American University of Central Asia

Statistical Research in the Center for Civic Engagement (AUCA CCE)

The comparative analysis of the effectiveness of trash cans

Research Project

BAECON

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Contents

Topic:

The comparative analysis of the effectiveness of trash can locations on different floors.

Objective:

In contemporary urban environments, effective waste management is paramount for maintaining cleanliness, hygiene, and a positive environmental impact. The distribution and quantity of trash cans within a building play a pivotal role in shaping occupants' behavior towards waste disposal and subsequently influencing the overall cleanliness of the facility.

Problems:

1) What is the optimal number of eco boxes on each floor?

At the core of this task lies the imperative analysis of daily waste collection indoors on campus floors environment. The primary objective is to determine the optimal number of eco boxes required on each floor to ensure an effective and sustainable waste management system. The challenge involves conducting a thorough examination of the waste generation patterns on various floors and assessing whether the current provision of eco boxes is adequate.

2) Are there necessary changes in eco-boxes to impact the disposal of incorrectly thrown garbage?

Another central challenge we aim to address revolves around the ineffective disposal of waste facilitated by eco-boxes. Our focus is on understanding and mitigating the instances of improper waste disposal, wherein individuals discard their waste incorrectly into eco-boxes. To understand the need for a change in eco boxes, we need to calculate how improperly waste is disposed of.

Mathematical Model:

To address the problem of whether there are necessary changes in eco-boxes to impact the disposal of incorrectly thrown garbage, we use a *hypothesis test with one sample*.

Defining of the population:

The total number of eco boxes in the building is 50. The distribution across different floors is as follows:

- Basement: 0 trash cans

- 1st Floor: 17 eco boxes

- 2nd Floor: 15 eco boxes

- 3rd Floor: 9 eco boxes

- 4th Floor: 9 eco boxes

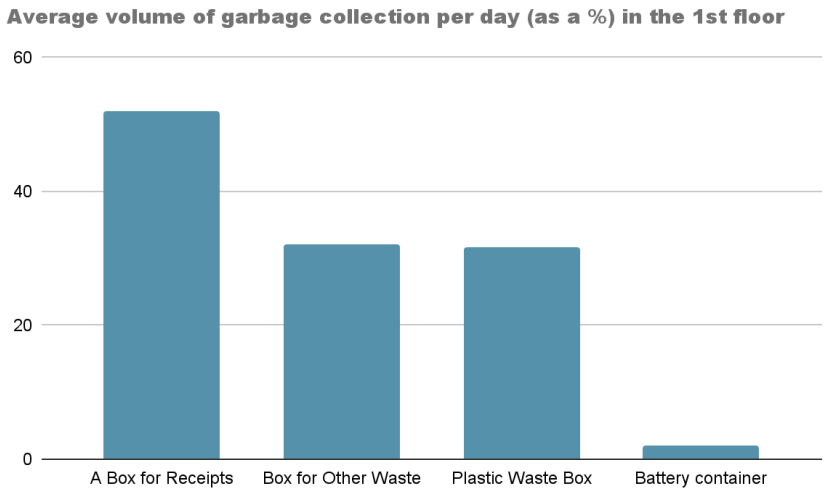
*Note: Rooms and coffee shops were not counted in this classification (as they are not regulated by CCE).

