UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Sorting Behaviours: Do 3D Display Boxes Improve Sorting Accuracy?

The Green Gang: Clare Talbot, Caroline Findikliev, Christina Davie, Ed Lau, Emma Noroian, & Nicole Pereyaslavsky

University of British Columbia

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Executive Summary

The purpose of our research study was to examine whether the sorting behaviours of individuals who frequented the Nest on the University of British Columbia campus would be improved by the addition of customized 3D display boxes to waste sorting bins, which originally featured 2D signage. To test our hypothesis that participants' sorting behaviours would be more accurate relative to the use of 3D display boxes, in comparison to existing 2D signage, participant behaviours at a sort-it-out station in the Nest were observed for a total of four weeks. The first two weeks consisted of a control condition, during which bins were observed with their original 2D signage, and the last two weeks consisted of an experimental condition, during which bins' 2D signage was replaced with 3D display boxes. When the conditions were compared through statistical analysis, the 3D display boxes were found to have a significant effect on the total number of items correctly disposed of, and on participants' individual measures of sorting accuracy. Our results show that 3D display boxes are an effective method of improving waste sorting accuracy and have valuable implications for sustainable policy and practices on and off the UBC campus.

Keywords: sorting accuracy, sustainability, 3D display boxes

Introduction

As public awareness of ongoing environmental degradation and accelerating climate change has evolved, and support for sustainable practices has increased, recycling has become a more frequently discussed topic. Some cities have developed more sustainable waste management programs, encouraging the adoption of composting and recycling practices. However, do such programs function as they are meant to? Are individuals informed enough to participate in such programs effectively? Are there sufficient resources to ensure accurate recycling behaviour?

Previous studies have sought to address these questions, many of which were conducted at the University of British Columbia (UBC), where the sustainability initiative is of great importance. Zelenika, Moreau, and Zhao (2018), studied the effects of three different types of waste management interventions at a campus event, including the implementation of bin tops, volunteer sorting assistance and the use of 3D display boxes. While their findings showed that the condition that featured volunteer sorting assistants reduced the greatest amount of contamination, certain complications could have contributed to insignificant results in the 3D box condition. Zelenika (2017) studied incidences of waste contamination at UBC. Following a control period, Zelenika (2017) compared measures of contamination among four different periods of intervention, which included basic signage, 'food is not garbage' signage, and new visual signage. The last intervention was a "door to door canvas" in which residents were reminded to participate in waste diversion. The research findings suggested that indicating the correct contents of waste bins through images, rather than through written signs, might improve recycling accuracy and reduce contamination. Lastly Wu, DiGiacomo, and Kingston. (2013), observed and compared recycling behaviours in the CIRS and Nest buildings on UBC campus. They found that participants observed at the CIRS building recycled more accurately than participants observed at the Nest. These results, however, may be explained by a tendency of those who frequently eat in the CIRS building to have a higher affinity towards sustainable behaviors and actions.

In our own study, we sought to explore how 3D display boxes alone, without 2D signage, would affect the sorting accuracy of disposables, compostables and recyclables among university students. We predicted that replacing existing 2D signage with 3D display boxes would improve sorting accuracy and reduce waste contamination.

Method

Participants

The study participants consisted of 986 people of various ages, ethnicities and socioeconomic backgrounds. During the control condition, observational data was collected from 474 participants. During the experimental condition, 512 participants were observed.

Conditions

The control condition consisted of empty display boxes above the sort-it-out station's existing 2D signage (see Images 1-4). The recycling accuracy of participants who used the waste disposal bins during the two weeks this configuration was maintained was observed and measured as part of the control condition. The experimental condition consisted of 3D display boxes filled with customized items indicating appropriate sorting categories, and the elimination of the sorting bins' original 2D signage (see Images 5-8). The recycling accuracy of participants who used the waste disposal bins during the two weeks this configuration was maintained was observed and measured as part of the experimental condition.

