Dev Amin
18 Central Ave, Floor 2
New Brunswick, NJ 08901

October 15, 2025

Mark McLane,
Assistant Vice President
Rutgers Environmental Health and Safety
74 Street 1603
Bldg. 4116 Livingston Campus
Piscataway, NJ 08854-8036

Re: Proposal to Enhance Recycling Efficacy and Reduce Waste at Rutgers University

Dear Mr McLane:

I would like to extend my sincerest thanks to you for attending my presentation on the impact of Rutgers University's waste on surrounding communities and wildlife, as well as the important changes that need to be made. I'm well aware of your diverse background in environmental health and safety, and I have no doubt that you possess the necessary skills to implement and support efforts to address this pressing issue at Rutgers University.

The purpose of this proposal was developed in response to my concern for the permanent residents of New Brunswick and Piscataway, who have been there for generations, unlike the temporary residents, such as University students. According to Yuan et al. (2021), a "single large university campus can exert a significant amount of garbage generated per day [which can] reach 12-14 tons" in turn presenting both a considerable environmental burden and a crucial opportunity for leadership in sustainability.

It would be beneficial to implement my cost-effective plan, which includes a dual-method approach designed to close the gap between student intent and actual disposal behaviour through the introduction of a Visual Graphics Board and a Data Collection Model. I look forward to exploring alternative strategies or constraints with you and your team.

The following paper provides an in-depth analysis of the issue, research rationale, proposed plan, and the costs associated with implementation at Rutgers University. If you have any questions about the proposal, please contact me at dja204@scarletmail.rutgers.edu or (999) 999-9999. Thank you for your time, consideration, and commitment to Rutgers University.

Sincerely,

Dev Amin

Proposal to Enhance Recycling Efficacy and Reduce Waste at Rutgers University

Submitted By:
Dev Amin

Submitted to:
Mark McLane
Assistant Vice President
Rutgers Environmental Health and Safety
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Bldg. 4116 Livingston Campus
Piscataway, NJ 08854-8036

Date:
November 19, 2025
Writing for Business
355:303:01
Professor Alex Buzick

Abstract

Despite widespread pro-environmental attitudes among university populations, the effective implementation of waste diversion remains hindered by a lack of an effective infrastructure foundation, as well as a lack of specific knowledge about recycling. Furthermore, current waste management practices often lack the necessary data to identify areas with the highest waste activities and associated contaminations. It is important to identify these contamination hotspots to motivate behavioural changes within the student and faculty bodies of our University. This proposal outlines a comprehensive waste reduction strategy for Rutgers University that integrates behavioural psychology with rigorous data analysis to address these deficiencies. The plan employs a two-pronged approach: the installation of visual graphics boards in high-traffic areas, along with the implementation of a robust "weigh-and-measure" data collection protocol. Based on extensive research conducted at other universities that has identified positive value in these implementations, we can implement visual boards that display real-time recycling rates and clear sorting guidelines, thereby bridging the gap between abstract environmental goals and daily disposal habits. Simultaneously, a student-led data collection model will quantify waste streams to refine bin placement and identify areas requiring targeted interventions.

The rationale for this dual approach is to leverage public feedback to shift social norms and increase perceived behavioural control, while the gathered metrics will allow for an agile management approach based on empirical evidence. The success of this initiative will be evaluated through pre- and post-implementation surveys, similar to those conducted by Camp et al. (2010), which included a "Knowledge, Attitude, and Practice" (KAP) score, alongside objectives aimed at reducing contamination rates. To execute this strategy, funding in the range of $23,500 is required to cover recycling hardware upgrades, digital scale equipment, labour for student researchers, and educational campaign materials. The implementation of this system aims to align with current campus operations and sustainability goals by transforming waste management from a hidden utility into a visible, educational opportunity that fosters generations of positive recycling attitudes.

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Statement of Need

 Universities are essentially small cities due to their scale and population density, which create significant challenges in managing the high volumes of solid waste generated daily. A single large university campus can exert a significant "amount of garbage generated per day [which can] reach 12-14 tons" in turn presenting both a considerable environmental burden and a crucial opportunity for leadership in sustainability (Yuan et al., 2021).

