client is a four-part design that meets the client gap in guiding waste managing. The design will help educate and implement a more efficient waste management system with cost-effectiveness. Next, the team will provide a final presentation of the specifics of the design to the client and the Teaching Assistant and Engineering Manager.

10.0 References

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11.0 Appendices

Appendix A: List of ideas generated from using the brainstorming design tool

Process:

- 20-minute rounds of brainstorming, 5-minute breaks
- Total of 3 rounds

Instructions:

Team members were instructed to type out ideas generated during the brainstorming session onto a shared document:

William:

1. Informative visual aids on a letter sized document on how to use the waste management system.
2. Setting up cameras by the garbage chutes on every floor to catch any tenants who uses garbage chutes improperly.
3. A fob reader by the garbage chutes that detects who uses the garbage chutes.
4. A PowerPoint or slides that are shown in the elevator to show how to use the waste management system
5. A compressor installed in the garbage chutes that allow tenants to use to compress any big garbage down the garbage chutes
6. A device that can detect if the items going inside the garbage chutes is too big
7. A garbage chute elevator that can move up and down to push any items that are stuck to move down
8. An informative environmental impact brochure that informs residence on the importance of proper waste management
9. Raising costs of strata fees for every repair that is made on garbage chutes
10. Implementing new and strict strata laws to limit improper waste management behaviors
11. A compressor device given to every tenant in the building that will allows garbage to be compressed before going into the garbage chutes
12. A device that imitates the size of the garbage chutes that can be used as a reference for residence to use to check if the size of the garbage can fit inside the garbage chutes.

Abdullah:

13. Informative Posters
14. Emails that send out information regarding the proper recycling techniques as well as consequences, similar to what the posters do
15. Handing out Flyers to each apartment
16. Town hall style meeting with resident's t0 inform them
17. Better, More Noticeable Labelling in the Chutes
18. Painting the Chutes to Indicate Garbage vs. Recycling
19. Cameras in room with chutes
20. Fines for people not disposing of waste properly
21. Hiring someone to be in the chute room to make sure people are disposing properly
22. Having residents take photos of their garbage and Recycling and submit to the building office so there is a record of who is throwing what
23. Ban the use of single-use plastics in the building
24. Make a Recycling club that promotes and encourages Recycling within the condo

Lulu:

25. Encourage residents by having contests like prizes and gift cards for the winning floor with the least blockage in the garbage chutes and proper waste management
26. Fining residents for the cost of the building for unblocking the chutes, and any additional labour needed.
27. Having easy access contacts of the condominium organizer and encourage residents to phone and report other residents when they see improper garbage management, with granted small prizes
28. implementing surveillance camera for all garbage chute rooms in all floors to monitor residents and identify residents who do not waste manage properly
29. Having posters on specific garbage items that fit in each category and which chute bins to put in, as well as specifying specific sizes of items that can fit through the chute, and which large items need to be compacted and brought to the main floor. Instructions to using the chutes are also provided right beside the chutes on all floors with appropriate visuals that are obvious to see.
30. Email landlords and condo owners to inform the condominium management whenever new tenants move in, so the condo management can email the new tenants regarding instructions and information for waste management and using the garbage chutes.
31. Enforcing the idea that all landlords are to provide instructions provided by the condo manager regarding waste management within the condominium, attached along with information when new tenants move in

32. Provide instructions on waste management in individual chute floors, as well as reminding residents on the importance of waste management in all notice boards, emails to residents, elevators, and screen monitors.
33. Send emails and attach information to all devices and public boards regarding consequences of the misuse of waste managing, as well as past photos of what would happen when garbage chutes are blocked, as well as environmental impacts.
34. Providing instructions and pictures of specific items and objects that can be thrown in each garbage chute on all floor chute rooms, and the specific size of object that needs to be compacted to bring to the main room. All instructions are obvious to see right beside the chute rooms. Residents are encouraged to report others when they see misuse of chutes and have contests between floors on the best waste managing floors with winning prizes. Construct waste management instructions of the condo and should instruct the condo owners and landlords to provide them to every new tenant moving into the condominium. All poster boards, emails, elevator monitors and screens are to include waste management information and consequences.
35. Having security personnel rotating around the garbage chutes during different times to monitor the waste management near the chutes
36. Creating a sensor on the garbage chute where whenever an object or item is put in the wrong sorting bin, it rings and alarm and alerts the resident that they have put the wrong item in the bin
37. Creating an iPad/application beside each garbage chute, where residents are able to use it and to search up their item, and the iPad will tell them which garbage chute the item belongs, and whether if that item is too large and should be compacted and brought to the main floor.

