Integrating Community-Based Social Marketing Theory to Improve Waste Sorting Behaviour at the University of Waterloo

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Introduction: Improving waste sorting has become an urgent matter in the global North since 2017 when China, the world's largest waste importer, announced that it would no longer accept highly contaminated waste. Consequently, new strategies for dealing with waste have been proposed in both the private and public sectors.

In 2018, the University of Waterloo (UW) introduced new waste sorting receptacles on campus to facilitate waste sorting, as part of its larger goal to become a zero waste campus by 2035. Despite rolling out these new waste stations, UW's annual waste audit still showed high cross-contamination and low waste diversion rates. Further complexity was added when a new sorting standard was released in 2019 to comply with UW's new waste management system. This new sorting standard presented an important opportunity to provide consistent and effective guidance for the campus community through the lens of Community-Based Social Marketing (CBSM). A number of past studies that examined changes in waste sorting behaviour merely focused on the signage, and considered only the numeric data changes, but neglected the connection with their users. By integrating the CBSM framework, this study was able to understand users' barriers and current behaviours before going straight into signage design. Moreover, the adoption of a comprehensive research design enabled the researcher to assess the waste sorting situation on the UW campus from different aspects.

Research Purpose: The purpose of this study was to improve correct waste sorting behaviour on the UW campus by leveraging the impact of altering signage at the new waste stations. Experimental signage options that were more user-friendly, straightforward, and less confusing were created and tested for effectiveness.

Methodology and methods: This mixed-method study included three phases, and follows the CBSM framework to test waste signage designs on the UW campus. The pre-phase included a survey, observations, and a waste audit, which helped develop an understanding of the target audience (i.e. the campus community) and identified the barriers and benefits in relation to waste sorting on campus. Subsequently, experimental waste signs were then designed and installed at selected sites, based on the results synthesized from the pre-phase. Lastly, the post-phase was conducted for follow-up purposes to explore users' interactions with the redesigned signs, and waste sorting outcomes.

Results: Improvement of diversion rates and sorting attempts were noted at sites installed with experimental signs. Positive interactions between the experimental signs and the users were also

observed in the post-phase. Moreover, it was found that not only the visual design of the signage matters, but also the visual attraction and the overall visual experience provided by the installation surroundings can influence a user's sorting behaviour.

Conclusion: Following the CBSM framework during the waste sign design process provided a strong connection between the signs' design and the users' experiences. In addition, altering the visual design of waste signage can be influential, but the effect is limited unless the users notice the change. Misconceptions and past experiences are two main reasons believed to heavily affect users' sign reading and waste sorting habits. Since signage is unlikely to significantly improve correct waste sorting behaviour alone, other interventions are needed to address this issue.

Keywords: Social marketing, waste management, signage design, pro-environmental behaviours, behaviour change, university

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List of Abbreviations

1. **4Ps:** Product, Place, Price, Promotion
2. **AHS:** Applied Health Science
3. **ANOVA:** Analysis of Variance
4. **CBSM:** Community Based Social Marketing theory
5. **Co-op:** Co-operative education
6. **CMH:** Claudette Millar Hall
7. **DC:** Davis Centre
8. **DP:** Dana Porter Library
9. **EV3:** Environmental 3
10. **IC&I:** Industrial, Commercial and Institutional sector
11. **LCA:** Life Cycle Assessment
12. **SDGs:** Sustainability Development Goals
13. **SLC:** Student Life Centre
14. **STC:** Science Teaching Complex
15. **TPB:** Theory of Planned Behvaiour
16. **REV:** Ron Eydt Village
17. **RIC:** Reuters Instrument Code
18. **RFID**: Radio Frequency Identification
19. **UW:** The University of Waterloo, Waterloo, Ontario, Canada.
20. **V1:** Village 1

Definitions of Key Terms

Key terms are listed here for clarification purposes, as some terms appear to be easily confused due to their similar meanings. Operational definitions are given at where applicable.

1. **Barrier:** Contextualized difficulties and challenges that prevent the target audience from adopting the desired behavior, i.e. conducting correct waste sorting.
2. **Benefit:** Contextualized advantages that may attract or motivate the target group members to adopt the desire behaviour, i.e., conducting correct waste sorting.
3. **Bin(s)/cart(s)/can(s):** one of the bins of the streamed waste station or a single waste collection bin/cart/can.
4. **Criteria**: the **guideline** used to determine the correctness of sorting for observation and waste audit results in this study.
5. **Contaminants:** Waste placed in the wrong waste stream.
6. **Capture rate:** the proportion expressed as a percentage of recyclables (by mass) successfully removed from disposal, e.g., landfill or incineration stream to the total mass of all waste materials that **could have been diverted**. The mass of contaminants should be excluded when calculating. (BOMA Canada, n.d.)
7. **Contamination rate:** the proportion expressed as a percentage of materials (by mass) that are **incorrectly disposed in wrong stream** to the total mass of all waste collected by that particular stream. (BOMA Canada, n.d.)
8. **Diversion Rate:** the proportion expressed as a percentage of all materials (by mass) successfully removed from disposal, e.g., landfill or incineration stream to the total mass of all waste materials collected. The mass of contaminants should be excluded when calculating. (BOMA Canada, n.d.; Bourner, n.d.; Buchan, n.d.)
9. **Frequent mis-sorted items:** the operational definition for this term is “a 70% or above mis-sort rate” of the sorting quiz in the study survey result; or items that are noticed to be commonly mis-sorted in waste audit or observations.
10. **‘Oops’ sign:** Experimental signs used in this study that present alternative disposal instructions when the best choice is not provided.
11. **Oops sign:** Experimental signs in this study that present alternative choice of waste dispose options when the best choice is not provided.

12. **Other bin**: an other bin is different from the “Other stream” among the five-stream waste diverting system (organic, paper, container/ recycling, garbage, and other). Other bins are extra receptacles other than the selected waste stations.
13. **Pre phase:** the stage conducted before the design and installation of the experimental signage (CBSM intervention).
14. **Post phase:** the stage conducted after the design and installation of the experimental signage (CBSM intervention).
15. **Receptacle(s):** Any waste bin(s), cart(s), or the entire waste station(s).
16. **Sorting Standard:** The waste sorting guideline to follow when discarding waste. It indicates the proper waste stream an item or a certain material should be disposed of.
17. **Social Marketing Campaign:** A program or intervention that is designed to influence a target audience to change their behaviours in order to meet a social objective
18. **Target audience:** A definition from marketing is *“A set of buyers sharing common needs or characteristics that the company decides to serve.”* (Armstrong et al., 2016, p. 684) Whereas in the scope of Social Marketing, the term target group (member/audience) generally implies the people that is focused by the study, who researchers wish to see behaviour changes. The target group for this research is **the waste stations users, i.e., the campus community.**
19. **Waste station:** A set of standardized streamed waste collection receptacles, either three-streamed or four-streamed. A waste station is equipped with a garbage stream and at least one container stream, while the composition of the third and the fourth stream can be another container stream, an organic, or/and a paper stream. The combination depends on the waste characteristic, waste traffic, and the collection capability of the custodial service personnel at that location. These waste stations are the selected study units in this research.

1. Introduction

1-1 Background

In 2015, the United Nations announced the Sustainable Development Goals (SDGs). Among these 17 goals, SDG 12 relates to *Responsible Consumption and Production* (United Nation [UN] General Assembly, 2015). More specifically Goal 12.5 calls for a "substantial reduction in waste generation through prevention, reduction, recycling and reuse". How to improve waste diversion and promote better waste sorting has indeed become a borderless issue.

Interestingly, in 2018, China, the biggest waste importing country in the world, announced that they would no longer accept "high contaminated" recycling waste (Ministry of Environmental Protection of the People's Republic of China, 2017). This step enlightened the public to the fact that prior to waste being imported to China, waste sorting was not done properly or thoroughly enough in many cases (Chung, 2018). If the high contamination rate of recycling waste is not adequately addressed, the waste sorting actions people have been told to do over the years to divert waste from landfill goes from being fact to fiction.

If recycling waste is not accepted by its end market, or if the overall input, including cost, energy, and resources to deal with the waste is higher than its output, then the items are likely to end up in landfill or incineration(BOMA Canada, n.d.; Brooks et al., 2018). Moreover, sending waste to landfill is also adding increased pressure to the remaining space left in existing landfill sites, while building new ones is often very challenging, particularly for countries with limited undeveloped land. Landfill sites are also generally seen as a 'not in my backyard' phenomenon, in that when a new site is needed, no one in the local community wants to be situated next to one.

Tracing back to 2016, the *Resource Recovery and Circular Economy Act* (2016) and the *Waste-Free Ontario Act* (2016) were enacted to update the repealed *Waste Diversion Act* set much earlier in 2002. The update of these laws can be regarded as the growing focus on waste management from a regulatory perspective. Later on in 2018, the Ministry of the Environment, Conservation and Parks of Ontario released a *Preserving and Protecting our Environment for Future Generations: A Made-in-Ontario Environment Plan* (2018). In the plan, commitments and goals were made on different aspects to lead Ontario reaching a sustainability future. Subsequently, a discussion paper followed that specifically targeted waste reduction in the Province of Ontario: *Reducing litter and waste in our communities* (2019). It concluded that, organic waste, including yard waste (leaves, soil), and food waste made up a high proportion of all waste. Particularly, organic waste is known to emit one of the most impactful greenhouse

gases – methane, as the waste breaks down in landfill sites. With the municipal and residential sectors doing a relatively better job on diverting waste from landfill, the Industrial, Commercial and Institutional (IC&C) sector, in particular, needs to make advancements in this area, which has led to the Province taking a stronger stance in this area.[1]

The Federal and Provincial governments' strategies and policies for ensuring better waste diversion rates have likewise filtered down to the institutional level. The University of Waterloo (UW), with a population of more than 40,000 students alone, with another couple thousands of faculty and staff (almost a small town) has also set its own goal, and started to take action (University of Waterloo, 2018c). By reviewing previous campus waste audit results (Waste Reduction Group Inc, 2017), a similar conclusion regarding waste diversion was drawn as was at the provincial level review. UW has a high potential for improvement particularly that over 80% of the waste can be diverted from garbage stream to organic and recycling streams (University of Waterloo, 2018c). Waste sorting, especially at the source, is a vital and initial step toward good recycling and waste reduction processes, and is the focus of this thesis.

In 2017, UW developed a Zero Waste Action Plan with a commitment of becoming a zero waste campus (90% diversion rate) by 2035. In 2018, waste audits on campus showed an overall diversion rate of 30.46% (University of Waterloo, 2019b). The Zero Waste Action Plan aims to reach a 60% diversion rate by 2025, with a goal of achieving a 90% diversion rate by 2035 (University of Waterloo, 2018a). The Plan includes five key approaches, which includes updating infrastructure and services as well as actively reaching out to students, faculty, and staff. UW aims to provide simple but tangible actions for people to join the effort The five approaches are: 1) Engage and train; 2) Reduce and eliminate waste; 3) Maximize recycling; 4) capture organic; e.g.,; and 5) expand reuse programs, e.g., used items sales. (University of Waterloo, n.d.-b)

As part of sustainability strategies on campus, a set of new waste sorting stations was introduced at UW in 2018. The waste stations include combinations of bins with different streams of garbage, recyclable materials, mixed paper, and most importantly, compost (organic). However, the new waste stations did not work as effectively as expected, with data still showing a high cross-contamination rate and a low overall waste diversion rate (30.46%) (University of Waterloo, 2019b). One explanation for the lower diversion rate is the inconsistency of waste bins and signage, as the new waste stations in some buildings sit alongside the previous bin/signage system as the new system is phased in. The new and old signs

[1] The acts and plans mentioned in this paragraphs were set by an earlier Ontario government.

show conflicting messages, some items are repeated on different waste categories, which may cause confusion. As discarding waste is seen as a minor issue in most people's daily lives, they may be more likely to give up quickly if the discarding process is confusing, complicated, or difficult (CleanRiver, n.d.). Furthermore, not long after the new system was introduced, a new campus sorting standard was released, adding further complexity (University of Waterloo, n.d.-a).

Due to the inconsistency of the bin signs and the new sorting standard on campus, there is a need to update the signs that aligns with the new sorting standard. That is, switching to more effective and efficient signage for the waste collection receptacles on campus is essential to increase UW's overall waste diversion rate. Since UW is in a transition phase in terms of its waste collection system and sorting standards, the current study is relevant and timely.

1.2 Purpose Statement

1-1.1 Research purposes and objectives

Research Purpose

The purpose of this quasi-experimental mixed method study aims to use the community-based social marketing (CBSM) framework to investigate the impacts of sorting behaviours of users on the UW campus, by altering the visual design of waste signage.

Previous studies have conducted related waste sorting research in higher educational institutions. However, few have thoroughly reviewed their target audience before prescribing solutions to the problems. In addition, some studies rely purely on numeric results to evaluate the effectiveness of signage, which neglects the examination of users' interactions with signs. This study, therefore, sets out to develop a comprehensive understanding of the intended audience through a three-pronged approach that includes: 1) an online survey of the campus community; 2) pre and post waste audits of both control and test sites at waste station locations, and 3) pre and post non participatory onsite observations of users' interaction with the waste stations and signs.

Previous research has provided ideas and evidence of good practice for waste signage design, but a number of studies have based results on tests/experiments conducted in a laboratory environment(Wu et al., 2018). However, it is also suggests that results gained from laboratory studies or theoretical concepts can experience some difficulties when conducting field work (Levitt & List, 2007a, 2007b; Wu et al., 2018).Moreover, waste sorting behaviours can be affected by users' cultural background and past

experiences (Kollmuss & Agyeman, 2002; Wu et al., 2018). In other words, waste sorting behaviours may differ case by case so even when a target audience with similar traits is targeted, the surroundings can have an important impact on behaviour.

As the focus of this study was to design signage for waste stations that could trigger better waste sorting on the UW campus, it is necessary to conduct a study that starts by developing an understanding of the target audience, uses these findings to develop communication tools that decrease current barriers and then assesses changes in user behaviour. This study draws in particular from findings by Ahmed, Khanani, & Koshy, (2016) and Wu et al., (2018), which both investigated and concluded that having signage that includes colour images of typical items above each sorting bin is the most effective method to improve sorting behaviour.

CBSM theory is used as the conceptual framework for this study (McKenzie-Mohr, 2011). The principles of CBSM start by narrowing in on a specific behaviour (in this case 'proper sorting of waste at the new waste stations on campus'), specifies a target audience (i.e. the campus community), identifies barriers and benefits of the behaviour from the point of view of the target audience and then develops strategies to reduce barriers and increase benefits. The intention is to let the contents of the experimental signs fit closer to users' needs by integrating CBSM tactics. The results of this study have the potential to set the foundation for future waste reduction initiatives on the UW campus, and the opportunity to provide useful information that helps UW get closer to its sustainability goal of reaching a "zero waste" campus by 2035 (University of Waterloo, 2018b).

Research objectives:

1.) To understand users' (i.e. the campus community's) current waste sorting behaviour on UW campus.
2.) To understand users' waste sorting knowledge level and awareness.
3.) To Identify barriers and benefits users have with respect to sorting waste on campus.
4.) To examine the effectiveness of changing waste signage design with visual images integrating CBSM strategies.
5.) To develop recommendations of potential CBSM strategies for UW to further improve waste management on campus.

1-1.2 Research questions and hypotheses

Research Questions

1. **How can changing the visual design of waste signage affects users' sorting behaviours?**

2. **What is the influence of integrating Community Based Social Marketing tactic into waste signage design?**

It is hypothesized that displaying images of actual items on waste sign can improve waste sorting (H1) and that larger signs can trigger grater positive waste sorting behavioural changes than smaller signs (H2).

1-3 Thesis Structure

To provide a clearer understanding of the flow of this thesis, this section outlines its structure. The thesis contains eight chapters.

Chapter 2 – Literature Review: Firstly, this chapter goes through a review of studies related to waste management or pro-environmental behaviours. Secondly, the theoretical framework with the main core of the CBSM theory is presented. Thirdly, the best practices of signage design research are synthesized and followed by a review of study tools used by previous research.

Chapter 3 – Research Methods: This chapter first illustrates the research design of this mix-method quasi-experimental study, followed by the implementation details and the analyzing plans of data collected by each research tool. The three research tools are survey, observation, and waste audit.

Chapter 4 & 6 – Pre and Post Phase Results: These two chapters present the data collected in the pre and the post intervention phases. Comparison analysis of the collected data is also covered in chapter 6. Due to the nature of the study design, the pre phase includes data from all study tools (survey, observation, waste audits), while the post phase only contains data collected from the follow up observation and waste audits.

Chapter 5 – CBSM Campaign Development - Signage Design: This chapter explains the development of the intervention message channel– signage. The design of the experimental signs, and how the contents are selected and grouped generally follows the best practices summarized from the literature review and the pre phase results.

Chapter 7 – Discussion and Study Contribution: This chapter starts with a statement of research limitations. Next, by investigating the research process following the five steps of CBSM, an overall discussion is provided. Subsequently, the research question and hypotheses are addressed based on the discussion above. The last part of this section will describe the study's contribution.

Chapter 8 – Conclusion: Overall arguments and findings are given in this chapter, with highlights of key statements of integrating CBSM with waste signage design. Recommendations for future research either conducting advance studies on the same site or for replication at different sites are covered. These suggestions are specifically about the research design, research tool selection, sign design, and experience of field work-study.

1-4 General Information of The Study Site

1-4.1 The study audience

The selected site for this study is the main campus of the University of Waterloo, located in Ontario, Canada. In 2018, 38,653 students were enrolled, including full time and part-time students. Enrolment was composed of 32,777 (79.8%) undergraduate students and 5,876 (20.2%) graduate students. The University's services and offices have a total academic-related operational staff population of 2,548 (2018), and 1,311 faculty members (2018) (University of Waterloo, 2019a). The mix ratios for international students in the 2018/19 academic year are 40% for graduate students and 21% for undergraduate students. Between staff, faculty and students, the campus community is made up of over 40,000 people, and the campus population continuously shows a growing trend over the years (University of Waterloo, 2018b).Most of the undergraduate programs in UW apply co-operative (co-op) education. During the term when this study was conducted, close to 21,574 students, which is roughly 68% of the undergraduate students, were enrolled in co-op programs. Therefore, most undergraduate students do not consistently stay on campus during their undergraduate study. The shift between a study term and a work term takes place every four or eight months. Since the population of non co-op based students, staff, and faculty members only made up about one fourth of the population, inconsistently staying on campus is the norm for most students on the UW main campus.

Particularly for the undergraduate population at UW, the switch between study and work terms poses challenges for creating social norms on campus in areas such as waste sorting and diversion. The clarity of the signage at waste stations therefore becomes even more important. Students may not notice that sorting standards have changed since their last stay on campus. Moreover, as they commonly move to different places, clear and helpful signage are good prompts to remind the users how to properly sort their waste on campus.

1-4.2 The Waste collection system and the campus sorting standards

For administrative reasons, the UW campus sorting standard was updated in January 2019, just a few months after the new waste sorting stations were introduced on campus. The latest sorting standard consists of five larger sorting streams (Figure 1-1): garbage (landfill), organic, container recycling, paper recycling, and other. Among the "other" type, cardboard recyclables are the most common one to the

general public. The container stream collects most recyclables other than paper products (except for beverage cartons) and plastic bags. (University of Waterloo, n.d.-a)
Interestingly, even though there are five sorting streams according to the sorting standard, the 'other' stream is made up of a miscellaneous collection of different specific wastes, e.g., electronic waste, hazardous waste, and cardboard box recycling. Moreover, waste falling into the 'other' stream is normally asked to be placed into carts without clear instructions, or only collected at specific drop-off points at a few designated locations on campus.

The main difference between the current sorting standard that began in 2019 and the previous one is that several types of waste are now diverted into different streams. Moreover, the organic stream is also a fairly new stream that only became available campus-wide with the roll-out of the new waste stations. In earlier days, organic waste collection was provided inconsistently by the UW Campus Compost club, with limited capacity at some locations on a seasonal basis (i.e. no collection during winter) and collection stopping between terms once classes had ended.

Figure 1-1 The five sorting stream

As mentioned earlier, in order to promote waste sorting, a set of standardized streamed waste stations were introduced on the main campus of UW in September 2018. There are up to four streams in one waste station depending on the style and the streams are differentiated using colours. Figure 1-3 shows the design of the waste stations. The four streams are garbage (black), containers (blue), organics (green), and papers (grey). Figure 1-2 shows the original signs installed with the waste stations when they were first placed on campus.

The rolling out of the streamed waste stations has been done gradually in multiple stages, and is currently in its second stage. In other words, some buildings have the new waste stations while others may have

Figure 1-3 Waste station – four streams

Figure 1-4 Original signs installed with the waste station

a mix of the old receptacles alongside the new waste stations. Likewise, some waste stations have a place for organics while others do not. The full rollout is planned to be completed by 2021 (Thijssen, 2018). Currently, about half of the buildings on campus have the new waste stations in the front foyers or at food outlets. These waste stations aim to serve areas with higher waste traffic, e.g., lounges and lunchrooms. The new collection receptacles also include outdoor streamed waste stations; however, the outdoor bins do not contain an organic stream.

With introduction of the new waste collection system, the existing waste receptacles on campus can be roughly divided into five types:

1) Waste stations that contain three to four waste stream bins in one unit;
2) Multiple bins/carts that are co-located close to each other, which form a streamed situation, but not in a whole set and not all streams are available;
3) One big single bin (with no recycling/organic streams co-located);
4) A small waste bin mostly located in classrooms, labs, or offices.
5) Outdoor waste stations

There is also an array of individual instructions, posters, or signs placed on the walls adjacent to bins across campus. These signs were installed at different times in the past, and few of them have been updated to align with the latest sorting standard. Some of them even provide overlapping messages, which brings more confusion. Due to the shift to the new waste sorting standard, the signs installed on the new waste stations also need an update.

2. Literature Review

From fundamental living needs to larger-scale production and constructions, most human activities, unavoidably, will generate some forms of waste in a solid, liquid, or gaseous state as by-products or residual. However, as mass waste production began during the industrial revolution in the 19th century and the trend continues today, it led to the significant increase of commercial goods and services. In addition, the global population grew and the increasing urbanization has also added pressure on waste management. In short, waste management is closely tied with consumerism and urbanization (Hoornweg et al., 2012). The above situations have made managing waste and minimizing associated environmental impacts become more challenging in modern society. (Statistics Canada, 2012; McDougall et al., 2008; *Waste Management*, n.d.)

Furthermore, since 1970s general environmental awareness has increased. The main focus of the conceptual and the philosophical core of waste management has shifted part of its weight from conservation of natural materials and energy perspective to pollution and environment deterioration view point (McDougall et al., 2008). Concerns related to public health, chemical used, sustainability, and the commonly known 3Rs solan: Reduction, Reuse, and Recycle were all brought to people's view and got widely accepted by the general public.

Consequently, the broad umbrella of 'waste management' covers a wide varity of topics and multiple perspectives, from the generation of waste to the end processing treatments, such as technological, mechanical, biological, chemical, thermal. One particular focus of waste management is related to waste generated at different scopes or specific sources of waste, including agricultural, municipal, constructional (Wang et al., 2010), manufacturing, and hazardous waste, etc. (McDougall et al., 2008; *Waste Management*, n.d.). Meanwhile, researchers and practitioners have put much effort into waste managements from many different aspects, including policy, education, economic management, behaviour, and environment assessments (e.g., LCA) (McDougall et al., 2008). Moreover, the discussion of waste management in developing countries and developed countries has also gained much attention (Tangwanichagapong et al., 2017). A number of approaches are used for solid waste management research, which span from fundamental and theoretical approaches to applied research (e.g., experiments and action research), and case studies.

2-1 Behaviour research on waste management related pro-environmental behaviours

In the scope of behavioural research, many studies investigated the behaviour itself, and their findings can be explained using the common five “Ws” and the one “H”, i.e., why, what, when, where, who, and how. With why stands for the reasons of people do or do not conduct certain behaviour; when is the timing; where stands for the spatial locations a behaviour may or may not take place; who conduct or do not take actions, or who are those to influence one’s behaviour; what are the meanings and influences behind a behaviour; and how a behaviour is implemented.

Whereas, in terms of **behaviour changes** studies, except for the five “Ws” and one “H” mentioned above, different behaviour change tools are adopted by researchers and practitioners to facilitate the implementation. These tools are either directly or indirectly used to create behaviour change or affect social issues, to name a few: regulatory tools, market-based mechanism, behavioural economics, technological innovations, social norms, etc. (Lee & Kotler, 2011). The reasons, strictness, and strength to motivate behaviour change differ from tools to tools, with some having mandatory power and even comes with punishment, e.g., regulatory tools; moderate social pressure, e.g., social norm; and voluntary based, e.g., non-profit/NGO marketing (Lee & Kotler, 2015).

Worthwhile notice, these behaviour change tools are seen to work both solely or in collocations when implementing. One example is the “Pay as you throw” policies, reported to be an effective approach to apply with existing waste collection systems at many municipals and communities over the world (Morlok et al., 2017). It is a combination of regulation and economic instrument based on unit pricing. On the other hand, the city-wide recycling shift from encouragement to enforcement in Shanghai *(The Regulations of Shanghai Municipal Living Waste Management*, 2019; Chen, 2010) in July 2019, is an example of implementing a regulatory tool on its own. Leveraging technological improvement in behaviour change is another popular way in waste management. A number of “smart” bins applying different technology are introduced and carefully studied for wide-implementation purposes. Seoul, Korea has implemented Radio Frequency Identification (RFID) to track who and how much waste they discarded, users are then charged based on the tracking amount of waste they have discarded. This system has reported to effectively reduce much household food waste on a city level (Hong et al., 2014). Cheng (2016) and her team created their smart bins using screens to show interacting messages to catch users’ attention.

Considering this research is a field study base at the UW campus, and target the waste sorting behaviour change within the existing regulatory and infrastructures that UW has; therefore, the following literature review and examples will mainly focus on best practices related to behaviour change and specifically connected to waste diversion and sorting.

2-1.1 Factors and variables discussed in previous waste related pro-environmental behaviour research

Past studies and previous findings discussed in this subsection mainly focuses on: 1) the interaction between waste sorting behaviours and internal factors; 2) the external factors; and 3) handling of waste receptacles and attached instructions, i.e., signage.

According to previous studies, the factors that contribute to individual pro-environmental behaviours can be roughly divided into two types: internal and external factors (Kollmuss & Agyeman, 2002; McKenzie-Mohr, 2000). Internal factors can mainly be described as the personal motivations and reasons that trigger or prevent the target audience from engaging in the desired behaviour. Whereas the external factors are often identified by manipulating the structural settings at sites where the behaviours take place. Although one study may not put the same weight on discussing the two types of factors, most studies agree that behaviours ultimately result from the interaction of internal and external factors. The following paragraphs will first review internal factors, then external factors will be covered in the reviewed literature.

1. **Internal factors** mainly relate to background info, personal value, and mental view that may impact the targeted behaviour.

Socio-demographic factors? show mixed results in terms of having an effect on waste sorting behaviour (Andrews et al., 2013), while some drew opposite statements (Austin et al., 1993; Hao et al., 2018). **Attitude**, which is often investigated through the use of surveys, is one of the most popular factors, mentioned by many waste related pro-environmental behaviour studies (reference?). Previous studies have concluded that most users nowadays reported themselves having high positive attitudes toward waste sorting (Barker et al., 1994), but many times their intentions to conduct pro-environmental behaviours are blocked or prevented by external (i.e. structural) factors (Stoeva & Alriksson, 2017). In these circumstances, an attitude-behaviour gap is likely to exist (Barker et al., 1994; Kollmuss & Agyeman, 2002); therefore, it is important that researchers avoid drawing a direct causal link between high positive attitudes or high knowledge levels and pro-environmental behaviours.

Several studies have highlighted **cultural background** (Wu et al., 2018)**, social norms, and past experience** (N. D. Miller et al., 2016) as possible factors that affect pro-environmental behaviours. Several of these studies identified a need for more in-depth research in this area to provide more concrete evidence to support (or not) the role of cultural background and past experience on waste sorting behaviour. Some studies have investigated pro-environmental behaviour from a cultural perspective, by

implementing the same experiment in different cities or countries. For example, Berger & Hevenstone (2016) conducted a littering behaviour study in New York City and two Germany cities, noting quite different results between the two countries.. The authors of this study infer that social norms and the cultural background of the target audience are likely the reasons that contribute to such differences, while they also mentioned that dummy variables, such as size of the cities, may exist and explain the differences in outcomes. In addition, higher education institutions are 'hot spots' of waste management pro-environmental behaviour research. As many researchers agree that higher educational institutions often have fairly large populations, and generating a certain amount of waste annually. Tangwanichagapong, et al, (2017) and Wu et al., (2018) both argued that higher education institution compose people coming from all over the world, with diverse cultural background, while

Stoeva & Alriksson (2017) recruited their survey respondents with different geographical background but with similar socio demographic. Even though the phenomena are noticed, no solid evidence has supported a specific reason among cultural background, social norm, and past experience.

2. **External factors:** The **external factors** mainly relate to the design of waste collection system, i.e., waste receptacles or their surroundings. The following external factors that are discussed include proximity and arrangement; shape of outlets; the attraction of receptacles; the numbers of streams; and signage.

Proximity and arrangement of the waste receptacles has been found to be influential. Receptacles located at shorter distances and more convenient spots for the users have been shown to have a higher ability to capture waste or recyclables (Austin et al., 1993). However, if appropriate streams are not provided at shorter and more convenient spots comparing to other receptacles/streams, the contamination increases. Even a few steps away can make a difference, Several studies (Andrews, Gregoire, Rasmussen, & Witowich, 2013; Jiang et al., 2019; Miller, Meindl, & Caradine, 2016) conclude that multiple streams commingled or placed side by side have been shown to have lower contamination levels.

Convenience, simplicity, and consistency is another group of popular factors mentioned by many reviewed studies (Ahmed et al., 2016; Menzer et al., n.d.; Rousta et al., 2017; Wu et al., 2018). Inconsistent receptacles and a large variety of signs has been found to be a serious issue shared among many previous studies, especially those studies conducted at universities or colleges. (Ahmed et al., 2016; Cheng, 2016; Johnson, 2013)

It is emphasized earlier that most studies agree a behaviour is an output of interaction between internal and external factor.

Simplicity (perceived behaviour control) is regarded as people's estimation of their ability to conduct this behaviour, whereas the more difficult, no matter mentally being hard, need more knowledge, or far away, subjectively decide it is not worth paying so much effort.

As of the shapes of the waste receptacle outlets, Jiang et al., (2019) reported an opposite result of their fieldwork experiment and their users' self-report. The researchers infer that this is because the outlets with special shapes confused the users when they had waste that belonged to a particular stream but did not fit the shape, instead uniformed outlet, which are commonly rounded or rectangle shaped, performed better on collecting sorted waste.

The increase of **receptacle attraction** comes with higher waste capturing ability. The visual attraction is higher if a receptacle is designed with decoration and brighter colours. Especially when the other receptacles are placed together but with lower visual attraction, the organic waste receptacles captured more users' attention and collected more organic waste. (Lin et al., 2016) Other ways of raising the attraction of receptacles can be integrating fun element, e.g, add sound effect to the receptacles, to make it sounds like an endless hole, and the sound will be trigger when waste is collected. (Cheng, 2016; *The Fun Theory 2 – an initiative of Volkswagen*, 2009).

Except the external factors mentioned above, signage has also been studied as a variable that affects waste sorting behaviours, though the effectiveness of signage in facilitating better waste sorting behaviours is still under debate (Andrews et al., 2013; Austin et al., 1993). As signage is the main focus of this study, a more in-depth literature review is discussed in the next subsection.

Occasions: Waste sorting behaviours also differ between **occasions**. Individual pro-environmental behaviours can happen at different levels, e.g., municipal, IC&I (Industrial, Commercial and Institution) sector, and general public areas (Bourner, n.d.; Ma & Hipel, 2016). Studies show that people tend to perform differently on waste sorting/pro-environmental behaviours depending on the occasion. For example, people's pro-environmental behaviours are different when they are on vacation (D. Miller et al., 2015), at home, at work or at school. Since a significant proportion of waste is generated by households, waste sorting at the municipal level has already gained much scholarly attention (Berglund, 2006; Choon et al., 2017; De Feo et al., 2019), while the IC& I sector has also been called to take waste sorting

seriously (Government of Ontario, Ministry of the Environment, Conservation and Parks (Ministry of the Environment and Climate Change), 2016).

2-2 Signage design and experiments on waste sorting

Signage has been broadly used and studied for directional or alert need, such as washroom and road signs (Calori & Vanden-Eynden, 2015). The following paragraphs will still focus on waste management related signage.

Types of waste signage study

Many signage-related waste sorting behaviour studies are field studies, with some of them investigating the influence of sign replacement or different contents (Ahmed et al., 2016), some manipulated the existence of signs (Austin et al., 1993; Menzer et al., n.d.), or both (Andrews et al., 2013; Bourner, n.d.),; and several conducted their study on a one-time occasion, and displayed signs with different contents at an event (Verdonk, Chiveralls, & Dawson, 2017).

Sign existence

Some studies examined whether the existence of the signage made a difference in regards to waste sorting behaviours, and then stated if the “existence” of signage matters (Andrews et al., 2013; Austin, Hatfield, Grindle, & Bailey, 1993). In other words, these studies investigated behaviour changes based on whether or not there were signs on the receptacles. Results from these studies show conflicting evidence, with some claiming signage to be effective, while others claim the existence of signage does not sufficiently affect waste sorting behaviour.

Sign replacement

It is fairly common to have signs attached on or close to the waste receptacles; in fact, many studies already had original or baseline signs before their intervention that were replaced by experimental signs during the intervention (Andrews et al., 2013; Dupré & Meineri, 2016; Ummat, 2013). Some studies made noticeable changes, such as displaying larger signs than the original ones (Austin et al., 1993; Ummat, 2013), or placing the signs at an eye-catching position, different from the previous ones (Ummat, 2013). How behaviour changes are accessed, measured, and interpreted may also affect the conclusion, sorting accuracy, lower contamination, captured more waste, diversion extent (N. D. Miller et al., 2016). Andrews et al., (2013) focused only the data changes in the recycling receptacles, however, the waste collected in the garbage/landfill stream was neglected, while their data show the post intervention has an increase

in the weight of waste collected by the recycling bins. A more comprehensive discussion toward the tools of recording data and assessing the behaviour changes are in the next subsections.

Signage Content

In addition to examining the affect of sign existence and sign replacements on waste sorting behaviours, the content of signage should also be considered. The following paragraphs will discuss reviewed studies on **what** contents to present and **how** contents are presented on signage.

1. "What" contents to display on waste signs?

Contents presented in previous studies depended on what information or message the sign designer intended to pass on to the users. Therefore, waste signage can simply **provide information** and/or **serve as a prompt**, while it can also be hard to tell the two apart. Austin et al. (1993) reported in their study that it is unclear if the behaviour changes they noticed were triggered by the delivery of information or the reminder function, both of which were provided by the signs.

Various **types of content** can be displayed on waste signs, including a list of allowable and/or prohibited items; descriptions, explanations, and/ or instructions for waste sorting; specialized messages; or combinations of these. The list of allowable and prohibited items normally serves as an example for users to match the closest choice with the waste they intend to discard. While descriptions, explanations, and instructions that are mostly presented in word or sentence format provide further details to assist users to sort correctly. For instance, only items made from plastic number one to seven is accepted in this recycling bin; asking users to empty the bottle and rinse containers before discarding. Specialized messages presented on waste signs also vary widely. Some examples are persuasive messages and feedbacks (Dupré & Meineri, 2016) as well as persuasive messages and descriptive messages (Verdonk, Chiveralls, & Dawson, 2017). Each type of content can be displayed solely (Ahmed et al., n.d.; Dupré & Meineri, 2016; Jiang et al., 2019; Wu et al., 2018), while a combination of two or more types of content are used based on needs, as well (Andrews et al., 2013; Menzer et al., 2013; Ummat, 2013.; Verdonk et al., 2017). Studies implementing specialized messages show stronger ambition of testing different theories or ideas to trigger behaviour changes, in these cases, specialized messages is often the only content, or it takes the dominant role among all contents presented in one sign.

2. "How" to display contents on waste signs?

The common forms of displaying content used in previous studies include texts; iconic graphs; generalized practical items graphs; practical items graphs; practical item display; and combinations of the elements listed above. Ahmed et al., (2016) & Wu et al., (2018) have investigated displaying the same contents using different forms of signs under a field study and laboratory condition respectively. They both drew similar conclusions that displaying a practical items graph contributes to higher accuracy and efficiency on users' waste sorting behaviours.