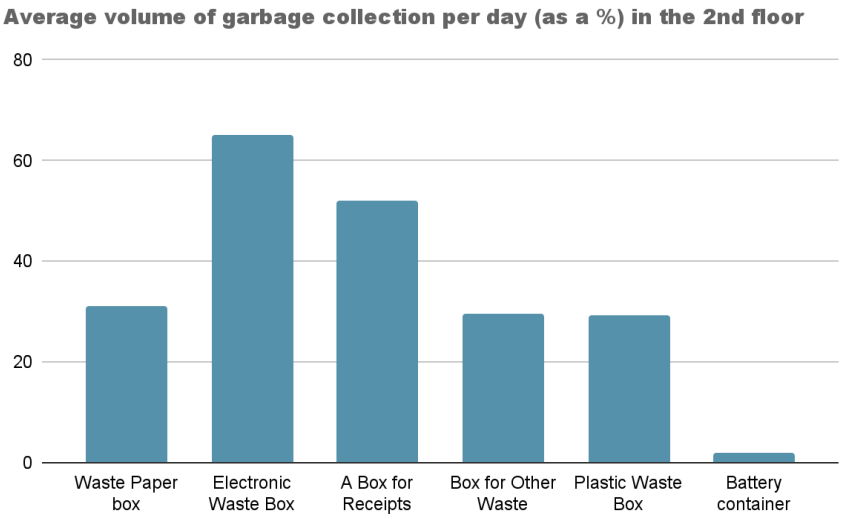
Decision on the sampling method:

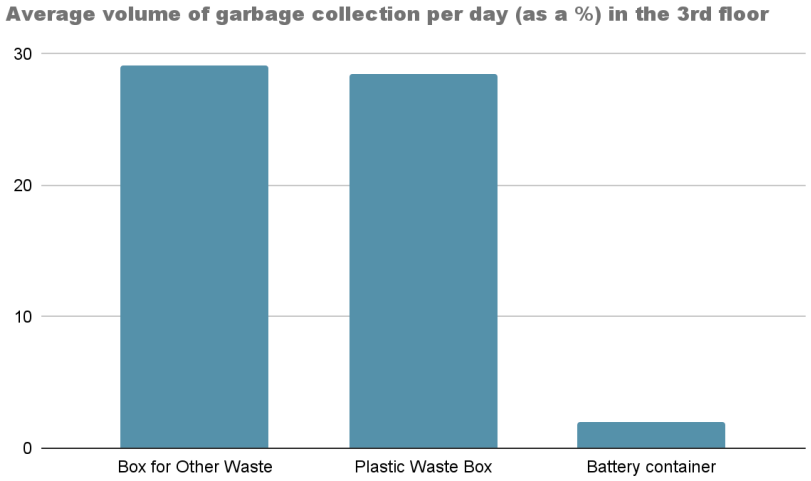
To collect the data, we used the *Stratified Sampling Method*. Here, each floor represents strata, and a proportionate number from each floor was taken for observation. Data was collected systematically and consistently regarding the usage and fill rate of each eco box over a set period. Thus, drawing conclusions about the building's usage and generalizing it as a representative of the whole.

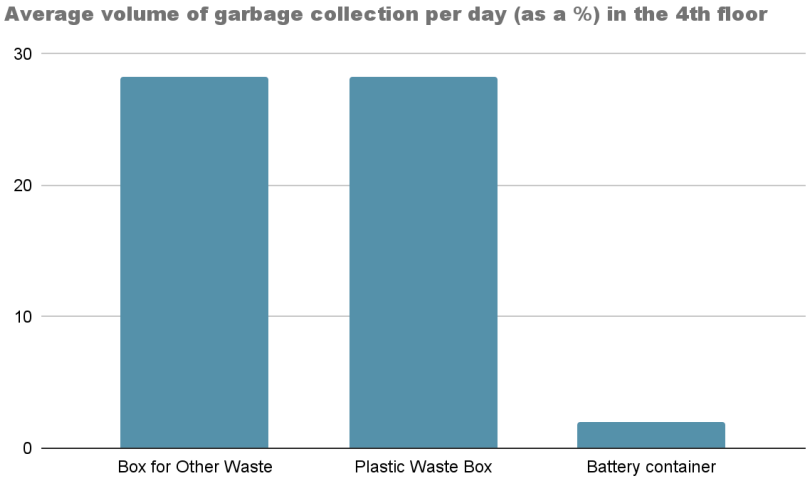
Data Representation:

The data provided below illustrates the daily average percentages of garbage collection for each trash bin on every floor of AUCA. This dataset offers insights into the frequency of usage for various bins across different floors, enabling us to identify both the most and least utilized bins. Additionally, it allows us to assess whether an adequate number of garbage cans is in place. The data was sourced from the Center for Civic Engagement, which conducts daily waste collection and calculates the average percentage of fullness for each type of eco box.