Yifei:

38. Poster with graphic of how-to recycling waste.
39. Graphic instruction of different type of waste (recycle, hazard, common).
40. 3D model of types of recycling wastes.
41. Monthly email push with educational videos or writings.
42. Posters that stick on the garbage chute doors using different color to separate recycle waste and other waste.
43. Educational video that plays in the elevators' screen.
44. Instruction about how to proper recycle large waste.
45. Provide feedback and update on the effectiveness of recycling and their actions.
46. Provide a "Welcome kit" for new tenants with information on how to manage their waste.
47. Give information about waste management on the website (or any other message delivery system)

48. Set up event for children that provide games that related to waste management (Recycling word games, Waste bingo, etc.)
49. All residents must put the waste to the garbage bin on the main floor to reduce the improper waste management.

Krishaj

50. Informative posters telling tenants how to use the system, the different types of waste, and the consequences of not properly waste managing.
51. A cell phone app that allows tenants to know what type of waste they have so it is easier for them to sort the waste.
52. A system that makes the tenants identify the type of waste they have and then sends it down the correct chute.
53. A system that sorts the different types of waste for the tenants, so they do not have to
54. Installing moderate sized waste storage bins at each tenant's residence so that it is easier for them to sort the waste. There is information on these storage bins that lets the tenants know the types of waste. The waste is collected by other building workers weekly, like it is don't for houses.
55. Give tenants big rewards for amounts of waste properly sorted so they will be more inclined to sort their waste.
56. Installing "key card" systems at the doors of the chute rooms and cameras in the rooms to let the manager know who used the system. If there are any problems in the system, the person can be tracked down easily and is fined an amount for the damage and receives information about how to waste manage.
57. Tell the tenants to leave their waste in a pile. Train monkeys to sort through the waste
58. Make the tenants make a solution to the problem in the building.
59. Hold monthly mandatory waste management meetings for tenants that have not been living in the building for more than around 2 months and for those who do not follow the rules. Inform and educate tenants in these meetings.
60. Remove all tenants from the building. This will make the waste management problem go away.
61. Replace all tenants with ones that follow the rules.
62. If tenants follow rules, reduce fees for those tenants. Apply more fees to those who do not follow the rules.

Appendix B: List of ideas

In this list, the team used the list in Appendix A and eliminated any duplicated ideas or ideas that were unable to meet the constraints):

Abdullah:

1. ~~Informative Posters~~
2. ~~Emails that send out information regarding the proper Recyling techniques as well as consequences, similar to what the posters do~~
3. Handing out Flyers to each apartment
4. Town hall style meeting with resident's t0 inform them
5. Better, More Noticeable Labelling in the Chutes
6. Painting the Chutes to Indicate Garbage vs. Recyling
7. ~~Cameras in room with chutes~~
8. Fines for people not disposing of waste properly
9. Hiring someone to be in the chute room to make sure people are disposing properly
10. Having residents take photos of their garbage and Recyling and submit to the building office so there is a record of who is throwing what
11. Ban the use of single-use plastics in the building
12. Make a Recyling club that promotes and encourages Recyling within the condo

Lulu:

13. Encourage residents by having contests like prizes and gift cards for the winning floor with the least blockage in the garbage chutes and proper waste management
14. ~~Fining residents for the cost of the building for unblocking the chutes, and any additional labour needed.~~
15. Having easy access contacts of the condominium organizer and encourage residents to phone and report other residents when they see improper garbage management, with granted small prizes
16. ~~implementing surveillance camera for all garbage chute rooms in all floors to monitor residents and identify residents who do not waste manage properly~~
17. Having posters on specific garbage items that fit in each category and which chute bins to put in, as well as specifying specific sizes of items that can fit through the chute, and which large items need to be compacted and brought to the main floor. Instructions to using the chutes are also provided right beside the chutes on all floors with appropriate visuals that are obvious to see.