In addition, how contents of the signage are presented also affects **the attraction and readability of the signage.** Titles, colours, clusters, simplicity, familiarity, visual complexity, and distance also play important roles in waste signage design. Several guidelines are synthesized from previous studies to make waste signs visual appealing. Similar to the influence that the proximity of waste receptacles has on users' waste sorting behaviours, Austin et al.(1993) also mentioned that the proximity of signs in regards to where the behaviour takes place makes a difference, The closer the sign is placed to the proper receptacles, the more the correct sorting increases. It aligns with the emphasis of the CBSM framework that prompts should be close and easy to be seen where the targeted behaviour is taking place (McKenzie-Mohr, 2011). Moreover, Austin et al (1993) replaced original signs with much larger signs, and they saw positive changes in sorting behaviour. They then suggested that making the sign change obvious is likely to increase the effect of the intervention. (Verdonk et al., 2017) They also suggested that the sign should be self-explanatory, and use lay language to minimize language obstacles. Selecting brighter colours (Lin et al., 2016); fewer clusters, and keeping the layout consistent have also been recommended. (Verdonk et al., 2017) Larger sign sizes and sans Serif font have also been recommended, as well as using colours that present high contrast. Numbers of words, numbers of signs placed together. Simply listing out a number of items, descriptive words and sentences, messages. Jiang et al., (2019) reported that complexity can increase with the number of signs. The more signs/streams there are, the less likely people will pay attention to one sign and conduct the desire behaviour.

However, showing comprehensive information does not necessarily bring better results, and the more guidelines followed does not guarantee better outcomes. It is evident that seeking a balance of what to present and how to present is critical. A comprehensive list or a large cluster that covers everything can surely provide more information, but the complexity also increased, and the efficiency and simplicity are likely to be traded off. A worst-case scenario is information overload if too much information is provided, and leads to a reverse affect that overwhelmed the users, then they turn down their interest toward signs reading. Wu et al., (2018) pointed out that presenting both Yes and No items, i.e., permitted and not

permitted items, does not result in better outcomes than showing only the Yes items. In addition, Verdonk et al., (2017) designed their experimental signs using a combination of text, images of generalized practical images, and specialized messages. However, even though bright colours, larger signs with high contrast text, the same images; and a fixed layout were all present, the overall visual design violated many principles and suggestions provided by other studies. The vivid and colourful background picture of the experimental signs greatly increased the visual complexity, and likely caused visual exhaust because the images of the items to sort, the background, and additional descriptive words all blended, which made it difficult for users to distinguish them. In short, there is hardly an absolute answer, as mentioned above, too many factors may affect (Miller et al., 2016) , which again reinforced the CBSM importance of piloting and evaluation.

Moreover, according to the CBSM framework (McKenzie-Mohr, 2011), behaviour changes differ case-by-case, since the sorting standard and collection categories can vary widely in different spaces or at different times. However, the typical way of designing waste sorting signs normally follows a top-down procedure, many are done without consulting their users. Although most studies reported to use either observed or estimated common discarded items (Andrews et al., 2013). While things commonly discarded are not necessarily problematic. Even though, a few studies have conducted focus groups with experts and custodial services (Ummat, 2013), or gathered ideas through interactive workshops (Verdonk et al., 2017); many do not consider whether or not the content and design of the signage truly fits the users' needs, or if it will be attractive to them. This conflicts to the core value of CBSM, which emphasizes the essentialness of understanding the target group members, and the importance of revising and piloting.

Summarized from the review above, firstly, it is determined that a combination of text and coloured practical images will serve as the basis to develop the CBSM intervention in this study. Secondly, a group of experimental signs will be altered in size to make the sign replacement noticeable. Thirdly, the background colour that represents different waste streams will align with the existing system, i.e., black for garbage, blue for containers (recycling), green for organics (compost), and grey for paper. Lastly, only permitted items will be presented, and the images will not be presented in one big cluster to avoid information overload. Other design details, e.g., the selection of contents, and the wording is expected to be developed as the study goes on.

2-3 Theoretical framework:

From a **theoretical** perspective, studies adopted theory of planned behaviour or social marketing are discussed in this paragraph. Theory of Planned Behaviour (TPB) , first proposed by Ajzen in 1985 is one of the most popular concepts used for explaining and interpreting pro-environmental behaviours in reviewed literatures (Ajzen, 1991a, 2011). On the other hand, the concept of social marketing proposed by Kotler & Lee (1971) also shows an increasing trend lately. Other theories, such as Behavioral Economic and Nudge (Thaler & Sunstein, 2009), are also used in pro-environmental behaviour studies (Menzer et al., n.d.).

Due to the nature of the theories themselves, when comparing the findings concluded from these two theories on pro-environmental behaviours, those use TPB tend to draw more convergent conclusions on waste sorting behaviour, while those adopt social marketing as the main framework show more divergent findings. As TPB intend to explain the reasons that contribute to people's behaviours, including attitude, social norm, intention, and perceived behaviour control. While, in practical field work, many researchers or project conductors intend to practically change the behaviour (Lee & Kotler, 2011). Therefore, those adopt social marketing as the main framework show more divergent findings, with the theory framework help break down the factors and labeled the negative factors as barriers and the positive ones as benefit. By reducing or eliminating the barriers and encourage the benefits, the users' intension and perceived behaviour control toward waste sorting increase. Moreover, Social Marketing suggested adopters to segment study audience, which also helps to narrow down the focus and come up with specific interventions.

2-3.1 Social Marketing

Social Marketing, as named, first emerged from the commercial marketing scope, and borrowed the 4Ps strategy (Product, Place, Promotion and Price) as its practice approach (Kotler, 1971). However, instead of convincing consumers to purchase certain items or switching to a certain brand, the promoted "merchandize" of Social Marketing is often social goods or ideas that benefit the adopter or the society, often with a final aim of triggering behaviour change. Moreover, the competitor is not other brands or commercial goods with similar functions, but the target audience's current lifestyle or habit. (Lee & Kotler, 2011, 2015)

Later, much effort has done on Social Marketing to reduce its heavy reliance on marketing approaches (Peattie & Peattie, 2003), but the thoroughly consumer study and audience orientation still maintained.

With an emphasis on the use of marketing mixes, rather than merely doing advertising, a sequential 10-step Social Marketing model was established. To date, Social Marketing is found broadly used in the public health area, e.g., tabaco use (Diehr et al., 2011); environmental issues, e.g., encouraging households to reuse other than merely recycle (Barr et al., 2013); and financial decisions (Lee & Kotler, 2011, 2015)

As Social Marketing thrives and becomes more completed than earlier. Many practitioners and scientists agree that social marketing should not limit its scope influencing behaviours at the individual level (Lee & Kotler, 2011), because it is noticed that individual behaviour has interactions and are influenced by people and the structural surroundings at different levels. Therefore, Social Marketing then gradually expended its focuses from merely on individual level (downstream) to mid- and upstream. "*Upstream e.g., technological innovations, scientific discoveries, economic pressures, laws, improved infrastructures, changes in corporate business practices, new school policies and curricula, public education, and the press. Midstream influences are family members, friends, neighbours, peers, healthcare providers, friends on social media, and others our target audiences listen to, observe, or look up to."* (Lee & Kotler, 2011, 2015)

Similar as mentioned above, behaviour changing tools are often combined when using, there are also some models and theories often integrated with the implementation of Social Marketing. In this study, Social ecological model, Social cognitive, and Social diffusion will be combined and use with CBSM serving as the core idea, several related models or theories used for interpretation or explanation purposes in this study are further reviewed in section 2-3.3.

2-3.2 Community-Based Social Marketing (CBSM)

Although social marketing intends to serve as a bridging mechanism between knowledge and action (Kotler & Zaltman, 1971), evidence appeared that knowledge and awareness are often successfully raised, but then did not always result in actual behaviour changes. Gaps are often reported between one's attitude and actual behaviour, which brings many challenges to social marketers, since they wish to engage people in changing behaviour. (Cole & Fieselman, 2013; Kollmuss & Agyeman, 2002; McKenzie-Mohr, 2011)

Community-Based Social Marketing (CBSM) theory emerged after several previous studies had found little to no behaviour changes with conventional information campaigns, especially in the field of environmental sustainability (Kollmuss & Agyeman, 2002; McKenzie-Mohr, 2011; McKenzie-Mohr,

2000). In the early 1990s, Doug McKenzie-Mohr proposed CBSM theory, which was based on the existing social marketing approach, but also drew heavily on social psychology (McKenzie-Mohr, 1996, 2011). As a subset of social marketing, with a five-step framework, CBSM put more focus on barrier and benefit studies (Lee & Kotler, 2015), and highlighted its pragmatic approach, which aimed to induce environmentally-related behaviour changes (Kennedy, 2010; McKenzie-Mohr, 2011; McKenzie-Mohr, 2000).

Similar to social marketing, topics addressed with CBSM are mostly related to the public health field, e.g., tobacco use; HIV/AIDS prevention and environmental sustainability, e.g., energy and water saving, sustainable transportation, green purchasing, and waste reduction (Cole & Fieselman, 2013; Dale, Nobe, Clevenger, & Cross, 2012). CBSM is widely used at municipal and institutional levels (Haldeman & Turner, 2009; Mildenberger, Stokes, Savan, Kolenda, & Dolderman, 2013). It is not a brand-new idea to introduce CBSM into higher education institution communities when addressing waste management issues. Some studies target the general campus community (Ahmed et al., 2016; Austin et al., 1993; Johnson, 2013; Ummat, n.d.), while others target only the staff in offices (Cole & Fieselman, 2013), people using cafeterias (Dupré & Meineri, 2016), or people living in residence (Chow & Tsun, 2005; Gallant et al., 2001)

The following paragraphs will discuss how the five steps of Community Based Social Marketing will navigate the implementation of this study (McKenzie-Mohr, 2011).

1. Selecting behaviour

The first step of CBSM is to select a desirable behaviour after assessing the importance, necessity, and effect for behaviour change. From time to time, there can be more than one behaviour chosen that may lead to the same ultimate environmental objective. However, if the desirable behaviour has already been adopted by many of the target group members, then promoting such behaviour is not likely to have high impact and may not be cost effective to pursue. A lot of time and effort might need to be put in for the remaining target group members who are small in number, and it may be too difficult to change their behaviour if they do not align with the majority (Lee & Kotler, 2011). Andrews et al. (2013) could be regarded as an example related to waste sorting: if the selected bins or location already has a high recycling rate, then changing the signage in order to improve sorting at this site might not be worthwhile. Lastly, CBSM also suggested the selected behaviour to have lower penetration to the target audience's personal territory (McKenzie-Mohr, 2011). In other words, the selection of targeted behaviour is recommended to be less intrusive, which allow the practitioner to easier assess the behaviour changes.

Therefore, CBSM has suggested that researchers should choose target behaviours that have high impact, high probability, and low penetration.

2. Identifying Barriers and Benefits

The second step of CBSM is to uncover the barriers and benefits that the target audience has toward the desired behaviour. **Barriers relate for challenges that prevent the target audience from conducting the desired behaviour; while benefits stand for reasons that can motivate the target audience to engage in the desired behaviour.**

CBSM strongly urges adopters not to skip this step and simply speculate or assume that they know the possible barriers or benefits, even though they may seem obvious. Particularly, adopters are often experts of the research scope, are familiar with the study site and know the target audience very well. However, it is critical to think out of the box, as preconceptions can block the adopter from understanding the true barriers or benefits that lie between the target group members and the targeted behaviour, as some of them can be relatively implied or be neglected earlier. Therefore, relying on speculations or assumptions may lead the adopters to fall into such pitfalls. Rather, adopters should thoroughly understand the target group using methods such as a literature review, observations, survey, focus groups, or interviews.

The pre phase in this study, which includes a user survey, onsite observation, and waste audit, is set to match this step. By analyzing the results and data gathered in the pre phase, I expect to discover the barriers and benefits that can affect the chance and willingness of the campus community to conduct proper waste sorting.

3. Developing Strategies

After the barriers and benefits between the target audience and the selected behaviour are identified, the CBSM framework then guides the adopters to develop strategies according to these uncovered barriers and benefits. Barriers and benefits with higher priority should be prioritized.

The developed strategies intend to encourage the desired behaviour (the selected behaviour) by lowering the barriers and increasing the benefits, and discourage the undesirable ones (the original behaviours, or behaviours other than the selected one) by manipulating the barriers and benefits the other way around.

To address different kinds of barriers and benefits, seven behaviour change tools are proposed by CBSM. Each approach has its own best apply timing and situations.

1. Commitment: Good Intentions to Action
2. Social Norms: Building Community Support
3. Social Diffusion: Speeding Adoption
4. Prompts: Remembering to Act
5. Communication: Creating Effective Messages
6. Incentives: Enhancing Motivation to Act
7. Convenience: Making it Easy to Act

Here is an example for explaining the relationship between barriers and benefits, behaviour change tools, and strategies. Encouraging consumers to go strawless is selected as the end behaviour. Forgetting to act and feeling awkward to act alone are identified as the barriers. Therefore, some targeted members are asked to put stickers on their laptop. In this case, the sticker is the strategy that is built on such tools as prompts, commitment and social diffusion. The sticker prompted the laptop owner to remember to reject disposable straws. While the sticker also serves as a public commitment, and it can likely lead to social diffusion by letting others know that they do not feel alone or awkward to go strawless when consuming beverages.

Experimental sign design stage in this study corresponds to this step.

4. Piloting

Once strategies have been developed, piloting these potential strategies is the next step. Piloting strategies means doing a test run of a strategy, rather than setting off a large-scale implementation in the community at once. It enables the adopter to estimate the effectiveness of the developed strategies. The adopter can then assess if an amendment is necessary, and eventually come up with the best overall strategy for the CBSM campaign.

Piloting is a useful step. It is particularly handy when the same strategy can apply to multiple combinations of tools. Piloting all possible combinations can assist the adopter to find out the most effective one to apply to the developed strategy. For instance, a piece of sticker displayed where the public can see may utilize self-commitment and social diffusion as the tools. Whereas applying the sticker in one's personal space may utilize self-commitment and prompts as the tools. A suggested setting for a CBSM pilot is to

set at least two groups, a control group, and a pilot group; more pilot groups may be needed if different combinations of tools are applied to one strategy.

Next, instead of starting to examine the pilot right away, baseline results should be collected first. By doing so, the adopter would then be able to evaluate the influence and the cost-effectiveness of the intervention by comparing the extent of behaviour change between baseline and pilot results. While if the behaviour change did not yet reach a desirable level, CBSM suggests that the practitioners adjust the intervention, and then continue the pilot. In this study, the post phase, where a second round of onsite observation and waste audit are to be implemented, serves as the piloting and evaluation step.

5. Broad-scale implementation

If the implementation of the campaign has reached a desirable level of behaviour change in the pilot stage, the last step of CBSM is to increase the scale of intervention to wider implementation. However, this current study does not proceed to a broad-scale implementation stage.

2-3.3 Related models

1. Social Ecology Model

The Social Ecology model was first proposed by (Bronfenbrenner in 1977 with his study focused on child development. It was then introduced to the field of health promotion, and started serving as a model to promote behaviour changes.

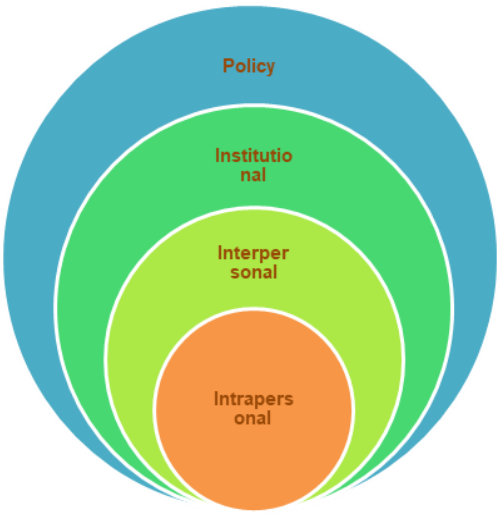

Figure 2-1 Social Ecology Model

(Source: "Bronfenbrenner's Ecological Systems Theory," 2019)

The most important feature of the Social Ecology model is its focus on multiple layers surrounding an individual's behaviour. In other words, one's behavioural decisions are not merely caused by factors only related to the person who displays the behaviour, but also the context around them, which includes environmental and social factors from all layers and at different scales. Collins, Tapp, & Pressley (2010) has used social ecology as the framework when addressing young males' reckless driving and increasing cycling cases. They conclude that interaction across different layers is shown to have profound influence on the decision-making of the researched population.

The multiple level feature emphasized by the Social Ecology Model also delivers a similar message with the call that social marketing should not only be focused on the individual level, which is labeled as the 'downstream', but more focus should be put on the upstream systems, such as policy, regulation, organization, etc. (Wymer, 2011)

2. Stages of Change Theory (The Transtheoretical Model)

The Stages of change theory emphasized that behaviour is not transformed all at once, but rather occurs in five stages.

1. Precontemplation: Not aware of the issue.
2. Contemplation: Knowing the issue or problem, but remain sitting on the fence, do not show intention to adopt changes.
3. Preparation (Determination): Estimating one's own ability to make change, gathering information or knowledge.
4. Action
5. Maintenance

Figure 2-2 Stage of Change Theory

(Source: "Transtheoretical Model (or Stages of Change)—Health Behavior Change," n.d.)

As many behaviours require more than a one-time change, but regular maintenance is needed to regularly repeat the behaviour, many efforts and resources are necessary to put into it, in order to have

people keep their behaviour consistent. Even when people have moved to the next stage, it is still possible that they may move back and forth between stages, which reinforces the importance of the last stage, i.e. maintenance. The Stages of Change theory is very frequently used in studies related to smoking and alcohol misuse. (Diehr et al., 2011)

3. Social Cognitive Theory

Originally known as the Social Learning Theory in the early 1980s, Social Cognitive Theory considers that human behaviour changes are an outcome of personal and environmental factors. Social influence on individual behaviour. (Bandura, 1991, 2000)

Social cognitive theory emphasizes the importance of internal and external factors that reinforce each other to increase the motivation to change behaviour. In addition, one important element of the social cognitive model is that the internal and external factors trigger not only the motivation to change, but also self-efficiency, which leads the person who adopts the behaviour to increase self confidence.

One critique of the social cognitive model is that what exactly triggers the individual to change behaviour is often implicit, because it is hard to tell whether it is the mental issue or extrinsic concern, or perhaps both that provoke one's final decision to change their behaviour. Furthermore, the interaction between and impact of internal and external factors varies between individuals, since each person possesses different abilities, confidence, and internal willingness to conduct and maintain a certain behaviour. (Glanz, Rimer, & Viswanath, 2008)

Even among different social marketing theorists, there is a shared consensus that emphasizes the importance of knowing the target audience before an intervention, rather than using mess communication. Keeping good communication with the target group is vital. There are also negative examples showing the outcome of not communicating well, which leads to a disappointing outcome (Young, Russell, Robinson, & Barkemeyer, 2017). Furthermore, Pearson & Perera (2018) have suggested that social marketing researchers do segmentation of the target group when addressing wood waste reduction. They estimated that by segmenting the target group when communicating can increase the effectiveness of social marketing tactics and the internal validity of the research.

2-4 Methods of investigating and assessing pro-environmental behaviour changes

A variety of tools were used to investigate, record, and assess waste sorting behaviour changes in the reviewed literature. Among all, waste audits are the most frequently used tool. Other tools include focus groups, interviews, surveys, observations, and waste volume estimation. Some studies conducted only

one tool (Andrews et al., 2013; Stoeva & Alriksson, 2017), while some used multiple tools (Ahmed et al., 2016; Cole & Fieselman, 2013; Dale et al., 2012; Heathcote et al., 2010; Verdonk et al., 2017).

Generally speaking, adopting multiple tools allows researchers to investigate various aspects of waste sorting behaviours, or view one variable from different perspectives. Each tool has its advantages and disadvantages, and since many pro-environmental behaviour research are done as field study, many implementation challenges may occur. For example, limited funding and time (McKenzie-Mohr, 2011); insufficient human resource; extra requirement of collaboration and coordination from stakeholders (Heathcote et al., 2010; Johnson, 2013); and many unexpected situations (Verdonk et al., 2017), etc.

Other than reviewing literatures and past documents, some studies conducted interviews and focus group with custodial services, hauler contractors, or other related personnel to gain some basic understandings and advice toward the situations of the targeted pro-environmental behaviour (Dahle & Neumayer, 2001; Heathcote et al., 2010). Interviews and focus groups are good tools to understand the situation in depth, and collected qualitative data. If an intervention were implemented in a pilot study, CBSM framework also suggested to conduct small interview toward target group members if the piloted social marketing campaign do not trigger expected amount of behaviour changes.

Survey is one powerful tool widely used for understanding the respondents' background information, attitude, intention, and experiences toward the targeted pro-environmental behaviours. Comparing to interview and focus group, surveys normally aim to reach more respondents, and gather quantitative data. While, conducting surveys require higher technique and time on designing, spreading, and analyzing. In addition, if intervention was conducted, surveys are sometimes selected as the tools to conduct before and after the intervention for the purpose of assessing behaviour changes and evaluating the effect of interventions.

Unobtrusive observation is another research tool adopted or suggested by several previous studies both on interventional or exploratory studies (Ahmed et al., 2016; Austin et al., 1993; Barker et al., 1994; Verdonk et al., 2017). Observations conducted in field studies help researchers gather first handed behavioural records from the users. Conducting unobtrusive observations, i.e., observing without being noticed by the people who are observed, is important, because if the people are aware of themselves being observed people tend to behave differently (McKenzie-Mohr, 2011). People would likely change their behaviours based on their assumptions of the researchers expectation, and in many cases they will behave on the positive side but differ from their normal behaviours.

Waste audit is likely the dominant research tool adopted on waste sorting and recycling behaviour studies. Conducting waste audits allow researchers to collect a considerable number of quantitative data from directly analyzing the composition of waste, and most importantly, generate several numeric metrics that are regarded as indicators of waste sorting progress: diversion rate, capture rate, and contamination rate. However, the smaller the audit sample size is, the greater the chance of the audit results are skewed by outliers.

After reviewing the selected research tools used in previous studies, and combining considerations of an available timeline, practical condition, and coordination with related stakeholders, a survey, observations, and waste audits are selected as the main study tool in this research. The following subsections will discuss the three selected tools for this study.

2-4.1 Survey of waste sorting behaviours

The **timing** of conducting a survey in pro-environmental behaviour studies varies. Some studies conducted survey before and after of their interventions and then conduct analysis of pre and post comparison (Cole & Fieselman, 2013); while some used survey as the only research tool (Dahle & Neumayer, 2001; Wan et al., 2012, 2014, 2017) ; and some use a combination of survey and other tools (Heathcote et al., 2010; Tangwanichagapong et al., 2017). However, it is argued that rely survey as the only base to determine behaviour changes is not solid and concrete enough, as self-reported data are often criticized to be less reliable since people tend to self-inflate when doing a survey. Barker et al., (1994) reported to encounter with attitude-behaviour gap of their study that only a small proportion of users conducted the pro-environmental behaviour they claimed in the survey done earlier. In addition, Jiang et al. (2019) also noticed that the waste receptacles' outlet shape preference stated by users in the survey turned out to be less effective toward users' experience when they conducted a field experiments later with the same group of people. Therefore, we argue that only rely on survey may not be sufficient to fully assess behaviour changes.

Nonetheless, survey still showed to be a very powerful research tool, especially when examining the inner factors that can heavily affect behaviours, but can be difficult to investigate from the outward. Most reviewed surveys related to pro-environmental subjects again evolved from psychology field, and again, many have evolved their survey questions form the theory of planned behaviour since it has readily

provided a systematic framework for analyzing human behaviours (Hao et al., 2018; Tonglet et al., 2004; Wan et al., 2012, 2014, 2017).

Almost all of the reviewed studies spent much effort trying to find out the relationships between determinants that can influence people's pro-environmental behaviours, and how strong the influences are toward their study audience. Determinants evolve from the TPB include but not limited to attitude, intention, perceived behaviour control, norms (e.g., subjective norms, social norms, moral norms), etc. Some other additional factors also used by previous researchers are, for instance, past experiences (Dahle & Neumayer, 2001; Terry et al., 1999; Tonglet et al., 2004) and situational factors (Tonglet et al., 2004). Neither situational factors nor past experience (or past behaviour) are a separated determinant according to the TPB. Situational factors are normally treated as partial reason that may affect one's perceived behavioural control. On the other hand, the determinant past experience was supported by a considerable number of study findings (Fredericks, 1981; Kollmuss & Agyeman, 2002; Terry et al., 1999; Tonglet et al., 2004) that the developer of the TPB has also reviewed and reflected on its impact toward human behaviour later on (Ajzen, 2011).

Except for the relationships between determinants and behaviour, researchers were also fairly interested in knowing the associations of a survey participants' attribute toward the studied behaviour. One conventional attribute was sociodemographic, while recently researchers proposed that different culture backgrounds as another one (Stoeva & Alriksson, 2017; Tangwanichagapong et al., 2017). In addition, past researchers also used surveys to check the knowledge and awareness level (Heathcote et al., 2010). Cole & Fieselman (2013) conducted survey both before and after their intervention to assess the pro-environmental knowledge and awareness level change of their participants, in order to evaluate the effectiveness of their CBSM campaign.

Amongst the reviewed literature, for those research and projects that conducted surveys under campus surroundings, adopting questionnaires with only closed questions is the mainstream (Heathcote et al., 2010; Tangwanichagapong et al., 2017; Wan et al., 2012, 2014, 2017; Wu et al., 2018). An advantage of this type of survey is that they can collect larger samples from more people with standardized data, they then allow the researcher to proceed with statistical analysis and interpret their findings in a quantitative way. This types of survey are especially beneficial when researchers are comparing the strength of each determinant toward the studied behaviour. Moreover, researcher can easily compare if the impact of certain factors to the studied behaviour vary between participants with different attributes or backgrounds. Whereas Dahle & Neumayer (2001) conducted their survey using a semi-structured interview in person,

with a number of open-ended questions, their survey questions allow the respondents to better address their opinion, it then enabled the researchers to gain an in depth understanding over the questions wished to be addressed.

In addition, CBSM highly suggested practitioners to do a focus group before generating and implementing surveys in a CBSM program. Based on the results of the focus group, a larger scale survey can then be designed and implemented. However, the adoption of a focus group can be skipped by merging open-ended question specific related to barrier and benefit identification, e.g., what do you find challenging/motivating to do …….(the desired behaviour). By blending such open-ended questions in the survey, it allows researcher to learn the information they need from the target audience without doing both focus group and survey. This strategy can help reaching the objective of understanding the target audience at lower cost but higher efficiency. (McKenzie-Mohr, 2011)

To summarize, a lot of survey questions related to different aspects of recycling and /pro-environmental behaviour have been well-developed and tested in previous studies. However, since it is not the focus of this study to accurately measure the influential extent of each determinants, it is believed that prioritizing the most influential ones are more important for this study. As a result, rather than using a structural instrumental questionnaire that asks several questions to precisely and carefully examine each construct, it is determined that the survey in the pre phase will use a questionnaire that combines both close and open-ended questions. Nonetheless, questions designed and surveyed by previous studies particularly based on TPB are still valuable, therefore, selected questions will be adapted then adopted.

Moreover, I particularly wish to learn from the survey participants about 1) their waste sorting knowledge and awareness of the UW campus sorting standard, and 2) identify the pragmatic barrier and benefits the campus community have toward waste sorting on UW campus.

2-4.2 Observation of waste sorting behaviour

Observations are mainly conducted through video records (Cheng, 2016; Verdonk et al., 2017) or manually (Ahmed et al., 2016; Austin et al., 1993; Dale et al., 2012; Menzer et al., n.d.) in earlier studies. Both methods have their pros and cons, while ethnical concerns (Menzer et al., n.d.; Verdonk et al., 2017) and keeping the observation method unnoticeable are shared concerns for both methods. Likewise, CBSM suggested that observation of a behaviour should be unobtrusive (McKenzie-Mohr, 2011), as people are likely to act different from their normal behaviours, either act what makes them look better, or

behave as how they anticipate the researchers want to see. The following paragraphs will first go through the advantages and disadvantages of video-recorded and manual-recording observations, then follow with a review of the type of collected data and the analysis approaches of previous studies.

Video recordings provide solid records for reviewing, but installation of the recording devices require certain conditions, e.g., the installation is not easily recognized by the users; the installation allows the devices to adjust the surroundings especially at out-door space; etc. Moreover, missing data can happen if there were technical issue or misfunction happened (Verdonk et al., 2017).

The ethical concern is one reason that may impact the sight of recording (Verdonk et al., 2017). Chen (2016) filmed a full view to observe their bin users' interactions with their interactive waste system, while Verdonk et al (2017) recorded their observational data with a relatively limited view, because they avoided to specifically identify each user. The later was then only able to identify users' gender by traits of their hands or jewellery they wore (Verdonk et al., 2017).

Subjective bias or errors can happen since waste discarding behaviours generally happen within a few seconds, or the view of observers are blocked by others in reality. To overcome this challenge, Austin et al, (1993) conducted reliability checks among observers to secure a certain level of interobserver agreement. They had a proportion of observation sessions conducted by multiple observers, then calculate the agreement rate over the total records. Another way of reducing the inconsistency brought by subjective judgement is to repeatedly assign an observer to the same observation site (Ahmed et al., 2016; Menzer et al., n.d.) Although the subjective bias is likely the main flaw, manual observation appears to have higher flexibility and better at adjusting if shifts were needed (Dale et al., 2012). Manual observation is also suitable for researchers, who wish to have a full view when observing but not do not want to simultaneously record the identity of the users. Furthermore, manual observation also provide more flexibility to adjust to the observation site (Dale et al., 2012), and it is easy to conduct, because lower devices' requirement is needed comparing to video record method.

Observation for waste management studies can be an exploratory and tentative process, researchers might not always know what to record at the beginning. Therefore, free forms are adopted by some at the initial phase, then later on narrow down to a more specific recording form after several adjustments Dale et al., (2012). Alternatively, many others who conducted observations used forms that contain some leading questions, or a check list that researchers wish to find out from observations, but observers are still often asked to record anything worthwhile to be noted based on their judgements (Menzer et al., n.d.).

What data to collect varies according to the purpose of the study and the surroundings of where the study is conducted. The following paragraphs review the type of data collected in previous observations are synthesized from five studies done by Ahmed et al., 2016; Austin et al., 1993; Dale et al., 2012a; Menzer et al., 2013; and Verdonk et al., 2017.

One main type of data collected was about the practical onsite sorting. Differentiating the correctness of sorting is one popular type of data to collect, especially for studies share a similar goal to improve waste sorting at selected study sites (Menzer et al., n.d.; Verdonk et al., 2017). Moreover, if a wrong sorting was done, researchers were also interested in which bin(s) was/were the waste placed eventually. Other data types including the number of disposed subject; was there any recycling behaviour?; was the sorting onsite or offsite (pre-sorted)?;how is the waste/recyclables discarded? (e.g. loose, mix with recyclables/waste, in separated bags, using small grocery bag, using large garbage bags) (Dale et al., 2012)

Another type of data collected related to the interactions with the receptacles or signs. Researchers are interested if the users have visually acknowledged recycling option exists, and the way a user approach or leave to the receptacles. Ahmed et al., (2016) focused on recording the discarding time changes, and they reported an issue of standardizing the recorded time, since waste discarding can happen very rapid. As a result, they determine to record those with a 0.5 second if the recorded time was less than 0.5 second. In addition, the attributes of users are also common data to include, e.g., gender, age, alone or in a group (the number of people in the group). Verdonk et al. (2017) pre-segmented their users into “chuckers” or “thinkers”, and later on suggested to add a “follower” type in their research findings.

The above data are mostly collected in a relatively structural way, e.g., answering planned questions, or using check lists. However, additional qualitative notes were also reported to be recorded. These notes basically covered anything noticed by the observers and determined that it can contribute to the overall study purposes. Some examples of qualitative notes are overhearing verbal observation, unique waste items, or guidance given by people other than the one who actually dispose the waste/recyclables. (Dale et al., 2012; Menzer et al., n.d.) Except for the receptacles units/sites with intervention applied, some studies not only observed selected but also other receptacles existing at the same space (Menzer et al., n.d.)

To sum, a broader view allows researchers to better investigate the users’ interactions with the receptacles and signage, however, it is not necessary to identify each bin user, and according to the

UW's research ethic regulation, the observation should be conducted without recording the identity of users. Manual observation would be easier to achieve the aim of fully observe but filter out the identity of the observed public. Moreover, it is estimated that installing video recording devices at suitable spots is more challenging than having manual observers, due to the restriction of the surroundings, and limited access to appropriate devices. Pioneer exploratory observation can help form a tailor-made observation form that better fits the study objective.

Therefore, manual observation is believed to be a more cost-effective and plausible methods over video record in this study. As of the data to collect, according to the objectives of this research, the following information is what I particularly wish to know from the observation: did the user visually acknowledge the sign; the intention of sorting; and the correctness of sorting. Discarding time, qualitative notes, and observation of using other bins will also be observed in order to more thoroughly understand target audience's interaction toward the waste signs.

2-4.3 Waste audit

A period between a day to a week is the common duration for sample collection of a waste audit. It is suggested to select the sample collection duration wisely that no special events are taking place, and the weather and season are not too harsh for implementation (Buchan, n.d.). Two potential challenges for researchers who wish to conduct waste audits are to seek coordination and to do good communications with related parties, e.g, custodial services, waste haulier. Johnson (2013) reported unable to conduct waste audits because cooperation was not gained from stakeholders, as waste audit is unavoidable adding extra workload to the personnel who are in charge of waste collection. A similar situation happened to the study done by Miller et al. (2016) as well. Andrews et al. (2013) also reported samples got mixed up that increase the difficulty and error of analyzing.

Researchers generally selected an analyze method according to what information they wish to learn from the audit. Waste audit can be conducted in different levels (Buchan, n.d.). It can simply be measuring the weight of collected waste (N. D. Miller et al., 2016); conducting visual estimation then infer the total amount by calculation; or doing a thoroughly audit that separate and record all the correct and incorrect sorted waste.

There is no known standardized waste audit procedure, but guidelines and descriptions given by different studies and reports shared much in common (BOMA Canada, n.d.; Bourner, n.d.; Buchan, n.d.). Ontario

provincial government also has a waste audit guideline released under the *Environmental Protection Act, O. Reg. 102/94: Waste Audits And Waste Reduction Work Plans* (1994).

When calculating the metrics, BOMA Canada Waste Audit Guide specially indicated contaminants should not be included (should be deducted) when calculating diversion and capture rate. The operational definition for the three metrics used in this study, i.e., diversion rate, contamination rate, and capture rate, are further presented in Chapter 3: Research methods (3-3.4 Waste Audits)

Waste audit results from studies done in campus surroundings shared many similarities in common. Leigh (2018) found about 70% of the waste disposed in the landfill stream of her study institution could have been diverted to recycling and compost streams. Likewise, the waste audit report conducted in the university of Illinois mentioned organic and compostable waste made up a dominated share of their sample collected from landfill streams (Illinois Sustainable Technology Center (ISTC), 2014). Both general findings of waste characteristic is similar to the status UW has, as UW is reported by the its 2017 waste audit report to have a potential of diverting 80% of its waste from landfill stream to recycling or organic streams (Waste Reduction Group Inc, 2017).

Moving on to some specific items or materials that were found problematic in past waste audits. Firstly, paper-based coffee cups and their lids were identified to be the most confusing items. Although most coffee cups seemed made out of paper materials, they are usually coated with plastic liners. With the plastic liners coated, many waste diverting programs then do not regard coffee cups as recyclables. (Ahmed et al., 2016; Heathcote et al., 2010; Ummat, 2013). Several Canadian universities also saw coffee cups composed a considerable proportion of waste in their landfill streams as a single type of waste alone (Heathcote et al., 2010; University of Western Ontario, Enviro Western, 2008). This situation again aligned with the 2017 UW waste annual report that coffee cups have made up 7.6% of the waste samples collected from garbage stream itself. Secondly, napkins/used paper towel, and food-soiled waste, e.g., used paper plates, were reported to confuse the public as well. Finally, plastic is noted to be another troublesome material. Many items people use nowadays are made of plastic, with soft plastic wrapping being one common packaging material. Most of the institutions in the reviewed literature recycle plastic in their waste diverting programs, however, plastic items were not always accepted. Some of the plastic-made items were labelled with a symbol following the Resin Identification Coding System (RIC). However, the RIC symbol is used to identify the composition of the plastic in order to facilitate end stream recycling. Some of the waste diverting programs in the reviewed studies recycled only plastic items with the RIC codes, and some only accepted items symbolled with a few specific RIC codes. Whereas, these

studies, which reported plastic to be problematic, concluded that their study audience were often unclear about the detail about plastic recycling at their facilities. Moreover, the RIC symbol looks very much like the widely recognized recycling symbol. Researchers also pointed out this may be part of the reason that plastic has troubled their study audience so much. (Leigh, 2018; Menzer et al., n.d.)