Rutgers University's current recycling model is falling short of its sustainability goals due to inconsistent bin placement, unclear signage, widespread contamination of recyclables, and a fundamental lack of sustained engagement from students, faculty, and staff. Many campus buildings still rely on outdated, poorly labelled waste stations, which results in recyclable materials being incorrectly disposed of and significantly increases the volume of waste sent to landfills. This challenge is not unique to Rutgers, as university environments worldwide struggle with the "value-action gap," where strong pro-environmental attitudes among students fail to translate into consistent recycling behaviour because of physical and knowledge-based barriers (Hansen et al., 2008; Cho, 2019). Studies confirm that students frequently cite confusion over what is recyclable as a primary obstacle to participation (Liu et al., 2024), and poorly configured or non-centralised waste stations only compound this problem (Fritz et al., 2017). The inability to capture precise, accurate data on waste composition further exacerbates this inefficiency, leaving administrators unable to implement targeted interventions or fully understand the extent of contamination, which is a necessity for any effective solid waste management system (Ghazvinei et al., 2017).

This widespread inefficiency not only undermines Rutgers' public commitment to environmental responsibility but also leads to higher long-term waste management costs and a missed opportunity to model climate leadership in higher education. As one of the largest public research universities in the nation, Rutgers has both the influence and responsibility to establish a more effective, standardised, and intuitive recycling system that promotes sustainable behaviours and aligns campus practices with the environmental values it promotes in its academic mission. Research on behavioural interventions has consistently shown that public feedback and visual reinforcement are powerful tools for improving waste separation accuracy and participation rates (Kim et al., 2005). Without meaningful reform to its current model that incorporates data-driven feedback mechanisms and standardised infrastructure, Rutgers risks continued inefficiency, environmental harm, and a failure to meet the expectations of students and the broader community it serves. The implementation of a Visual Graphics Board and Data Collection Model is therefore essential to transform waste disposal into a visible, measurable, and reinforced collective action.

Barriers to Effective Recycling

Further investigation into peer-reviewed studies that closely examined recycling programs on various university campuses revealed a consistent pattern of obstacles that hinder students' participation, even with a positive outlook on recycling. Therefore, the papers will be supported by statistics and additional information through edits to provide a suitable framework for understanding specific issues that likely impact recycling efforts at Rutgers University. For instance, convenience and accessibility are consistently identified as key determinants of recycling behaviours (Hansen et al., 2008). Various studies have demonstrated that, due to the considerable effort required from students, participation in recycling noticeably decreases dramatically (Hansen et al., 2008). According to a survey stated in Hansen's paper, one student stated, "I am not going to hold onto a bottle all day just to put it in the recycling bin" (Hansen et al., 2008), highlighting the fundamental issue of behaviour. A personal survey that I conducted in a Rutgers Classroom revealed a common issue of inadequately marked recycling bins across the campus, such as in hallways, common areas, and near points where waste is more prevalent, such as next to a vending machine (Fritz et al., 2017). Furthermore, due to the lack of readily available options for recycling various materials and objects, such as different types of plastics, in residence hall locations, this also presents a significant barrier. Simply making more bins available, whilst necessary, is not a complete solution but a temporary fix.
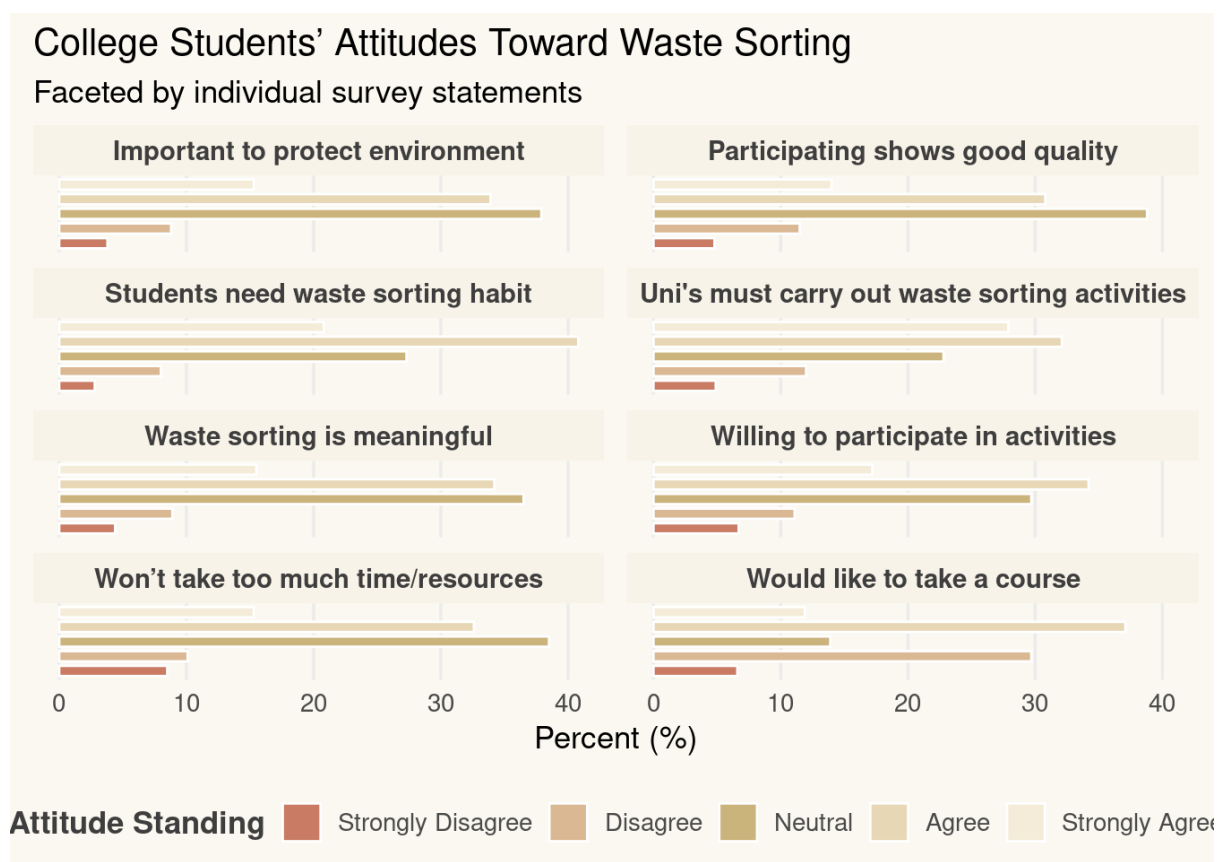