18. Email landlords and condo owners to inform the condominium management whenever new tenants move in, so the condo management can email the new tenants regarding instructions and information for waste management and using the garbage chutes.
19. Enforcing the idea that all landlords are to provide instructions provided by the condo manager regarding waste management within the condominium, attached along with information when new tenants move in
20. ~~Provide instructions on waste management in individual chute floors, as well as reminding residents on the importance of waste management in all notice boards, emails to residents, elevators, and screen monitors.~~
21. Send emails and attach information to all devices and public boards regarding consequences of the misuse of waste managing, as well as past photos of what would happen when garbage chutes are blocked, as well as environmental impacts.
22. Providing instructions and pictures of specific items and objects that can be thrown in each garbage chute on all floor chute rooms, and the specific size of object that needs to be compacted to bring to the main room. All instructions are obvious to see right beside the chute rooms. Residents are encouraged to report others when they see misuse of chutes and have contests between floors on the best waste managing floors with winning prizes. Construct waste management instructions of the condo and should instruct the condo owners and landlords to provide them to every new tenant moving into the condominium. All poster boards, emails, elevator monitors and screens are to include waste management information and consequences.
23. Having security personnel rotating around the garbage chutes during different times to monitor the waste management near the chutes
24. Creating a sensor on the garbage chute where whenever an object or item is put in the wrong sorting bin, it rings and alarm and alerts the resident that they have put the wrong item in the bin
25. Creating an iPad/application beside each garbage chute, where residents are able to use it and to search up their item, and the iPad will tell them which garbage chute the item belongs, and whether if that item is too large and should be compacted and brought to the main floor.

Yifei:

26. ~~Poster with graphic of how-to recycling waste.~~
27. ~~Graphic instruction of different type of waste (recycle, hazard, common).~~
28. 3D model of types of recycling wastes.
29. ~~Monthly email push with educational videos or writings.~~
30. Posters that stick on the garbage chute doors using different color to separate recycle waste and other waste.

31. Educational video that plays in the elevators' screen.
32. ~~Instruction about how to proper recycle large waste.~~
33. Provide feedback and update on the effectiveness of recycling and their actions.
34. Provide a "Welcome kit" for new tenants with information on how to manage their waste.
35. Give information about waste management on the condo website (or any other message delivery system)
36. Set up event for children that provide games that related to waste management (Recycling word games, Waste bingo, etc.)
37. ~~All residents must put the waste to the garbage bin on the main floor to reduce the improper waste management.~~

Krishaj

38. ~~Informative posters telling tenants how to use the system, the different types of waste, and the consequences of not properly waste managing.~~
39. ~~A cell phone app that allows tenants to know what type of waste they have so it is easier for them to sort the waste.~~
40. A system that makes the tenants identify the type of waste they have and then sends it down the correct chute.
41. A system that sorts the different types of waste for the tenants, so they do not have to
42. Installing moderate sized waste storage bins at each tenant's residence so that it is easier for them to sort the waste. There is information on these storage bins that lets the tenants know the types of waste. The waste is collected by other building workers weekly, like it is don't for houses.
43. Give tenants big rewards for amounts of waste properly sorted so they will be more inclined to sort their waste.
44. Installing "key card" systems at the doors of the chute rooms and cameras in the rooms to let the manager know who used the system. If there are any problems in the system, the person can be tracked down easily and is fined an amount for the damage and receives information about how to waste manage.
45. Tell the tenants to leave their waste in a pile. Train monkeys to sort through the waste
46. Make the tenants make a solution to the problem in the building.
47. Hold monthly mandatory waste management meetings for tenants that have not been living in the building for more than around 2 months and for those who do not follow the rules. Inform and educate tenants in these meetings.
48. Remove all tenants from the building. This will make the waste management problem go away.
49. ~~Replace all tenants with ones that follow the rules.~~

50. If tenants follow rules, reduce fees for those tenants. Apply more fees to those who do not follow the rules.

William:

51. ~~Informative visual aids on a letter sized document on how to use the waste management system.~~
52. ~~Setting up cameras by the garbage chutes on every floor to catch any tenants who uses garbage chutes improperly.~~
53. ~~A fob reader by the garbage chutes that detects who uses the garbage chutes.~~
54. ~~A PowerPoint or slides that are shown in the elevator to show how to use the waste management system~~
55. A compressor installed in the garbage chutes that allow tenants to use to compress any big garbage down the garbage chutes
56. A device that can detect if the items going inside the garbage chutes is too big
57. A garbage chute elevator that can move up and down to push any items that are stuck to move down
58. An informative environmental impact brochure that informs residence on the importance of proper waste management
59. ~~Raising costs of strata fees for every repair that is made on garbage chutes~~
60. ~~Implementing new and strict strata laws to limit improper waste management behaviors~~
61. A compressor device given to every tenant in the building that will allows garbage to be compressed before going into the garbage chutes
62. A device that imitates the size of the garbage chutes that can be used as a reference for residence to use to check if the size of the garbage can fit inside the garbage chutes.

Appendix C: Ideas after the multi-voting process (See table below)

Instructions:
Each team member was given three votes to vote on three ideas that they believed were plausible design solutions.

Ideas with votes	Number of votes
25. Creating an iPad/application beside each garbage chute, where residents are able to use it and to search up their item, and the iPad will tell them which garbage chute the item belongs, and whether if that item is too large and should be compacted and brought to the main floor.	William, Lulu
24. Creating a sensor on the garbage chute where whenever an object or item is put in the wrong sorting bin, it rings and alarm and alerts the resident that they have put the wrong item in the bin.	William, Krishaj
44. Installing "key card" systems at the doors of the chute rooms and cameras in the rooms to let the manager know who used the system. If there are any problems in the system, the person can be tracked down easily and is fined an amount for the damage and receives information about how to waste manage.	William, Krishaj
22. Providing instructions and pictures of specific items and objects that can be thrown in each garbage chute on all floor chute rooms, and the specific size of object that needs to be compacted to bring to the main room. All instructions are obvious to see right beside the chute rooms. Residents are encouraged to report others when they see misuse of chutes and have contests between floors on the best waste managing floors with winning prizes. Construct waste management instructions of the condo and should instruct the condo owners and landlords to provide them to every new tenant moving into the condominium. All poster boards, emails, elevator monitors and screens are to include waste management information and consequences.	Abdullah, Lulu
36. Set up event for children that provide games that related to waste management (Recycling word games, Waste bingo, etc.)	Yifei

17. Having posters on specific garbage items that fit in each category and which chute bins to put in, as well as specifying specific sizes of items that can fit through the chute, and which large items need to be compacted and brought to the main floor. Instructions to using the chutes are also provided right beside the chutes on all floors with appropriate visuals that are obvious to see.	Abdullah, Yifei
42. Installing moderate sized waste storage bins at each tenant's residence so that it is easier for them to sort the waste. There is information on these storage bins that lets the tenants know the types of waste. The waste is collected by other building workers weekly, like it is done for houses.	Abdullah, Krishaj
34+18. Email landlords and condo owners to inform the condominium management whenever new tenants move in, so the condo management can email the new tenants regarding instructions and information for waste management and using the garbage chutes. & Provide a "Welcome kit" for new tenants with information on how to manage their waste.	Lulu, Yifei

Appendix D: Edited ideas after multi-voting process

The team removed any ideas with less than two votes from the table in Appendix C:

Idea Number	Voters
25*	William, Lulu
24*	William, Krishaj
44*	William, Krishaj
22*	Abdullah, Lulu
17*	Abdullah, Yifei
42*	Abdullah, Krishaj
34*+18*	Lulu, Yifei

*Refer to Appendix C for description of the ideas

Appendix E: Multi-Voting Process

Objective 1: Design should be effectiveness.
Objective 2: Design should be low-cost.

Objective 1 is scored higher than objective 2 is because objective 1 is more important objective 2 according to the detailed requirement section of the document.