2-5 Past waste management research related to pro-environmental behaviour conducted at the selected study site

A number of waste management related studies and projects have been done at this study site, i.e., main campus of UW. Many of these studies and projects have either particularly selected one or a few areas/buildings with similar attributes, e.g. campus pub, libraries, food services (Clarke et al., 2005), administrative buildings, offices (Lampi, 1998), or residences (Chow & Tsun, 2005). Some of them targeted specific types of waste, e.g. paper (Viola et al., 2005) and batteries (Cushing et al., 2005). Even though the thoroughness and methodologies vary, the majority of the reviewed studies have adopted waste audit as their dominant data collection and assessment tools.

Several factors reviewed in earlier sections, which were believed to have impact on waste sorting behaviour, were also investigated by some previous studies done on UW campus. Allin, Battiston, Lowry, & Thompson (2003) evaluated the influence of convenience toward recycling on campus by assessing how far a waste disposer is willing to travel with their waste for recycling. McEachren, Formanek, & Dance (2004) have suggested a campus-wide organic collection system with multi forms of composting collection to serve the public on campus at different scales, smaller scale e.g., offices, versus larger scale, e.g., lounge and dinning areas. Although the newly introduced organic waste collection system is different from their suggestion since the waste management backgrounds and conditions have changed considerable, the idea of multi forms collection that serves users at different scales have been implemented with the current system. In terms of waste signs, Kozak, Elliot, Reid, & Harvey (2004) also pointed out recycling options were not always available in their case, which likely related to worse waste sorting outcomes. Moreover, they have also reported phenomena including inconsistent, misleading, or missing signs of recycling bins. In addition, Bator, Schierholtz, Woods, & Scoular (2001) conducted a student recycling knowledge evaluation research in subsequence of earlier studies, and reported their surveyed students from the Environment faculty still lack of recycling knowledge.

Based on the reviewed studies above, it is obvious that recycling have been implemented on the UW campus for years, but it appears there are much space fore improvement on waste sorting. Many

recommendations were given by these past studies, however, most of the reviewed research and projects were done over a decade ago; the entire waste management system, infrastructure has changed much over time. In the past, residence, colleges, and main campus each has their own waste collection system and waste hauler, while now UW intend to launch a universal standard and system. Furthermore, the campus has continuously experienced a growing population, as a result, the waste sorting system should be re-assessed. In other words, this study is still in need.

2-6 Summary

Through the literature review, it has clearly revealed the complexity of behaviour changes on pro-environmental subjects. Intending to change a users' waste sorting behaviour on UW campus can relate to factors from inner personal factors to the larger external systems and social networks; from the individual downstream level, to the mid and upstream scale. Moreover, it is also clear that "recycling" has become a very common initiative to the general public, and a high level of awareness is often reported by the study audience in past studies. However, it is now the matter of "sort it right" (Cheng, 2016; Johnson, 2016), especially waste sorting nowadays has been more complicated than ever. The introduction of the organic stream on campus and the shifting of the campus sorting standard are likely to challenge users' existing knowledge and habits.

A solid foundation has been set by previous studies theoretically and practically for this study, and many insightful recommendations were given as well. Dos and don'ts are either directly or indirectly provided by reviewed literature for the selected research tools, i.e., survey, observation, and waste audit; sign design; experiment and intervention (sign) design. Supporting examples that adopted CBSM on subjects related to waste management related also gave valuable experiences. By synthesizing the findings and experiences from these past studies, I am able to select those promising and suitable good approaches that fit the existing infrastructures and regulations on UW campus. However, as some reviewed studies have fewer waste streams; some target one or few specific types of waste; and some have very different sorting standards than this current study. Considering waste management study is case-sensitive, slight revisions are certainly in need.

This study also expects to verify and expend some findings from several prior studies (Creswell, 2014). With the main approach of displaying coloured images of practical items, this study attempts to implement laboratory findings into fieldwork, and partially replicate findings concluded by research done under a similar surrounding but with a slightly larger scale and more in-depth.

The following methodology chapter builds the mix-method research design upon the synthesized best practices from reviewed literature and the CBSM framework.

3. Research Methods

3-1 Mixed Method Approach

This quasi-experimental case study research uses a convergent mixed method approach (Campbell & Stanley, 2015; Creswell, 2014; Creswell & Clark, 2011; Chiou, 2009), and applies CBSM theory as its main framework. (Figure 3-1) Research diagram illustrates the relationship between the study design and the CBSM procedure. Chronologically, there were four phases in this study: pre-phase; intervention development; intervention; and post-phase.

Firstly, in the pre-phase, a user survey, the first-round onsite observation, and the first-round waste audit were conducted. The user survey and the waste audit in the pre-phase collected both quantitative and qualitative data. Secondly, in the intervention development phase, all data collected from earlier phase were analyzed separately with the results being used to develop the intervention, i.e., signage, for the experiment (i.e. intervention phase). Thirdly, in the intervention phase, nine selected experiment sites were divided into three groups based on their function of the buildings on campus. In each group of three, one site was assigned as a control group with the remaining two groups were assigned respectively into one of the two experimental groups. The sites that were assigned into the two experimental groups had either large or small experimental signs placed at a set of waste stations in the building (see also Figure 3-2 in section 3-3.1). Lastly, in the post phase, the second-round of onsite observation and waste audits were conducted after the experimental signs were installed. By comparing the pre- and post- phase results, the research questions were then addressed.

A mixed method approach was adopted because the quantitative and qualitative data collected in the earlier phases of the research (i.e. the survey in the pre phase and its subsequent analysis) provided a general understanding of the research problem and the target group members, which helped to build a good foundation that guided the development of the intervention in the later stage. Moreover, collecting both qualitative and quantitative data simultaneously helps to cross-validate and strengthen the findings of the study.

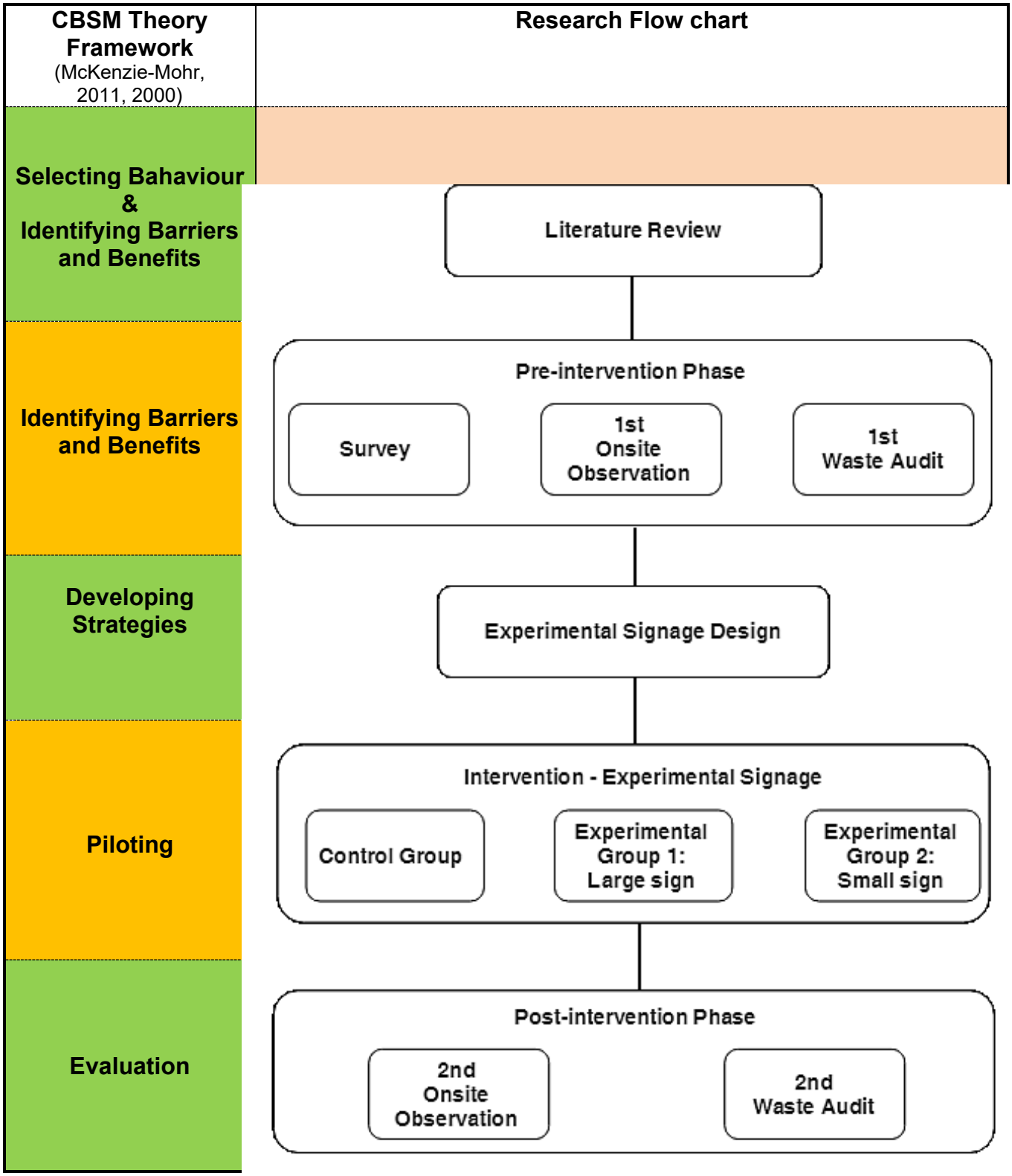

Figure 3-1 Research Diagram

3-2 Research Design

3-2.1 The experimental sites

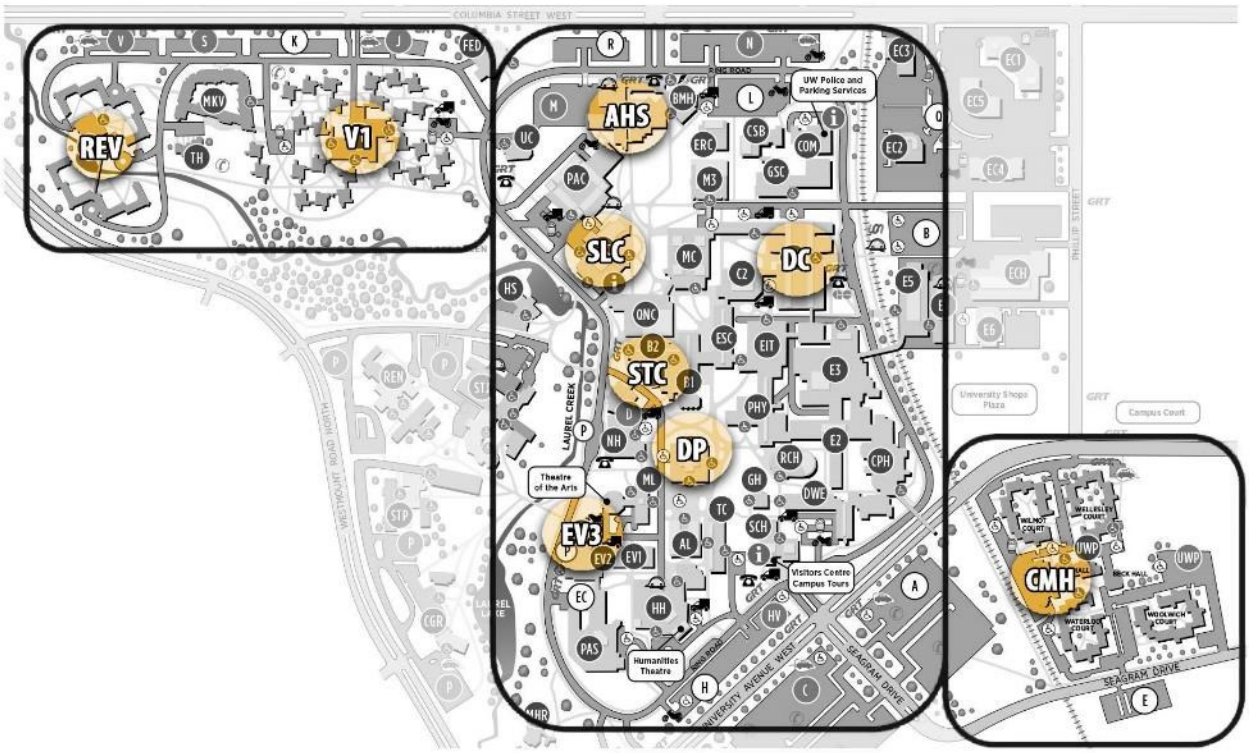

Figure 3-2 Experimental Sites Map

Nine of the new streamed waste stations in different buildings over the campus were selected as study sites (Figure 3-2). Selected waste stations were all located on the main floor of each building, close to food outlets (café, cafeteria, or food providers) operated by the UW Food Services.

1. Group A included three sites that were located in buildings that are multi-function and/or serve the general campus community (e.g. student centre and libraries). The buildings that fall under Group A are the Student Life Centre (SLC); Dana Porter Library (DP) and the Davis Centre (DC) – which has offices, classrooms and a library. The study units selected in Group A had three-streamed waste stations (i.e. recyclable materials and waste but no compost stream).

2. Group B included three sites that serve as specific faculty buildings. The buildings falling under Group B are Environment 3 (EV3), Applied Health Science (AHS), and Student Teaching Centre (STC). The study units selected in Group A had four- streamed waste stations that contains all categories of waste including compost.

3. Group C included three sites that are student residences. The buildings falling under Group C are Village 1 (V1), Claudette Millar Hall (CMH), and Ron Eydt Village (REV). The study units selected in Group C had large four-streamed waste stations with two organic bins but no paper category. The selected waste stations have the largest waste capacity among all groups.

The nine selected sites were then divided into experimental groups and a control group. For the three sites in each of Groups A, B & C, one site was designated as a 'large sign experimental group', one as a 'small sign experimental group' and one as a control group. (Figure 3-3)

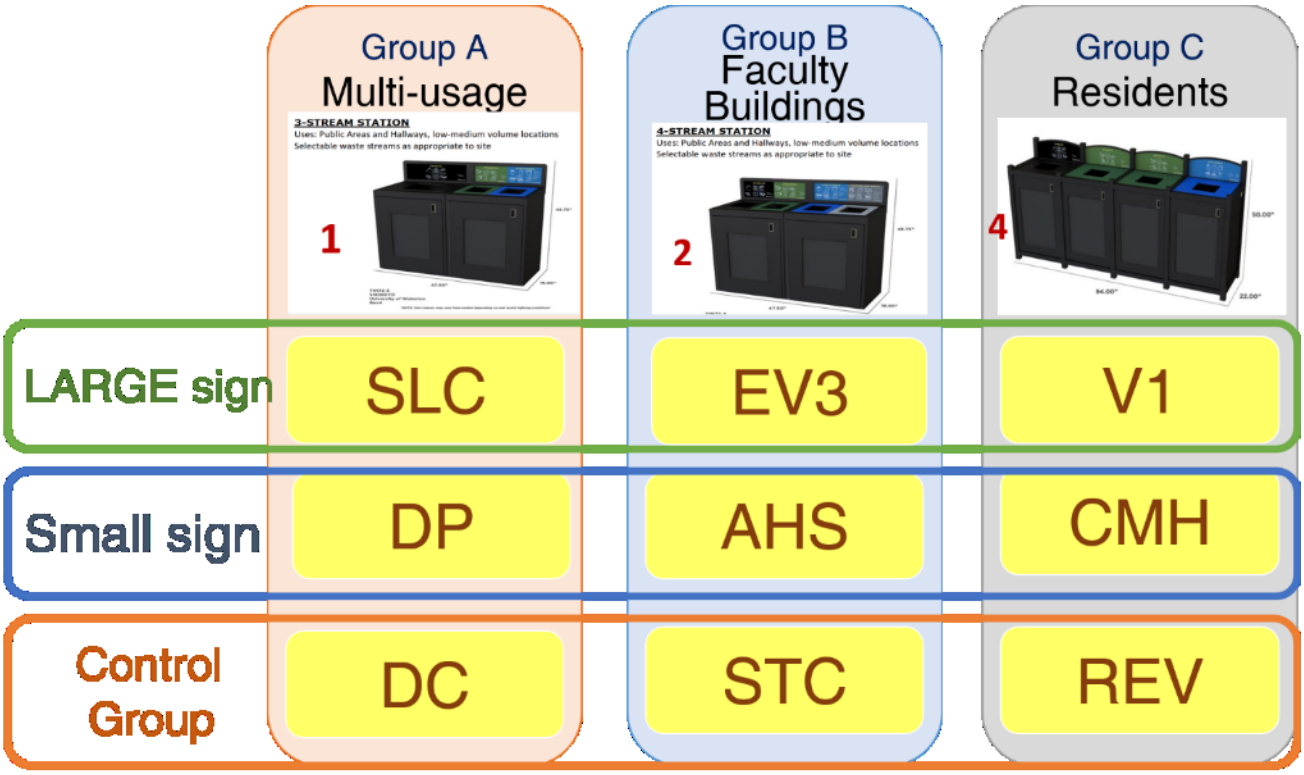

Figure 3-3 Experimental sites and groups

3-2.2 Survey

A survey was conducted with participants in the UW campus community and included a mix of faculty, staff and students (see Appendix 0 for a full copy of survey questionnaire). The objectives of the survey were four-fold:

1.) To understand users' (i.e. the campus community's) current waste sorting behaviour on UW campus.
2.) To understand users' waste sorting knowledge level and awareness.
3.) To Identify barriers and benefits users have with respect to sorting waste on campus.
4.) To develop recommendations of potential CBSM strategies for UW to further improve waste management on campus.

The aim of the survey was to develop a thorough understanding of the users' current sorting behaviour, and determine the level of familiarity of the campus community with the current campus sorting standard.

The anonymous user web survey was designed and conducted in the pre phase, and the questionnaire was sent out to participants via the online survey platform, Qualtrics. The survey samples that were collected was convenience sampling. University of Waterloo Office of Research Ethics approval was obtained prior to the survey being distributed. The consent letter of this survey is present at the very beginning of the questionnaire, combining the introduction of the questionnaire. The participants' consents were gathered using digital format.

This survey was designed to have both face validity and content validity. Many questions and content of the questionnaire were drawn and adapted from previous studies that were found in peer-reviewed journals (Cole & Fieselman, 2013; Heathcote et al., 2010; Menzer et al., n.d.; Tangwanichagapong et al., 2017; Tonglet et al., 2004; University of British Columbia, n.d.; Wan et al., 2012, 2014, 2017; Wang et al., 2010; Wu et al., 2018). In addition, the full questionnaire not only went through peer review, but reviewed by experts specialized on behavioural research and the UW Survey Research Centre and was pre-tested with a group of 20 staff and students on campus. Reliability was not further validated because the majority questions in the questionnaire are ranking questions or open-ended questions.

1. The composition of the survey

The survey questionnaire included four main sections with a total of 22 questions. The four sections were: 1) socio-demographic, 2) user sorting experience on campus, 3) user knowledge evaluation, and 4) sorting motivations and challenges.The four sections were designed and arranged based on the flow of complexity of the questions (i.e. starting with easier questions and then gradually moving on questions

that require more thought. Part of the survey questions are modified from previous studies (Cole & Fieselman, 2013; Menzer et al., n.d.; Tangwanichagapong et al., 2017; Tonglet et al., 2004; University of British Columbia, n.d.; Wan et al., 2012, 2014, 2017; Wu et al., 2018). A more detailed description of each section of the questionnaire is included below.

1. **Sociodemographic / basic information and related experience:** This section contains six questions; all questions are closed-answer questions. Questions in this section ask for information such as gender identity, age group, current status on UW campus, related faculty, etc.

2. **Evaluating the users' knowledge and awareness toward the latest campus sorting standard:** This section contained two subparts; all questions are single-answer questions with correct answers. The first part included four True/False questions; the second part was a sorting quiz with four questions displaying 25 images of waste, and asked the participants to choose the answer they believe was the correct sorting option for the displayed waste (e.g. if an image of a pizza box was shown, the respondent had to choose which to put it in among the options of recycling, compost or waste streams).

3. **Identifying motivations and challenges (i.e. the benefits and barriers) of waste sorting on campus at UW:** This section consisted of five questions, including two structured questions; three open-ended questions. Using the CBSM framework a group of open-ended 'top-of-mind' questions were asked first followed by a similar close-ended question. In this case the questions were related to what motivates and hinders the users from carrying out proper waste sorting on campus.

4. **User waste sorting experience on campus:** This section contained five questions. Several questions asked users to rank their responses including a question that asked users to rank the frequency of using different types of the waste receptacles on campus and another that asked users to rank who/what impacts their sorting decision on campus. Another question used a continuous scale, the Likert scale, asking users to self-assess how confident they were in their receptacle and sorting knowledge as well as their satisfaction toward the waste management setting on UW campus.

3-2.3 Onsite observation

Onsite observations were conducted both before the new experimental signs were implemented as well as after. The objectives of the onsite observation include:

1. To understand users' (i.e. the campus community's) current waste sorting behaviour on UW campus.
2. To examine the effectiveness of changing waste signage design with visual images integrating CBSM strategies.
3. To identify barriers and benefits users have with respect to sorting waste on campus.
4. To develop recommendations of potential CBSM strategies for UW to further improve waste management on campus.

The overall aim of the onsite observations was to gain an understanding of users' waste sorting behaviour and examine the effectiveness of sign changes by observing users' interactions toward the study units and the attached signs. Onsite observation served as a part of the comprehensive research design, that helped to crosscheck and/or reinforce the results and findings gathered via other research tools.

A **non-participatory observation** session was conducted each in the pre and the post phases with the aim of the observer to not be noticed at the site of observation. Each selected site was observed on two weekdays, 90 minutes each time by a trained observer. In total each site was observed for three hours in both phases. The residence group observation was during dinner time from 5:00 pm to 6:30 pm, while the other two groups (the multi-use group and the faculty building group) were done during lunch hours from 11:30 am to 1:00 pm. Times were selected to observe higher traffic periods (and thus higher waste traffic). The observers conducted their observation on designated seats and direction, an area of starting and ending the timing was also designated. Each designated seat fell within a distance of less than five meters of the selected observation waste receptacle.

There were 10 observers including the researcher. Each observer received a 30-minute training session which was delivered by the researcher as well as a 90-minute trial observation period on site with the researcher. Interobserver reliability checks were conducted during 9 of 36 sessions (25%). Interobserver agreement rates were computed by dividing agreements by the total records, i.e., agreements plus disagreements in observed data. The interobserver agreement rate had to reach a level of at least 75%. To reduce variance and to assure the record reliability within the same location, observers were mostly assigned to repetitive study sites in the pre and post phase.

The observations were done visually and recorded in a way that included both quantitative (i.e., time) and qualitative (i.e. how did the user interact with the waste station?) records. The following variables were recorded: 1) the time an item was discarded 2) the extent to which the user read the sign; 3) the

extent to which the user sorted the item(s), 4) the extent to which the user sorted the item(s) correctly, 5) whether the user discarded only one item, 6) Did the user decide to use another bin that was not part of the waste station?; and 7) other notes. Table 3-1 explains the scale and record guideline of the observation form. See Appendix C for the full record form.

Table 3-1
Observation variables and data collection details

Observed variables	Scale / Record codes	Details
Discarding time	Seconds (to first decimal)	- Using convenient random sampling - Sorting time over
The extent of sign reading	From 1 to 3, with 1 represent the lowest extent, and 3 stands for the best extent.	- Those who scan and recognize the colour of the streams are mark with "2" for the sign reading variable.
The extent of sorting		
The extent of sorting correctness		
Discarding one item	Yes or No	
Using other bins	Yes or No	- Only DC, DP, STC, and EV3 has other bin(s) close by.
Other notes	text	-What was the discarded items and which steam did they sorted. - The users' interaction with the waste station, especially the signs.

Discarding time: Waste traffic at selected sites varies widely and the numbers of timed records were different among all sites. However, at least 23 users were timed and recorded for each site during the observation period. Convenience random sampling was used for measuring the discarding time. When conducting the pre -post comparison, descriptive statistical analysis was primarily used to compare the pre- and post-discarding time change.

The extent of sign reading"; "sorting or not"; and "sorting correctness": For items 2, 3 and 4, a scale of 1 to 3 was used to denote the extent to which a user read the signage, attempted to sort items and whether those items were sorted correctly (with '1' representing 'poorly' and '3' representing 'very good'. Statistical Package for the Social Sciences (SPSS), version 18.0 (*PASW Statistics for Windows*, 2009) was used for statistical analysis in this study. Descriptive analysis including means and standard deviations which are expected to be present in both pre and post phase results.

When conducting the pre-post comparison, except for descriptive statistics analysis, independent t tests were be used to check if there were any significances within each site. Whereas, if the within site pre-post comparison results do not show much meaning, data from each intervention type were comingled,

i.e., large sign, small sign, and control group. Subsequently, independent t tests were be conducted again to compare the pre and post data within groups. Moreover, a one-way Analysis of variance (ANOVA) with a Tukey HSD (Honestly significant difference) post hoc test was be used to determine if observed data differed among sign types. Whereas, if the results of Levene Statistic - test of homogeneity of Variances – showed significant, i.e., the data violates the assumption of homogeneity, a robust test of equality of means was conducted and a Games-Howell post hoc will be used. A p-value of less than 0.05 is considered significant. The analyzing method is referred to study done by Andrews et al. (2013).

Discarding only one item: If a user discarded only one item, the sorting intension and behaviour was harder to determine compared to those who discard more than one item. As a result, we specifically identified those who only discarded one item, and a percentage was computed in the results.

Using other bins: Only four of the test sites had other bins placed near the waste stations that were being observed, including DP and DC in Group A; STC and EV3 in Group B. Two extra recycling (container) carts were placed beside the study units at STC and DC, while DC has two external garbage cans nearby as well. The condiment tables were designed with a hole that serves as a garbage can, and the study units were located right beside the condiment tables. If a user disposed of something in a bin other than the waste station bin, the variables of sign reading and sorting or not were then marked with “X”, but the extent of correctness of sorting was still recorded.

Other special notes: Other special notes include any qualitative records that the observer believed could contribute to the overall observation objective, e.g., repetitive user (such as UW Food Service staff), the user were guided to throw their waste by others, the users treated the waste receptacles as basketball hoop, etc.

Due to the nature of the study, the sorting criteria in the pre-phase was a bit ‘looser’, i.e., we allowed both the previous standard that showed on the original signs, and the latest campus sorting standard. The rationale of allowing both new and old sorting standards was because we were testing the impact of signs toward users’ waste sorting behaviours. Even though the original signs contained incorrect information, it is unreasonable if we judged those who sort their waste according to the original signs.

3-2.4 Waste audits

Waste audits conduction link to the following study objectives.

1. To understand users' (i.e. the campus community's) current waste sorting behaviour on UW campus.
2. To Identify barriers and benefits users have with respect to sorting waste on campus.
3. To examine the effectiveness of changing waste signage design with visual images integrating CBSM strategies.
4. To develop recommendations of potential CBSM strategies for UW to further improve waste management on campus.

The aim of the waste audits what to determine which items were frequently missorted and which streams are they commonly be sorted to rather than the correct stream. Quantitative data including diversion rate, cross-contamination rate, and capture rate were gained by conducting waste audits, which also served as part of the comprehensive research design. By thoroughly reviewing the collected samples in both phases, the effectiveness of sign changes was able to be measured.

As was the case with the onsite observations, waste audits were also conducted both in the pre and post phases. For each waste audit, a 48-hour sample was collected from each selected site.

Due to the nature of the study, the sorting criteria used in the pre and post phase were different. For the experimental groups, the pre phase used a looser criterion that allowed both the new and old (old sign) sorting standards, while the post phase use the stricter sorting criteria presented on the experimental signs. In other words, looser sorting criteria were used in the pre phase, while stricter criteria were used in the post phase. Whereas the control group used the looser criteria in both phases, because no sign change was made.

The waste audits were done under the assistance of the campus custodial service—Plant Operations. Waste samples from the chosen waste bins were collected separately and labelled. The date of the waste audits overlapped with the on-site observations. The pre phase waste audit was conducted on March 13 and 14, 2019. The post phase waste audits are done separately in two consecutive weeks due to the availability of plant operations staff (who were collecting the waste samples). The post phase waste audits samples were collected on April 3 and 4, 2019 and April 11 and 12, 2019. These dates were all Wednesdays and Thursdays. In the post phase waste audits, samples from Group A and Group B with a total of six selected sites were examined in the first week, while Group C were done in the following week. However, during the period when the later waste audit in the post phase was conducted, the University has started its exam season, the waste bin users' behavioural patterns; user numbers and frequencies; and the waste amount may have been affected.

1. The types of data collected, and the analyze method

The analyzed samples and results of waste audits were recorded with pre-made record forms shown in Appendix C. The record variables from the samples included the total weight; contaminant weight; numbers of contaminants; number of a certain type of waste; other notes. Metrics including diversion rate, cross-contamination rate, and capture rate were then calculated from the total weight and contaminant weight. The formulas are as the following (BOMA Canada, n.d.; Buchan, n.d.):

Diversion rate: *The diversion rate is the percentage of the total waste generated that is diverted from disposal into the reuse and recycling streams/programs available at the facility. This number should not include contaminated waste.* (BOMA Canada, n.d.; Buchan, n.d.)

$$\frac{Weight\ of\ Recycling - Weight\ of\ Conteminants}{Total\ Weight\ of\ Collected\ Sample\ (\ Weight\ of\ Recycling + Weight\ of\ Garbage)}\ X\ 100$$

Contamination rate: *The percentage of material found in a wrong/incorrect diversion bin/stream that should belong to other stream/bins. A high contamination rate may lead to the hauler not accepting the material for the diversion program and redirecting the material for disposal.* (BOMA Canada, n.d.; Buchan, n.d.)

$$\frac{Weight\ of\ Conteminants}{Total\ Weight\ of\ Collected\ Sample}\ X\ 100$$

Capture rate: *The capture rate is the percentage of a recyclable material collected, out of the total amount of that material generated. It is an excellent indicator of how well a recycling program is working for a particular material. Give information of waste is currently diverted from disposal toward the total volume of waste that could have been diverted. This number should not include contaminated waste.* (BOMA Canada, n.d.; Buchan, n.d.)

$$\frac{Weight\ of\ Recycling - Weight\ of\ Conteminants\ in\ Recycling\ stream}{Total\ Weight\ of\ collected\ Sample}\ X\ 100$$

2. The procedure of a waste audit

The following section outlines the details of the procedure that was used for the waste audits. Waste samples were collected from the selected streamed bins by the custodial service personnel. Each bag was labeled with its day and category (i.e. garbage, organic, container, and paper), and then gathered for analysis.

All examined samples were weighed by the same two spring scales (Figure 3-4). Sample weight sizes that exceeded 500g were weighed by the spring scale with weighing capability up to ten kilograms, while samples lighter than 500g were then weighed by the other spring scale that is capable to show a result to an accuracy of 10g. The weights of all samples are weighed and recorded to hundred grams, i.e., to the first decimal of kgs.

Figure 3-4 Scales used for waste audits

To analyze a waste sample, the auditor first weighed the total weight of the bag (Figure 3-5).Next, the auditors picked out the mis-sorted items (Figure 3-7), and then weighed the total weight of the contaminants picked out from the same bag. By deducting the contaminants' weight from the total weight, the diverted waste weight was then calculated. With the results, we were able to calculate diversion rates, cross contamination rates, and the capture rates. Aside from the weight of the sample, the auditors also recorded the numbers of certain type of wastes (Figure 3-6 Record contaminants counts), and add additional notes if need.


Figure 3-5 Weigh total weights of samples

Figure 3-7 Pick out contaminants


Figure 3-6 Record contaminants counts

4. Pre-Phase Results

4-1 Survey

The time duration of survey responses collection is from Mar. 2019 to Apr.30.2019, and the valid responses come to 276. Responses that did not finish the sorting game section, or skipped five or more non open-ended questions, i.e., structural questions, are not regard as valid responses.

4-1.1 Sociodemographic and basic info:

1. Current status

Table 4-1
Users occupation

Current Status at UW		
	N	**Percent**
Undergraduate Student	130	47.10 %
Graduate Student	56	20.29 %
Faculty Member and Lecturer	17	6.16 %
University Staff	65	23.55 %
Others	8	2.90 %
Total (N)	**276**	**100.00 %**

2. Faculty

There are six main faculties in UW, and four affiliated colleges. Considering the waste collection system and waste bins of the affiliated colleges are not aligned with the main campus of UW at this current stage, and the samples collected from each college are far too small, they are then combined into the “other” group. University staff who work in the university offices and services are considered as a separated category. (Table 4-2)

Table 4-2
Faculty composition and sorting game score

			Sorting Game Score	
Faculty	**N**	**Percent**	**Mean**	**Std. Deviation**
Arts	18	6.52 %	15.44	3.518
Applied Health Science	14	5.07 %	14.64	4.765
Engineering	32	11.59 %	15.25	3.759
Environment	68	24.64 %	15.93	3.857
Mathematics	63	22.83 %	16.08	3.371
Science	26	9.42 %	17.85	3.728
Other	18	6.52 %	16.94	2.733
University Offices and Services	37	13.41 %	18.92	2.900
Total	**276**	**100.00 %**	**16.43**	**3.737**

The One-Way ANOVA result shows that participants from University offices and services perform better sorting among all, while the rest faculties do not have significant difference between each other (Table 4-3).

Table 4-3
ANOVA results of faculty sorting game scores

Variance Source	*SS*	*df*	*MS*	*F*	*p*
Faculty	417.85	7	59.69	4.66	.00
Error	3421.98	268	12.77		
Corrected Total	3839.83	275			

The significance threshold uses a priori alpha level of 0.5. F (7, 268) = 4.66, p=0.000 < 0.01, η_p^2 =.109. We can state the independent variable, i.e., faculty, has a medium explanation power to the sorting game score. The result of the Levene's test of Equality of error variances not significant (Levene = 1.977, p= .056), so the dependent variable is equal across groups that the data satisfy the hypothesis of homogeneity of variance.

The Scheffe post-hoc test show the University offices and services is significant toward Engineering (M=15.25, SD=3.76, p=.014), Environment (M=15.93, SD=3.86, p=.021), Mathematic (M=16.08, SD=3.37, p=.044), and Applied Heath Science (M=14.64, SD= 4.77, p=.046); but not Arts (M=15.44, SD=3.52, p=.125), Science (M=17.85, SD= 3.73,p=.986), and others (M= 16.94, SD= 2.73, p=.813). However, the rest groups do not show any significant difference between each other.

3. Age Group

Table 4-4.
Age group composition

Age group		
	Frequency	Percent
17 - 23	136	49.45%
24 - 30	72	26.18%
31 - 40	28	10.18%
41 - 50	22	8.00%
51 and above	17	6.18%
Total (N)	**275**	**100.00%**

4. Gender identity

According to the survey result, the female sample size is slightly more than 2.5 times the male sample size. Female also scored better on average four points than male in the sorting standard evaluation section. (Table 4-5)

Table 4-5
Gender composition

Gender Identity		
	N	**Percent**
Male	75	27.37%
Female	197	71.90%
Gender diverse (variant/ non-conforming)	2	0.73%
Total (N)	**274**	**100.00%**

4-1.2 Campus sorting standard evaluation

There are two main parts of the campus sorting criteria evaluation:

1. **Sorting standard knowledge check:** We used this question to check whether the participants are aware of the sorting criteria differences from a national scale to a campus scale. This true and false questions include four sub questions asking the participants if the two places mentioned in the questions have the same or different waste sorting criteria.

Q8 - The following statements ask you about waste sorting criteria in different geographic areas. Please select "True" if you think the statement is correct, and select "False" if you think the statement is incorrect.
The result is presented in Table 4-6

Table 4-6.
The sorting standard at different level of geographical areas

Scale	Question	True	False	N
National	8-1. Waste sorting criteria are exactly the same **throughout Canada**.	18 (6.52%)	**258 (93.48%)**	276
Provincial (Ontario)	8-2. Waste sorting criteria are exactly the same **throughout Ontario**.	39 (14.13%)	**237 (85.87%)**	276
Regional	**8-3 Waterloo region** waste sorting criteria are different from **other regions in Ontario**.	**230 (83.03%)**	47 (16.97%)	276
Campus level	**8-4**. Waste sorting criteria on **UW campus** are different from the **region of Waterloo.**	**146 (53.09%)**	129 (46.91%)	275

***The correct answers are shown in bold**

At present, neither does Canada have a national wide, nor does the Ontario province have a provincial wide standardized sorting standard. In addition, as mentioned in earlier paragraph, UW has released a new sorting standard that is different from the region of Waterloo, where the main campus located, a few months before this study is conducted. Therefore, all levels of regions or territories mentioned in the questions have different sorting criteria.