Measures

We conducted an observational study, which aimed to reveal the effects of the addition of customized 3D display boxes to disposal bins on sorting accuracy. We manipulated the disposal bins by adding thoughtfully chosen items to the 3D display cases, as well as by removing the bins' original 2D signage. The contents of the 3D display bins consisted of takeaway materials distributed by food vendors in the Nest, particularly those items which participants in the control condition seemed to find most difficult to sort. Sorting accuracy was measured by tracking the number of items participants sorted, as well as whether each items was sorted correctly or incorrectly in its category.

Procedures

Participant observations were conducted on the first floor of the UBC Nest. The sort-it-out stations observed were those facing Iwana Taco and the Grand Noodle Emporium. Observations were conducted on Tuesdays, Wednesdays and Thursdays between the hours of 11:00 am and 3:00 pm, with each observation period lasting two hours. During each observation period, a pair of coders observed participants' sorting accuracy and tallied, with the use of laptops, the types of items sorted, whether these items were sorted correctly or incorrectly, and the total number of items sorted.

The control condition was conducted over two weeks, from March 5, 2019 to March 1, 4, 2019, for a combined total of 12 hours. Prior to conducting observations on the experimental condition, the 3D display boxes above the sorting bins were filled with items available from food vendors in the Nest. UBC text-based and visual waste sorting guides were consulted to ensure the display boxes accurately depicted proper sorting guidelines (see Images 9 and 10). We made an effort to include in the 3D displays, items participants in the control condition had not sorted correctly. For example, we displayed a compostable soup bowl from the Deli above the compost bin to indicate this bin as the appropriate destination for this item of waste. The experimental condition was also conducted over the span of two weeks, from March 19, 2019 to March 28, 2019, also for a combined total of 12 hours.

Results

To analyze our observed data, we conducted an independent samples t-test to compare participants' correct and incorrect sorting behaviours. After collecting independent samples t-tests across all categories in each condition, we compared the total number items sorted correctly in the control condition ($M= 1.494$, $SD= 1.319$) and experimental condition ($M= 1.670$, $SD= 1.283$); $t(984.0)= -2.127$, $p= 0.017$ (Appendix Tables 1 & 2). We then considered the total number items sorted incorrectly in the control condition ($M= 0.806$, $SD= 1.043$) and experimental condition ($M= 0.801$, $SD= 1.045$); $t(984.0)= 0.077$, $p= 0.531$ (Appendix Table 1 & 2). We found that, while the 3D display boxes did not significantly affect the total number of items incorrectly disposed of, a significant effect was observed for the total number of items correctly disposed of.

Additionally, we calculated the percentage of sorting accuracy displayed by each participant, to determine if there was a change in values between conditions. To find this ratio, we divided the number of correctly sorted items by the total number of items. This percentage was calculated for each of our 986 observed participants. When comparing the percentage accuracy for the control condition ($M = 65.188$, $SD = 41.040$) to the percentage accuracy for the experimental condition ($M = 70.067$, $SD = 36.406$); $t(984.0) = -1.978$, $p = 0.024$, we found a significant effect (Appendix Figure 1 & 2).

We also analyzed the results for both correctly and incorrectly sorted items across the four types of sorting bins, which are compost, container recycling, paper recycling, and garbage. These overall results are shown in Appendix Table 1.

Discussion

The purpose of this study was to examine the effect of 3D display boxes as a replacement for 2D signage, on sorting behaviours displayed at waste sorting stations. As our results demonstrate, sorting accuracy per person significantly improved from the control condition to the experimental condition, proving our hypothesis. While the overall results showed a significant effect for the impact of 3D display boxes on sorting accuracy, this effect varied across the different categories of the sorting bins. Though a significant effect was not found across all of the categories of the sorting bins, there are a number of implications, limitations and suggestions which can be drawn from the study results.

The implications of our study are extensive, and can impact waste sorting systems both on and off the UBC campus. The custom 3D display boxes are easily interpretable, as participants simply match their disposable items to the contents of the boxes. The display boxes are not large enough to hold all possible items a participant may have, but remain a useful tool for showcasing items which prove to be more difficult to sort. An added benefit of 3D display boxes over 2D signage, is that they can be more quickly processed, reducing the amount of time individuals take when deciding how to sort their items. This is especially useful for UBC students who often sort their waste in a rush. When rushed, individuals will pay less attention to written 2D signage than to physical, 3D copies or representations of the items they are trying to sort. 3D display boxes may thus increase individuals' sorting accuracy and reduce their sorting times. Compare to the UBC student population, populations in urban cities are often equally in a rush to finish their lunches and return to work in a timely manner. These types of 3D sorting displays could thus prove very useful for sorting stations in urban environments.