Instructions:

Each team member was instructed to give a score of 4,5, or 6 on the idea's performance on objective 1 and score of 1,2, or 3 on the idea's performance on objective 2.

Process:

The scores from each team members were then averaged out for each idea's performance on objective 1 and 2. Then, the scores for objectives 1 and 2 were summed. The three highest scores were then selected to be the three-alternative process.

Idea Number	Overall score for Objective 1 (points=4,5,6)	Overall score for Objective 2 (points=1,2,3)	Total
25*	5	1.5	6.5
24*	5	1	6
44*	4.5	1	5.5
22*	5	3	8
17*	3.5	2.75	6.25
42*	4.25	2.5	6.75
34*+18*	5.25	1.75	7

*Refer to Appendix C for description of the ideas

Ideas with the Highest Scores:

1. 22*
2. 34*+18*
3. 42*

*Refer to Appendix C for description of the ideas

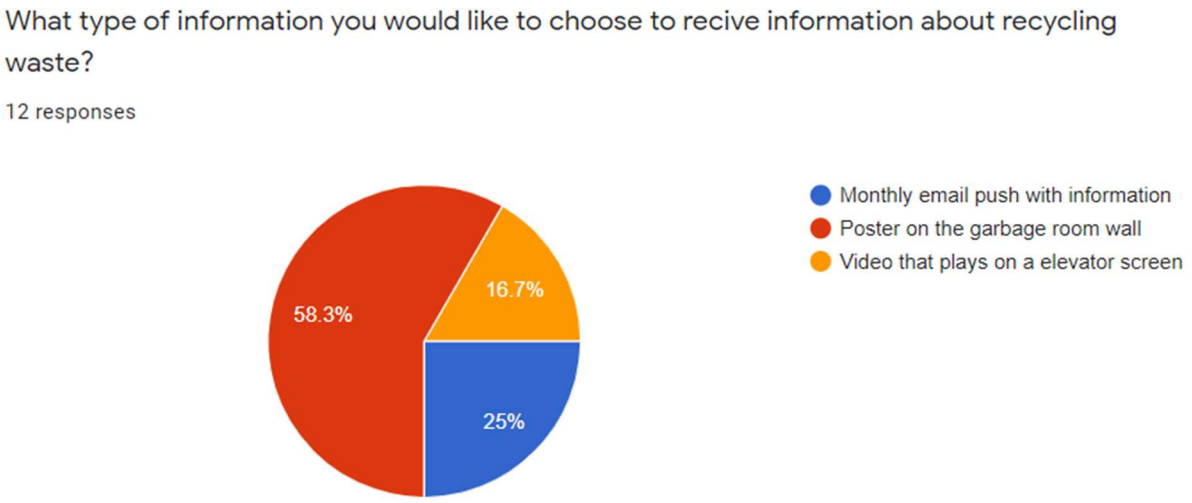
Appendix F: Pugh Method to decide the most optimal solution amongst the three selected ideas (See table below)

Solutions Objectives	Standard design	Alternative design 1: 22	Alternative design 2: 34+18	Alternative design 3: 42
Effective	S	+1	0	-1
Low-cost	S	-1	0	-1
Proper Size	S	0	0	0
Simple	S	0	-1	-1

Standard design: The conventional standard design that is currently being used within condominium to encourage waste management is the use of posters of instructions near garbage bins, which is as described by idea 17 generated by the team.