(Table 4-6) A decreasing trend is noticed for the correctness toward the understanding of sorting standard from a lager scale of national level to a smaller scale of campus level. A big gap is particularly found between the regional level and campus level, with the former one still has a high portion (83%) of respondents getting the right answer, while the later shrink to just over half (53%) of the respondents getting it right. Only 46% of the respondents earned a full score among the four questions. A conclusion that many of the participants are not aware of the changes of the latest sorting standard can be drawn. Based on the result of this serial question asking the participant to whether they think the sorting standard at different geographical scope are the same or different. According to the big gap between the regional level (Waterloo region VS other region in Ontario) showing a decrease of correct rate falling 30%, and less than half of the participants getting a full mark in this question. We can draw a conclusion for this question that many of the participants are not aware of the changes of the latest campus sorting standard.

Table 4-7.
Sorting standard evaluation

True/False Score	Frequency	Percent
0	13	4.71%
1	15	5.43%
2	20	7.25%
3	100	36.23%
4	128	46.38%
Total (N)	276	100.0%

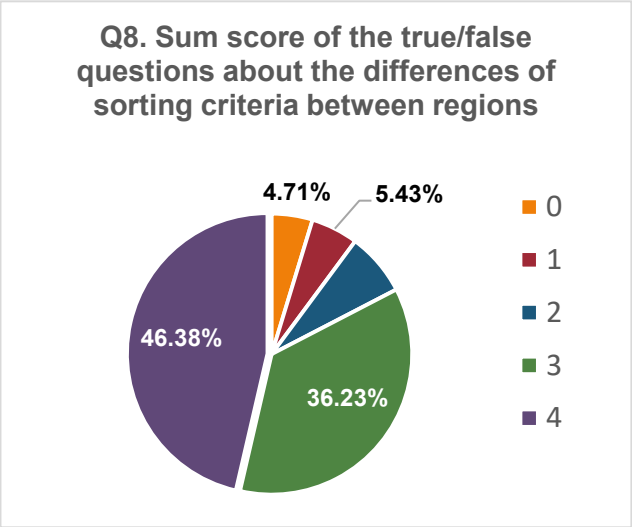

Figure 4-1 Sorting standard evaluation (pie chart)

2. **Sorting quiz:** 25 items are listed, then asked the respondents to match the waste category they think is the right category to place the item. All items come with a practical item picture.

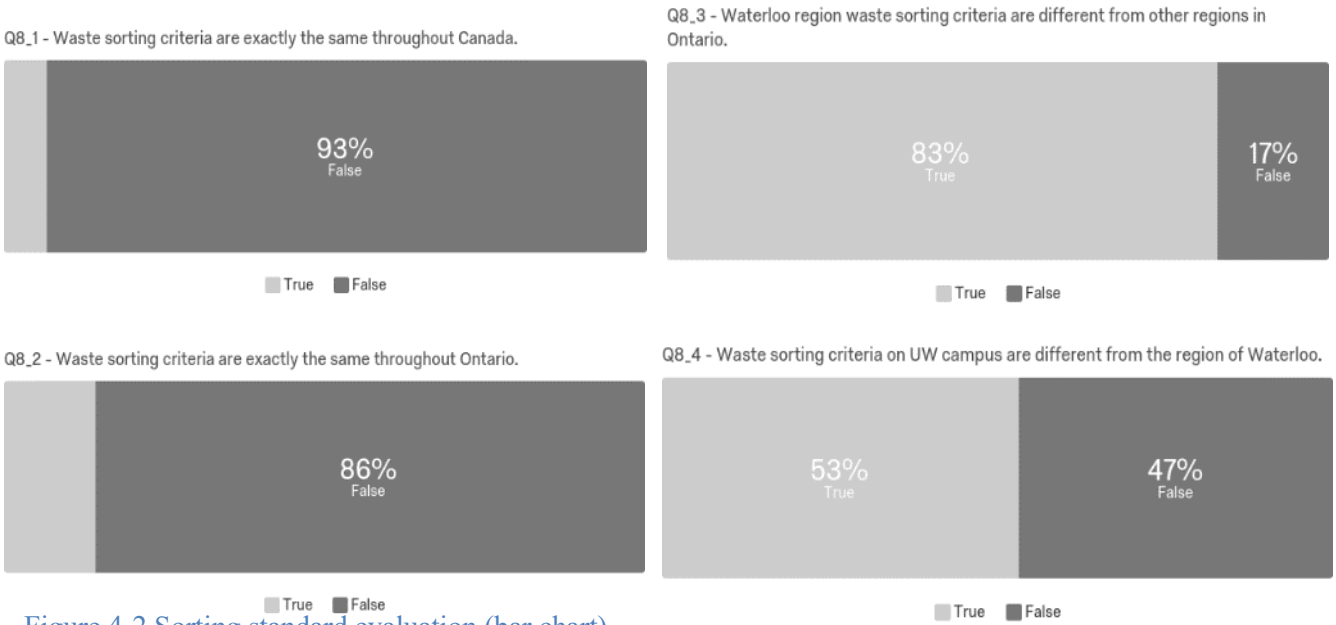

Figure 4-2 Sorting standard evaluation (bar chart)

*Q8 Please **sort the following waste items into their appropriate waste bins** by clicking one of the five waste categories indicated on the right side of the screen.*

The range of the respondents' sorting scores span from 6 points to 25 points (full mark). The sorting game results are then categorized into four levels: Poor (6-10), fair (11-15), good (16-20), and Excellent (21-25). The average score of 276 participants is 16.43 points out of 25 points. (Table 4-8 & Figure 4-3)

Table 4-8.
Sorting quiz results

(N = 276)	Min	Max	Mean	Std. Deviation
Sorting Quiz Score	6	25	16.43	3.74

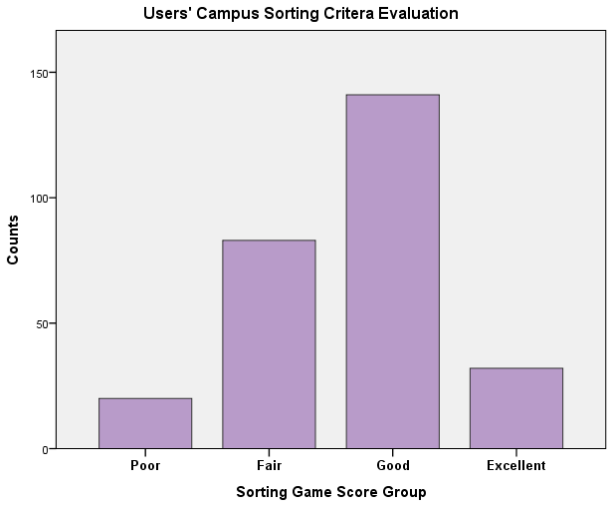

Figure 4-3 Sorting quiz result distribution

Frequent mis-sorted items

In the following, the 25 selected items are separated into their correct categories among the 5 options: organic, paper, container(recycle), garbage, and other. Figure 4-3 & Table 4-8 illustrate the numbers and ratios of the correct responses from the total 276 responses. The frequent mis-sorted items, i.e., items that has a correct sorting rate lower than 70%, will be specially highlighted. These frequent mis-sorted items are then chosen and emphasized later on in the sign design (intervention development) phase.

1.) Organic

(Figure 4-4 & Table 4-9.

Sorting quiz result (organic)Table 4-9) Four items out of the six selected items in the organic category turned out to meet the 70% mis-sort cut-off line. Coffee cup had merely a 16% correct rate, however, according to previous campus waste audit results. Coffee cup made up 8% of all the waste collected on the main campus of UW in 2018. Paper straw, used paper plate, and used napkin also fell into the group of frequent mis-sorted items. With paper straw having a correct response rate lower than half (43%), used paper plate just over half (53%), and used napkin reaching closer to the cut-off line (69%). The data illustrate that the survey respondents are having the most trouble with properly sorting organic waste.

Table 4-9.
Sorting quiz result (organic)

Items (Organic)	Counts	Percentage
Coffee Cup	45	16.30%
Paper Straw	118	42.75%
Used Paper Plate	147	53.26%
Used Napkin	190	68.84%
Coffee Filter	223	80.80%
Food Scrap	270	97.83%

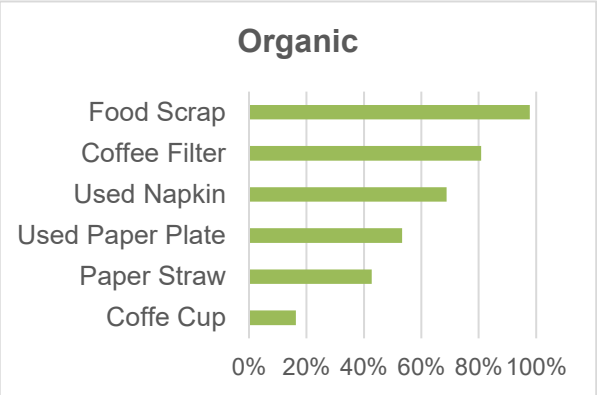

Figure 4-4 Sorting quiz result (organic)

2.) Paper

(Table 4-10 & Figure 4-5 Sorting quiz result (paper) Shredded printing paper and flyers are the only two selected items in the paper category. They both have high correct sorting rates, 88% and 95 % respectively, so there is no item fulfill the definition of frequent mis-sorted items.

Table 4-10.
Sorting quiz result (paper)

Items (Paper)	Counts	Percentage
Shredded Printing Paper	243	88.04%
Flyers	263	95.29%

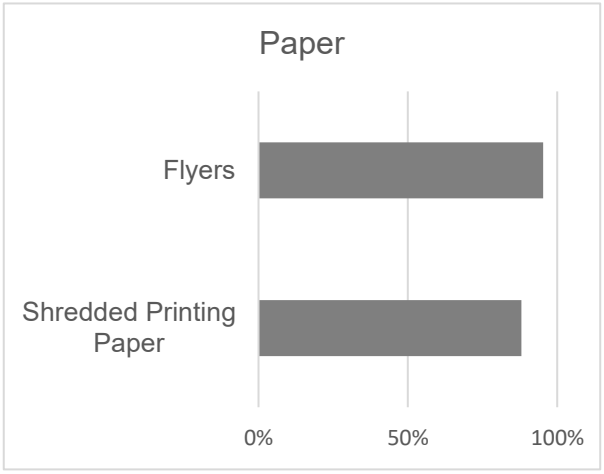

Figure 4-5 Sorting quiz result (paper)

3.) Container/Recycling

(Table 4-11 &Figure 4-6) There are nine selected items in the container/recycling category, with two of them fitting the definition of frequent mis-sorted items: plastic cutlery and tetra pek. Plastic cutlery has a fairly low correct sorting rate of 31%, and tetra pek has a correct sorting rate of 63%.

Table 4-11.
Sorting quiz result (container)

Items (Container/ Recycling)	Counts	Percentage
Plastic Cutlery	85	30.80%
Tetra Pek	174	63.04%
Coffee Cup Lid	204	73.91%
Milk Carton	204	73.91%
Yogurt Tub	244	88.41%
Plastic Food Container	245	88.77%
Plastic Beverage Cup	249	90.22%
Pop Can	251	90.94%
Plastic Bottle	256	92.75%

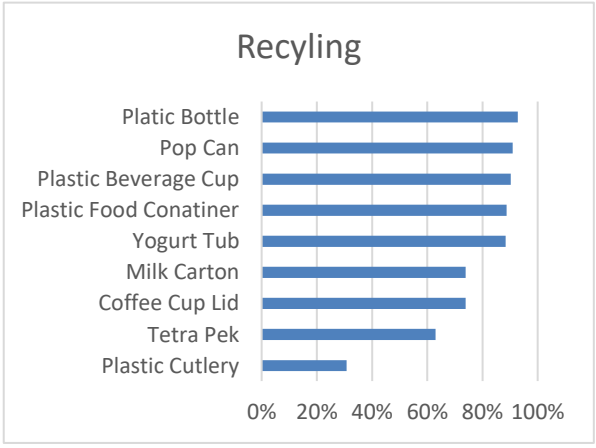

Figure 4-6 Sorting quiz result (container)

4.) Garbage

(Table 4-12 & Figure 4-7) Half out of the six selected items in the garbage category are mis-sorted items. Both fountain drink cup (34%) and plastic bag (38%) show correct sorting rates lower than 40%, and the correct sorting rate of styrofoam food container is 68%.

Table 4-12.
Sorting quiz result (garbage)

Items (Garbage)	Counts	Percentage
Fountain Drink Cup	95	34.42%
Plastic Bag	106	38.41%
Styrofoam Food Container	187	67.75%
Plastic Straw	204	73.91%
Cling Wrap	226	81.88%
Chip Bag	235	85.14%

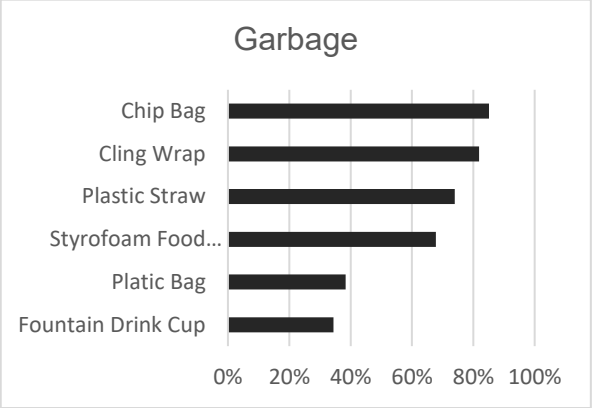

Figure 4-7 Sorting quiz result (garbage)

5.) Other

(Table 4-13 & Figure 4-8) There are only two items in the Other category, pizza box and cardboard box. Both of them have extremely low correct sorting rate that meets definition of the frequent mis-sorted items, with the cardboard box having a mere 15%, and pizza box having 11%. Pizza box is the selected item that has the lowest correct sorting rate among all.

Table 4-13.
Sorting quiz result (Other)

Items (Other)	Counts	Percentage
Pizza Box	30	10.87%
Cardboard Box	42	15.22%

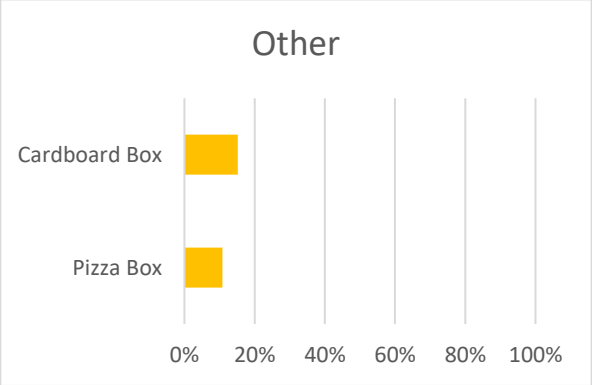

Figure 4-8 Sorting quiz result (other)

4-1.3 Waste sorting experience on UW campus

Q19. How much do you agree or disagree with the following statements based on your experience of waste sorting on UW campus?

This question asked the respondents about their waste sorting experiences from eight aspects. A four-point Likert scale is used, with 1 representing "strongly disagree" and 4 representing "strongly agree", and an additional option of neither agree nor disagree, but those responses choosing the option neither agree nor disagree are considered as invalid response.

There are three internal factors related to the respondents themselves as users, including "Having sufficient on waste sorting"; the rest five are external factors. The range of the average score of the eight factors is from 2.49 to 3.31 out of 4.

According to the results show in (Table 4-14). Firstly, the three factors with lower average scores around 2.5 are "sufficient instructions and information"; "sufficient infrastructures": and "location convenience". That is, users show less agree on the statements that UW provides enough information and waste receptacles to assist them conduct proper waste sorting behaviour on campus. Except for not providing enough information and waste receptacles, the statement that UW placed waste receptacles at convenient location also earn less agreement from the users. Secondly, another three factors that gained medium average agreement scores around 2.8 from the respondents include "knowledge/information"; "clarity of the instructions"; and "location". Lastly, the two factors with high agreement average exceeding 3 are an external factor, "collection frequency/capacity", and an internal factor, "time". The high average scores illustrate that the respondents are more satisfied with the numbers of waste collection times; or the waste receptacles are generally not overflow when needed. While the high average score for the factor "time" shows that the respondents do not find themselves in a rush or they can spare time doing sorting at the receptacles.

Table 4-14.
Users' self assessment and satisfaction of current waste management setting

Factors Min 1 (Strongly disagree), Max 4 (Strongly agree)	Mean	Std Deviation	Variance	N
Sufficient instructions and information: UW provides enough information to help me properly sort my waste on campus	2.49	0.77	0.59	261
Sufficient Infrastructure: UW have enough bins for me to sort my waste.	2.51	0.86	0.74	263
Location Convenience: The bins are located at convenient places for me to approach.	2.54	0.77	0.59	263

Knowledge/Information: I know what items can be recycled/ composted on campus.	2.79	0.82	0.67	264
Clarity of the instructions: The images, symbol, colour, and words attached to the bins are easy for me to understand.	2.82	0.81	0.65	265
Location: I know where to take my recyclables/ compost for sorting and throwing.	2.84	0.9	0.81	264
Collection frequency/capacity: the bins have space (i.e. are not overflowing) for me to sort my waste when I need to	3.02	0.87	0.76	262
Time: I have enough time / I spare time for waste sorting.	3.31	0.79	0.62	261

4-1.4 Identifying the barriers and the benefit (motivation and challenges)

The open-ended questions in this section are asked first than followed with the structural questions with basically the same content. The open-ended questions are coded based on the options of the close questions, coding key words are also presented in Table 4-15. For the structural questions with the same content, we ask the participants to rank up to three options in the structural questions, and we coded the open-ended questions up to two codes. Factors that show percentages more than 10% are highlighted.

1. Benefits

Q17 is the open-ended question that asks users about their motivations toward waste sorting, which can further enable the researcher to identify the benefits that can trigger behaviour change. Q18 is the structural question that asks similar content.

Q17. What motivates you to sort your waste on campus?

Table 4-15.

Survey Q17 coding table (counts)

Code	Q17. Open-ended question	#	%	#	%	#	%
11	I am concern for planet / environment / natural resources / animals / climate change **(Environmental concern)**	90	38.96%	19	28.36%	109	36.58%
5	Proper waste sorting **reduces** the amount of waste goes into **landfills**	32	13.85%	10	14.93%	42	14.09%
7	Proper waste sorting aligns with my personal **principles** /value/ opinion **(individual)**	27	11.69%	6	8.96%	33	11.07%
12	Other	30	12.99%	3	4.48%	33	11.07%
3	Proper sorting is **responsible**, because we, human, need to deal with our own waste. **(collective)**	21	9.09%	10	14.93%	31	10.40%
2	Proper sorting is **useful,** because waste gets **reused/recycled**	11	4.76%	7	10.45%	18	6.04%

4	Proper sorting is practical benefits the **processing** of waste afterwards.	11	4.76%	6	8.96%	17	5.70%
10	I am concerned with the health and well-being of the surrounding I study / work in	4	1.73%	5	7.46%	9	3.02%
8	I feel **good** about myself when I properly sort waste	3	1.30%	0	0.00%	3	1.01%
9	I feel **guilty** about myself when I don't sort waste	2	0.87%	0	0.00%	2	0.67%
……							
	Valid response	231		67		298	
99	Blank	44		0		43	
	Total (N)	275					

*** Coding key words or concepts are show in bold.**

Q18. Based on the following statements, which would you consider as motivations for you to sort your waste on campus? (Please rank up to 3 motivations from the list below by dragging and dropping them into the boxes on the right)

Table 4-16.
Survey Q18 coding table (counts)

Code	Q18. Motivation	Rank1	Rank2	Rank3
3	Proper sorting is **responsible**, because we "humans" need to deal with our own waste.	39.55%	19.78%	12.31%
5	Proper waste sorting reduces the amount of waste goes into **landfills**.	27.24%	27.99%	12.69%
2	Proper sorting is useful, because the waste gets recycled and reused.	13.81%	16.42%	10.07%
7	Proper waste sorting aligns with my personal principles.	11.19%	11.94%	15.30%
10	I am concerned with the health and well-being of the surrounding I study/work in.	3.36%	6.72%	12.69%
4	Proper sorting is practical, because it benefits and speeds up the processing of waste afterwards.	2.24%	7.46%	10.07%
9	I feel guilty about myself if I did not properly sort my waste.	1.87%	3.73%	17.91%
8	I feel good about myself when I properly sort my waste.	0.37%	5.60%	8.58%
	……			
	Total (N)	268	268	268

The results of these two questions only share similarities in code 3 and code 5. Code 3 stands for the construct of **perceived collective responsibility**. Responses mentioned keywords such as "responsibility", and collective nouns "human being" and/or "we/us/our" are coded 3. Responses mentioning the key word "land fill" are coded 5.

Table 4-15) In the open-ended questions many responses mentioned key words related to environmental concerns, such as environment protection, climate changes, animal rights, etc., responses with these keywords are coded 11 that stands for “Environmental concern”; Code 7, stands for individual principles, and code 12 stands for ”other”.

Whereas in the close question (Table 4-16), code 3, 5, and 2 are ranked as the top three factors that can motivate the respondents to conduct waste sorting on campus.

2. Barriers

Q21. What are the possible reasons, barriers, or concerns that stop you sorting your waste properly on campus? (please rank up to 3 challenges from the list)

Table 4-17.
Survey Q21 coding table (counts)

Code		Rank 1	Rank 2	Rank 3
1	There is no streamed bins or appropriate **bins/carts** for waste sorting around.	26.72%	13.43%	10.99%
4	I am not sure where to put things because I don’t have enough information or **knowledge**.	20.61%	18.52%	16.75%
2	I find it **confusing**, because **the instructions** for sorting are not clear.	17.56%	22.69%	19.90%
9	I find the recycling bins are **not in convenient locations**	15.65%	26.85%	19.90%
5	Not Applicable: I don't see any challenges	12.98%	2.78%	9.42%
10	I'm always in a rush.	3.05%	3.24%	11.52%
7	I find it inconvenient to do the sorting at bins.	1.53%	5.56%	4.71%
6	The others are not sorting their waste, I then don’t think I need/should do it.	1.15%	3.70%	1.57%
3	I find it a waste of time.	0.38%	0.00%	0.52%
12	I don' t think it makes much difference to the world /environment.	0.38%	0.93%	1.57%
11	I find it annoying/boring/tedious.	0.00%	1.85%	1.57%
8	I don't see enough benefit, advantage, or necessity for me of doing it.	0.00%	0.46%	1.57%
	Total (N)	262	216	191

Table 4-18.
Survey Q20 coding table (counts)

Code	Q21 Open-ended question	1st #	%	2nd #	%	Total #	Total %
1	There is no streamed bins or appropriate carts for waste sorting around	61	28.11%	13	13.00%	74	23.34%
2	I find it confusing because the instructions for sorting are not clear	33	15.21%	22	22.00%	55	17.35%
4	I am not sure where to put things because I don't have enough information or knowledge	40	18.43%	8	8.00%	48	15.14%
13	Inconsistency	25	11.52%	10	10.00%	35	11.04%
9	I find the recycling bins are not in convenient locations	17	7.83%	15	15.00%	32	10.09%
14	Other	15	6.91%	14	14.00%	29	9.15%
6	The others are not sorting their waste, I then don't think I need/should do it.	10	4.61%	8	8.00%	18	5.68%
7	I find it inconvenient to do the sorting at bins	7	3.23%	1	1.00%	8	2.52%
5	Not applicable	7	3.23%	0	0.00%	7	2.21%
12	I don't think it makes much difference to the world / environment	0	0.00%	7	7.00%	7	2.21%
10	I am always in a rush	1	0.46%	2	2.00%	3	0.95%
8	I don't see enough benefit, advantage, or necessity for me of doing it	1	0.46%	0	0.00%	1	0.32%
.....							
	valid response	217	100.0%	100	100.0%	317	100.0%
99	Blank/invalid	58		0	0	58	58
		275	275	100	100		317

(Table 4-17 & Table 4-18) Codes 1, 2, and 4 are rated as the highest three factors in both questions for challenges that prevent the respondents from doing waste sorting on campus. Code 1 stands for insufficient waste receptacles; code 2 stands for unclear instructions that caused confusion; code 4 represents not having corresponding knowledge. In both questions, the factor "insufficient infrastructure" is rate as the top challenges among all. This result aligns with the question of waste sorting experience part in earlier paragraph, the section of sorting experience on campus Q20.

Comparing the benefits identifying part to the barrier identifying part, the former show less agreement between the results of the open-ended question and the structural question; whereas the two results from the later part show a stronger similarity.

Q22. *Please comment on any other challenges you have experienced adapting to UW's waste sorting practices on campus?*

(*Table 4-19*) One response is coded up to four different codes, and there are 145 valid responses. Codes show up more than 10 times among 145 responses are considered as identified barriers or benefits.

Table 4-19.
Survey Q22 coding table (counts)

Code	Counts	Content
1	39	Not enough receptacles
15	32	Different from past experiences Facing different sorting standards between past and present, or between different places
9	22	Convenience Inconvenient/ convenient devil /Arrangement
2	15	Unclear or unhelpful signage (a list of common waste items (coffee cups) that are wrongly sorted and their correct sorting practices, instead of (irrelevant) generic but less helpful items, the convenience devil (arrangement), pictures of items selling near by, the symbol don't match common items on campus
16	15	Not enough promotion / education / communication/ instructions/ information/ guidelines
18	13	Grey areas, common list. grey areas (food container with food, multi-material packages), different from what the packages show, a list of common waste items (coffee cups) that are wrongly sorted and their correct sorting practices, instead of (irrelevant) generic but less helpful items,
13	12	Inconsistency between receptacles or signs bins/colour coding/ shapes / signs (new and old)
17	11	Skeptical attitude: (colour of the bags, recycling is a fraud, don't know the proceeding of the waste(transparency and disclosure of the proceeding procedure after it goes into the bins) , seeing custodial service mixing them together, frustration among others not doing it, etc.)

6	5	The others are not doing it
4	4	Knowledge
14	6	Others incentive to promote more sorting behaviours, special occasions (conference, events)
20	3	Not aware/ noticing difference between places

Facing different sorting standards between past and present, or between different places (e.g., standard on campus is different from previous international experiences; different from hometown; different from off campus; or different from the past campus sorting standard

4-2 Pre-phase Onsite Observation

1. Pre phase observation

(Table 4-20) The average sorting time for each site is between 1.8 to 7.9 seconds, with group C having a higher average time. According to our observation, this is likely because the units in group C are mainly serving the cafeteria employee and customers near-by, these users tend to spend more time scraping off their leftovers. In the variable of discarding only one item, except DC has the highest rate with a percentage of 97.62, and V1 has the lowest rate with a percentage of 32.23%, the rest falls roughly around 40% to 60%.

No other obvious trend is found by solely looking at the observation results for the variables of sign reading; sorting or not; and correct sorting. Further discussion is made in section 7 where comparisons between the pre and the post phase observation results are made.

Table 4-20.
Pre phase onsite observation descriptive statistics

		Mean	SD
Large N = 202	Sign Reading	1.88	0.74
	Sorting or Not	2.01	0.85
	Correct sorting	2.26	0.80
Small N = 138	Sign Reading	1.99	0.73
	Sorting or Not	2.14	0.77
	Correct sorting	2.29	0.82
Control N = 84	Sign Reading	1.96	0.77
	Sorting or Not	2.18	0.76
	Correct sorting	2.52	0.78

Table 4-21.

Pre phase onsite observation record (multi-use buildings)

Pre-phase Onsite Observation Record (Group A)							
Multi-use buildings	**Average Time (sec)**	**Extent**	**Sign reading**	**Sorting or not**	**Correct sorting**	**Discarding only one item**	**Using an other bin**
Control Group DC	2.6	1	33.33%	27.27%	24.24%	97.62 %	21.43%
		2	21.21%	15.15%	6.06%		
		3	45.45%	57.58%	69.70%		
Small Sign DP	3.7	1	29.82%	21.05%	17.54%	43.48%	17.39%
		2	45.61%	47.37%	26.32%		
		3	24.56%	31.58%	56.14%		
Large Sign SLC	1.8	1	26.19%	33.33%	23.81%	57.14%	
		2	52.38%	42.86%	30.95%		
		3	21.43%	23.81%	45.24%		

Table 4-22.

Pre phase onsite observation record (faculty buildings)

Pre-phase Onsite Observation Record (Group B)							
Faculty buildings	**Average Time (sec)**	**Extent**	**Sign reading**	**Sorting or not**	**Correct sorting**	**Discarding only one item**	**Using an other bin**
Control Group STC	5.3	1	28.00%	24.00%	23.81%	52.00%	16.00%
		2	60.00%	52.00%	14.29%		
		3	12.00%	24.00%	61.90%		
Small Sign AHS	2.7	1	24.44%	26.67%	31.11%	53.33%	
		2	37.78%	33.33%	35.56%		
		3	37.78%	40.00%	33.33%		
Large Sign EV3	5.6	1	21.74%	41.30%	4.35%	51.67 %	23.33%
		2	58.70%	30.43%	47.83%		
		3	19.57%	28.26%	47.83%		

Table 4-23.
Post phase onsite observation record (residences)

Pre-phase Onsite Observation Record (Group C)							
Residences	**Average Time (sec)**	Extent	**Sign reading**	**Sorting or not**	**Correct sorting**	**Discarding only one item**	**Using an other bin**
Control Group REV	5.9	1	31.03%	10.34%	6.90%	62.07%	
		2	55.17%	65.52%	17.24%		
		3	13.79%	24.14%	75.86%		
Small Sign CMH	7.9	1	21.95%	20.00%	20.00%	51.22%	
		2	63.41%	40.00%	7.50%		
		3	14.63%	40.00%	72.50%		
Large Sign V1	7.1	1	40.50%	33.05%	31.03%	32.23%	
		2	33.88%	19.49%	19.83%		
		3	25.62%	47.46%	49.14%		

2. Qualitative notes - Pre phase observation

Many sites have records mentioning the repetitive use of waste stations by the employees of the food outlets nearby. Particularly, these employees would often discard large numbers of repetitive items, e.g., receipts, and milk and cream cartons from the condiments table.

4-3 Pre-phase Waste Audits

Due to the same reason, a looser sorting criterion is used to assess the waste audit samples in the pre phase waste audit.

Quantitative part – Pre phase waste audit

V1 has the largest amount of waste samples among all sites (16.1kg/day), and DC has the smallest sample size (2.35/day). V1 have two lowest indexes among all, diversion rate (25.94%) and capture rate (52.65%). The results indicate many compostable or recyclable waste are discarded into the garbage stream. Whereas, REV show to have the lowest cross contamination rate among all with only 6.61%.

Table 4-24.
Pre phase waste audit metrics

	Index	Group A	Group B	Group C
Large sign		**SLC**	**EV3**	**V1**
	Diversion Rate	42.11%	60.14%	**25.94%**
	Cross contamination Rate	**35.26%**	27.33%	25.72%
	Capture Rate	61.78%	84.08%	**52.65%**
Small sign		**DP**	**AHS**	**CMH**
	Diversion Rate	48.82%	59.78%	67.77%
	Cross contamination Rate	16.97%	33.76%	13.25%
	Capture Rate	78.77%	71.65%	86.54%
Control group		**DC**	**STC**	**REV**
	Diversion Rate	55.26%	46.09%	62.20%
	Cross contamination Rate	13.16%	33.26%	**6.61%**
	Capture Rate	91.30%	62.91%	94.43%

Qualitative part- Pre phase waste audit

1. **Straws and plastic lids remain attached to coffee cups and plastic beverage cups:** Many plastic lids of coffee cups and plastic beverage cups are not separated when we go through the samples. However, according to the original signs (looser criterion), all three items belong to the container (blue) category. While we consider that coffee cups belong to the organic (green) category under the new sorting standard (stricter criterion), and plastic lids are always encouraged to be separated even they fall into a same category. Therefore, we purposely make plastic lids stand on its own as one type on the experimental sign to make emphasis.

2. **Plastic cutlery:** Many plastic cutleries are found in the garbage stream, especially in group C, where there are cafeterias. Discarding these plastic cutleries into garbage stream is regarded as correct sorting under the looser criterion, however, according to the latest standard, they should go into container (blue) streams. The problematic sorting of plastic cutlery is similar as the survey result.

3. **Compostable beverage cups:** Particularly, in CMH, a certain brand of paper beverage cups are compostable, however, they are found in all streams, and the container itself has no label or instruction identifying itself as compostable.

4. **Paper food bags:** Many paper food bags (Table 4-9) are found in garbage streams, especially in AHS and STC, where they both have a Starbucks close by. These bags should be sorted into paper streams according to the new sorting standard. However, paper food bags are not displayed on the original sign, this phenomenon aligns with the observation results that these bags tend to be problematic.

Figure 4-10 Paper food bags

3. Two machine use milk bags are found in the container stream of DC. (Table 4-9)

Figure 4-9 Machine use plastic milk bag

4. Two unopened aluminum bottles of cokes that weighed around 700g are found in the organic stream of EV3. (Table 4-11)

Figure 4-11 Unopen canned Coke

5. CBSM Campaign Development - Signage Design

5-1 Basic settings of the signage

Through the literature review and the design of the research, it has been determined that images of practical items will be used to design the experimental signs. This section covers descriptions of the layout, size, material used, and the selection of the content of the experimental signs.

The layout of the original signs of the study units are spatial consistent displaying both yes and no items using a mixture of icons with text, and a list of texts on the right (taking about 1/3 of the space). While I intend to prioritize the frequently mis-sorted items, therefore, the images on the experimental signs are not consistently spatial located. Moreover, because the space and shapes for sign frames are different in types, some are wider in width, but some has longer vertical side. Nonetheless, the same layout format is used on the original design regardless of the shape and size, which left much unused space on certain type of the receptacles. As a result, in order to maximize the space of each frames, the arrangements of the signs are not exactly the same but the images remain the same.

1.) Text: use lay language for descriptions.
2.) Remain the colour coding with the original system to keep consistency.
3.) Prevent message over-load: Not showing in one big single cluster.

The experimental signs are produced with different materials and vary in size, but the installations all cover the original signs. (Table 5-1) Large signs are colour printed on vinyl materials then mounted on corrugated boards. There are two sizes of large signs, adopted and installed according to the original frame: 10” by 16”; and 20” by 16”. The large sign is larger than the original frame of the signs, but they are installed in a way that is hard to avoid noticing when approaching the waste stations. Small signs are laminated colour printing papers, and they fit exactly to the frame on the waste stations. There are also two sizes of small signs: 10” by 7”, and 20” by 7”. Generally speaking, the large signs are two times the height of the small signs, and the small are the same size of the original sign.

There is a time difference up to three-day between the installations of the large signs and the small signs, the larger ones are installed earlier than the small signs. The selected units installed with experimental signs are shown in Table 5-1.

Table 5-1.

Sizes of the study signs

Size of the signs	Multi-use building	Faculty buildings	Residence
			
Large sign			**20” X 16”** **10” X 16”**
Small sign			**20” X 7”**
			**10” X 7”**

Table 5-2 presents the contents of items displaying on the experimental sigs, and the reasons of selecting. Four categories, including garbage, container, organic, paper, and an additional type, i.e., Oops signs, are developed. The “Other” type that contains the two items that have the lowest correct sorting rate: pizza box and cardboard boxes, are not covered. This is because the waste that goes into the “other” type is collected by different receptacles other than the selected experimental units. Each category

contains five types of items on the experimental signs, and all items are “Yes” items, which means items not belong to that stream are not displayed on the same sign, i.e., no mixed messages.

There are two exceptional “Oops signs” specially designed and installed at DP library (Group B, smaller sign). DP library is the only experimental sites that do not come with an organic stream. However, we see the demand for high volume of organic waste based on the pre phase results. Especially all study sites are intentionally selected beside food outlet, it is reasonable to see people discarding organic waste.

The Oops signs are the results of a dilemma situation. The latest campus sorting standard try to divert people to throw organic items in alternative streams as a second choice when there is no responding streams. However, it is concerned to generate unwanted and unnecessary confusion if presenting the same item on different categories, the inconsistent and complicated messages may repeat the conflict of co-existing of new and old signs depicted in the beginning. Alternatively, the researcher decided to design external signs for the selected site, DP library.

The Oops signs use the same colour (green) background of the organic stream, in order to pass on the message to the users that these are the alternative solution for organic waste when there is no according bin, instead of putting the photos of the items directly on the less desirable signs.

5-2 The content selection of the experimental signs

The selection of the content of the experimental signs are generated following the principles in the followings.