Data Analysis:

The charts above illustrate the average use percentages of different types of eco boxes such as boxes for receipts, paper waste, plastic waste, electronic waste, battery containers, and other wastes. Each of these types has been represented with different percentages. The main factor is the number of users (students, faculty members, staff, and so on) on each floor. Likewise, some other dependent factors on the main factor which we cannot deny their affections are the kitchenette and number of classes being held on each floor.

To explain better, we found out that the number of trash cans on each floor differs:

Floors	**Number of Trash cans**
Basement	0
1st Floor	17
2nd Floor	15
3rd Floor	9
4rth Floor	9

As the bar charts show above, almost all the types of trash cans on all floors are the same (Boxes for receipts, plastic waste, other wastes, and battery containers). Also, the averages are between the same percentages on all the floors which is because of having a suitable number of trash cans on each floor. For instance, the first floor has the greatest number of eco boxes (17) due to the existence of the kitchenette which is why we have the same percentage for the boxes for receipts, plastic waste, other wastes, and battery containers as the second, third, and fourth floor. On the second floor, based on our analysis, the majority

of the offices, classes, as well as students are on the second floor, so the number of trash cans is around 15 to give us the same percentage as the other floors. The rest of the floors are either zero or 9 which is as well dependent on the factors discussed above.

In addition, we can see that the boxes for the receipts have the most percentages from 50% to 55%, the battery container has the lowest amount 3% to 5%, and the boxes for plastic waste and other wastes have around 25% to 30% in all floors.

Nevertheless, we have also collected some other data on the daily usage of the trash cans on our own. We found out that:

- The three most common types are boxes for bottles (Plastic waste boxes), and two other waste boxes on all the floors (one is made from square cardboard and another from a plastic bin).
- We have the boxes for the receipts only on the first (Kitchenette) and second floor (near ATMs), but not on the third and fourth floor (which contradicts the given data from CCE).
- Based on our findings, the average volume percentage for the boxes for receipts is around 60% on the first floor, and 30% to 40% on the second floor.
- The box for the electronic battery and paper waste is not collected daily (maybe once a month).
- Boxes for other waste and plastic have a medium volume of garbage collection on each floor.

Predictions:

1. **At least 5% of the garbage collected from each trash box will be incorrectly thrown:**

The primary prediction for this research is the accuracy of garbage collection for each trash box. Due to its normal occurrence, the prediction of seeing items such as plastic waste in other waste trash boxes and vice versa is an interesting factor to note. Thus, to its occurrence, we predict that from each of the trash boxes that the garbage is collected, at least 5% of said garbage will be incorrectly placed. Moreover, the frequency and the amount of inaccuracy will be measured and compared between locations and floors.

2. **The 1st Floor will collect the most volume of garbage:**

One prediction that seems possible within the realm of data that is collected is that the 1st floor will collect the most amount of garbage consisting of plastic waste and other wastes. Simply comparing these two sets of garbage collected, the eco boxes on the 1st floor will have collected more garbage on average than the other floors. The reasoning for this prediction is first because the 1st floor contains more garbage boxes than the other floors as listed in the table above due to the high volume of people on the first floor because of the Kitchenette location there. Thus, when comparing the 17 trash boxes to the other values of the other floors the prediction of having the 1st floor collect the most garbage within the plastic and other waste categories seems logical.