3D display boxes have more inclusive potentiality than 2D signage. Those who may have trouble interpreting 2D signage, such as young children or individuals with disabilities which impair their reading ability, could greatly benefit from the visual nature of the 3D display boxes. These boxes may also be more accessible for tourists and individuals experiencing a language barrier relative to the 2D signage, potentially leading to increased sorting accuracy among these populations.

As with every research project, there are limitations to our observations and findings. Despite our best efforts as researchers to conduct accurate observations, by organizing a trial run prior to the study, constructing a detailed table to keep track of data, and having two researchers present during ever observation period, we still found ourselves somewhat limited in our ability to observe. As we did not want participants to be aware that they were being observed, and for their sorting behaviours to be influenced, we maintained a certain amount of distance from the bins, which did affect their visibility. The bins were often crowded, with multiple participants disposing of waste at one time, making it difficult to discern how materials were being sorted. We also suspect that we were at times inaccurate in noting the number of items disposed of by participants, as it is possible there were additional items, such as cutlery or napkins, stored inside larger items, such as takeout containers.

One of the greatest difficulties we encountered as researchers was the variety of takeaway materials sold within the Nest, all of which required different methods of disposal. UBC Sustainability has established guidelines as to what kinds of takeaway materials vendors in the Nest are authorized to distribute, which include compostable and fibre-based cutlery and food containers, with recyclable drink containers (UBC Vancouver Campus Zero Waste Action Plan, 2014). Despite the guidelines, there is much inconsistency among vendors. For example, compostable, recyclable, and non-recyclable cutlery are all available from different vendors. The lack of consistency among takeaway materials led to confusion during the assembly of our 3D display boxes and during observations, as we struggled to identify the different materials and the proper disposal methods for each, which has likely led to some inaccuracies in our data. There were certain materials we had thought were meant to be disposed of as garbage, namely checkered wax paper and brown paper pastry bags with plastic inserts, which we learned were compostable partway into the study. If we as researchers, having educated ourselves on the sorting guidelines upheld by UBC, found the waste disposal process to be confusing, it is likely the general public may feel even more confused and overwhelmed by guidelines for proper waste disposal.

The waste disposal bins and descriptive 2D signage have been used at UBC for a number of years, thus participants were more familiar with the 2D signage than with our 3D display boxes. Our experimental condition took place only over a period of two weeks, thus participants were not given time to habituate to the 3D display boxes. As a result, participants may have found the display boxes confusing, especially if the cues for proper waste disposal were different from those displayed by the original 2D signage, or from what participants had previously understood as proper disposal technique.

It is also important to acknowledge that this study was conducted on a university campus, and in Vancouver, a city known for its commitment to sustainable urban practices. The sample of participants whom we observed are arguably more knowledgeable about, and committed to, living sustainably than other populations in Canada and around the world.

Recommendations for our UBC Client

With our study findings in mind, there are multiple initiatives our client can take on to improve sorting accuracy amongst individuals who use the sort-it-out stations located on UBC campus. Our most critical recommendation is to add 3D display boxes to all sort-it-out stations on campus. To further improve, and make more effective, the contents of the 3D display boxes, it would be beneficial to extensively study where specifically individuals are misplacing their waste. With data of this kind, our client can address sorting misconceptions and misunderstandings by tailoring the contents of 3D display boxes on different stations across campus to fit the specific sorting needs of each location.

One policy change which could significantly impact the sorting behaviors of individuals who frequent the UBC Nest would be to enforce the standardization of all waste materials provided by food establishments in the building. In doing this, there would be much less confusion around whether or not certain types of an item is compostable, recyclable or disposable, just as was witnessed most frequently with the many types of cutlery given out by various food vendors in the building. One cost-effective method to improve overall sorting awareness and behaviors of more difficult to sort items would be to make a sorting video containing items specifically found in the Nest and to play the video on the television that faces the lower floor of the building and at the various charging stations found around the building.