A. **Frequent mis-sorted items:**
   i. Survey results: Items that did not reach a 70% correct sorting rate in sorting quiz of the survey.
   ii. Waste audit results: Items recognized to be often mis-sorted in waste audit results.
   iii. Observation results: Items recognized to be often mis-sorted in onsite observation results.

B. **Easily confused grey areas:**
   e.g., food soiled waste, multi-material packaging.

C. **Large amount of repetitive waste:**
   e.g., plastic cutlery.

D. **Categories changed after the new sorting standard applied**
   e.g., plastic bags, plastic cutlery

E. **Different from the Waterloo region sorting standard**

F. **Alternative options**
   When the most appropriate stream is not provided, e.g., Oops signs.

G. **Other consideration**
   Mostly for clarification, explanation, emphasize, or reminding purposes.

Table 5-2.
Experimental signs content selection

Stream	Display waste	Rationales of containing in the experimental signs
Organic	**Coffee cup**	**A. Frequent mis-sorted items** i. Survey results: correct rate* -organic (16%); paper (47%); incorrect rate - container (35%); garbage (19%); *Note: Based on the new sorting standard, the organic stream is the preferred choice, and the paper stream is the alternative choice when organic stream is not available. ii. Waste audits and observation show high cross contamination, coffee cups are found in all streams. **B. Easily confused grey areas** Pre-phase results show users are sometime troubled by unfinished liquid in coffee cups. **C. Large amount of repetitive waste** Past campus waste audit report (8%) and waste audit results both show coffee cups made up a considerable share of waste as a single type of waste. **D. Categories changed after the new sorting standard applies** Changed from container to organic or paper stream. **E. Different from the Waterloo region sorting standard** Coffee cups are sorted into blue bin under regional sorting standard **G. Other consideration:** The sorting for coffee cups are very disagreeing from places to places, this situation causes chaos on sorting campus wide. Therefore, I decide to have it displayed solely on the signs itself for emphasis and clarification purpose.

	compostable paper food container	**A. Frequent mis-sorted items** i. Sorting quiz result: correct rate - organic (53%); incorrect rate- paper (18%); garbage (22%). ii. Waste audit: Many are found in garbage stream. **B. Easily confused grey areas** Survey results illustrate that many users are troubled by food soiled waste, because they are not as clean as showed on signs, therefore, images of used (food-soiled) waste are particularly displayed to help clarify for the users. **C. Large amount of repetitive waste** This type of waste is commonly seen on campus, especially close to food outlets, but not clearly stated as compostable. **G. Other consideration:** Nearly half of survey respondents do not have organic stream provided at their residential places, therefore, I infer some users might not know food soiled paper food containers can be placed into organic stream because they are compostable. As a result, clean and used compostable paper food containers are displayed on the experimental signs.
	paper straws	**A. Frequent mis-sorted items** i. Survey result: correct rate - organic (43%); incorrect rate - paper (50%). **B. Easily confused grey areas** Can be confusing because they are made of paper, so they are sometimes mistakenly regarded as waste that goes into paper stream. **G. Other consideration:** Paper straws are often not separated with the beverage cups, therefore, I have it displayed solely on the experimental signs as an emphasis and a reminder to the users.

	napkins/ paper towel	**A. Frequent mis-sorted items** i. Survey result: correct rate: organic (69%); incorrect rate: paper (17%); garbage (14%). ii. Waste audit result: napkins and paper towels spread among all streams, with many of them threw within food containers into container streams and garbage streams. iii. Observation results: this type of waste was already displayed on old signs, however, it is still observed to be one of the most problematic waste when users discard and sort their waste. **C. Large amount of repetitive waste** Past campus waste audit report (14%) and waste audit results both show napkins and paper towels made up a considerable share of waste as a single type of waste alone. **G. Other consideration** Nearly half of survey respondents do not have organic stream provided at their residential places, therefore, I infer some users might not know used napkin and paper towels can be placed into organic stream because they are compostable.
	food scrap	**C. Large amount of repetitive waste** The largest amount of organic waste
Paper	**Non-waxed paper take-out bags**	**A. Frequent mis-sorted items** ii. Waste audit result: many samples are found in the garbage stream, which is not captured by the correct stream, especially when they are food-soiled or with food remain in the bags. **B. Easily confused grey areas** Survey results illustrate that many users are troubled by food soiled waste, because they are not as clean as showed on signs. Moreover, these paper take-out bags can be easily confused with other waxed paper wrap.

		C. Large amount of repetitive waste Large amount of repetitive waste but it was neither displayed on the original signs nor on the sorting standard.
	Shredded paper	**G. Other consideration** Common office waste
	Cardboard paper packaging	(*Note: this type of waste turned out to be wrongly displayed, it falls into "other" steam instead) **A. Frequent mis-sorted items:** i. Survey results: ii. Waste audit results: Items recognized to be often mis-sorted in waste audit results. **B. Easily confused grey areas** Both corrugated and normal cardboard boxes are made from paper, this is reasonable that users would see them as waste that should go into paper stream. While, they, in fact, need to be separated and placed in the "other" type under the new campus sorting standard. **C. Large amount of repetitive waste** This type of waste is very commonly seen on campus. **D. Categories changed after the new sorting standard applied** Corrugated cardboard boxes experienced no sorting change (remain go into the "other" stream), while thin cardboard boxes and cardboard packaging changed from paper stream to the "other" stream. **E. Different from the Waterloo region sorting standard** According to the regional sorting standard, cardboard paper boxes or packaging are generally collected by the blue box program, while the campus has more streams need to differentiate. **G. Other consideration** The sorting for cardboard boxes and packaging can vary from places to places, as a fairly common paper-based waste, I consider it necessary to be emphasized on the experimental signs.

	paper bags	**C. Large amount of repetitive waste** Common paper-based waste.
	mixed paper	**C. Large amount of repetitive waste** General paper-based waste, including post-it notes.
Container	**plastic cutlery**	**A. Frequent mis-sorted items** i. Survey results: correct rate – container (31%); incorrect rate - garbage (58%); other (11%). ii. Waste audit results: Many are mis-captured in garbage streams. **C. Large amount of repetitive waste** Especially at study sites close to food outlets. **D. Categories changed after the new sorting standard applied** Changed from garbage to container stream. **E. Different from the Waterloo region sorting standard** Plastic cutlery is treated as garbage according to the Waterloo regional sorting standard. **G. Other consideration** It is often discarded within food container.
	plastic food container	**A. Frequent mis-sorted items** ii. Waste audit results: Many are mis-captured in garbage stream, especially with food remain. **B. Large amount of repetitive waste** **G. Other consideration** Plastic food containers are sorted differently in some near-by regions.
	plastic lids	**C. Large amount of repetitive waste at the study units** **G. Other consideration** Often not separated from other attached parts.
	plastic cups	**A. Frequent mis-sorted items**

		ii. Waste audit results: Many are mis-captured in garbage stream, especially with liquid remain. **B. Easily confused grey areas** liquid remain in beverage containers are reflected to be problematic by some survey respondents. **C. Large amount of repetitive waste** **G. Other consideration** Liquid remain can lead to users' hesitation.
	mix containers	**A. Frequent mis-sorted items** i. Survey results: -Tetra Pak: correct rate - container (64%); incorrect rate - garbage (14%); paper (19%). ii. Waste audit results: Items recognized to be often mis-sorted in waste audit results. **B. Easily confused grey areas** liquid remain in beverage containers are reflected to be problematic by some survey respondents. **C. Large amount of repetitive waste** **G. Other consideration** Post phase results show most beverage containers are less problematic to users, therefore, they are determined to present as mixed containers in one cluster.
Garbage	**multi-material packaging**	**A. Frequent mis-sorted items** ii. Waste audit results: Some samples are found in wrong streams. **B. Easily confused grey areas** Items that are made from compound materials are generally treated as garbage on UW campus, because they need extra procedure to separate different materials apart, and the current campus waste contractors do not provide such service. However, waste with combined materials that fall into two or more different streams can be hard to determine the correct sorting. e.g., paper sandwich bag/box with plastic window, waxed paper, take-out paper food containers with waxed liner. Moreover, multi-material packaging is

		sometimes hard to differentiate with others, because they can look similar. Therefore, I consider it necessary to display certain common ones on campus to help lower the difficulty when users are sorting on site. **C. Large amount of repetitive waste** **D. Other consideration: clarification** The package itself sometime has confusing/misleading information, e.g., showing “recycle” wording. The sorting for this type of waste can vary from places to places, or from time to time.
	plastic straw	**C. Large amount of repetitive waste** **G. Other considerations** Often not separated from the beverage cups.
	Styrofoam	**A. Frequent mis-sorted items** i. Survey results: correct rate: garbage (68%); incorrect rate: container (27%). **C. Large amount of repetitive waste** **G. Other considerations** Many take-out food containers from off campus food outlets are made by Styrofoam.
	plastic bags and chip bags	**A. Frequent mis-sorted items** i. Survey results: - plastic bags: correct rate (38%); other (23%); container (22%); paper*-17% * Note: The old sign for paper stream is “Paper and bags” **C. Large amount of repetitive waste** **D. Categories changed after the new sorting standard applied** Changed from paper to garbage stream. **E. Different from the Waterloo region sorting standard** Certain types of plastic bags are recyclable according to the regional sorting standard.

	fountain drink cup	**A. Frequent mis-sorted items:** i. Survey results: correct rate – garbage 34%; incorrect rate – container 42%; paper - 21%. ii. Waste audit results: often mis-sorted to container stream. **B. Easily confused grey areas** Easily be confused with other paper-based beverage cups or food container, e.g., coffee cups. **C. Large amount of repetitive waste** Especially at UW food service outlets.
Oops[2] sign	**Items treated as paper**	**F. Alternative options:** when organic stream is not provided.
	Items treated as garbage	**F. Alternative options** when organic stream is not provided.

[2] Experimental signs used in this study that present alternative disposal instructions when the best choice is not provided.

5-3

5-4 Experimental Signs

Figure 5-1 Experimental sign (organic)

Organic		
Original signs		**Experimental signs** (Emphasized items are show in bold)
Yes items (icon with text): 1. All food scraps 2. Compostable food containers 3. Paper plates 4. No items (icon) 5. Cans bottles, bags, wrappers	**No items (text only)** 6. chip bags 7. Styrofoam 8. wax paper 9. cling wrap 10. tin foils	**Yes items** (photos with text) 1. **coffee cup (Group A & B)** 2. **compostable paper food container (Group C)** 3. paper straws 4. napkins/paper towel 5. food scrap

Figure 5-2 Experimental sign (container)

Original signs		Experimental signs
• **Yes items (icon with text)** 1. cans 2. glass/plastic bottles 3. cartons 4. plastic food packages 5. coffee cups and lids (just removed the lid) 6. plastic cups	• **Yes items (text only)** 7. juice boxes 8. yogurt cups 9. foil containers 10. tin foil 11. items with 1-7 recycling symbols • **No items (text only)** 12. Styrofoam 13. food waste 14. cling wrap 15. dishes 16. straws	• Yes items (photos with text) 1. **plastic cutlery** 2. plastic food container 3. plastic lids 4. plastic cups 5. mix containers

Figure 5-3 Experimental sign (paper)

Papers		
Original signs		**Experimental Signs**
• **Yes items (icon with text)** 1. Paper 2. Shopping bags 3. Envelopes 4. Newsprint/magazines 5. Cereal and tissue boxes • **No items (icon with text)** 6. No coffee cups or lids	• **Yes items (text only)** 7. Books Toilet paper rolls 8. Paper towel rolls 9. Egg cartons 10. Coffee trays • **No items (text only)** 11. Styrofoam 12. Food waste 13. Labels/stickers 14. Wax paper	• **Yes items (image with text)** 1. **unwaxed paper food bag** 2. Shredded paper 3. paper packaging 4. paper bags 5. mixed paper.

Garbage	
Original signs	**Experimental Signs**
• **Yes items (icons with text)** 1. Plastic straws 2. Chip bags 3. Granola bar and snack wrappers 4. Cling wrap 5. Wax paper 6. All Styrofoam • **No items (text only)** 1. Batteries 2. Light bulbs	• **Yes items (photos with text)** 1. **multi-material packaging** 2. plastic straw 3. Styrofoam 4. plastic bags and chip bags 5. fountain drink cup

3. Electronic waste

Figure 5-4 Experimental sign (garbage)

Figure 5-5 Experimental sign (Oops signs)

Oops sign	
Items treated as paper	**Items treated as garbage**
• Yes items (photos with text) 1. Coffee cups / Compostable paper cups	• Yes items (photos with text) 1. Food scraps 2. Napkin / Paper towel 3. Compostable food containers 4. Biodegradable cutlery

6. Post-phase Results and Comparisons

6-1 Post-phase Onsite Observation

The average discarding and sorting time in the post phase has a range from 2.4 to 9.2 seconds. Most recorded time length fell between 3 - 5 seconds, while group C (residence) had a higher average time than other groups.

In the variable of “discarding only one item”, DC remains its leading place of having the highest rate at 71.43%, the rest fall into the range of 35% to 60%. As of the variable of “using an other bin”, In the post phase, DP has a much higher ratio at 43.18%, that is about triple times the ratio of DC and EV3, while STC has a mere 3.57% of other bin using rate.

No other obvious trend is found by only looking at the observation results for the variables of sign reading; sorting or not; and correct sorting. Further discussions of the extents of these variables are made in section 7, where comparisons between the pre and the post phase observation results are made.

Table 6-1.
Post phase onsite observation record (multi-use buildings

Post-phase Onsite Observation Record (Group A)							
Multi-use buildings	**Average Time**	**Extent**	**Sign reading**	**Sorting or not**	**Correct sorting**	**Discarding only one item**	**Using an other bin**
Control Group DC	4.4	1	16.67%	8.33%	4.17%	71.43%	14.29%
		2	12.50%	16.67%	4.17%		
		3	70.83%	75.00%	91.67%		
Small Sign DP	2.4	1	10.20%	26.00%	32.65%	56.82%	43.18%
		2	18.37%	10.00%	8.16%		
		3	71.43%	64.00%	59.18%		
Large Sign SLC	4.0	1	19.51%	24.39%	19.51%	36.59%	
		2	31.71%	21.95%	36.59%		
		3	48.78%	53.66%	43.90%		

Table 6-2.
Post phase onsite observation record (faculty buildings)

Post-phase Onsite Observation Record (Group B)							
Faculty buildings	**Average Time**		**Sign reading**	**Sorting or not**	**Correct sorting**	**Discarding only one item**	**Using an other bin**
Control Group STC	3.9	1	17.86%	14.29%	3.70%	57.14%	3.57%
		2	25.00%	28.57%	18.52%		
		3	53.57%	53.57%	77.78%		
Small Sign AHS	3.3	1	22.73%	13.64%	27.91%	43.18%	
		2	25.00%	9.09%	25.58%		
		3	52.27%	77.27%	46.51%		
Large Sign EV3	4.9	1	27.91%	18.60%	19.05%	58.82%	15.69%
		2	37.21%	53.49%	23.81%		
		3	34.88%	27.91%	57.14%		

Table 6-3.
Post phase onsite observation record (residences)

Post-phase Onsite Observation Record (Group C)							
Residences	**Average Time**		**Sign reading**	**Sorting or not**	**Correct sorting**	**Discarding only one item**	**Using an other bin**
Control Group **REV**	8.1	1	10.81%	10.81%	5.41%	43.24%	
		2	67.57%	51.35%	18.92%		
		3	21.62%	37.84%	75.68%		
Small Sign **CMH**	9.2	1	38.46%	27.69%	29.69%	50.77%	
		2	32.31%	26.15%	23.44%		
		3	29.23%	46.15%	46.88%		
Large Sign **V1**	5.8	1	39.04%	32.88%	29.50%	39.73%	
		2	36.30%	32.19%	19.42%		
		3	24.66%	34.93%	51.08%		

Table 6-4.
Contingency table – Large sign

Sign Reading	Sorting Or Not	Pre			Post		
		Correct Sorting Mean	N	%	Correct Sorting Mean	N	%
1	1	1.42	48	23.76%	1.24	45	20.93%
	2	2.00	12	5.94%	2.63	19	8.84%
	3	2.38	8	3.96%	2.00	4	1.86%
	Total	1.63	68	33.66%	1.68	68	31.63%
2	1	2.24	21	10.40%	1.17	12	5.58%
	2	2.60	40	**19.80%**	2.70	43	**20.00%**
	3	2.62	29	**14.36%**	2.61	23	**10.70%**
	Total	2.52	90	44.55%	2.44	78	36.28%
3	1	1.00	2	0.99%	1.00	5	2.33%
	2	2.80	5	**2.48%**	2.88	8	**3.72%**
	3	2.78	37	**18.32%**	2.64	56	**26.05%**
	Total	2.70	44	21.78%	2.55	69	32.09%
Total	1	1.65	71	35.15%	1.21	62	28.84%
	2	2.49	57	28.22%	2.70	70	32.56%
	3	2.68	74	36.63%	2.60	83	38.60%
	Total	2.26	**202**	100.00%	2.23	**215**	100.00%

Table 6-5.
Contingency table – Small sign

Sign Reading	Sorting Or Not	Pre			Post		
		Correct Sorting Mean	N	%	Correct Sorting Mean	N	%
1	1	1.42	12	14.46%	2.00	5	5.75%
	2	2.78	9	10.84%	2.67	3	3.45%
	3	3.00	5	6.02%	3.00	4	4.60%
	Total	2.19	26	31.33%	2.50	12	13.79%
2	1	1.67	6	7.23%	2.00	1	1.15%
	2	2.71	21	**25.30%**	2.83	24	**27.59%**
	3	2.75	8	**9.64%**	2.80	10	**11.49%**
	Total	2.54	35	42.17%	2.80	35	40.23%
3	1	N/A	0	0.00%	1.33	3	3.45%
	2	2.33	3	**3.61%**	2.50	4	**4.60%**
	3	2.95	19	**22.89%**	2.97	33	**37.93%**
	Total	2.86	22	26.51%	2.80	40	45.98%
Total	1	1.50	18	21.69%	1.78	9	10.34%
	2	2.70	33	39.76%	2.77	31	35.63%
	3	2.91	32	38.55%	2.94	47	54.02%
	Total	2.52	83	100.00%	2.76	87	100.00%

Table 6-6.
Contingency table – Control sign

Sign Reading	Sorting Or Not	Pre			Post		
		Correct Sorting Mean	N	%	Correct Sorting Mean	N	%
1	1	1.3	20	14.39%	1.42	24	15.58%
	2	2.25	12	8.63%	2	4	2.60%
	3	2.6	5	3.60%	1.8	10	6.49%
	Total	1.78	37	26.62%	1.58	38	24.68%
2	1	1.56	9	6.47%	1.33	6	3.90%
	2	2.51	35	**25.18%**	2.92	13	**8.44%**
	3	2.86	21	**15.11%**	2.45	22	**14.29%**
	Total	2.49	65	46.76%	2.44	41	26.62%
3	1	1.67	3	2.16%	1.17	6	3.90%
	2	1.5	8	**5.76%**	1.88	8	**5.19%**
	3	2.85	26	**18.71%**	2.56	61	**39.61%**
	Total	2.46	37	26.62%	2.37	75	48.70%
	1	1.41	32	23.02%	1.36	36	23.38%
	2	2.31	55	39.57%	2.44	25	16.23%
	3	2.83	52	37.41%	2.45	93	60.39%
	Total	2.29	139	100.00%	2.19	154	100.00%

Table 6-7.
Multi-use building pre & post phase comparison

Group A	Average Time		Extent	Sign reading	Sorting	Correct sorting	Using an other bin		Discarding only one item	
	Pre	Post					Pre	Post	Pre	Post
Control Group DC	2.6	4.4	1	-16.67%	-18.94%	-20.08%	21.43%	14.29%	97.62%	71.43%
			2	-8.71%	1.52%	-1.89%				
	+1.8		3	25.38%	17.42%	21.97%				
Small Sign DP	2.1	2.4	1	-19.62%	4.95%	15.11%	17.39%	43.18%	43.48%	56.82%
			2	-27.25%	-37.37%	-18.15%				
	+0.3		3	46.87%	32.42%	3.04%				
Large Sign SLC	1.8	4	1	-6.68%	-8.94%	-4.30%			57.14%	36.59%
			2	-20.67%	-20.91%	5.64%				
	+2.2		3	27.35%	29.85%	-1.34%				

Table 6-8.
Faculty building pre & post phase comparison

Group B	Average Time		Extent	Sign reading	Sorting or not	Correct sorting	Using an other bin		Discarding only one item	
	Pre	Post					Pre	Post	Pre	Post
Control Group STC	5.3	3.9	1	-9.48%	-9.19%	-19.96%	16.00%	3.57%	52.00%	57.14%
			2	-34.07%	-22.37%	4.95%				
	-1.4		3	43.56%	31.56%	15.02%	-12.43%			
Small Sign AHS	2.7	3.3	1	-1.71%	-13.03%	-3.20%			53.33%	43.18%
			2	-12.78%	-24.24%	-9.98%				
	0.6		3	14.49%	37.27%	13.18%				
Large Sign EV3	5.6	4.9	1	6.17%	-22.70%	14.70%	23.33%	15.69%	51.67%	58.82%
			2	-21.49%	23.05%	-24.02%				
	-0.7		3	15.31%	-0.35%	9.32%	-7.64%			

Table 6-9.
Residences pre & post phase comparison

Group C	Average Time		Extent	Sign reading	Sorting or not	Correct sorting	Discarding only one item	
	Pre	Post					Pre	Post
Control Group REV	5.9	8.1	1	-20.22%	0.47%	-1.49%	62.07%	43.24%
			2	12.40%	-14.17%	1.68%		
	2.2		3	7.83%	13.70%	-0.18%		
Small Sign CMH	7.9	9.2	1	16.51%	7.69%	9.69%	51.22%	50.77%
			2	-31.10%	-13.85%	15.94%		
	1.3		3	14.60%	6.15%	-25.62%		
Large Sign V1	7.1	5.8	1	-1.46%	-0.17%	-1.53%	32.23%	39.73%
			2	2.42%	12.70%	-0.41%		
	-1.3		3	-0.96%	-12.53%	1.94%		

Observation results - Variation within site (by unit location)

To investigate if the interventions have caused behaviour change within site, independent t tests were done with the data from each site of the pre and the post phase individually. With only a few significances results spread among different sites, which are showed in Table 6-10. However, no consistent trend is noticed.

Table 6-10
Within site independent t test significance results

	Large sign	Small sign	Control
Sign reading	SLC	DP	STC
Sorting or not	SLC	AHS	STC
Correct sorting		CMH*	DC
*The post phase mean score of correct sorting is lower than the pre phase.			

Observation results - Variation within group (by intervention type)

As no obvious trend is found about the within site pre-post comparison data, data from each individual site are grouped using the intervention type, i.e., larger sign group, smaller sign group, control sign group. Independent t tests are again conducted within each group, in order to compare the pre and the post phase results of each group. The results of independent t test for each intervention group is showed in *Table 6-11*. The t test results for observation data (sign reading, sorting or not, and sorting correctness) of the large sign group all showed insignificent results between pre and post test. That is, no significent difference is found between the pre and post observation of the large sign group.

1.) Sign reading: t (415) = -1.64, p = .10, d = 0.16;
pre (M = 1.88, SD = 0.74) vs post (M = 2.00, SD = 0.80) , difference is not significent.
2.) Sorting or not: t (415) = -1.02, p = .31, d = 0.11;
pre (M = 2.01, SD = 0.85) vs post (M = 2.10, SD = 0.82) , difference is not significent.
3.) Correct sorting: t (415) = 0.38, p = .71, d = -0.04;
pre (M = 2.26, SD = 0.80) vs post (M = 2.23, SD = 0.86) , difference is not significent.

Table 6-11
Independent t test results of large sign group between the pre and post phase

Large sign	Mean (SD)		df	*T* value	*p*	Effect size(*d*)
	Pre (*N*= 202)	Post (*N*=215)				
Sign Reading	1.88 (0.74)	2.00 (0.80)	415	-1.64	.10	0.16
Sorting or Not	2.01 (0.85)	2.10 (0.82)	415	-1.02	.31	0.11
Correct Sorting	2.26 (0.80)	2.23 (0.86)	415	0.38	.71	-0.04

*: p<0.05, **: p<0.01.

(*Table 6-12*) Two observe variables, “sign reading” and “sorting or not”, of the small sign group showed siginifent differences between the pre and post t test result. The post test results improved significently comparing to the pre test results.

1.) Sign reading*: t* (298) = -2.56, *p* = .01, d = 0.30;
pre (M = 2.00, SD = 0.72) vs post (M = 2.23, SD = 0.83) , difference is significent.
2.) Sorting or not: *t* (298) = -2.45, *p* = .02, d = 0.29;
pre (M = 2.14, SD = 0.76) vs post (M = 2.37, SD = 0.84) , difference is significent.
3.) Correct sorting: *t* (298) = 0.27, *p* = .27, d = -0.13;
pre (M = 2.31, SD = 0.82) vs post (M = 2.20, SD = 0.88) , difference is not significent.

Table 6-12
Independent t test results of small sign group between the pre and post phase

Small sign	Mean (SD)		df	*T* value	*p*	Effect size(*d*)
	Pre (*N*=139)	Post (*N*=143)				
Sign Reading	2.00 (0.72)	2.23 (0.83)	298	-2.56	.01*	0.30
Sorting or Not	2.14 (0.76)	2.37 (0.84)	298	-2.45	.02*	0.29
Correct Sorting	2.31 (0.82)	2.20 (0.88)	298	0.27	.27	-0.13

*: $p<0.05$, **: $p<0.01$.

(*Table 6-13*) The t test results of the control group for all observed variables showed significent between the pre and post test.

1.) *Sign reading: t* (173) = -3.28, *p* = .001, d = 0.50;
pre (M = 1.94, SD = 0.75) vs post (M = 2.31, SD = 0.72) , difference is significent.
2.) Sorting or not: *t* (173) = -2.39, *p* = .018, d = 0.36;
pre (M = 2.16, SD = 0.76) vs post (M = 2.42, SD = 0.69) , difference is significent.
3.) Correct sorting: *t* (168) = 0.38, *p* = .021, d = 0.36;
pre (M = 2.52, SD = 0.79) vs post (M = 2.76, SD = 0.53) , difference is significent.

Table 6-13
Independent t test results of control sign group between the pre and post phase

Control group	Mean (SD)		df	*T* value	*p*	Effect size(*d*)
	Pre (*N*=83)	Post (*N*=87)				
Sign Reading	1.94 (0.75)	2.31 (0.72)	173	-3.28	.001**	0.50
Sorting or Not	2.16 (0.76)	2.42 (0.69)	173	-2.39	.018*	0.36
Correct Sorting	2.52 (0.79)	2.76 (0.53)	168	-2.33	.021*	0.36

*: $p<0.05$, **: $p<0.01$.

To sum, when comparing the pre and the post observation data, the control group showed statistically significant improvements on all three observed variables. The small sign group having observed variables sign reading and sorting or not also improved significantly. While the large sign group did not show any statistic significance when comparing the pre and the post observed variables.

Observation results - Variation between groups (by intervention type)

Subsequently, to investigate if the interventions have caused different extents of behaviour changes between groups in the post phase, the data grouped by intervention type are then analyzed with one-way ANOVA test. However, the test of homogeneity (Levene statistic) results showed significant for all three variables, which violate the assumption of ANOVA that the compared data are homogeneous. Therefore, Welch statistic is used instead, and the follow up Post-Hoc procedures (Games-Howell) is conducted to test the difference between each pairwise comparisons. The following statistic analysis wordings refer to "*Intermediate Statistics One-Way ANOVA- In-class Example, Adjusting For Heterogeneity of Variance" (*n.d.) The significance threshold uses a priori alpha level of 0.5.

1.) Sign reading: *Welch's F* (2, 236.05) = 7.02, $p < .05$, it is concluded that at least two of the three groups differ significantly on their "sign reading" average scores.
2.) Sorting or not: *Welch's F* (2, 241.59) = 8.49, $p < .001$, it is concluded that at least two of the three groups differ significantly on their "sorting or not" average scores.
3.) Sorting Correctness: *Welch's F* (2, 268.11) = 28.06, $p < .001$, it is concluded conclude that at least two of the three groups differ significantly on their "sorting correctness" average scores.

Games-Howell post hoc procedure is used since the homogeneity of variance assumption was not met.

1.) **Sign reading**

Large vs Small (mean difference = -0.23*) is significant, *p (0.025)* < α (*.05)*

Large vs Control (mean difference = -0.30*) is significant, *p (0.004)* < α (*.05)*

Small vs Control (mean difference = -0.08) is not significant, *p (0.72)* > α (*.05)*

2.) **Sorting or not**

Large vs Small (mean difference = -0.27*) is significant, *p (0.01)* < α (*.05)*

Large vs Control (mean difference = -0.32*) is significant, *p (0.00)* < α (*.05)*

Small vs Control (mean difference = -0.53) is not significant, *p (0.85)* > α (*.05)*

3.) **Sorting correctness**

Large vs Small (mean difference = 0.33) is not significant, *p (0.93)* > α (*.05)*

Large vs Control (mean difference = -0.53*) is significant, *p (0.00)* < α (*.05)*

Small vs Control (mean difference = -0.56*) is significant, *p (0.00)* < α (*.05)*

For sign reading and sorting or not variables, significant differences are found between the large sign group to the other two groups; the large sign group showed significantly lower mean average than other two groups on sign reading and sorting or not variables. For sorting correctness, significant differences are found between control group with the other two groups; the control group showed significantly higher mean average than other two groups on the sorting correctness variable.

Observation result- Qualitative notes of post phase

Some users stood and carefully read the signs, while some users read the signs only after they threw their waste, instead of reading them beforehand. Furthermore, a few users seemed to notice the signs have changed after they have discarded their waste.

Nevertheless, there were records showed some users read the signs carefully, but they still ended up sorting their waste into wrong streams. This happened multiple times to the napkin, some users hesitated after reading the sign or discussed with people around, but then threw napkins into garbage stream. In addition, several records showed the users are confused when reading the experimental signs.

Napkin/tissue, plastic cutlery, coffee cups, and fountain drink cups remain to be the most problematic waste. However, those who are marked 3 in the sign reading variables mostly sorted them correctly. Afterall, the experimental signs did catch more attention than the original signs.

6-2 Post-phase Waste Audit

(Table 6-14) Except for EV3 the diversion rates of rest experimental sites in the post phase exceed 50%, with AHS hitting 63% becomes the highest diversion rate among the experimental group.

Whereas the control group includes the sites with the lowest and the highest diversion rate in the post phase. The lowest is DC (45.70%), and the highest is STC (75.12%). Worthwhile notice a small bag of household style compost bag is found in the organic stream of STC, therefore the diversion rate of STC is likely to be skewed. However, REV with a diversion rate of 71.05% is the second highest rate among all, and it is also in the control group.

When looking at the capture rate, except for DC having a low capture rate of 57.33%, all other sites reached or exceed 75%.

Table 6-14.
Post phase waste audit metrics

	Post Phase	Group A	Group B	Group C[1]
Large sign		**SLC**	**EV3**	**V1**
	Diversion Rate	58.21%	45.81%	56.65%
	Cross contamination Rate	26.53%	28.51%	23.48%
	Capture Rate	82.66%	75.50%	75.87%
Small sign		**DP**	**AHS**	**CMH**
	Diversion Rate	54.16%	63.02%	57.56%
	Cross contamination Rate	22.81%	29.57%	14.83%
	Capture Rate	80.74%	74.95%	83.82%
Control group		**DC**	**STC[2]**	**REV**
	Diversion Rate	45.70%	75.12%	71.05%
	Cross contamination Rate	35.18%	18.82%	15.71%
	Capture Rate	57.33%	82.11%	88.82%

[1] The post phase waste audit of group C (residence) was done one week later than group A & B.
[2]A bag of household compost bag is found in the organic stream

Waste audit: Qualitative notes of post phase

1. STC: A bag of household compost bag is found in the organic stream.
2. Uncommon waste items discarded by staff:
   1.) DP: A total 18 pieces of large waxed paper sheets are discovered in the paper stream. These sheets are likely to be disposed by the café staff close to the study unit.

2.) DC: machine use milk bags are again discovered in the sample.

3. Site-wide: Although many **plastic cutleries** are found in garbage stream, a similar number of the cutleries are found in the container stream as well.
4. Residence: fountain drink cups

Waste audit

Table 6-15.

Diversion, contamination, and capture rate of waste audit – Pre phase

	Pre phase	Group A	Group B	Group C
Large sign		**SLC**	**EV3**	**V1**
	Diversion Rate	42.11	60.14%	25.94%
	Cross contamination Rate	35.26%	27.33%	25.72%
	Capture Rate	61.78%	84.08%	52.65%
Small sign		**DP**	**AHS**	**CMH**
	Diversion Rate	48.82%	59.78%	67.77%
	Cross contamination Rate	16.97%	33.76%	13.25%
	Capture Rate	78.77%	71.65%	86.54%
Control group		**DC**	**STC**	**REV**
	Diversion Rate	55.26%	46.09%	62.20%
	Cross contamination Rate	13.16%	33.26%	6.61%
	Capture Rate	91.30%	62.91%	94.43%

Table 6-16.

Diversion, contamination, and capture rate of waste audit – Post phase

	Post phase	Group A	Group B	Group C
Large sign		**SLC**	**EV3**	**V1**
	Diversion Rate	58.21%	45.81%	56.65%
	Cross contamination Rate	26.53%	28.51%	23.48%
	Capture Rate	82.66%	75.50%	75.87%
Small sign		**DP**	**AHS**	**CMH**
	Diversion Rate	54.16%	63.02%	57.56%
	Cross contamination Rate	22.81%	29.57%	14.83%
	Capture Rate	80.74%	74.95%	83.82%
Control group		**DC**	**STC**	**REV**
	Diversion Rate	45.70%	75.12%*	71.05%
	Cross contamination Rate	35.18%	18.82%	15.71%
	Capture Rate	57.33%	82.11%	88.82%
* A bag of household compost bag is found in the organic stream				

Table 6-17.
Waste audit pre & post phase comparison

	Pre- Post	Group A	Group B	Group C[2]
Large sign		**SLC**	**EV3**	**V1**
	Diversion Rate	+16.10%	-14.33%	+30.71%
	Cross contamination Rate	-8.73%	+1.18%	-2.24%
	Capture Rate	+20.88%	-8.58%	+23.22%
Small sign		DP	AHS	CMH
	Diversion Rate	+5.34%	+3.24%	-10.21%
	Cross contamination Rate	+5.84%	-4.19%	+1.58%
	Capture Rate	+1.97%	+3.30%	-2.72%
Control group		DC	STC[1]	REV
	Diversion Rate	-9.56%	+29.03%	+8.85%
	Cross contamination Rate	+22.02%	-14.44%	+9.10%
	Capture Rate	-33.97%	+19.20%	-5.61%

[1] A bag of household compost bag is found in the organic stream
[2] The post phase waste audit of group C was conducted one week later than group A & B

7. Discussion and Study Contribution

This section will start by going through the recognized research limitations, then follow with a discussion using the CBSM procedure. Next, the two research questions will be addressed and the hypotheses that were set in the first section will be confirmed. Finally, the contribution of this study will be discussed.

7-1 Synthesized Analysis and discussion

This subsection will follow the procedure of CBSM to synthesize and interpret the results of the survey, onsite observations, and waste audits in different phases.

7-1.1 CBSM step1: Selecting behaviours

The first step of CBSM is to select a behavior that can aid UW improve the campus waste sorting, while as reviewed, the selected behaviour should have high impact, high probability, and low penetration.

Onsite waste sorting of the general public on the UW main campus is selected as the target behaviour in this study. Firstly, by estimating based on the pre-phase results and the reviewed literature, it is obvious that UW has a high potential to divert a considerable amount of recyclables from the garbage stream to recycling streams. Moreover, as the organic stream, which collects composting waste, is going to be more assessable than before, increasing organic waste diverted from landfill is also expected. In short, onsite waste sortin is predicted to have high impact on improving UW's campus waste sorting situation. Secondly, it is also promising that promoting waste sorting on UW campus has high probability. Likewise, according to the reviewed literature and the results of the pre-phase, there are still many people to engage. Finally, I argue onsite waste sorting has low penetration, since this behaviour is almost always exposed to the general public.

As a result, it is strongly believed that promoting proper onsite waste sorting of the general public on the UW campus is beneficial to improve the campus waste sorting situation, because it has high impact, high probability, and low penetration.

7-1.2 CBSM step2: Identified Barriers and Benefits

The identified benefits (Table 7-1) and barriers (Table 7-2) are synthesized from the survey results, observation records, and waste audit analysis. Aside from the results presented in the table, there are likely more benefits or barriers that can be identified. In comparison, the benefits identified in this case study are less specific than the barriers.

The identified benefits that can trigger a user to conduct proper waste sorting on UW campus are provided with details in Table 7-1.