3. **Fridays will collect the least amount of garbage within the weekdays:**

Another prediction concerning waste or garbage collection has to do with daily consumption or more specifically the lack thereof. In this case, the prediction of having the least amount of garbage collected from the plastic and waste section is compared each day to efficiently determine the optimal level of trash boxes depending

on which day of the week it is. The reasoning for this is due to our observation of students within AUCA hypothesizing that some portions of students do not have classes on Friday as compared to other days of the week. Thus, the campus will be less populated by students that can decrease the amount of garbage collected on Friday.

Analysis and Comparison of Predictions with Actual Results:

1. *At least 5% of the garbage collected from each trash box will be incorrectly thrown.* The primary prediction centered on the precision of garbage sorting in each bin, assessing the extent to which each trash can collected the appropriate waste it was designated for. Our forecast assumed that at least 5% of the garbage collected from each bin would be improperly disposed of. To substantiate our predictions, we conducted a thorough data collection process focusing on the proper disposal of waste and instances of inaccurate waste disposal within each ecological context. Our approach involved a meticulous examination, utilizing a representative sample size of 35 eco boxes. Data collection was carried out by visually measuring the fullness of each eco-box. Our analysis revealed that out of the 35 eco boxes in our dataset, 28 had more than 5% of inaccurately disposed waste. The following tables detail the inaccuracies observed, confirming our prediction that many campus trash bins would accumulate a significant amount of improperly discarded garbage.

    Furthermore, among the 28 bins with inaccurately thrown waste exceeding 5%, the mean stood at 16.5%, signifying a substantial proportion of mismanaged waste in each bin. Even when considering bins with under 5% inaccuracies, the mean remained high at 14.25%. This suggests that a considerable portion of the AUCA

community either disregards proper waste disposal or is unaware of the correct bins for different types of waste.

To make sure that our prediction is correct we conducted a hypothesis test using the following data:

H_0: $p \leq 0.05$ – Null Hypothesis

H_a: $p > 0.05$ – Alternative Hypothesis

$n = 35$ – sample size

$p_0 = 0.05$

$q_0 = 0.95$

$\alpha = 0.05$ – significance level

$c = 0.95$ – confidence level

We made calculations using the data above using the formula for *hypothesis test with one sample* for a single population proportion:

$$z_c = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0 q_0}{n}}}$$

From our calculations we found that z_c equals 2,43 which is within the Rejection region. Therefore it can be concluded that we should reject our null hypothesis. This proves the rightness of our prediction that at least 5% of the garbage collected from each trash box will be incorrectly thrown. In the following link the more precise calculations can be found: https://drive.google.com/file/d/19VFM40OLPmxYeXEO5m2oy-ApkYn2rlxk/view?usp=drive_link

Some more analysis of the data collected:

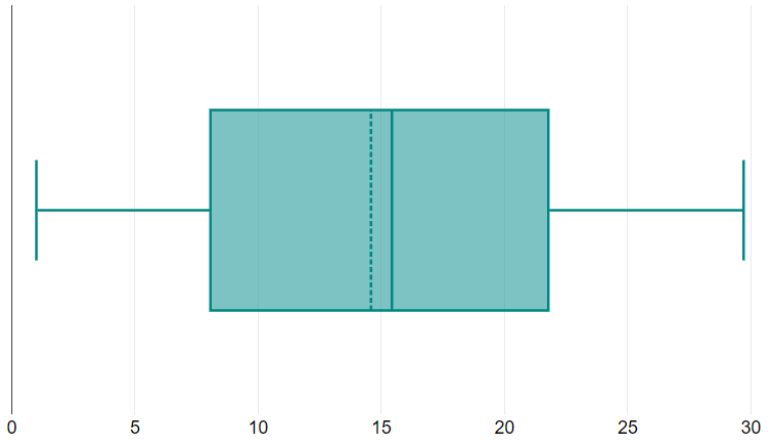
- 1st Floor: This floor, along with the 3rd floor, had only one bin collecting below the tested misthrown percentage. Despite boasting the highest number of bins at 13, the 1st floor had only one bin under 5%. This could be attributed to the high footfall of students, teachers, and staff on the 1st floor, exacerbated by the presence of the Kitchenette. The concentration of activity likely contributes to the increased mean of incorrectly thrown garbage.