Figure 1: College Students' Attitudes Toward Waste Sorting (Liu et al., 2024)

A lack of access to proper recycling knowledge and persistent confusion stemming from ignorance regarding recycling protocols furthers this issue of unsuitable recycling methods. In Hansen's paper, it was stated that students, faculty, and staff frequently express uncertainty regarding the specifics of items that are acceptable for recycling within the current campus system (Hansen et al., 2008). For example, one student said, "Recycling is kind of complicated when you go beyond cans and bottles," which reflects a common experience among adolescents (Hansen et al., 2008). This, in turn, leads to two outcomes that Yuan et al., in their peer review, mentioned: "aspirational recycling", where items that are not identified as recyclable are mistakenly placed into recycling bins, which increases the processing and separation costs, or recycling items being discarded in trash bins because of uncertainty. A survey by Liu et al. confirms this lack of uncommon knowledge and understanding, with scores around 55.6%. Another fact from Liu's paper is that wrongful understanding is unfortunate in thwarting recycling practices. This is further supported by the fact that formal education on waste sorting is lacking within universities, with only 30.7% of students reporting that they have received proper knowledge on the subject, primarily relying on social media platforms or search engines (Liu et al., 2024).
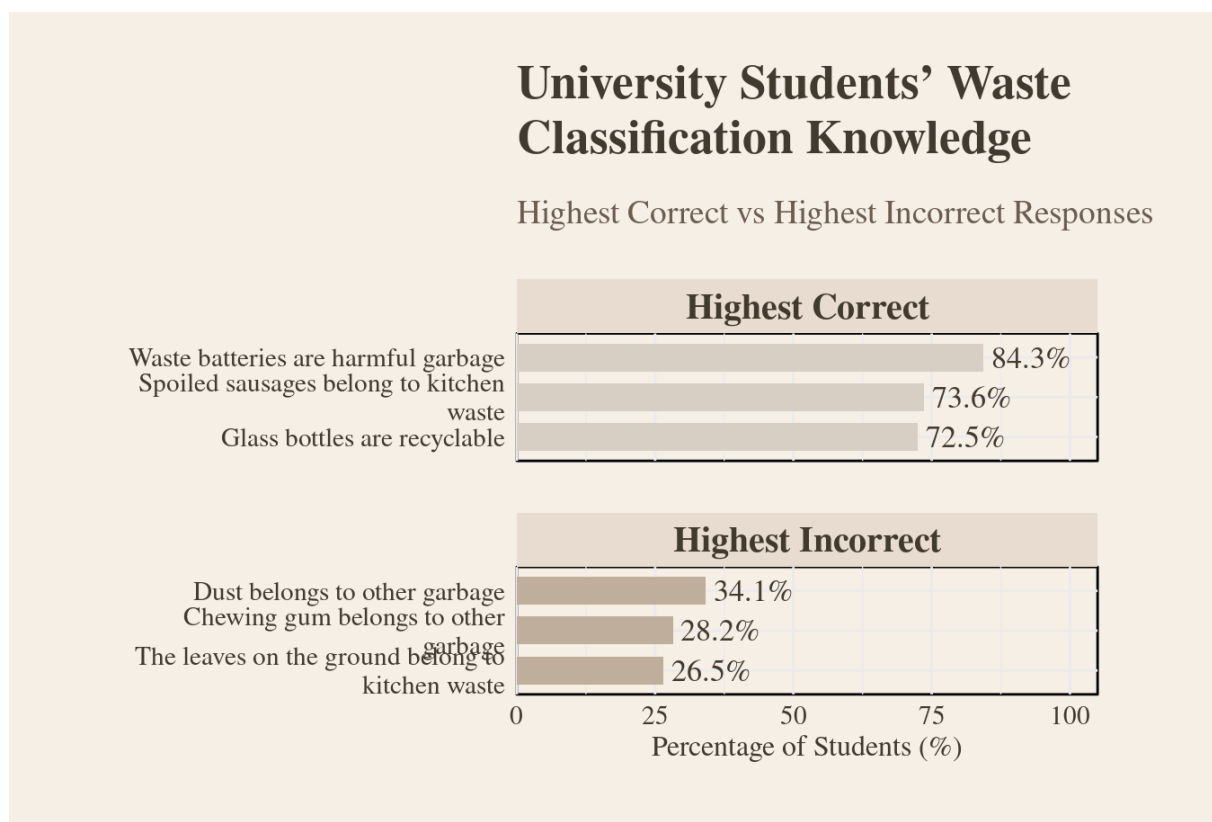