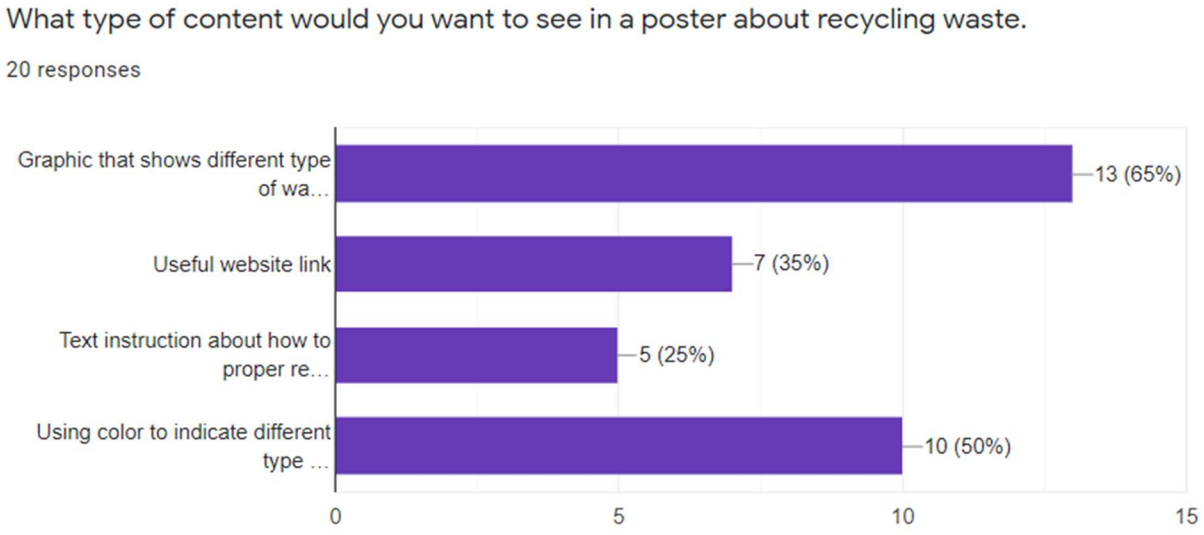
Based on evidence from the Pugh chart, it was decided that design 22 would be the most desired solution, followed by design 34+18 and design 42 based on the calculated score. Design 22 has an overall score of 0, while design 34+18 and design 42 has a score of –1 and –3, respectively. Even though the most optimal design 22 has a score of 0, which seems to function the same as the standard solution, the team still believe it is a better solution since it greatly exceeds the primary objective of the project, which is its effectiveness. Considering that design 22 has a great extent of advantage for the primary objective than the standard design, the team believes it would be the most optimal solution.

Appendix G: Survey result on what type of information people would like to choose to receive information about recycling waste.

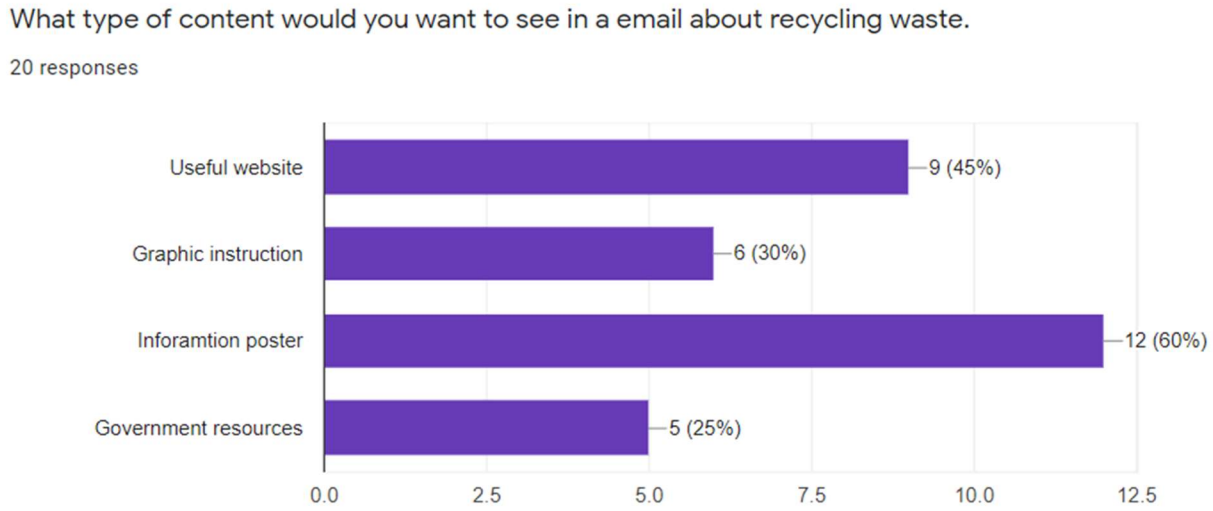


The survey results also provided guidance for the team to verify that the final alternative solution is feasible and will likely be useful once implemented.