Table 7-1.
Identified benefits

Identified benefits	Content	Potential CBSM Tools
Environmental concern	Many survey participants commented that they can be motivated by environmental concerns such as, climate change, protecting the environment, animal right, etc.	Prompt Communication
Personal principals	Some participants commented they are self-disciplined to always do waste sorting if available. That is, not practicing waste sorting on campus go against their own moral principals or self disciplines	Norm
Perceived collective responsibility	Many survey participants agreed that collectively all human being should be responsible for the environment. In addition, some participants also stated that they care about the environment condition for the future generations.	Norm
Resource conservation	A lot of participants identified the 3Rs (reduce, recycle, reuse), and commented their concerns about limited landfill space.	Prompt Communication
Transparent waste dealing procedure	A number of users are skeptical of whether their sorting are meaningful, practical, and useful. Therefore, making the waste processing after collected from the waste stations transparent is also likely to help increase the willingness of some users to conduct correct waste sorting on campus.	Communication
Convenience	A high proportion of users mentioned the current arrangement and accessibility of waste sorting options are too inconvenient for them. Moreover, previous studies conducted at the study site has also suggested a certain distance that users are willing to carry their waste for disposal.	Convenience
Simplicity	Too many instructions offered at once is too overwhelming, and detailed sorting is considered too troublesome for some users.	Convenience
Incentive	Offering incentives such as discounts or creating a reward system. Moreover, more promotion and encouragement are in need to users even if incentives are provided.	Incentive Communication

The identified barriers that can hinder a user to conduct proper waste sorting on UW campus are shown in (Table 7-2), with potential CBSM tools matching in accordance with them. The barriers are further separated into internal barriers or external barriers in (Figure 7-1).

Table 7-2.
Identified barriers

Identified barriers	Content	Potential CBSM Tools
1. Insufficient receptacles	No appropriate receptacles available.	Convenience Prompts Communication
2. Receptacles at inconvenient locations	Users stated knowing where the appropriate receptacles are, but the location of the desire stream is too inconvenient to reach. Meanwhile, there are other receptacles at relatively convenient locations.	Convenience Prompts
3. Unclear signage	The original signage is too generic, it is hard to recognize and understand in a brief glance. The signs do not display common discarded items, and there are some grey areas that users are having issue with, e.g., soiled food container, packaging made with combined material.	Communication Prompt Social diffusion Convenience
4. Inconsistency of the waste collection system	The inconsistencies of available streams; colour coding; outdated signage; and different shapes of the outlet are all adding difficulties for users to conduct proper sorting.	Convenience Communication
5. Misconception	Users either did not notice the change of the campus sorting standard, or did not notice the sorting standard is different from their past experience.	Communication Prompt Social diffusion
6. Lack of Knowledge	Users are either aware or not aware of the fact that they do not know which category to sort some items, and some said they are afraid of making mistakes that will cause contamination.	Communication Social diffusion Prompt
7. Perceived attitude and lack of motivation	Some users reported skeptical and distrust attitude toward waste sorting on campus, they doubt the necessity of conducting such behaviours. The reasons lead to their attitudes include the not transparent procedure of the dealing of the waste, inconsistent colour of the waste bags, and the already poorly sorted waste in the receptacles, or other users' reckless sorting behaviour. In addition, lack of social pressure, and low or no motivation also contribute to individuals' inconsistent sorting behaviours.	Communication Social diffusion Social norm Commitment Prompt

8. Insufficient promotion	Users stating issues such as lack of instructions and guidelines, too many misleading information from different parties, and not knowing where to look up the latest and correct sorting standard.	Communication Convenience Social diffusion Prompts
9. Other external factor	Expected or unexpected real-world challenges, e.g., overflowing, occasional events that produced larger amount of waste than average, etc.	Convenience Communication
10. Other internal factors	Other internal factors include but not limit to the followings: a user is in a rush, influence from people beside or acquaintances, the devil of convenience, follower effect, etc.	Social Norm Social diffusion Incentive Communication

Notably, many barriers are cross-related. Interactions and chain effects make the borders between the identified barriers vague and hard to divide clearly. Several cross- related examples are given in the following discussion.

This study shared many similarities from the backgrounds to the issues on waste management with several previous studies that also conducted under university campuses (Ahmed, Khanani, & Koshy, n.d.; Johnson, 2013; Cheng, 2016; Ummat, 2013). It appears that inconsistency of receptacles and signage is an issue shared among studied campuses. The waste audit results also show similar signs, as a single type of waste, coffee cups, compose a considerable proportion of the waste collected from the general public, and food-soiled waste appears to be very confusing for most of the studied audience. In addition, many higher educational institutions (Tangwanichagapong et al., 2017; Wu et al., 2018) also have a diverse population, with people having a great variety of past experiences.

The number and the location convenience of the receptacles are two closely related barriers. They are not exactly the same, but the outcomes are similar. That is, there are no appropriate stream or receptacles when needed. However, when users claim insufficient receptacles being an issue, it is possible that there are available receptacles around, but the users are not aware of them. While when users state the receptacles are not at convenient locations, it can also mean there are other relatively convenient ones around. Many studies have illustrated that the proximity of receptacles can heavily affect users' waste sorting behaviours. Appropriate streams at a shorter distance has a stronger ability to attract users to conduct the desired waste discarding behaviour (Austin et al., 1993). According to the CBSM framework and the literature reviewed (McCarty & Shrum, 1994; McKenzie-Mohr, 2011; Rousta et al., 2017), it has already been emphasized that "convenience" can be a powerful and helpful method when benefiting the desired behaviour, but convenience can also have negative effects if it is easier to conduct

the undesired behaviours. The survey and observation results have all strongly supported that many users are prone to use the closest bin available, even when the proper receptacles are nearby. Many survey respondents have also pointed out that those single garbage cans placed in classrooms are what they regard to be one significant reason that may contribute to bad sorting, because they are much more convenient than the streamed waste receptacles often located in the hallways, lobbies, or other common areas. Students are the main users on campus, and classrooms are where a great volume of waste is generated.

Unclear signage and inconsistency of the waste collection system is another pair of closely related barriers. Signage can be regarded as part of the waste collection system, since waste sorting signs are normally attached or displayed close to the waste receptacles. The campus sorting standard has changed over time, however, and many old signs with outdated information were not renewed. These signs either show information that is no longer helpful to the users, or shows misleading instructions, e.g., directing the same item to be thrown into different streams. In addition, based on the pre phase results, some users commented that they are also confused by the title of the signs. For instance, the stream titled "containers" not only collects containers, but most of the recycling items other than paper, while the paper stream does not collect paper cardboard. Cardboard boxes are barely displayed on any sign on campus, but according to campus waste audit results from the past (Waste Reduction Group Inc, 2017), pizza box, defined as cardboard box, is a very common waste item collected on campus. It is not surprising, then, that the survey results show that a high proportion of participants do not know how to correctly sort a pizza box.

Furthermore, the available streams at each waste collection point are not consistent, and the receptacles come in different shapes and sizes. Some receptacles on UW campus have shaped outlets, while past studies have shown that shaped outlets can actually cause more confusion (Jiang et al., 2019).

The barriers discussed above are more on the structural side, while the following ones show more interactions between structural and non-structural barriers.

"People began to realize that they don't know everything about recycling and composting."
Cheng, (2016)

Misconception (Cole & Fieselman, 2013; Cheng, 2016) and **lack of knowledge** (Dahle & Neumayer, 2001; Heathcote et al., 2010) are both identified as critical barriers, while users having different **past experiences** (Dahle & Neumayer, 2001; Kollmuss & Agyeman, 2002) is likely to be one of the main

reasons that lie behind these barriers. Possessing different past experiences can happen to all users alike but result in different outcomes, two situations are noticed to be the major outcomes in this study. Some users find conducting proper sorting difficult due to the differences, because they lack the corresponding knowledge; while many others might not notice the sorting standard is different from their past experiences then resulted in a misconception situation mentioned above.

Particularly, it is noted in this study that many people with similar past experiences to the sorting standard and system on campus, tend to easier misconceived the sorting standard on campus is the same as their past experiences. Users having local or nearby communities' living experience tend to claim that they have none or less problem to adjust to the new sorting standard on campus, because they believe the entire process is almost the same, and they have the correct sorting knowledge in mind. Although, based on the pre-phase results, the sorting standard and system generally matches with close communities, it is noticed that those slight differences are often what cause confusion and end up with high contamination. Other than that, misconception still happened when users noticed that the waste management situation was different from their experiences. However, rather than recognizing that the sorting standard and waste management procedure were different, some users had a questioning or doubting attitude, as they believed the experiences they had in the past stands for correction.

On the other hand, those users with living experiences from further places or newcomers to the campus were more aware of the difference between the sorting standard on campus and their previous experiences. Although, this does not necessarily link with correct sorting behaviour, because many users still reported that they lacked knowledge or information to assist them to conduct proper waste sorting even when they recognized their incompetence to conduct correct sorting on campus.

Although a number of users reported that they simply did not know which category to sort some items, and some said they were afraid of making mistakes that would cause contamination so they discarded everything into one bin, on average, respondents believed that insufficient knowledge causes less problems than insufficient infrastructure (i.e., not enough bins) in terms of their ability to sort properly. However, the results of the sorting quiz illustrate that a gap exists in between. Observation records also noted that some users only check the signs after their discarding is completed; many only scanned rapidly to recognize the colour or the category of the bin, while some showed surprise or hesitation when they became aware that the information shown on the signs was different from their understanding. All in all, I argue that misconception is a critical barrier of which the target audience is unaware.

Chain effects may exist between the barrier of **not enough instruction and promotion** and other barriers. Some users state there is too much misleading information given by different parties, which links to the barrier on unclear signage and inconsistent settings. Most importantly, many stated that they do not know where to look up the latest, correct sorting standards. Another supportive sign is that more than half of the survey respondents believe the waste sorting standard on campus is the same as the Region of Waterloo. This reflects the issue that not enough promotion is done to notify the users about the change to campus sorting standards.

Moreover, as stated in the earlier section, the organic stream is one major difference between the newly introduced waste stations and the old receptacles. The survey results show that more than half of the respondents do not have organic stream available at their residential places. In addition, organic waste is indicated to be the most problematic type of waste to be correctly sorted based on the survey sorting quiz. Therefore, it is likely that users are unfamiliar with what can go into the organic stream. This highlights that the instructions currently provided are not sufficient to assist users to adjust to the introduction of organic streams.

Except for the classified barriers discussed above, there are **other external and internal factors** that are also identified as barriers. Some of the external factors relate to the procedure or setting of waste management, such as the waste handling process of the custodial personnel. On the other hand, internal factors often relate to users' behaviour or attitudes, whether positively or negatively. From a behavioural point of view, a follower phenomenon was observed. Verdonk, Chiveralls, & Dawson (2017) noticed a follower effect in their waste sorting behaviour study. They divided their study audience into thinkers, chuckers, and followers. Thinkers think through the correct decision, while chuckers dump everything into one bin without thinking, and followers simply follow the actions and decisions done by thinkers or chuckers. The pre phase observation results also indicated that some users follow others in front of them when making sorting decisions regardless of the correctness of those they are following.

Similarly, from an attitude perspective, some users stated that other users' poor waste sorting behaviours may decrease their motivation to conduct proper waste sorting. This may include seeing it in person or simply by seeing the receptacles already filled with improperly sorted waste. This can be explained with the broken window theory: once an outcome of undesirable behaviour is noticed, the invisible moral obstacle is then decreased, and people are likely to follow the undesirable behaviours. Berger & Hevenstone (2016) summarized that sites with garbage intentionally placed on the floor turned out to have more littering behaviour than controlled sites with no garbage at the first place. Except for the broken window theory, the Social Ecology model can be used to interpret this situation. One's behaviour is not

only affected by influences at the individual level, but also influences from the meso to macro level, including one's inter-personal social network, the surrounding community, culture, etc. (Bronfenbrenner, 1977).

Information, especially verbally from family, peers, or colleagues are noticed to impact users' sorting behaviour. Nearly 70% of survey respondents stated that they first rely on their own judgement when conducting waste sorting. However, peers, colleagues, family members, and environmental groups are stated to be the most influential factors other than "myself", the result can be verified by the observation results of this study. The impact, however, can either be positive or negative. (Verdonk et al., 2017) also reported that children in particular are a group of users that often be directed by their parents. This phenomenon is also observed in this study – at least in the case of the student respondents.

Overflowing is nominated as one situation that can decrease users' willingness or ability to conduct proper waste sorting on site. Overflowing can be caused by structural issues, such as low collection frequency, or it can be caused by occasional events that took place and generated a larger amount of waste than usual. Overflowing can also be caused by non-structural factors such as poor waste discarding behaviour. For example, pizza boxes are again pointed out to be a problematic waste item by the custodial services staff. They reported that some users squeezed the pizza box into the receptacle, which pretty much filled the space of the receptacle at once, and then prevented the receptacle from properly functioning for subsequent users.

Perceived attitude is one of the barriers that is heavily affected by the interactions between barriers. Many examples are given above, such as the chain effect between the internal factor, i.e., other users' attitude or behaviour, can affect a specific users' sorting behaviour or motivation.

Interactions can also exist between perceived attitude and other external factors. Some users reported skeptical and distrusting attitudes toward waste sorting on campus, which led to doubts of the necessity of conducting such behaviours. The reasons leading to their attitudes included the lack of transparency of waste management procedures, and possibly some misunderstandings or misinterpretations of the custodial personnel's waste collection processes on site. Several survey responses stated situations in which they had witnessed custodial services staff mixing the waste collected from different streams. Some responses questioned the fact that recycling or organic materials are collected in black garbage bags, since they believed it should only be used for garbage streams. The above situations made some users doubt if they should continue waste sorting.

Insufficient promotions can lead to negative attitudes whereby users do not feel that waste sorting is regarded as an important issue on campus, which also means lack of social pressure to carry out the behaviour. Low or no motivation can also be reasons for which individuals do not conduct proper waste sorting behaviour on a regular basis.

7-1.3 CBSM step 3: Developing strategies

In this subsection, I will convert the CBSM tools proposed earlier into potential interventions, and develop a semi CBSM campaign. The proposed interventions are shown in Table 7-3, and more detailed discussions follow.

Table 7-3.
Potential CBSM tools

Potential intervention	Corresponding barriers	Potential CBSM Tools & Content
Adding receptacles	- Insufficient receptacles - Receptacles at inconvenient location	**- Convenience:** add receptacles, and rearrange existing receptacles **- Prompts:** indicate nearby receptacles' location or available categories
Rearranging receptacles	- Insufficient receptacles - Receptacles at inconvenient location - Inconsistency of receptacles and their settings	**- Convenience:** add receptacles, and rearrange existing receptacles **- Prompts:** nearby receptacles' location or available categories
Improving signage design	- Unclear signage - Inconsistency of receptacles and settings - Insufficient instructions/promotion - Misconception - Lack of knowledge	**- Communication:** improve sign design, and keep consistency of signage **- Prompt:** enlarge the size of the sign, and manipulate the overall visual experience of sign. **- Social diffusion:** pre phase results and reviewed literature suggested that users will sometime discuss the content of the sign. **- Convenience**: the experimental signs are easier to recognize and straightforward than the original signs.
Promotion and education	- Insufficient instructions/promotion - Other structural factors - Misconception - Lack of knowledge - Perceived attitude - Other non-structural factors	**- Communication:** clarify users' misconception and address the distrust perceived attitudes. - Social norm: - Social diffusion - Commitment: - Prompts:
Optimizing waste	- Inconsistency of receptacles and setting - Insufficient receptacles	- Communication - Convenience - Prompts

management service	- Receptacles at inconvenient location - Other structural factors - Perceived Attitude	

Although McKenzie-Mohr (2011) suggested CBSM practitioners tackle several barriers or benefits with one strategy if applicable, after reviewing the identified benefits and barriers from the previous step, it is estimated that several different interventions are needed to make up a semi CBSM campaign to address the waste sorting issue on UW campus. Moreover, it is recognized in this case that when users intend to do proper waste sorting on campus, the blocking impact of barriers may overpower the attraction of benefits. In other words, if obstacles are not dealt with in the first place, more psychic and/or mental efforts are required from users when conducting the desired behaviour. While according to the literature reviewed earlier that adopt the TPB, more psychic or mental efforts required can lower users' perceived behavioural control and end up with decreased motivation (Ajzen, 1991b; Kollmuss & Agyeman, 2002). In addition, it is also assessed that the identified benefits are not as specific as the barriers. Therefore, only the removal of barriers will be focused on in this study.

To tackle the identified barriers in the previous step, five potential interventions are proposed in Figure 7-1 and match the barriers accordingly. The potential interventions include adding more waste stations, rearranging existing receptacles, improving signage design, more communication and education, and optimizing waste management services. The following paragraphs further discuss each intervention.

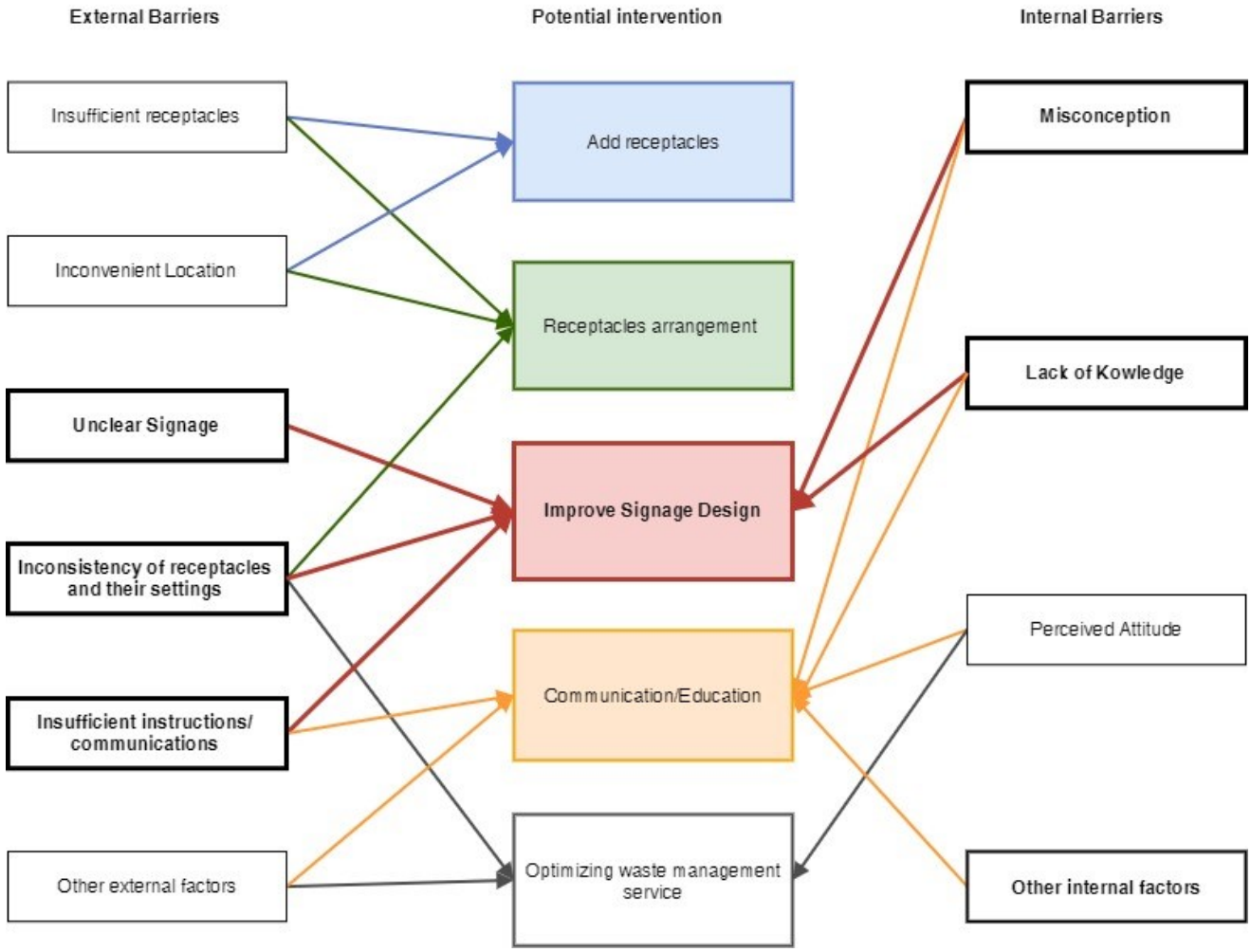

Figure 7-1 Semi-CBSM campaign towards the identified barriers

*Barriers that can be addressed by signage design improvement are present in bold lines and font

It is believed that **adding more receptacles** (Malakahmad, 2010) and **rearranging existing receptacles** are two ideal interventions to address the barriers of insufficient receptacles, receptacles at inconvenient locations, and inconsistency of receptacles and their settings. These two interventions also fit to be grouped and conducted together. Adding more receptacles is relatively easy and fast; however, by reassessing the locations, evaluating the waste traffic, and rearranging the existing waste receptacles, adopters could maximize the usage of the existing receptacles. In addition, prompts can be used to help remind users if there are other available streams or receptacles nearby. Adding more receptacles not only means adding more undesired workload to the waste management service (Johnson, 2013), but it also becomes less cost effective.

Improving signage design aims to deal with five barriers; namely, unclear signage, inconsistency of receptacles and their settings, insufficient instructions/communication, misconception, and lack of knowledge. Communication and prompts are the two main strategies behind the sign improving intervention. Convenience can also be adopted. Although only barrier removal is to be discussed, I believe benefit promotion can be integrated in signage improvement as well.

It has been determined in the earlier stage that the experimental signage will adopt practical images as the main core of the experimental design. The contents, such as what items to list, how to group the displayed items, and other details are based on the findings in the pre-phase results. The rationale and detailed determination process of content selection for the experimental signs of each stream, and how the messages are framed are explained in depth in section five. Several highlights are discussed in the following, and additional concerns that are worthwhile considering if other potential signs are to be designed.

For the prompt strategy, the enlarged size and the vivid images are designed to prompt the users to notice the sign change and remind them to sort their waste. For the communication strategy, in this pilot study, effective messages are created mainly from considerations in two aspects: the visual design, visual attractiveness, and overall visual experience of the sign; and giving specific information.

Firstly, we intend to make sign reading and waste sorting easier for users by improving the visual design, visual attractiveness, and the overall visual experience of the sign. Replacing the original signs, which is designed with generic icons, with images of practical items is the core value of the **visual design** of the experimental signs. Other considered factors include presenting less clusters, readable font size, consistent layout, keep the colour coding as the original design, etc. Secondly, we intend to **present the specific information** most in need, including items in grey area, e.g., food-soiled waste, multi-material packaging, items that are differently sorted from the regional or old sorting standard, and frequently mis-sorted items synthesized from the pre-phase. Moreover, it is worthwhile mentioning that the content of the sign and the messages distributed by the experimental sign in this study is not the only and final option. CBSM suggested many different possibilities when framing the messages. Messages can be effective as long as they are generated based on a good understanding of the target audience. Therefore, presenting link or QR codes that can lead users to the latest campus sorting standard can also be a potential way to implementing the convenience strategy.

The intervention **promotion and education** have great flexibility and possibility; I argue that this intervention can also be integrated with benefits promotion. A number of CBSM strategies can be

implemented in this intervention, including communication, social diffusion, social norms, and commitment. Six barriers are estimated to be tackled by this intervention, including insufficient instruction and promotion, lack of knowledge, misconception, perceived attitude, other structural factors, and other non-structural factors.

Communication that passes on effective and precise messages can help to clarify the several different types of misconceptions, and relieve skeptical and distrusting attitudes. As was mentioned earlier, many users are facing different levels of “culture shocks” with regard to waste sorting because it is different from their past experiences. In addition, effective communication can directly help or indirectly provide the users access to the latest correct sorting standard and tips on campus to assist them to overcome the lack of knowledge barrier.

Promotion and education can be done in many forms, such as through community networking in person, through physical hard copies, or through online platforms. Some potential ones are proposed here.

Researchers or campaign adopters can seize the chance to implement interventions when events are held. For example, **orientation**, when the new students arrive and are adjusting to campus life. **Modeling** can also be part of the interventions for events, because it is believed to be a good way to deal with the follower effect and broken window effect mentioned earlier. (Lin et al., 2016; McKenzie-Mohr, 2011; Verdonk et al., 2017). Face-to-face in-person interactions, such as volunteer modelling, can certainly have significant effects, but the scale of the audience exposed is likely to be small, which means that it is less cost-effective (Lin et al., 2016). Therefore, if considering reaching a larger population on campus, **social media** can be an effective communication path. However, many studies have provided valuable experiences that highlighted social media needs to be used wisely in order to reach the target group members, otherwise it could be less effective (McKenzie-Mohr, 2011). In order to have one’s message delivered effectively through social media, many have emphasized the importance of good segmentation of the audience, because social media messages need to be very specific.

Adding waste sorting information into **employee training** can be beneficial. Compared to students, who have higher mobility around campus, it was noticed during the observation and waste audits that employees or staff on campus stay and use fixed receptacles, and they often discard large volumes of repetitive items. Whereas it is also noticed that many items commonly discarded by the staff are different from other general users, and some of them can be difficult to tell which is the best category to sort. For instance, most waste discarded by users in this study is recognized to be food related, stationery, or writing papers, while waste discarded by staff included milk bags for commercial coffee machines, large

waxed papers, etc. However, it has already been emphasized earlier that information provided on signage should be as brief and precise as possible to avoid message overload, and it does not seem reasonable to present the items commonly thrown by the staff who are the minority of the users, instead of the majority of general users. Therefore, I argue that it can be beneficial and profitable to conduct employee education.

The barriers to be tackled correspond with **optimization of waste management service** are the inconsistency of receptacles and their settings, insufficient instructions and promotion, and perceived attitude, while potential CBSM tools that can be adopted when optimizing waste management are communication, convenience, and prompts. For the strategy communication, the passing on of effective messages does not always need to be active; instead, passive or indirect communication can also pass on implied messages. A potential example can be ensuring that the colour of the bags placed in receptacles is uniform, which can increase the consistency of setting, and relieve some users' skeptical attitude. Another example is to set special procedures or guidelines for events or conferences, such as increasing the frequency of collecting waste or placing additional temporary receptacles. Most importantly, it is important to let users know about the changes. These changes can give users the impression that UW is taking waste management seriously. Additionally, optimization of the waste management service unavoidably needs a strong connection and assistance from the custodial service and other stakeholders.

The proposal of this semi CBSM campaign could act as a piece of supportive evidence for the Social Ecology model. Simply relying on either social marketing tactics or interventions at the individual level is insufficient. In fact, except for the Social Ecology model, several social marketing studies that systematically review the social marketing implementation also call for **systematic changes**. They pointed out that behaviour changes should not only be focused on the individual level; that is, downstream, but the upstream and middle streams should also be involved. Otherwise, the effect of triggering behaviour change is likely to be limited. For example, optimization of waste management service can involve rule formation, while setting rules is neither a common strategy considered in the scope of social marketing nor can it be done at the individual level without the involvement of stakeholders in upper streams.

7-1.4 CBSM step 4: Piloting results discussion

The pilot results discussion will start with the comparison of the pre and post observation results, including descriptive analysis and statistical analysis conducted in section 6-1, then will include a comparison and discussion of the waste audit results with partial analysis referring to section 6-2.

Onsite Observation

The statistical analysis of the observation data of the experimental signs mostly showed insignificant results when conducting pre and post comparisons within sites and within intervention groups. However, the contingency tables with plain ratios showed improving trends. On the other hand, the control group showed improvements as well. Except for subjective judgements and manual errors between observers, several reasons are inferred to possibly cause such phenomena, and some qualitative notes can explain the insignificances to a certain extent.

Firstly, there may need to be a longer time to see a greater sorting behaviour adjustment, as the follow up post phase was conducted with little to no time gap after the installation of the experimental sign. The users may need a longer time to adjust to the changes. In this study, progress was subtle and less obvious at this initial phase. The qualitative observation notes indicate that there were some users who either only read or only noticed the sign change “after” their waste discarding was complete, then figured out that they made a correct or an incorrect sorting choice. In addition, some users were observed shrugging their shoulders, and some discussed the content of the signs with the person beside them. While only one week follow up was done in the post phase, we are unable to know and claim whether the users shifted their sorting behaviour the next time or later in the future according to the replacement signs.

Secondly, the new sorting standards are different from the original signs that follow the regional sorting standard, which also applies to most residential buildings around the campus, i.e., off campus housing. It is understandable that users show hesitation or doubts toward the experimental signs, because the information displayed on signs is likely against their perceived knowledge. Plastic cutlery is one good example, as the experimental signs direct users to sort it into the recycling/container stream, while they are regarded as garbage according to the regional sorting standard.

Thirdly, uneven samples of each intervention group may also be one reason that leads to the insignificant statistical analysis. Those with smaller sample sizes are more easily skewed. Each site is selected near to a food outlet at the first place, and many repetitive records are, in fact, observed from the food service staff. According to the pre phase survey result, it is believed that employee and staff generally performed better on waste sorting. That is, the control group already has a smaller sample size than the experimental group in general, while a high proportion of records is attributed to staff, which can then lead to an outcome with the control group having better performance in the post phase.

Lastly, the comparison of the observation results of the factor “correct sorting” shows no obvious trend for the experimental group. It has been emphasized earlier that due to the nature of the study, a stricter

sorting criteria for correctness applied in the post phase for the experimental group, while the control group remained with the looser sorting standard that allows both new and old sorting standards.

In addition, as mentioned earlier, the qualitative notes reported that users sometimes show hesitation and an unsure attitude toward several items displayed on the experimental signs, because they are likely against users' perceived knowledge, e.g., napkin, cutlery, and coffee cups. In the post phase observations, a number of users were noted to show surprise when they found napkins displayed on the organic sign.

However, if omit the insignificant advance statistic analysis, but only focus on descriptive statistic analysis. In general, the average waste sorting and discarding **time** increased around one to two seconds on average (Table 6-7,Table 6-8, and Table 6-9). This phenomenon aligns with the experiment results of Ahmed et al. (2016) that discarding time increased at the early stage of the intervention. Although we should be cautious to claim a causal relationship, it is believed that chances are users took a longer time to read, adjusted to the signage changes, then acted accordingly.

According to the three structural recorded factors: sign reading, sorting or not, and sorting correctness. In the pre phase "2" was the most rated code for "sign reading" and "sorting or not" at most study sites. A "2" was given to those who quickly scanned or gave the signs a glance for the sign reading variable, and a "2" was given to those who conducted a basic sorting that fell between no sorting and a thorough sorting. Interestingly, for these two variables, the percentages of users marked with "2" decreased at most sites installed with experimental signs in the post phase. In addition, from the contingency tables - Table 6-4, Table 6-5, and Table 6-6, the post phase observation results showed that those who noted the sign changed (rated 2 or 3 in "sign readings") linked to a higher "sorting or not" performance. It illustrated that once users visually acknowledge the experimental signs, more attempts are made to sort, even though the sorting correctness did not increase by much. In other words, behaviour change for waste sorting attempts occurred, though it did not increase the correctness simultaneously.

It is inferred that these people marked with "2" in the pre-phase are "the middle users" who processed the intention of conducting waste sorting, but were too used to the earlier signs and setting that they did not think of reviewing their sorting. As they already had impressions and memories in mind, they did not read the signs closely and carefully every time, and likely did not notice the campus sorting standard had changed. In addition, based on the survey results, most respondents did not state their own lack of knowledge as a top issue when sorting waste on campus. In other words, many users are somewhat confident with their own judgement toward waste sorting that they only recognized which bin they are

throwing, rather than carefully checking if the item they are discarding should go into that bin. Used napkins and tissues are good examples. In the post phase observations, some users were recorded to show surprise when they found used napkins and tissues displayed on the organic signs. However, once the noticeable sign replacements were made, the experimental signs effectively prompted these “middle users” to note the difference of the sign, they then quickly reacted according to the alternation of the signs.

If we explain this phenomenon with the Stages of Change model, these middle users are either at the stage of “Precontemplation” or “Contemplation” in which they are not aware, or they are aware of the issue but the instructions are too confusing for them to take action at once, and actively gathering more information is not a priority for them. Since the experimental signs are tailor made and visually designed to improve ease of read and understanding, these users then quickly reached the later stages, “Preparation” or “Action”. Whereas, the post phase was too short to allow us to know whether these users have also reached the maintenance stage or not.

Moreover, even though the experimental signs caught more attention from the users, there are only six experimental sites in total, and they are spread in different buildings. That is, the experiment itself may cause another sign inconsistency to the users, while previous studies and the survey results all indicate that inconsistency is one barrier that can prevent users from conducting correct sorting.

A following effect is noticed in the variable “Using other bins”. The selected study unit in DP and EV3 are both near a condiment table that is mounted with a garbage can, and the majority of users’ travel routes will pass the condiment table first before reaching the study units. As most study sites that have other bins showing use rates of other bins lower than 25% in both phases, however, in the post phase, DP has a relatively high other bin use rate at 43.18% (Table 6-7). EV3, with a similar setting, however, did not show a similar outcome on other bin use rate. It is supposed that there is a follower effect (Verdonk et al., 2017) in DP. As the observations are conducted during the lunch hours, it is likely that users simply followed the others in front of them and discarded all their waste into the garbage can mounted with the condiment table. In addition, though it is only a few steps away, the mounted garbage can still provide more convenience than the study unit. Moreover, the study unit at EV3 is installed with the larger signs that is likely to catch more attention for those using the other bin nearby, but DP was installed with smaller experimental signs that is likely less eye-catching than the larger signs.

Nevertheless, it is still too soon to draw a conclusion by only discussing the observation data. Instead, an overall conclusion will be drawn later after discussing the waste audits.

Waste Audit

In general, when comparing the two phases of waste audit results, study sites installed with the larger signs experienced much greater progress than sites installed with smaller signs. This may be due to the fact that the larger signs not only serve as informative instructions to guide the user, but their eye-catching nature increased users' tendency to become aware of the changes. In addition, the control group DC and REV show deteriorating results, while STC in the faculty group performed improvements on three metrics as a controlled site. However, a bag of household organic waste was discovered in the audit sample, and we believe this is an example of an outlier heavily skewing the result. Otherwise, the post phase results might not be so optimistic in STC.

DP showed improvement on capture and diversion rates, while the contamination rate deteriorated, this might be due to the installation of the "OOPS" signs at this site. Oops signs were adopted because there were no organic receptacles accessible to the public at the same level. Organic waste such as coffee cups, napkins, and biodegradable utensils are noticed to compose a certain share of the waste collected at DP in the pre phase waste audit. However, it was considered inappropriate if the experimental signs at this site were designed in the same way as other sites, because users' organic waste needed to be directed into alternative options when the most suitable stream was not provided. E.g., coffee cups were then expected to be placed in the paper stream, and the organic waste was expected to be placed in the garbage stream. If the experimental signs simply displayed the waste images with the alternative options, it was estimated that it became a violation of sign consistency. Therefore, "OOPS" signs were installed at DP instead. Nevertheless, even with Oops signs applied, it is likely too much mind work for the users. This is a practical example illustrating the insufficiency of infrastructure being a real barrier at this site, and it may have seriously prevented the users from conducting proper waste sorting.

Among all the study sites, the residence group has the most repetitive users and the waste mostly coming from the cafeteria nearby. While CMH also belongs to the residence group, it is closer toward other off-campus food outlets, therefore more outward waste was discovered in the waste audit samples collected from CMH. In addition, CMH also reported that there were some groups of external visitors using the study unit during the post phase period. V1 in group C (residence) experienced a great improvement of more than 30% diversion rate. The selected unit in V1 was placed right beside another unit that was exactly the same. Both units were then installed with experimental signs, and there was no additional other bin close by. It was noticed later that because experimental signs were only installed on one selected unit during the intervention at all study sites excluding V1, it actually caused the unwanted sign

inconsistency situation. In contrast, both units in V1 were installed with the larger signs, the change was obvious, very eye-catching, and hard to avoid. We then see that when sign replacement was done in a consistent and noticeable way, the influence on behaviour change was notable as well.

A Comprehensive study method has been beneficial in this study. The waste audit results of each study site generally correspond with the results from the observations. The results of the survey, observations, and waste audits reinforce each other in certain ways. Those that show improvements in observation results in the post phase also show progress in the waste audit, and those who performed poorly in the observations had worse waste audit results than the pre phase outcome. Therefore, we believe it is reasonable to state that multiple methods are reliable and provide more solid evidence for behavioural research.