References

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Appendix

Tables

Table 1

The table of t-test, degrees of freedoms, and p-values for each observed correct or incorrect category, the total number of these items, and the percentage of accuracy per person.

Independent Samples T-Test

	t	df	p
Correct Compost Disposal	-0.786	984.0	0.216
Incorrect Compost Disposal	2.069	984.0	0.981 [a]
Correct Container Disposal	1.553	984.0	0.940 [a]
Incorrect Container Disposal	0.591	984.0	0.723
Correct Paper Disposal	-2.157	984.0	0.016 [a]
Incorrect Paper Disposal	0.276	984.0	0.609
Correct Garbage Disposal	-5.784	984.0	< .001 [a]
Incorrect Garbage Disposal	-2.437	984.0	0.007 [a]
Total Number of Items per Person	-1.975	984.0	0.024
Total Items Correctly Disposed	-2.127	984.0	0.017
Total Items Incorrectly Disposed	0.077	984.0	0.531
% of Accuracy per Person	-1.978	984.0	0.024 [a]

Note. Student's t-test.

Note. For all tests, the alternative hypothesis specifies that group *Control* is less than group *Experiment*.

Table 2

The table of number of samples, the means, standard deviations of disposal rates, and standard error per correct or incorrect category, the total number of these items, and the percentage of accuracy per person.

Group Descriptives

	Group	N	Mean	SD	SE
Correct Compost Disposal	Control	474	0.932	1.003	0.046
	Experiment	512	0.982	0.990	0.044
Incorrect Compost Disposal	Control	474	0.449	0.816	0.038
	Experiment	512	0.348	0.727	0.032
Correct Container Disposal	Control	474	0.373	0.708	0.033
	Experiment	512	0.307	0.642	0.028
Incorrect Container Disposal	Control	474	0.129	0.429	0.020
	Experiment	512	0.113	0.389	0.017
Correct Paper Disposal	Control	474	0.055	0.228	0.010
	Experiment	512	0.096	0.349	0.015
Incorrect Paper Disposal	Control	474	0.063	0.269	0.012
	Experiment	512	0.059	0.266	0.012
Correct Garbage Disposal	Control	474	0.116	0.358	0.016
	Experiment	512	0.293	0.570	0.025
Incorrect Garbage Disposal	Control	474	0.190	0.554	0.025
	Experiment	512	0.279	0.595	0.026
Total Number of Items per Person	Control	474	2.297	1.326	0.061
	Experiment	512	2.471	1.421	0.063
Total Items Correctly Disposed	Control	474	1.494	1.319	0.061
	Experiment	512	1.670	1.283	0.057
Total Items Incorrectly Disposed	Control	474	0.806	1.043	0.048
	Experiment	512	0.801	1.045	0.046
% of Accuracy per Person	Control	474	65.188	41.040	1.885
	Experiment	512	70.067	36.406	1.609

Images:

Image 1.

Image 2.

Image 3.

Image 4.

Image 5.