Appendix H: Survey result on what type of content people would like to see on a poster about recycling waste.



Appendix I: Survey result on what type of content people would like to see on a email about recycling waste.



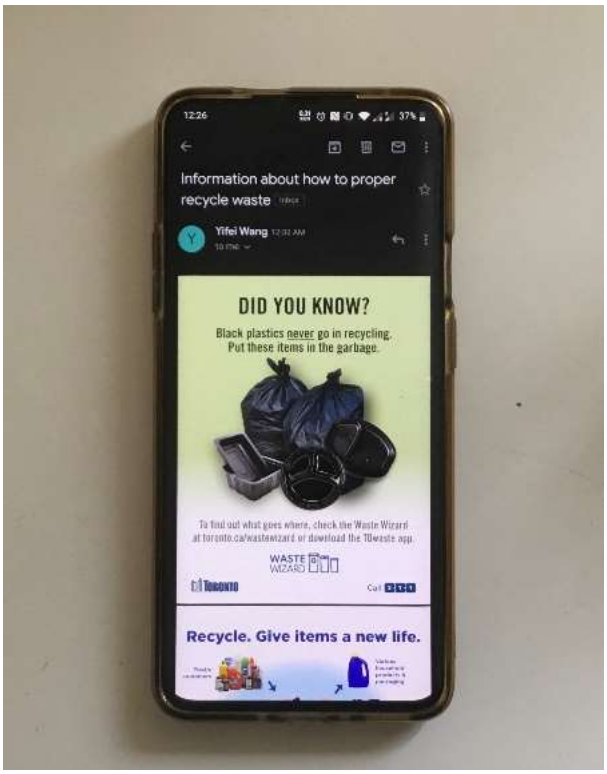
The survey for Appendix H and I provide guidance on the specific content and area to focus on within our final prototype design to meet the client need.

Appendix J: Prototype

Below are the prototypes that we made to try to represent how our solution works. The posters are printing on a standard letter size paper (8.5x11 inches). That can be stick to the well in the chute room using glue or tape. Also, it can be attached to the poster board on every floor.

Figure J.1: Simulation of the posters on the chute room

Figure J.2: Posters that printed using a common household printer.



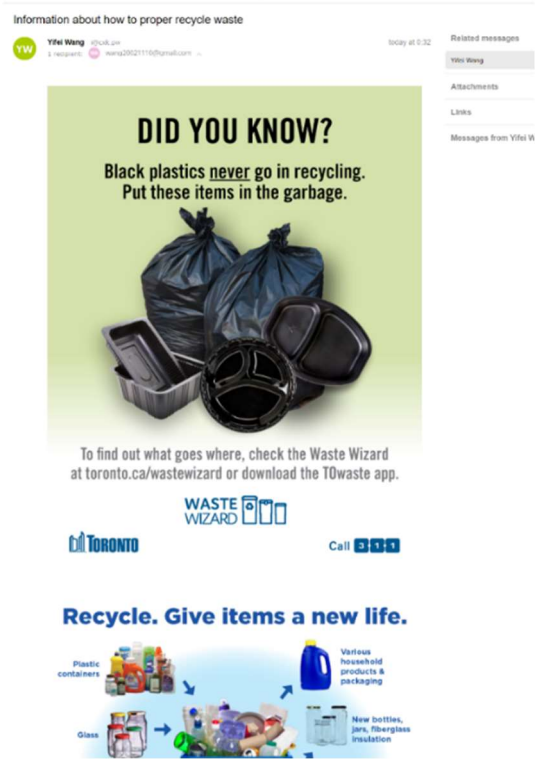


Figure J.3: The email that delivery the information about how to proper recycle waste with useful link. Read from a phone and a computer screen.

Appendix K: Pairwise Comparison

The table below represents the pairwise comparison used to determine the ranking of the most to least important objectives.

	Effective	**Simple**	**Low-Cost**	**Proper Size**
Effective	-	1	1	1
Simple	0	-	0	0
Low-Cost	0	1	-	1
Proper Size	0	1	0	-