In addition, adopting multiple methods helped reinforce the findings and supplement the insufficient parts as well. For instance, in this study, onsite observations were only able to examine small numbers of users' sorting correctness, while waste audits allowed us to fully examine all the waste collected in a period. Waste audits can only reveal the waste sorting rates and the composition of collected waste, but the observations helped the researcher closely examine how people interact with the signs on site. Moreover, though it is undeniable that the reliability of the manual observation results can be affected by the subjective judgement of observers, we argue for the importance of conducting onsite observations. Even though a user survey was conducted in the pre-phase. A gap between self-report data and onsite observation data were also noticed in this study (Barker et al., 1994). Furthermore, it should be noted that the survey participants were recruited on a voluntary basis, i.e., convenience sampling. Those who are not interested or who have a lower willingness to conduct waste sorting are less likely to answer the survey in the first place. Therefore, the results of the survey should not be the only reference before designing and implementing the intervention, and it is reasonable to believe that the survey results may show more positive results than the overall results.

Why do signs with similar designs that use the same images but slightly different layouts result in such different outcomes? We believe it is because of the follower effect. Verdonk et al. (2017) categorized the waste receptacles users into thinker, chucker, and follower. Thinker are those who read the signs and react to it, chucker are those who dumped everything in one bin without giving a second thoughts, and a big share of users are, in fact, the followers who either follow user throw their waste in front of them, or throw their waste according to the waste already been placed in the receptacles. They then suggested that modeling the desired behaviour can possibly improve the target group members' waste sorting behaviours. The possibility of the follower effect is also supported by the pre phase user survey, as there

are some respondents stating that others' waste sorting behaviours would also influence their own sorting. In addition, other uncontrolled external factors may also influence the results, e.g., confusions caused by the colour of the bags. Furthermore, the observation and audit durations in this study are likely too short to collect concrete results, as the total observations were only done in two weekdays, and only 48-hour samples were analyzed for the waste audits.

Although the collected data do not show many statistical significances, I argue that more obvious trends and improvements could be recognized if the study duration were longer. Cole & Fieselman (2013) conducted a term long CBSM case study at a university campus, promoting pro-environmental behaviour; however, they still claim the six-month implementation time was too short to see significant outcomes. In addition, due to the nature of the study, the sorting standard in the post phase of this study turned out to be much stricter than the pre phase, so even the observation results or the waste audit result did not see great difference. I believe it is reasonable to claim that the actual behaviour change is greater than the numeric numbers shown.

7-1.5 Step 5: Evaluation toward experimental signage intervention

The CBSM framework has suggested that adopters do multiple revisions and continuous piloting until the campaigns have received a desirable level of behaviour change before conducting a broad scale implementation. However, this pilot study has not yet reached a broad scale implementation stage. In this subsection, I will go through **some possible revisions** that could be done if additional pilots are to be done before a broad scale implementation is conducted.

Some possible improvements could be done toward the signage design. Firstly, increase the **simplicity** of the experimental signs. The current experimental sign design still contains too many clusters, which can cause message overload. Users found that differentiating between most bottles and plastic containers was not problematic; therefore, multiple images of various plastic beverage cups and coffee cups are not necessary. It is estimated that users are able to generalize all the coffee cups, so instead of displaying many different brands of coffee cups, displaying one of them should be sufficient and also help reduce the clustering situation.

Secondly, **more clarification can be done for problematic items and sharing confusion.** After the post phase, it was noticed that there were some problematic items missing from the current design, e.g., tea bag wrappers, energy bar and chocolate stick wrappers, etc. Furthermore, aside from simply improving the type of the displayed image, revisions could be done on giving more emphasis on clarifying

those grey areas. Some examples are adding ”used” or “soiled” in to text the explanation, explain what specific type of plastic materials are accepted (recycling sign 1-7), or clarify that cardboard boxes do not go into the paper stream.

Thirdly, the **title** of each stream can be re-evaluated and tested. Confusing titles have already been identified as a barrier that hinders users from proper sorting; however, title alterations were not made in the current design.

Fourthly, avoiding or reducing the **undesired inconsistency situation.** As mentioned above, expect for the residence V1, sign changes done at the rest study sites are likely violating consistency. Therefore, if applicable, sign change should be done consistently, i.e., changing all the signs of nearby receptacles, and removing other conflicting signs or instructions.

Lastly, **collecting more observation records and waste audit samples** are preferred. By doing so, the researcher should be able to have stronger supports to claim arguments

7-2 Discussion Toward Research Questions

1. How can changing the visual design of waste signs affect users’ sorting behaviours under a real-world implementation?

This question can be addressed from two perspectives: **users’ interactions with the signs, and the numeric results of waste sorting.**

The discussion of **users’ interactions with the sign** is mainly based on the observation results. The three observed factors, sign reading, sorting or not, and correct sorting show a positive association between each other. Many users who noticed the sign changes and read the signs were prompted to conduct better waste sorting; however, not all the users noticed or read the signs. In other words, those who are recorded with 2 or 3 for the sign reading variables basically performed better on the *sorting or not* factor, but they did not always do better at sorting correctly. Some of the referred studies are done purposely for aim of testing the readability of sign design in laboratory surroundings that all the participants read the signs (Wu et al., 2018), whereas, in the reality, users do not always read the sign, which waters down the effect of the sign changes with different visual designs. As mentioned above, possibly because most users are already familiar with the original signs, some users only quickly scanned

for the colour or the stream to which they would dispose their waste, rather than carefully reading the sign. While, many users act accordingly once they noticed the change.

Some users were observed pausing and carefully reading the signs when they noticed the change of the signs, and some discussed it with the person beside them. A small number of observation notes report users expressed **confusion and hesitation** toward the experimental signs. I argue that it may be because the users are still adjusting to the shift. Especially, the information passed on by the experimental signs is likely against their perceived knowledge, past experience, and not consistent with other existing units around.

I argue that the visually optimized sign design **increased the readability**, and the signs became **more self-explanatory**. By replacing the mono-colour generic icon graphic with colourful practical item images, the signs are easier to read and understand, as some users reported the original designs are difficult to recognize at first sight or they need to further read the descriptions. Although images of practical items have higher complexity, Isherwood, McDougall, & Curry (2007) mentioned that the closer the image is depicted toward the real item, the participants show higher speed and accuracy in recognizing the displayed items. Since the average waste discarding time is often only a few seconds, signs that are intuitive and easy to recognize in a very short period of time are more favoured.

In addition, as the difficulty of recognition has reduced, the experimental signs were able to assist the users to increase their perceived behaviour control. That is, because the new design is much more intuitive and requires less mind work to recognize, users may then have a higher ability to conduct proper waste sorting. In addition, less mind work means that users are also more willing to conduct proper waste sorting. Moreover, fewer texts are displayed while larger font and larger images are presented on the experimental signs. This helps avoid unwanted message overload and retains simplicity.

Instead of improving the visual design of the signage, I argue that the **visual attractiveness** of the signs matters and plays a vital role as well. The larger signs were not only intended to present larger and easier-to-read images, but also aimed to attract and prompt users to notice the sign change, then likely discover the concept gap they have. On the contrary, the smaller signs were designed to be the same size as the original sign, and fit exactly into the sign frame, which means there is a possibility that the users did not notice the change or if they only scanned for colour coding. As a result, both larger and smaller signs resulted in positive improvements, while the larger sign group generally showed a greater positive improvement than the smaller sign group. The improvements to the diversion rate of the smaller signs group are all lower than 6%, while the larger group signs are all above 16%. Verdonk et al. (2017) also

reported the receptacles with study signs that had higher visual attractiveness were used by a lot more users in their study, even though the overall waste sorting did not show much difference.

As mentioned in the earlier paragraphs, users recorded with “2” or “3” for the “sign reading” factors are those who recognized the sign changes. Most of these users reacted accordingly right away; however, the specially designed signs have no or less impact toward those users that did not read or did not notice the sign changes. Therefore, I argue that when sign changes are made, researchers should **assure the sign changes are noticeable** to the users. Otherwise, one should be more careful in concluding that sign changes have a significant impact on waste sorting since the users might not even notice the difference.

A set of interactive signs was designed by (Cheng, 2016) that aim to solve the users’ misconception problem. The interactive signs were shown to be fairly effective on attracting users’ attention. However, broadly implementing such interactive signs can be pricy. Under most circumstances, cost effectiveness is regarded as an important concern for sign design and installations. In addition, a broad scale implementation of the interactive signs is also likely to reduce the attractiveness of each sign. Therefore, I argue that even with the implementation of several interactive signs, the commonly seen signs should provide clear and straightforward information that help trigger better waste sorting behaviours. While the interactive signs help users to notice their misconception, clear signs with high readability can then assist users with their last mile toward proper waste sorting at the source, on-site, and on time.

Furthermore, **the installation surrounding is also important,** because it heavily affects the **overall visual experience.** Keeping installation of the signs consistent and reducing distractions as much as possible are likely to bring better sorting results. This is supported by the waste audit results of V1 in group residence, where more units at study sites are installed with the larger experimental signs, and there are no other bins or waste related signs close by. Jiang et al., (2019) noted that the more different signs are presented at once, the analyzed waste sorting behaviours are less thoroughly. The sign change in V1 is unavoidable, very eye-catching, and consistent. Moreover, there are more repetitive users (with higher familiarity) and smaller verity of the discarded waste items, which are mostly from the adjacent cafeteria. All the conditions above made V1 the site that had the most controlled setting with the strongest manipulation level of intervention, as the conditions were closer to a laboratory study. As a result, V1 performed the best in terms of diversion and capture rates.

The discussion **from the numeric results** is mostly derived from the comparisons of the pre and the post phase waste audits. In general, even with the adoption of the stricter sorting standard in the post

phase, the study sites installed with experimental signs increased diversion and capture rates, and showed a decrease on the cross-contamination rate, while the control group decreased or remained even with the looser sorting standard.

Most experimental study sites experienced an increase of **reaction time** in the post phase. This phenomenon aligns with (Ahmed et al., 2016), who found that in the earlier stage of the installation of experimental signs during their experiments, the sorting time increased as well. (Isherwood et al., 2007) also mentioned that familiarity plays a key role in waste sorting. As the experimental signs are new to the users, a learning curve may exist, and before the users get used to it, the reaction time tends to be longer. In the post phase of this study, only a one-week observation and waste audits were done soon after the installation of the experimental signage; therefore, no further reaction time fluctuation was noticed other than the increase.

2. What is the influence of adopting the Community Based Social Marketing framework with waste signage design?

Integrating the CBSM framework into waste signage design allows researchers to more precisely target the issues users face when interacting with signs, then combine specific solutions in the design as much as possible.

The CBSM framework reinforces the idea that knowing the target group is an essential start off point (McKenzie-Mohr, 2011). As mentioned in earlier sections, some previous studies made sign changes without first getting to know their audience thoroughly (Andrews et al, 2013), which came with much different results. It was observed in this study that not only certain specific items were causing trouble to the users, but also some conceptual confusion. It is concerning if researchers do not try to deal with these issues, but simply replace images or the content of an informative sign, as this is not likely to bring about the desired behaviour change. It is known to be a bad idea to present an exhausting list on the sign. If researchers do not fully understand the target audience and identify what are the true barriers and benefits behind the study behaviour, then, throwing out a design merely based on the perceived concept can be dangerous, because some small but critical details can be neglected.

By following the CBSM procedure, and fully understanding the target group members in the pre-phase, the researcher was able to clearly and precisely target several specific issues:

1. Select helpful content for signs, and filter out uncommon and less problematic items.

2. Identify other details that many users found difficult
3. Use the design to address misconceptions

1. Select helpful content for signs, and filter out uncommon and less problematic items

By integrating CBSM and understand the target audience, through the pre phase, the researcher was then able to recognize problematic items, and then either add them into the experimental sign content selection if they were not already on the sign, or emphasize them. This particularly included items that were sorted differently from the old signs that follow the regional sorting standard, and some items that were defined as frequent mis-sorted items. For instance, napkins, cardboard boxes, disposable plastic cutlery, coffee cups, fountain drink cups, compostable soup cups, sandwich bags, etc.

Similarly, I was able to filter out those less helpful ones. It was mentioned earlier that message overload is undesirable for signage design (Wu et al., 2018); therefore, displaying the most critical information is important. Every piece of information, image, and text needs to be fully considered before adding and displaying. Waste signage design aims to be simple but precise, so it is important to avoid displaying relatively unhelpful information, which will add unwanted mind work to the users. For example, newspapers and magazines are less common waste items for the general public on campus, and most users find them less problematic to sort. By filtering out the uncommon and less problematic items, the researchers are able to prioritize the more important ones.

2. Identify other details that users found difficult

Except for specific problematic items, integrating the CBSM framework also helped identify some shared confusion among users. The confusion identified in this study includes some grey areas, unclear titles, etc.

Some examples of grey areas are food-soiled waste and items combined with multi-materials, e.g. paper sandwich boxes with plastic windows. Users were found to have a lot of trouble with food-soiled waste, because this waste matched with one of the examples displayed on the signs, but users were then concerned that the waste they had in their hands might not be clean enough to be recycled. Most pictures displayed on signs are normally clean items without food stains; however, in reality, these food-related containers are hardly as clean as shown on the signs, and rinsing before discarding is not always possible. Examples of this include beverage containers with liquid or ice remaining, and used food containers.

These small details are likely to be overwhelming for the users. Therefore, the researcher then purposely put images of waste that are food-soiled, and added multi-material packaging into the experimental design to decrease the uncertainty caused by these grey areas.

Although the research intends to cover the most recognized issues as possible with the experimental sign, it is undeniable that the design adopted in this study was not able to fully address all the issues. There are other details that were unfortunately unable to be tackled in the design of this study.

3. Use the design to address misconceptions

Aside from the content of the experimental signs, adopting the CBSM framework has guided the researcher to identify misconceptions as a barrier for users on campus. In response, the researcher decided to enlarge part of the experimental signs to make the sign changes inviable, unavoidable, and eye-catching. The purpose was to prompt the users to be aware of their potential misconceptions toward waste sorting on campus.

We can draw a conclusion that integrating the CBSM framework is a promising way of improving signage design in this case. However, the benefit of integrating the CBSM framework is not limited to improving the signage design. More discussions about the findings of implementing CBSM are covered in other subsections.

7-3 Study Contribution

There are three contributions of this study toward the topic of waste signage design. These contributions are mainly attributed to the action-based nature of this study, and related to the methodological study design and experiences of data collection when conducting a field work study.

As a study that drew from action research and practically tested potential solutions toward a real-world problem, this study has brought together the related stakeholders and had their attention toward the studied issue topic. Although merely at the initial status, it still allows the future researchers to easier be on board if they are to conduct a continue or follow up research based on the result of this study, because the persuasion and communication work has already been done.

The second contribution of this study toward waste signage design is its comprehensive way of addressing the research question by adopting three different research tools in one study. By adopting the survey, observations, and waste audits, this allowed the researcher to assess the targeted behaviour changes, the intervention, and the results from different angles instead of a single view. The three

different research tools supplement each other's weaknesses by explaining the blind spots, and strengthening the findings. Although the outcomes of this particular study were not able to provide strong evidence from all aspects, valuable experiences can still be referred to in future studies.

The last contribution of this study relates to the experiences gained from conducting the study, as they can help reduce unexpected variances caused by external factors in a real-world setting. When conducting a real-world case study, many unexpected situations or limited conditions can occur, especially during the data collection or experiment implementation. By reviewing this study's processes, future researchers should be able to determine whether specific approaches should be adopted to control certain background conditions, reduce the noise from external disturbances, or prevent undesirable scenarios that can affect the results of the study under similar settings.

8. Conclusion

8-1 Research limitation

This research is subject to several limitations, either caused by the research design or challenges from real world implementation.

8-1.1 Research limitation caused by the research design

Firstly, the results of the survey may be affected by selection bias, because instead of a random sample, a convenience sample was used when recruiting the public.

Secondly, in the onsite observation part, insufficient records, man-made mistakes, and subjective bias could have affected the accuracy of the records. Some of the selected sites have very few records within the three-hour observation duration in each phase, which may have affected the statistical analysis. A possible solution to deal with insufficient records can be setting a target number of records, instead of setting a fixed time duration. In terms of man-made mistakes, these happen because the observations are manually done. Due to ethnic concerns, onsite observation is selected over videotaping as the main research tool to record the users' interaction with the signs. Although the observers are trained, it is undeniable that the results may still be subjectively affected by each observer's personal judgement or recording mistakes. Possible solutions can be assigning multiple observers from different angles at the same time, to reduce the chance of being visually blocked, and reduce man-made mistakes. In addition, comparing records made by different observers at the same time can also allow the researcher to ensure the reliability of observations.

Thirdly, the analysis of the waste audit could have been heavily affected by outliers. Either the baseline (pre-phase) or experimental outcomes (post-phase) waste audit results can be skewed by outliers, e.g., one or two users discarding a large amount or heavy mis-sorted items, and vice versa. Outliers can either boost or shrink the diversion rate and cross contamination rate. A possible solution could be collecting a larger sample. By doing so, the researcher can recognize if the sorting changes happen over a longer period of time.

Fourthly, there may have been an unintentional "inconsistency" problem caused by the experimental signs. Nine buildings and separated units were selected because the study aims to test the effect of signs in different surroundings. However, the researcher was only able to install the experimental signs on one selected unit, instead of every waste station in the building. There were sometimes several other waste stations located nearby, which caused a potential unwanted "inconsistency".

Lastly, due to a limited timeline, only one round of observation and waste audits was conducted right after the installation of the experimental signs in the post phase. This is a limitation because behaviour changes do not always happen quickly or at one point in time, and we know from observation that some users recognized the changes to the waste station only after they had discarded their waste. Previous studies also indicate that familiarity plays an important role in waste sorting, and one week might not be enough to capture the whole picture yet. This issue can be solved by extending the post phase period and conducting more follow ups.

8-1.2 Challenges for the real-world experimental study

One main difference between this study and some previous studies is that the experiments were conducted in a real-world setting rather than in a laboratory setting. Therefore, there were some challenges and unexpected situations that could not be controlled by the researcher.

The changing of the sorting standard may have heavily affected the outcomes. Due to the nature of the study, the sorting standard was not consistent through out the entire study. In addition, unexpected situations occurred including missing samples of waste audits (Verdonk, Chiveralls, & Dawson, 2017). The samples collection for the waste audits was done with the assistance of custodial services at the University of Waterloo. The nine sites were taken care of by many different custodians (day and night shifts), and the communication involved to help collect and store the samples instead of dumping them as usual was a big task. A few samples were, however, not successfully collected in the end due to some miscommunication. Moreover, in each audit, during the process of storage, transfer, and gathering before the samples were finally ready to be analyzed, there were a few labels that had fallen apart from bags, which caused difficulty in identifying the bags.

Another unexpected challenge was the change of observational surroundings at STC (group B, control group) in the post phase that caused a certain level of disruption. The furniture was rearranged for the repainting of walls that influenced the designated seat for observation. Observers stated that they missed several records because they could not see clearly some users' sorting behaviours and interactions with the signs from their limited vantage point. Unfortunately, adding additional chairs would have blocked the walkway and made the observer suspicious, and there was no better alternative spot.

The existence of the "other bins", i.e., waste receptacles other than the study units, was another serious challenge that occurred during our real-world experiment. Taking away the "other bins" may have resulted in overflow because the remaining receptacles might not have been able to accommodate the volume of

waste if the researcher manipulated the existing waste bins. Although the other bins did cause some "noise", we argue that not taking away the other bin actually reflected the reality of how users' may behave when other options exist simultaneously with sorting options.

Lastly, an unexpected plan change resulted in the delay of the post phase waste audits on group C (residence), so the group C had its post phase waste audit done one week later than the other two groups. By the time the separated waste audit was conducted for group C, the university had started off the exam season. We considered that students are the dominant users of waste stations in residence, while students' living schedule and behaviour may be different between exam and non-exam seasons. Therefore, the waste audit results may have been affected.

8-2 Conclusion

This study sought to develop communication tools for waste stations on campus that would contribute towards UW's sustainability goals by improving waste diversion rates. Community-based Social Marketing was used as a framework for identifying barriers, benefits and strategies that would appeal to the target audience (i.e. the campus community).

To sum, the results of this study demonstrated that **improving the visual design of waste signage using pictures of practical items** had a positive effect on waste sorting behaviors on campus. While the signage demonstrated a movement towards higher diversion rates (and lower cross-contamination rates), it cannot be relied on as the sole means for improving these rates as other factors need to come into play (such as consistent waste stations and signage across campus). The adoption of practical images has been adapted from findings if the studies done by Wu et al (2018) and Ahmed et al (2016). Both studies suggested waste signs with colourful practical images are tested to gain results with higher accuracy and efficiency. By replacing the original design of iconic images with images of practical items, reassessing the amount of delivered messages given by the signs, and improving the visual design of a sign, the readability and the self-exploratory extent increased. Moreover, the adoption of CBSM framework also helped to optimize the waste signage design, including recognizing the grey areas, confusing title, and the frequent mis-sorted items. Although the overall behaviour change effect is likely limited from real-world implementation comparing to laboratory results (Levitt & List, 2007a, 2007b), the outcomes of this study are positive to support the adoptions.

The **visual attractiveness** of the sign, and the **overall visual experience** given by the sign and its installation surroundings are also important. If sign replacements are to be done, the change should be

noticeable by the users. A previous study also showed signs having higher visual attractiveness tend to appeal more to users (Verdonk et al, 2017). Although larger user numbers do not necessarily relate to better sorting, the behaviour change effect is scarce if the users hardly notice or read the sign, even if a well-designed sign is installed. The larger signs in this study not only intend to present larger and easier readable images, but the enlarged size also aim to attract and prompt users to be aware of the sign change, and then were more likely to discover the knowledge gap they have.

In addition to factors related to the visual design of the signage, several other identified barriers and benefits were also noticed during this study. As mentioned in earlier sections, interactions exist between these barriers. Structural barriers can generally be solved by optimizing the waste management, manipulating the number and the locations of the receptacles. The decrease of structural barriers can then assist with communications or prompts to trigger physical transitions of internal barriers, and eventually increase engagement of behaviour changes. There are several non-structural factors worthwhile to be highlighted, discussed in detail below, including users' misconception, the follower effect, and different levels of social norm/cultural background. These additional factors provide valuable insight and are worthwhile to be mentioned in order to prevent unstable factor to experiment, especially under a real-world implementation.

Misconception is noticed to be a critical issue in this case, and some past waste sorting behavioural research studies (Cole & Fieselman, 2013; Cheng, 2016). People believe they have the correct sorting standard in mind and they are conducting correct sorting without realizing the standard on campus is different from their understanding. The pre-phase results in this study supports this statement. This is a barrier that is not aware by the respondents, instead, far more respondents claimed insufficient receptacles being the main factor that contribute to problematic sorting on campus. Inspired by the standard changing in this study, and all the different sorting standards applied in other studies, I argue rather than focusing on telling the users what is right what is wrong, it is more important to let the users understand that the sorting standard changes from place to place, so there is a necessity to always check when going to a new place, and frequently check even if at the same place.

The sorting on campus is **different from many users' past experiences** (Kollmuss & Agyeman, 2002), and this can result in two situations. They either find conducting proper sorting difficult due to the difference, or users might not notice there are differences toward their past experiences, then lead to misconception mentioned above. Particularly, it is noticed that in this study the more similar past experience is, the more likely users misconceived the sorting standard on campus is the same as their experiences in the past. Rather, those users with backgrounds from further places are more aware of the

sorting standard on campus is different from their previous understanding. However, this does not necessarily link with correct sorting behaviour, because many users also reported their lack of knowledge or information to assist still make proper sorting very challenging even when they have noticed the difference exists.

Similar as Verdonk et al.'s (2017) study, which they divided their study audience into thinkers, chuckers, and followers; **a follower effect** is noticed in this study as well. Although most survey respondents claiming themselves as the dominant factor when conducting waste sorting on campus, the observation records showed a number of users actually followed the decision made by users before them regardless of whether the previous users have done proper or poor sorting decisions. It does not mean the users must witness the previous users' actual discarding process and action. Instead, by looking at the waste already placed in the receptacles, users can still become the "follower" that follower previous users' sorting decision (Verdonk et al., 2017). Berger & Hevenstone (2016) have reported that people tend to litter more if there are already waste littered out of the garbage bin. Therefore, I argue that modeling and effective communication could be potential interventions to address the follower effect in this case.

From the findings of this study, rather than directly claiming if signage changes make difference, I believe it is more convincing to argue whether **it is a good design** matter. Despite a well-designed signage and a noticeable change can be powerful, switching signage is not likely to bring a sharp shift and great improvement on sorting behaviour at once. Users may need a certain amount of time to adjust the new sign, since **familiarity** has been mentioned as an influential factor (Isherwood et al., 2007). Moreover, **relying strictly on the effect of signage might not be sufficient to help reach a desire level of waste sorting improvement**, i.e., a high level of diversion rate goal (Andrews, Gregoire, Rasmussen, & Witowich, 2013). That is, solely relying on the effect on sorting behaviour is unlikely to help UW raise its diversion rate to the goal of zero waste campus in the near future. Therefore, I believe it is reasonable to claim that signage is not a one-way solution toward the entire waste sorting behaviour change issue.

Moreover, **adopting CBSM** also gives the issue a bird eye look that allow the researcher to fully examine the users' experiences, sorting behaviours; and the structural setting. CBSM has served as a strong framework in this study that enables the researcher to break down the obstacles, and deal with each barrier individually or in smaller groups, rather than trying to solve them together at once with higher difficulty. As mentioned above, it is evaluated that signage improvement was not able to cover all the identified barriers in this study. Therefore, a **semi CBSM campaign composed of multiple interventions** are proposed. It is believed that integrating other interventions can multiply the advantages and trigger greater sorting behaviour changes on UW campus. However, as signage improvement was

the only intervention implemented in this initial pilot study, with limited time, it is assessed that removing the barriers should be prioritized but not promoting the benefits. Although not all barriers and benefits related to waste sorting on UW are addressed in this study, they are now uncovered which future studies can take steps to address. Except for the already identified ones, there can likely be other barriers to identify if examining from different angle, or in different time or scale. Furthermore, many conclusions of social marketing research also call for **systematic changes and cross-sector cooperation at and between all levels** (Lee & Kotler, 2015). The outcomes of this research supports this statement.

Lastly, I would like to reinforce **the advantage of adopting a comprehensive research** method that includes multiple research tools. Many previous studies have criticized the reliability of self-report data collected from surveys (Barker et al., 1994). Several gaps are noticed between the self-reported survey results and the observation records in this case as well. In addition, respondents of the survey in this study participated on a voluntary basis, in other words, those who are willing to answer the survey may already be more involved to the selected subject. Observations allow researchers to more closely investigate user interactions with the sign and receptacles, while the waste audits provide more thoroughly quantitative data. However, observations can only cover a small number of records while waste audit provide an overall result, but waste audit results are likely to be skewed by unknown outliers. **Therefore, adopting multiple research methods can either strengthen the findings or supplement the blind spots. Although the specific sign design in this study may not fit the need of every case, the adopted method and the core value is generalizable with small revision, especially with studies conducted under similar campus or institutional surrounding.**

Although the analysis does not show much statistical significance, likely due to the limited time duration, we believe it is reasonable to expect promising results since positive trends are already seen in this is pilot study. Greater progress can be expected if revisions are made and a larger implementation is done. In addition, because the study was conducted during the transition between a new and old sorting standard, the pre-phase was done with looser criteria that allow both new and old sorting standards, while the post phase was conducted with the stricter criteria that only allows the new standard. Therefore, I argue that actual improvement is larger than the statistic analyzed result.

8-3 Recommendations for Future Research

8-3.1 Specific recommendation for future research on the selected study site

If future research were to take place at the same study site and continue targeting the waste sorting behaviours, it is recommended the researcher **refer the full CBSM plan proposed in this study**, which

comes with potential interventions. Otherwise, future researchers could also refer to the identified barriers and benefits uncovered in this study, then develop interventions based on needs. As stated earlier, the benefits identified in this study are less specific comparing to the identified barriers, so future research should take further steps to synthesize or identify other potential benefits.

McKenzie-Mohr (2011) suggested CBSM adopters continue to revise **and pilot their social marketing campaign** until the extent of behaviour changes has reached a desirable level, before introducing the intervention to a broad scale implementation. Therefore, it is recommended that future researchers further improve or revise the experimental signage design proposed in this study. Particularly, researchers can conduct revisions based on the three aspects that are related to the overall visual experience of waste signage including the visual design, the visual attractiveness, and its installation surroundings.

8-3.2 General recommendation for future research

If future researcher would like to partially or fully replicate this study, several recommendations are provided in the following.

It is recommended to **fully understand the targeted audience,** no matter whether CBSM is adopted as the main framework or not. McKenzie-Mohr (2011) has pointed out that researchers often fall into the pitfall attributed to their own preconceived notions. For example, developing interventions based on their prior knowledge without knowing their audience. Although many barriers and benefits can be identified according to the researchers' expertise and experiences, there can be vital challenges or opportunities left unaddressed. Ahmed et al. (2016) only conducted their sorting quiz in the middle of their study instead of at the initial phase, even though their survey results basically align with their study design, it is not recommended under the framework of CBSM. Failing of understanding the targeted audience thoroughly can result in identifying inappropriate or irrelevant barriers and benefits, resulting in low or no influence intervention because the main issues are not dealt with. Reviewing similar cases and literature is critical, however, challenges and chances can be very different even with similar study background, since waste sorting behaviour research can be case sensitive.

Future research can also consider **segmenting the target group members,** and then identify the specific benefits toward each segmented group of audiences. Segmentation was not conducted in this study because it was considered that the sign change aimed to be widely implemented, and universally used by the public on campus. As stated above, due to the standard change, the experimental sign designed in this study aimed to reach as many users' attention as possible, so segmentation was not

considered. Several previous studies and the stage of change model have suggested that interventions and messages should be given to the targeted audience according to which stage they are in the process of behaviour changes (Pearson & Perera, 2018), because concerns regarded important to each users' segmentation can differ.

Adopting a comprehensive method with more than one research tool can help address disadvantages and strengthen the advantages of the selected research tools, which can provide strong research findings. Since each research tool has its pros and cons, relying on only one research tool might be unable to provide strong evidence. Whereas by combining multiple research tools, the researchers are then able to investigate the research question from different perspectives, then come up with more convincing arguments.

If observation is selected, some suggestions are concluded from this study, especially for future field work researchers. As mentioned earlier, signage change might not bring major changes to behaviour at once; therefore, a longer duration and larger sample is suggested. A fixed three-hour observation time did not seem to result in sufficient records for statistic analysis in this study. While the user traffic varies from places to places, so instead of setting a fix observation time, future researchers can consider setting a goal number for records (Ahmed et al., 2016). Observations can be done using electronic video recording devices if applicable. In addition, rather than quantitatively distinguishing the users' sorting behaviour with standardized variables, qualitative descriptions recorded in the observation have showed to be fairly informative in this study. For example, with a same result of sorting napkins wrongly, some users read the sign after the sorting has been completed; some users simply threw everything in one bin; and some users showed hesitation toward the information given by the sign. These examples resulted in the same way, while the reasons can be different, and different response or solutions can then be provided according to each reason.

If waste audit is selected, this study demonstrated that a two-day waste sample was not enough to see obvious trends in waste-sorting behaviour. One week or several consecutive weeks are considerable duration for waste audit sample collection (BOMA Canada, n.d.). In addition, it is better not to rely only on the numeric metrics, i.e., diversion rate, contamination rate, and capture rate. These metrics were shown to work well in studies that analyze annual or monthly samples, or large volume samples. However, it is noticed in this study that many mis-sorted items are very light, e.g., plastic cutlery and napkins, while they only make up very small share of the waste sample if only analyzed by weight.

Avoiding or reducing any unwanted noises and inconsistency is highly recommended for real-world implementation. If the noises are unavoidable, researchers should include them in the results, because it is noticed that users' sorting behaviour is very sensitive, and small disturbances can make a great difference. Wisely select study unit can also help avoid undesired inconsistency. An unexpected inconsistency situation happened in this study. The experimental signs were only installed on one selected unit, while there are other units installed with the original signs or other type of receptacles. As a result, users may experience inconsistent signs and waste collection system, which accidentally generated another inconsistency that is already identified to be a barrier. Therefore, rather than having the experimental units spread out, selecting one or few specific buildings or sites would improve this study, as well as changing all receptacle signs within the selected area.

Adopting other messages or manipulating other factors related to visual design of waste signage is an important step for future research**.** Particularly, this study had a shift of sorting standards, which also restricted the flexibility of selecting what content to display in the design, since delivering the correct information is one of the top concerns. However, future researchers could try to test other messages or to promote the identified benefits instead of merely presenting informative examples, if sorting standards remain the same before and after the intervention. After all, the sign design used in this study is example-based, while signage can not only display information, but pass on other messages (Dupré & Meineri, 2016; Verdonk et al., 2017). Future researchers can adopt messages that may shape social norms, or descriptive, normative or persuasive messages reportative messages setting personal or collective goals (Dupré & Meineri, 2016); adding fun factors (Lin et al., 2016), or giving rationales instead of examples.

Moreover, future researchers can also investigate how signage can assist users with **different past experiences.** It is fairly common nowadays that many institutions or events have people with diverse cultural backgrounds (Tangwanichagapong et al., 2017; Wu et al., 2018) or people who processed different past experiences on waste sorting (Dahle & Neumayer, 2001; Kollmuss & Agyeman, 2002).

The strength of **social norms can change according to different cultural backgrounds**, with the follower effect adding on, such that the overall waste sorting results can vary widely from places to places. Stoeva & Alriksson (2017)have pointed out that variances of cultural background can results in different pro-environmental behaviours, and Berger & Hevenstone (2016) also stated that the same intervention end up with different outcomes at sites in different countries.

In addition, researchers can also manipulate other factors related to visual design, e.g., displaying practical items (Johnson, 2013); the density of displayed items; or the total numbers of signs presented

at once. Similar visual experience research has been done on receptacles, such as the arrangement, the proximity, the shape of the outlets, with or without lids, while research discussing about waste signage are relatively fewer.

This study has demonstrated the potential of altering the visual design of waste signage integrating CBSM to improve the waste sorting behaviour of the community on UW campus. Promising behaviour change findings are concluded, however, it is believed by solely implementing waste sign may not result with strong enough stimulation to motivate a desirable level of waste sorting improvement. Misconception and past sorting experience are noticed to be very influential factors that are seriously affecting the effect of signs toward the target audience. Therefore, other interventions or advance improvement on signs are in need.

References

2008 UWO Waste Audit Report. (2008). University of Western Ontario, EnviroWestern. http://www.usc.uwo.ca/envirowestern/Projects/Waste%20Audit/WasteAudit_2008.pdf

Ahmed, F., Khanani, R., & Koshy, T. (2016). *Comparative Analysis of Visual Triggers in Waste Management* (p. 44).

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In *Action control* (pp. 11–39). Springer.

Ajzen, I. (1991a). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211.

Ajzen, I. (1991b). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, *50*, 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2011). The theory of planned behaviour: Reactions and reflections. *Psychology & Health*, *26*(9), 1113–1127. https://doi.org/10.1080/08870446.2011.613995

Allin, D., Battiston, A., Lowry, J., & Thompson, K. (2003). *How far would you go to recycle?*

Andrews, A., Gregoire, M., Rasmussen, H., & Witowich, G. (2013). Comparison of recycling outcomes in three types of recycling collection units. *Waste Management*, *33*(3), 530–535. https://doi.org/10.1016/j.wasman.2012.08.018

Armstrong, G. M., Kotler, P., Trifts, V., Buchwitz, L. A., & Gaudet, D. (2016). *Marketing: An Introduction, Sixth Canadian Edition*. Pearson Education Canada. https://books.google.ca/books?id=7KRYjgEACAAJ

Austin, J., Hatfield, D. B., Grindle, A. C., & Bailey, J. S. (1993). Increasing recycling in office environments: The effects of specific, informative cues. *Journal of Applied Behavior Analysis*, *26*(2), 247–253. https://doi.org/10.1901/jaba.1993.26-247

Barker, K., Fong, L., Grossman, S., Quin, C., & Reid, R. (1994). Comparison of Self-Reported Recycling Attitudes and Behaviors with Actual Behavior. *Psychological Reports*, *75*(1), 571–577. https://doi.org/10.2466/pr0.1994.75.1.571

Barr, S., Guilbert, S., Metcalfe, A., Riley, M., Robinson, G. M., & Tudor, T. L. (2013). Beyond recycling: An integrated approach for understanding municipal waste management. *Applied Geography*, *39*, 67–77. https://doi.org/10.1016/j.apgeog.2012.11.006

Bator, C., Schierholtz, J., Woods, R., & Scoular, M. (2001). *On campus recycling knowledge of Environmental Studies Students*.