- 2nd Floor: Surprisingly, the 2nd floor exhibited the lowest mean of incorrectly thrown garbage, even though it rivals the 1st floor in terms of activity. Notably, it also had the lowest percentage of inaccuracies for a single bin (1%). The diverse data within this floor, influenced by varying levels of human traffic and activities, might explain the slightly decreased mean compared to other floors. Areas with minimal human traffic could contribute to the lower mean, while cafe or lounge areas with more significant activity might show higher percentages.
- 3rd & 4th Floors: Both these floors, sharing the same number of bins, displayed similar patterns. The presence of cafes on both floors influenced data values, with bins closer to the cafes potentially accumulating more waste. Bins positioned farther away experienced lower garbage intake, reducing the likelihood of inaccuracies. This spatial influence explains the fluctuation in data values from high to low across the floors.

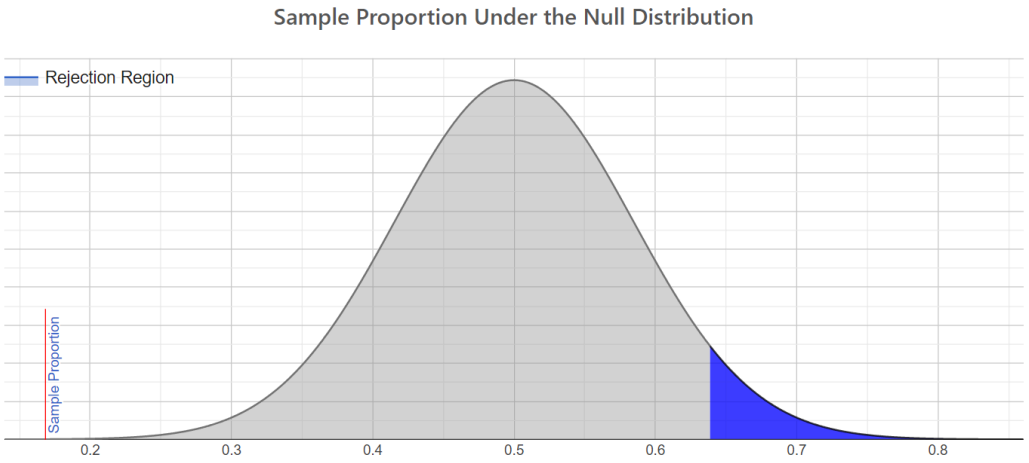
First Floor		Second Floor		Third Floor		Fourth Floor	
Eco Box	Portion %	Eco Box	Portion %	Eco Box	Portion %	Eco Box	Portion %
1	17	1	20	1	20	1	22,14
2	29,71	2	22,71	2	29,29	2	21,85
3	22,43	3	22,43	3	3	3	2,14
4	13,29	4	17,57	4	12,86	4	14,29
5	24,14	5	13	5	11,86	5	15,43
6	14,29	6	5	6	8,14	6	3,14
7	5,86	7	17,86	**Mean**	14,19166667	**Mean**	13,165
8	17,57	8	8				
9	15,86	9	1				
10	1	10	3,14				
11	21,71	**Mean**	13,071				
12	9,57						
13	23,14						
Mean	16,58230769						
Overall Mean	14,25249359						

- Evaluating the box plot constructed by this data it is important to note the skewness of the data in that it is negatively skewed or skewed to the left. This details that the median of the data is higher than the mean of the data set. The mode itself is also higher than the median depending on whether 15 or 22 is chosen as the mode of the data. Though it is a negatively skewed distribution it is only slightly so being that the distribution is somewhat symmetrical.

Box Plot of Inaccurate Garbage Collected



- Sample Proportion Distribution. The distribution indicates that a significant number of bins had substantial amounts of improperly disposed waste, far exceeding the initial 5% prediction across the sampled bins. This suggests issues with waste sorting compliance or awareness on campus.