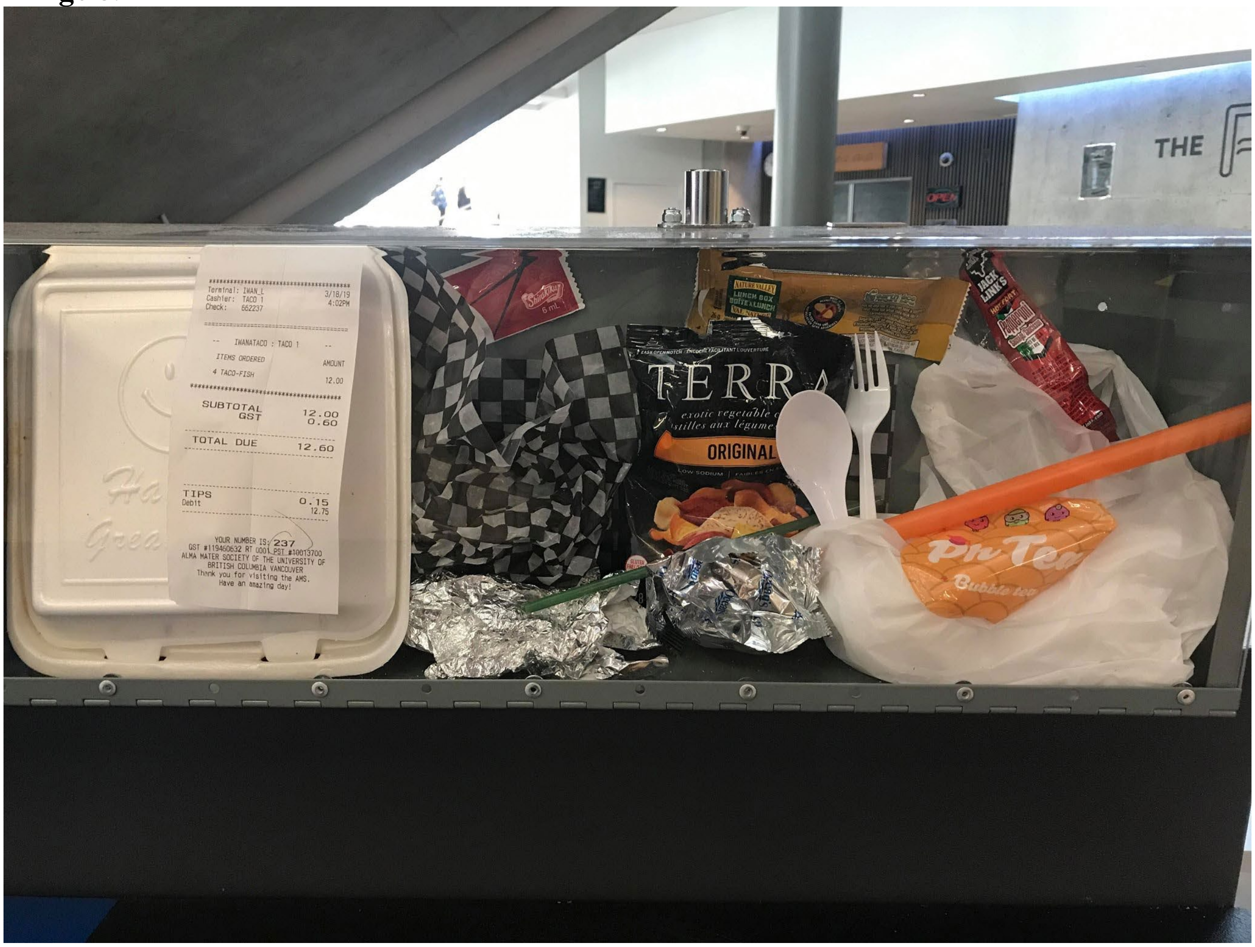
Image 6.


I just got my
Tea
Bubble tea
Nestlé
Pure Life
CLASSIC BOTTLED TEA
GoodDrink
MANGO TEA
WITH HIBISCUS & VANILLA
Coca-Cola
MOCHA
MOKA
STARBUCKS
DOUBLESHOT
ENERGY + COFFEE
ÉNERGIE + CAFÉ

Image 7.


BLENZ COFFEE
SnacKit
Light Tuna
Thon pâle
Häagen-Dazs
caramel salé

Image 8.


Terminal: IWAN_L
Cashier: TACO 1
Check: 662237
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-- IWANATACO : TACO 1 --
ITEMS ORDERED
AMOUNT
4 TACO-FISH
12.00
SUBTOTAL 12.00
GST 0.60
TOTAL DUE 12.60
TIPS 0.15
Debit 12.75
YOUR NUMBER IS: 237
GST #119460632 RT 0001 PST #10013700
ALMA MATER SOCIETY OF THE UNIVERSITY OF
BRITISH COLUMBIA VANCOUVER
Thank you for visiting the AMS.
Have an amazing day!
TERRA
ORIGINAL
JACK LINK'S
THE

Image 9.

Found at: https://sustain.ubc.ca/get-involved/campaigns/sort-it-out/sorting-guides

Image 10.

Found at: https://sustain.ubc.ca/get-involved/campaigns/sort-it-out/sorting-guides