Berger, J., & Hevenstone, D. (2016). Norm enforcement in the city revisited: An international field experiment of altruistic punishment, norm maintenance, and broken windows. *Rationality and Society*, *28*(3), 299–319. https://doi.org/10.1177/1043463116634035

Berglund, C. (2006). The assessment of households' recycling costs: The role of personal motives. *Ecological Economics*, *56*(4), 560–569. https://doi.org/10.1016/j.ecolecon.2005.03.005

BOMA Canada. (n.d.). *Waste Auditing Guide Guiding Principles*. BOMA Canada.

Bourner, R. (n.d.). *Public Space Recycling Project Assessment* (p. 25). AET Group.

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American Psychologist*, *32*(7), 513.

Brooks, A. L., Wang, S., & Jambeck, J. R. (2018). The Chinese import ban and its impact on global plastic waste trade. *Science Advances*, *4*(6), eaat0131. https://doi.org/10.1126/sciadv.aat0131

Buchan, B. (n.d.). *BENEFITS OF AN INTERNAL WASTE AUDIT*. 13.

Calori, C., & Vanden-Eynden, D. (2015). *Signage and wayfinding design: A complete guide to creating environmental graphic design systems*. Wiley Online Library.

Campbell, D. T., & Stanley, J. C. (2015). *Experimental and quasi-experimental designs for research*. Ravenio Books.

Chen, L (2010). Obstacle and suggestions to garbage sorting and recycling in Shanghai, *3*(12), 24–28. https://doi.org/10.3969/j.issn.1674-0912.2010.12.008912.2010.12.008

Cheng, K. (2016, September 16). *Smart Bins: An Interactive Installation at the University of Washington* [Interview]. https://vimeo.com/183034021

Chiou, H. (2009). Quantitative Research and Statistic Analysis: SPSS in Social and Behavioral Sciences. Chongqing University Press.

Choon, S.-W., Tan, S.-H., & Chong, L.-L. (2017). The perception of households about solid waste management issues in Malaysia. *Environment, Development and Sustainability*, *19*(5), 1685–1700. https://doi.org/10.1007/s10668-016-9821-8

Chow, S., & Tsun, T. (2005). *Organic waste diversion at Ron Eydt Village (V2)*.

Chung, E. (2018, April 6). Many Canadians are recycling wrong, and it's costing us millions | CBC News. *CBC*. https://www.cbc.ca/news/technology/recycling-contamination-1.4606893

Clarke, A., Jajko, M., & Droeske, S. (2005). *Waste audit of the Great Hall in the Student Life Centre*.

Cole, E. J., & Fieselman, L. (2013). A community-based social marketing campaign at Pacific University Oregon: Recycling, paper reduction, and environmentally preferable purchasing. *International Journal of Sustainability in Higher Education*, *14*(2), 176–195. https://doi.org/10.1108/14676371311312888

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed). SAGE Publications.

Creswell, J. W., & Clark, V. L. P. (2011). *Designing and Conducting Mixed Methods Research*. SAGE.

Cushing, J., Quan, N. Q., & Thornton, B. (2005). *Alkaline Battery Recycling at the University of Waterloo*.

Dahle, M., & Neumayer, E. (2001). Overcoming barriers to campus greening: A survey among higher educational institutions in London, UK. *International Journal of Sustainability in Higher Education*, *2*(2), 139–160. https://doi.org/10.1108/14676370110388363

Dale, E., Nobe, M. C., Clevenger, C., & Cross, J. (2012). Community-Based Social Marketing: An Application to Facilities Management. *ICSDEC 2012*, 552–560. https://doi.org/10.1061/9780784412688.066

De Feo, G., Ferrara, C., Iannone, V., & Parente, P. (2019). Improving the efficacy of municipal solid waste collection with a communicative approach based on easily understandable indicators. *Science of The Total Environment*, *651*, 2380–2390. https://doi.org/10.1016/j.scitotenv.2018.10.161

Diehr, P., Hannon, P., Pizacani, B., Forehand, M., Meischke, H., Curry, S., Martin, D. P., Weaver, M. R., & Harris, J. (2011). Social Marketing, Stages of Change, and Public Health Smoking Interventions. *Health Education & Behavior*, *38*(2), 123–131. https://doi.org/10.1177/1090198110369056

Discussion paper on reducing litter and waste in our communities | Environmental Registry of Ontario. (2019). Ministry of the Environment, Conservation and Parks. https://ero.ontario.ca/notice/013-4689

Dupré, M., & Meineri, S. (2016). Increasing recycling through displaying feedback and social comparative feedback. *Journal of Environmental Psychology*, *48*, 101–107. https://doi.org/10.1016/j.jenvp.2016.07.004

Fredericks, A. J. (1981). *Attitude-behavior relationships: A comparison of the Fishbein-Ajzen and Bentler-Speckart models*. 103.

Gallant, N., FitzGibbon, J., Derry, J., & Whittington, P. (2001). *Boom or Bust: An examination of the recycling system at the Residences and Colleges at the University of Waterloo*.

Hao, Y., Wang, L.-O., Chen, X.-S., & Wang, L. (2018). THE DETERMINANTS OF WASTE-SORTING INTENTION AND BEHAVIOR AMONG CHINESE UNDERGRADUATE STUDENTS: A CASE STUDY IN BEIJING. *The Singapore Economic Review*, 1–26. https://doi.org/10.1142/S0217590817410077

Heathcote, A., Wilson, T., Milnes, K., Thompson, J., Woods, J., & Zipursky, D. (2010). *Conducting a Waste Audit in the Killam Library at Dalhousie University to Establish Waste Habits and Locate Problem Areas*. https://cdn.dal.ca/content/dam/dalhousie/pdf/science/environmental-science-program/ENVS%203502%20projects/2010/WasteAudit.pdf

Hong, I., Park, S., Lee, B., Lee, J., Jeong, D., & Park, S. (2014). IoT-Based Smart Garbage System for Efficient Food Waste Management. *The Scientific World Journal*, *2014*, 1–13. https://doi.org/10.1155/2014/646953

Hoornweg, D., Bhada-Tata, P., & others. (2012). *What a waste: A global review of solid waste management* (Vol. 15). World Bank, Washington, DC.

Illinois Sustainable Technology Center (ISTC). (2014). *Baseline_Waste_Stream_Characterization_Study_Final_Report.pdf*.

Intermediate Statistics One-Way ANOVA- In-class Example Adjusting For Heterogeneity of Variance. (n.d.). University of Northern Arizona. http://oak.ucc.nau.edu/rh232/courses/EPS625/Handouts/One-Way%20ANOVA/ANOVA%20-%20Example%20-%20Welch%20and%20G-H%20-%20Key.pdf

Jiang, Q., Izumi, T., Yoshida, H., Dilixiati, D., Leeabai, N., Suzuki, S., & Takahashi, F. (2019). The effect of recycling bin design on PET bottle collection performance. *Waste Management*, *95*, 32–42. https://doi.org/10.1016/j.wasman.2019.05.054

Johnson, J. (2013). *Husky Den Waste Bin Signage*. 19 August 2019 Retrieved from University of Washington website: http://uwgarbology.weebly.com/uploads/1/3/0/1/13017489/husky_den_signage_analysis_v1.0.pdf

Johnson, J. (2016, September 16). *Smart Bins: An Interactive Installation at the University of Washington* [Interview]. https://vimeo.com/183034021

Kollmuss, A., & Agyeman, J. (2002). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, *8*(3), 239–260. https://doi.org/10.1080/13504620220145401

Kotler, P. (1971). *Social Marketing: An Approach to Planned Social Change*. 11.

Kozak, M., Elliot, L., Reid, C., & Harvey, B. (2004). *Co-Op building recycling program audit*.

Lampi, D. K. (1998). *Waste audit of information systems and technology*.

Lee, N. R., & Kotler, P. (2011). *Social marketing: Influencing behaviors for good*. Sage Publications.

Lee, N. R., & Kotler, P. (2015). *Social marketing: Changing behaviors for good*. Sage Publications.

Leigh, S. (2018). *There's No Such Thing as 'Garbage' | TEDxQuestU*. https://www.youtube.com/watch?v=xJYQafRwIv0

Levitt, S. D., & List, J. A. (2007a). What do laboratory experiments measuring social preferences reveal about the real world? *Journal of Economic Perspectives*, *21*(2), 153–174.

Levitt, S. D., & List, J. A. (2007b). Viewpoint: On the generalizability of lab behaviour to the field. *Canadian Journal of Economics/Revue Canadienne d'économique*, *40*(2), 347–370. https://doi.org/10.1111/j.1365-2966.2007.00412.x

Lin, Z., Wang, X., Li, C., Gordon, M., & Harder, M. (2016). Visual Prompts or Volunteer Models: An Experiment in Recycling. *Sustainability*, *8*(5), 458. https://doi.org/10.3390/su8050458

Ma, J., & Hipel, K. W. (2016). Exploring social dimensions of municipal solid waste management around the globe – A systematic literature review. *Waste Management*, *56*, 3–12. https://doi.org/10.1016/j.wasman.2016.06.041

McDougall, F. R., White, P. R., Franke, M., & Hindle, P. (2008). *Integrated solid waste management: A life cycle inventory*. John Wiley & Sons.

McEachren, J., Formanek, A., & Dance, K. (2004). *The Feasibility of a campus wide composting program at the University of Waterloo*.

McKenzie-Mohr, D. (2000). New Ways to Promote Proenvironmental Behavior: Promoting Sustainable Behavior: An Introduction to Community-Based Social Marketing. *Journal of Social Issues*, *56*(3), 543–554. https://doi.org/10.1111/0022-4537.00183

McKenzie-Mohr, D. (2011). *Fostering sustainable behavior: An introduction to community-based social marketing*. New society publishers.

Menzer, L., Parnell-Wolfe, I., O'Carroll, M., & Perkins, D. (2013). *Behavioral economics of waste management: Identifying factors that influence personal waste sorting practices*. 21 June 2019 Retrieved from University of California, Santa Barbara website:
https://www.facilities.ucsb.edu/files/docs/UCSB_R3C_Behavioral_Economics_of_Personal_Waste%20Sorting_Practices.pdf

Miller, D., Merrilees, B., & Coghlan, A. (2015). Sustainable urban tourism: Understanding and developing visitor pro-environmental behaviours. *Journal of Sustainable Tourism*, *23*(1), 26–46. https://doi.org/10.1080/09669582.2014.912219

Miller, N. D., Meindl, J. N., & Caradine, M. (2016). The Effects of Bin Proximity and Visual Prompts on Recycling in a University Building. *Behavior and Social Issues*, *25*, 4. https://doi.org/10.5210/bsi.v25i0.6141

Ministry of Environmental Protection of the People's Republic of China. (2017). *Notification on Catalogue of Solid Wastes Forbidden to Import into China by the End of 2017*. https://docs.wto.org/dol2fe/Pages/FE_Search/FE_S_S009-DP.aspx?language=E&CatalogueIdList=237688

Morlok, J., Schoenberger, H., Styles, D., Galvez-Martos, J.-L., & Zeschmar-Lahl, B. (2017). The Impact of Pay-As-You-Throw Schemes on Municipal Solid Waste Management: The Exemplar Case of the County of Aschaffenburg, Germany. *Resources*, *6*(1), 8. https://doi.org/10.3390/resources6010008

Ontario's Five Year Climate Change Action Plan 2016 – 2020. (2016). Government of Ontario, Ministry of the Environment, Conservation and Parks (was the Ministry of the Environment and Climate Change at released time). http://www.applications.ene.gov.on.ca/ccap/products/CCAP_ENGLISH.pdf

PASW Statistics for Windows (Version 18.0). (2009). [Computer software]. SPSS Inc.

Peattie, S., & Peattie, K. (2003). Ready to Fly Solo? Reducing Social Marketing's Dependence on Commercial Marketing Theory. *Marketing Theory*, *3*(3), 365–385. https://doi.org/10.1177/147059310333006

Preserving and Protecting our Environment for Future Generations: A Made-in-Ontario Environment Plan. (2018). 54.

Rousta, K., Ordoñez, I., Bolton, K., & Dahlén, L. (2017). Support for designing waste sorting systems: A mini review. *Waste Management & Research*, *35*(11), 1099–1111. https://doi.org/10.1177/0734242X17726164

Statistics Canada. (2012). *Human Activity and the Environment: Waste managment in Canada*. https://www.jstor.org/stable/3549992?origin=crossref

Stoeva, K., & Alriksson, S. (2017). Influence of recycling programmes on waste separation behaviour. *Waste Management*, *68*, 732–741. https://doi.org/10.1016/j.wasman.2017.06.005

Tangwanichagapong, S., Nitivattananon, V., Mohanty, B., & Visvanathan, C. (2017). Greening of a campus through waste management initiatives: Experience from a higher education institution in Thailand. *International Journal of Sustainability in Higher Education*, *18*(2), 203–217. https://doi.org/10.1108/IJSHE-10-2015-0175

Terry, D. J., Hogg, M. A., & White, K. M. (1999). The theory of planned behaviour: Self-identity, social identity and group norms. *British Journal of Social Psychology*, *38*(3), 225–244. https://doi.org/10.1348/014466699164149

Thaler, R. H., & Sunstein, C. R. (2009). *Nudge: Improving decisions about health, wealth, and happiness*. Penguin.

The Fun Theory 2 – an initiative of Volkswagen: The World's Deepest Bin. (2009). https://www.youtube.com/watch?v=qRgWttqFKu8

The Regulations of Shanghai Municipal Living Waste Management (上海市生活垃圾管理条例), (2019) http://lhsr.sh.gov.cn/sites/ShanghaiGreen/dyn/ViewCon.ashx?ctgId=36ce0624-66b4-470c-9f7b-22682eaec705&infId=e2825314-7f1a-4d9d-9fa5-5c70894c2776

Thijssen, M. (2018). *University of Waterloo Recycling Standard*. University of Waterloo. https://uwaterloo.ca/sustainability/sites/ca.sustainability/files/uploads/files/recycling_standard_2018.pdf

Tonglet, M., Phillips, P. S., & Read, A. D. (2004). Using the Theory of Planned Behaviour to investigate the determinants of recycling behaviour: A case study from Brixworth, UK. *Resources, Conservation and Recycling*, *41*(3), 191–214. https://doi.org/10.1016/j.resconrec.2003.11.001

Ummat, N. (n.d.). *Promoting Waste Diversion through Site Specific Waste Bin Standards Dalhousie University Case Study*. 80.

Ummat, N. (2013). *Promoting Waste Diversion through Site Specific Waste Bin Standards Dalhousie University Case Study*. https://divertns.ca/assets/files/FINAL-REPORT-Promoting-Waste-Diversion-through-Site-Specific-Waste-Bin-Standards-Dalhousie-University-Case-Study_compressed-2.pdf

United Nation [UN] General Assembly. (2015). *Sustainable Development goals*.

University of British Columbia. (n.d.). *Sort it Out*. Retrieved November 26, 2019, from http://sorting-game.herokuapp.com/

University of Waterloo. (n.d.-a). *A-Z Sorting Guide*. Sustainability - A-Z Sorting Guide. Retrieved January 20, 2020, from https://uwaterloo.ca/sustainability/projects-and-initiatives/waste/sorting-guide

University of Waterloo. (n.d.-b). *What you can do*. Sustainability. Retrieved January 20, 2020, from https://uwaterloo.ca/sustainability/projects-and-initiatives/waste/what-you-can-do

University of Waterloo. (2018a). *2018_sustainability_report_summary_accessible.pdf*.

University of Waterloo. (2018b). *Environmental Sustainability Report* (p. 40).

University of Waterloo. (2018c, August 15). *Zero Waste Action Plan*. Sustainability. https://uwaterloo.ca/sustainability/projects-and-initiatives/waste/zero-waste-action-plan

University of Waterloo. (2019a). *Student Headcounts | Institutional Analysis & Planning | University of Waterloo*. https://uwaterloo.ca/institutional-analysis-planning/university-data-and-statistics/student-data/student-headcounts

University of Waterloo. (2019b, November 11). *Waste and Water Data*. Sustainability. https://uwaterloo.ca/sustainability/about/reporting/waste-and-water-data

Verdonk, S., Chiveralls, K., & Dawson, D. (2017). Getting Wasted at WOMADelaide: The Effect of Signage on Waste Disposal. *Sustainability*, *9*(3), 344. https://doi.org/10.3390/su9030344

Viola, P., Hermsen, K., & Dunbar, B. (2005). *Environmental indicators for graphic services*.

Wan, C., Cheung, R., & Qiping Shen, G. (2012). Recycling attitude and behaviour in university campus: A case study in Hong Kong. *Facilities*, *30*(13/14), 630–646. https://doi.org/10.1108/02632771211270595

Wan, C., Shen, G. Q., & Choi, S. (2017). Experiential and instrumental attitudes: Interaction effect of attitude and subjective norm on recycling intention. *Journal of Environmental Psychology*, *50*, 69–79. https://doi.org/10.1016/j.jenvp.2017.02.006

Wan, C., Shen, G. Q., & Yu, A. (2014). The role of perceived effectiveness of policy measures in predicting recycling behaviour in Hong Kong. *Resources, Conservation and Recycling*, *83*, 141–151. https://doi.org/10.1016/j.resconrec.2013.12.009

Wang, J., Yuan, H., Kang, X., & Lu, W. (2010). Critical success factors for on-site sorting of construction waste: A china study. *Resources, Conservation and Recycling*, *54*(11), 931–936. https://doi.org/10.1016/j.resconrec.2010.01.012

Waste Management. (n.d.). Waste Management: International Journal of Integrated Waste Management, Science and Technology. Retrieved January 9, 2020, from https://www.journals.elsevier.com/waste-management

Waste Reduction Group Inc. (2017). *University of Waterloo—2017 Waste Audit*.

Wu, D. W.-L., Lenkic, P. J., DiGiacomo, A., Cech, P., Zhao, J., & Kingstone, A. (2018). How does the design of waste disposal signage influence waste disposal behavior? *Journal of Environmental Psychology*, *58*(Complete), 77–85. https://doi.org/10.1016/j.jenvp.2018.07.009

Wymer, W. (2011). Developing more effective social marketing strategies. *Journal of Social Marketing*, *1*(1), 17–31. https://doi.org/10.1108/20426761111104400

Appendices

A. Existing Waste Collection Receptacles on the UW Campus

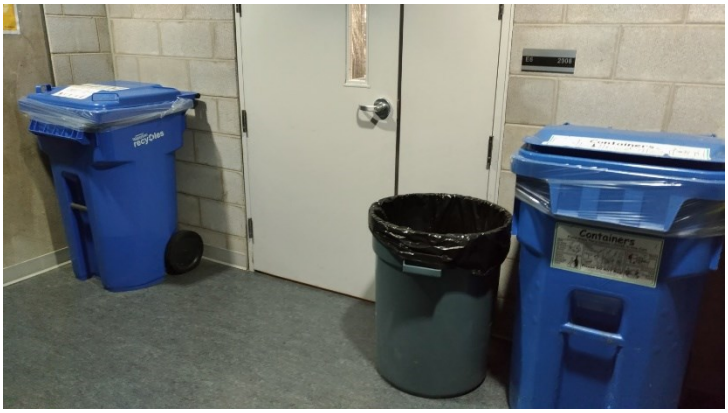

Figure A-1 Several bins placed side-by-side
(Different streams but not all options available)

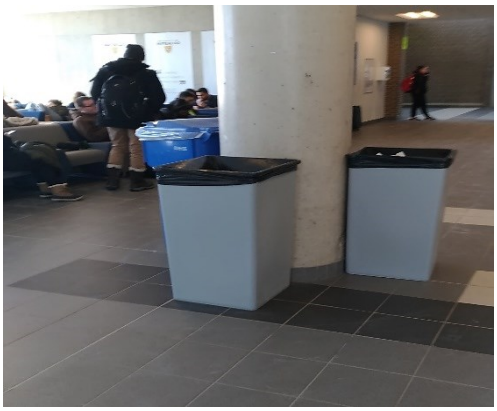

Figure A-2 Several bins placed close by
(Different streams but not all options available)

Figure A-3 Multiple bins placed close by
(Same streams)

Figure A-4 Single bin

Figure A-5 small garbage can
(Class room/ labs/ office, often show up alone)

Figure A-6 One receptacle with multiple streams
(Not all options available)

B. Survey Questionnaire

UW Campus Waste Sorting Survey

You are invited to participate in a study about **improving the waste sorting signage on the campus of the University of Waterloo (UW).** The purpose of this study intends to come up with more user-friendly and less confusing signage that could assist people on campus better sort their waste. This survey will help us have a better understanding of the current waste sorting habit and problem people share. This anonymous questionnaire includes **22 questions**, it will take you about **10-15 minutes**. We ask you to answer the questions base on your attitude, habits, and experiences related to waste sorting. Your participation in this study is voluntary. You may decline to answer any question or withdraw your consent of participating in this study at any time. In appreciation of the time for your participation, you can enter a draw. **Each prize is a $10 Watcard top up credit**.

Participants having related sorting experiences on the main campus of UW is important, because this research aims to improve the user experience and the design of the waste station signages, and eventually improve the waste sorting rate on campus. Therefore, **only people who currently work or study at the main campus of UW are eligible to participate**.

This study is conducted under the supervision of Dr. Jennifer Lynes Murray, and it is part of Ya Han Yang's master level thesis research for the School of Environment, Enterprise and Development, University of Waterloo. **The collected data will be shared with the UW sustainability office and may be used for future research**, while the confidentiality will remain the same standard. This survey uses an online survey operated by Qualtrics Insight Platform. When information is transmitted over the internet, privacy cannot be guaranteed. There is always a risk your responses may be intercepted by a third party. We will not collect or use internet protocol (IP) addresses or other information which could link your participation to your computer or electronic device without first informing you. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#40281). This study is funded by the UW sustainability Action Fund. For the full version of this consent letter please see here. If you have any question regarding this study or would like additional

information to assist you in reaching a decision about participation, please email yh6yang@uwaterloo.ca. Thank you.

○ **I understand and acknowledge that by checking this box I give my consent to participate in this study.**

Basic Info

Q1 **What is your current status at University of Waterloo?**

- **Undergraduate** Student of UW (including CO-OP term)
- **Graduate** Student of UW
- **Faculty member/lecturer** of UW (including sessional/adjunct)
- **Staff** of UW
- Any other **short-term status more than 4 months** in UW (e.g., Exchange / Visiting scholars, etc.)
- **None of the above**

Q2 **Which faculty or area of UW are you affiliated with?**

- Arts
- Applied Health Science
- Engineering
- Environment
- Mathematics
- Science
- Conrad Grebel University College
- Renison University College
- St Jerome's University
- St Paul's University College
- University offices and services (e.g. administration, plant operations, CECA, etc)
- Other _____

Q3 Which age group do you fall under?

- 17 - 23
- 24 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 or above
- Prefer not to answer

Q4 **Which gender identity do you most identify with?**

- Male
- Female
- Gender diverse (variant/ non-conforming)
- Prefer not to answer
- Other _____

Q5 **Do you currently live on campus or off campus?**

- I live **off campus**
- I live in a **campus residence**

Q6 **Except for garbage collection, which of the following waste collection options are available where you currently live?**

- Only **blue** bins or streams to collect **recyclable** items.
- Only **green/compost/organic** bins or streams to collect **composting /organic** items.
- **Both** blue bins (recycle stream) **AND** green/compost bins (organic stream).
- **Neither** blue bins **nor** green bins.

Sorting quiz

Q7 **The following statements ask you about waste sorting criteria in different geographic areas.** Please select "True" if you think the statement is correct, and select "False" if you think the statement is incorrect.

	True	**False**
Waste sorting criteria **are exactly the same throughout Canada.**		
Waste sorting criteria are **exactly the same throughout Ontario.**		
Waterloo region waste sorting criteria **are different from other regions in Ontario.**		
Waste sorting criteria on **UW** campus **are different from the region of Waterloo.**		

The next section asks you to sort different items into the appropriate bin. Please base on **your understanding of waste sorting criteria on the UW campus** to answer the following questions.

Q8-11 Please **sort the following waste items into their appropriate waste bins** by clicking one of the five waste categories indicated on the right side of the screen.

	Organic	Paper	Container	Garbage	Other
Bones /Egg shells /Food scraps	○	○	○	○	○
Used paper plates	○	○	○	○	○
Pizza boxes	○	○	○	○	○
Used napkins	○	○	○	○	○
Flyers/Brochures	○	○	○	○	○
Coffee cup	○	○	○	○	○
Coffee cup lid	○	○	○	○	○
Plastic food wrap /Cling wrap	○	○	○	○	○
Styrofoam container	○	○	○	○	○
Shredded printing paper	○	○	○	○	○

	Organics	Paper	Containers	Garbage	Other
Paper straw	○	○	○	○	○
Fountain drink cup	○	○	○	○	○
Plastic straw	○	○	○	○	○
Plastic beverage cups	○	○	○	○	○

Empty yogurt tub	○	○	○	○	○

	Organic	Paper	Container	Garbage	Other
Milk / Juice box	○	○	○	○	○
Plastic bottle	○	○	○	○	○
Cardboard box	○	○	○	○	○
Plastic bags	○	○	○	○	○
Plastic food container	○	○	○	○	○

	Organic	Paper	Container	Garbage	Other
Coffee filter	○	○	○	○	○
Potato chip bag	○	○	○	○	○
Tetra Pak	○	○	○	○	○
Pop can	○	○	○	○	○
Plastic disposable cutlery	○	○	○	○	○

User sorting experience on campus
Please answer the following questions according to **how you conduct waste sorting on campus.**

Q12 Please rank the waste bins you have used on campus according to how often you use them. **Drag and drop** the photo to the appropriate box. Note: sometimes it takes a few seconds for the photos to load.

Rank 1 (most frequent)	Rank 2	Rank 3 (least frequent)
_____ Multi-streamed waste station	_____ Multi-streamed waste station	_____ Multi-streamed waste station
_____ Bins/carts that collect single type of waste.	_____ Bins/carts that collect single type of waste.	_____ Bins/carts that collect single type of waste.
_____ Small garbage bin in classrooms, libraries, offices, labs, and other public areas.	_____ Small garbage bin in classrooms, libraries, offices, labs, and other public areas.	_____ Small garbage bin in classrooms, libraries, offices, labs, and other public areas.

Q13 **How often do you check the instructions attached to the bins before throwing your waste?**

- Always
- Most of the time
- About half the time
- Seldom
- Never

Q14 When you are at a waste station with multiple streams on campus, for example, recycling, waste, compost, etc., how do you decide which bin to throw your waste in? (please **select up to three statements that best describe your situation**)

- I simply put all my waste in one bin that is the closest or the most convenient one.
- I throw my waste based on past experience.
- I refer to the instructions/signs on or around the waste bins.
- I look on the packaging to see what material it is made from or look for disposal instructions on the package.
- I ask people who are around me, or I refer the suggestion of people who I trust.
- I search online before throwing away my waste.
- I follow others in front of me or throw it to the same bin where I can see similar waste thrown by others earlier.
- I refer to printed material other than instructions/signs, such as guidelines, brochures, etc., to help me decide which bin to sort my waste.
- Other: please specify _____

Barriers and Benefits

For the following questions, please tell us **your thoughts and experiences regarding waste sorting on campus**.

Q15. What **motivates** you to sort your waste on campus?

_____

_____

Q16. Based on the following statements, which would you consider **as motivations for you to sort your waste on campus**? (rank up to **3 motivations** from the list below)

Motivation 1 (i.e. top motivation)	Motivation 2	Motivation 3
_____ Not Applicable: I don't see any benefit or advantage of sorting waste.	_____ Not Applicable: I don't see any benefit or advantage of sorting waste.	_____ Not Applicable: I don't see any benefit or advantage of sorting waste.
_____ Proper sorting is useful, because the waste gets recycled and reused.	_____ Proper sorting is useful, because the waste gets recycled and reused.	_____ Proper sorting is useful, because the waste gets recycled and reused.
_____ Proper sorting is responsible, because we [humans] need to deal with our own waste.	_____ Proper sorting is responsible, be4e cause we [humans] need to deal with our own waste.	_____ Proper sorting is responsible, because we [humans] need to deal with our own waste.
_____ Proper sorting is practical, because it benefits and speeds up the processing of waste afterwards.	_____ Proper sorting is practical, because it benefits and speeds up the processing of waste afterwards.	_____ Proper sorting is practical, because it benefits and speeds up the processing of waste afterwards.
_____ Proper waste sorting reduces the amount of waste goes into landfills.	_____ Proper waste sorting reduces the amount of waste goes into landfills.	_____ Proper waste sorting reduces the amount of waste goes into landfills.
_____ Proper waste sorting improves my personal reputation.	_____ Proper waste sorting improves my personal reputation.	_____ Proper waste sorting improves my personal reputation.
_____ Proper waste sorting aligns with my personal principles.	_____ Proper waste sorting aligns with my personal principles.	_____ Proper waste sorting aligns with my personal principles.
_____ I feel good about myself when I properly sort my waste.	_____ I feel good about myself when I properly sort my waste.	_____ I feel good about myself when I properly sort my waste.
_____ I feel guilty about myself if I did not properly sort my waste.	_____ I feel guilty about myself if I did not properly sort my waste.	_____ I feel guilty about myself if I did not properly sort my waste.
_____ I am concerned with the health and well-being of the surrounding I study/work in.	_____ I am concerned with the health and well-being of the surrounding I study/work in.	_____ I am concerned with the health and well-being of the surrounding I study/work in.

Q17. What do you find **challenging** about sorting waste on campus?

_____

_____

Q18 What are the possible reasons, **barriers,** or concerns that **stop you sorting your waste properly on campus?** (please **rank up to 3 challenges** from the list below dragging and dropping them into the boxes on the right)

Rank 1	Rank 2	Rank 3
_____ Not Applicable: I don't see any challenges	_____ Not Applicable: I don't see any challenges	_____ Not Applicable: I don't see any challenges
_____ I'm always in a rush.	_____ I'm always in a rush.	_____ I'm always in a rush.
_____ I find it a waste of time.	_____ I find it a waste of time.	_____ I find it a waste of time.
_____ I find the recycling bins are not in convenient locations	_____ I find the recycling bins are not in convenient locations	_____ I find the recycling bins are not in convenient locations
_____ I find it inconvenient to do the sorting at bins.	_____ I find it inconvenient to do the sorting at bins.	_____ I find it inconvenient to do the sorting at bins.
_____ I find it confusing, because the instructions for sorting are not clear.	_____ I find it confusing, because the instructions for sorting are not clear.	_____ I find it confusing, because the instructions for sorting are not clear.
_____ I am not sure where to put things because I don’t have enough information or knowledge.	_____ I am not sure where to put things because I don’t have enough information or knowledge.	_____ I am not sure where to put things because I don’t have enough information or knowledge.
_____ I find it annoying/boring/tedious.	_____ I find it annoying/boring/tedious.	_____ I find it annoying/boring/tedious.
_____ I don’t see enough benefit, advantage, or necessity for me of doing it.	_____ I don’t see enough benefit, advantage, or necessity for me of doing it.	_____ I don’t see enough benefit, advantage, or necessity for me of doing it.
_____ I don’t think it makes much difference to the world/environment.	_____ I don’t think it makes much difference to the world/environment.	_____ I don’t think it makes much difference to the world/environment.
_____ There is no streamed bins or appropriate carts for waste sorting around.	_____ There is no streamed bins or appropriate carts for waste sorting around.	_____ There is no streamed bins or appropriate carts for waste sorting around.
_____ The others are not sorting their waste, I then don’t think I need/should do it.	_____ The others are not sorting their waste, I then don’t think I need/should do it.	_____ The others are not sorting their waste, I then don’t think I need/should do it.

Q19.
How much do you **agree or disagree** with the following statements based on your experience of waste sorting on UW campus? (move the bar along the scale)

	Strongly disagree 1	**Somewhat disagree** 2	**Somewhat agree** 3	**Strongly agree** 4	Neither agree nor disagree
Time: I have enough time / I spare time for waste sorting.					
Knowledge/Information: I know what items can be recycled/ composted on campus.					
Location: I know where to take my recyclables/ compost for sorting and throwing.					
Location Convenience: The bins are located at convenient places for me to approach.					
Sufficient Infrastructure: UW have enough bins for me to sort my waste.					
Clarity of the instructions: The images, symbol, colour, and words attached to the bins are easy for me to understand.					
Sufficient instructions and information: UW provides enough information to help me properly sort my waste on campus					
Collection frequency/capacity: the bins have space (i.e. are not overflowing) for me to sort my waste when I need to					

Q20. **Who/what influences your waste sorting behaviour the most on campus?**

(Please <u>rank up to 3 influences</u>)

Rank 1 (top influence)	Rank 2	Rank 3
_____ Myself.	_____ Myself.	_____ Myself.
_____ My family.	_____ My family.	_____ My family.
_____ My friends/peers.	_____ My friends/peers.	_____ My friends/peers.
_____ My co-workers/colleagues.	_____ My co-workers/colleagues.	_____ My co-workers/colleagues.
_____ The general public.	_____ The general public.	_____ The general public.
_____ The media.	_____ The media.	_____ The media.
_____ Rules or laws.	_____ Rules or laws.	_____ Rules or laws.
_____ My religion/belief.	_____ My religion/belief.	_____ My religion/belief.
_____ My community/housemates/ landlords/neighbourhood.	_____ My community/housemates/ landlords/neighbourhood.	_____ My community/housemates/ landlords/neighbourhood.
_____ Environmental groups.	_____ Environmental groups.	_____ Environmental groups.
_____ Other (please specify).	_____ Other (please specify).	_____ Other (please specify).

Q21. **Please comment on any other challenges you have experienced adapting to UW's waste sorting practices on campus?** (For example, if you come from another area with different sorting practices or if the sorting system at home is different from the one on campus, etc).

_____

_____

C. Onsite Observation Recording Form

Date:2019/_____ Site:_____ Recorder: _____

	Time (min: sec)	Sign Reading?	Sorting or not?	Correct sorting?	Only 1 item	Use Other Bins	Other
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
16.							
17.							
18.							
19.							
20.							

D. Waste Audit Form

Site		Day: Wed Thur	Name	

	Organic	Container	Paper	Garbage
Total weight				
Contaminants weight				
# of contaminant items				
% of contaminant items				
Contaminant items				
Food waste				
Coffee cup				
Paper straws				
Paper food container				
Paper food bag				
Biodegradable cutlery				
Coffee lids				
Plastic cup				
Plastic cutlery				
Plastic food container				
Plastic straws				
Pop drink cup				
Styrofoam				
Food wrapper (garbage)				

E. Sign installation at each study site

- **Group A: Multi-use buildings (three-streamed)**

Figure E-1 SLC (Pre)

Figure E-2 SLC (Post) -large sign

Figure E-3 DP (Pre)

Figure E-4 DP (Post) – small sign (oops sign)
* Other bins exist

Figure E-5 DC – Control group
*other bins exist

- **Group B: Faculty buildings (four-streamed)**

Figure E-0-24 EV3 (Pre)
* Other bin exists

Figure E-7 EV3 (Post) – large sign

Figure E-8 AHS (Pre)

Figure E-9 AHS (Post) – small sign

Figure E-10 STC – Control group
*Other bins exist

- **Group C: Residence (four-streamed)**

Figure E-11 CMH (Pre)

Figure E-12 CMH (Post) -small sign

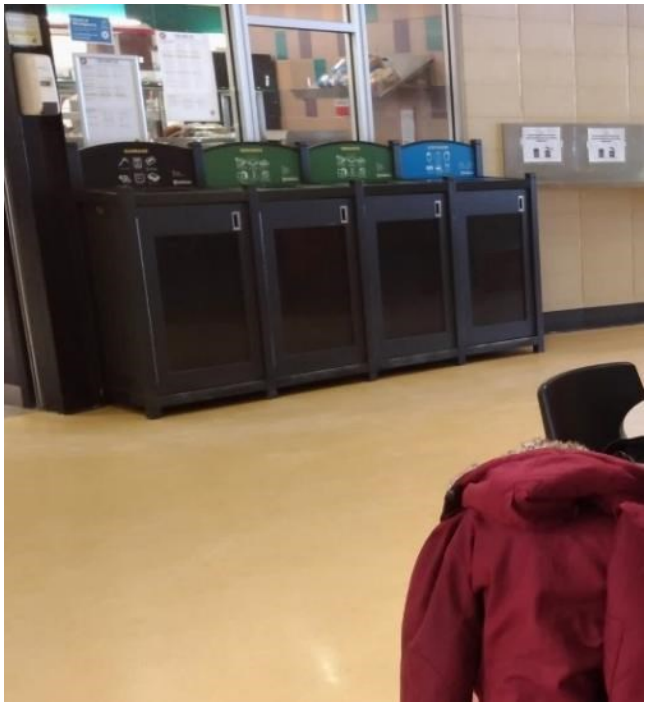

Figure E-13 REV – Control group

Figure E-14 V1 (Pre)

Figure E-15 V1 (Post) – large sign