2. *The 1st Floor will collect the most volume of garbage.* The results for this prediction were based on observation as well. However, it is also slightly based on the data collected for the first prediction. As seen from that table, it is known that the 1st floor collects a significant amount of garbage as compared with the other floors due to there being more trash boxes and more chances of students, professors, and staff being on that floor. Through observation, we can observe that many of the trash boxes on the first floor required to be emptied more times than the other floors. Through the previous prediction's table, it was seen that the 1st floor collected significantly more inaccurately thrown trash compared with the rest of the floors, drawing the conclusion that overall garbage collected on the first floor had to be more than the rest for this data to occur. This shows that our prediction was right.

3. *Fridays will collect the least amount of garbage within the weekdays.* Our reasoning for this prediction was based on our initial observation of students on the AUCA campus. In turn, our observation served to be correct as we witnessed fewer amounts of trash boxes filled on Fridays in comparison with other days of the week. Although the first floor was able to collect nearly the same amount of garbage, the other floors decreased in terms of volume based on our observations. This means that the number of students attending university plays a major factor in the garbage collection amount in a day.

Recommendations:

Based on the analysis and the research that has been done on the effectiveness of trash cans inside the campus, here are some recommendations and considerations

- **Implementing Campaigns and Awareness:** Informing and launching informative awareness for students about the proper waste disposals in the campus which can be done through any exclusive sessions, emails, posting posters on the boards of each floor, or presenting any campaigns or awareness on the projector in the forum by the center of Civic Engagement.
- **Changing Eco-Boxes Designs:** Another recommendation that we highly suggest is to change the designs or colors of the eco-boxes. For instance, outside the campus, there are trash cans that are for bottle waste in orange color and in a specific design which can be very thoughtful for students to throw their bottle/plastic trash in, and at the same time, it avoids incorrect throwing of other wastes in it. Therefore, some specific colors give a specific meaning in terms of the eco-boxes (red color is used for metal

waste, the orange color is used for plastic waste, the blue color is used for paper waste, black color is used for glass waste, and so on) that we can use for our campus's effectiveness of trash cans.

- **Increasing the Garbage Collection resources:** based on the data collected and our prediction, the first floor collects the highest amount of garbage, therefore we recommend that sufficient resources including changing/throwing trash from the cans twice a day (morning and noon) and cleaning stuff are allocated to manage the high volume of trash.
- **Monitoring and Enforcement:** we likewise recommend introducing penalties to avoid the incorrect throwing of garbage, as well as any other incentives to encourage the students to correctly throw the garbage.
- **Appreciating Community Engagement:** we also suggest not relying everything on the Office of Civic Engagement, hence we recommend engaging the AUCA students in waste management and creating a sense of community engagement and shared responsibilities for our university.

Conclusion

To conclude, the comparative analysis of the effectiveness of trash cans on each of the floors at AUCA provides us with significant insights into waste management procedures and practices on campus. This paper analyzed and discussed the main problems including identifying the optimal number of eco-boxes and preventing incorrect trash disposals. The research highlighted the importance of different approaches to waste management through comprehensive data collection and mathematical modeling with the influence of different factors on each floor, the position of the trash cans, and the user’s behaviors. We also made some predictions to investigate the campus waste dynamics about the percentages of incorrect

trash disposals, the volume of garbage on each floor, and daily fluctuations of trash inside the campus. On the other part, we analyzed and compared the actual results with our predictions in which we justified and accepted our findings through rational reasons and the hypothesis test. Therefore, summing up all of our findings, we came up with some recommendations and considerations that can improve the effectiveness of trash disposal and waste management inside the campus.

Optimal Questions for future students:

- What practical methods should be implemented to reduce incorrectly thrown garbage?
- How effective are informative seminars and awareness in establishing an efficient eco-trash box collection?

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