Figure 2: University Students' Waste Classification Knowledge (Ghazvinei., 2017)

It is apparent that, due to a lack of precise knowledge and persistent confusion, students struggle to distinguish between the proper methods of recycling and efforts to achieve environmental sustainability. This can be seen if Rutgers University incorporates campus-wide systemic and institutional changes. Because of a "chaotic organisation of the recycling program", a poor communication system between custodians, garbage collectors, and the recycling department often results in bins overflowing, and students resort to using regular bins for recyclable items (Hansen et al., 2008). There are many problems to point at, as one operational staff member from University of Michigan expressed, "We hear, 'You run it,' [the recycling program] but we get no help from above!" that points to a lack of support from the leaderships that can also be seen here at Rutgers University (Hansen et al., 2008). In addition to this, more cracks in the current foundations are commonly identified in university waste management, including, but not limited to, "insufficient resources and a lack of technical expertise" (Ghazvinei et al., 2017). To further examine the fundamental issues is also because of a lack of data, as Leah Filho et al said, "more than half of the universities (60%) do not measure the amount of FW (Food Waste) generated by their canteens; Hence, it is not possible to fully understand to what extent FW is being generated and its impacts in terms of waste and related costs to dispose of it" (Leh Filho et al., 2013). This represents a significant lack of coordination and a failure to collect data, hindering our understanding of environmental sustainability.

Therefore, the environmental repercussions of these shortcomings are not confined to our university campus but extend to the local wildlife and the surrounding communities. Due to an overreliance on landfills, which are the least environmentally friendly disposal strategy (Kim et al., 2005), the communities in the Garden State, New Jersey, suffer the most. Improperly managing waste and the resulting litter will contaminate local wildlife, including the nearby Raritan River, potentially harming aquatic life and leading to the degradation of ecosystems that have nowhere else to go. Therefore, the leadership must take action to maximise recycling and minimise wastage to conserve natural finite resources, save energy, reduce greenhouse gas emissions linked to climate change (Kim et al., 2005), and reinforce Rutgers University's commitment to environmental sustainability.

Research Rationale

When building upon the established need to bridge the disconnect between pro-environmental attitudes and actual disposal practices at Rutgers University, this plan is meant to employ a methodology grounded in behavioural psychology and data-driven feedback loops. The proposed strategy is beyond the simple "antecedent interventions," which one author suggested included merely placing recycling bins in convenient locations. The goal of this plan is to address the psychological and motivational deficiencies that hinder effective waste management. For instance, one approach for this is to implement a framework that relies on the "Knowledge-Attitude-Practice (KAP) model", which posits that accurate knowledge is a prerequisite for forming the attitudes that drive behavioural change (Liu et al., 2024). Furthermore, as recent research by Liu et al. (2024) has indicated, a lack of specific knowledge regarding waste sorting is the primary push factor influencing individual-level practices, which ultimately often leads to contamination or non-participation despite a willingness to recycle.
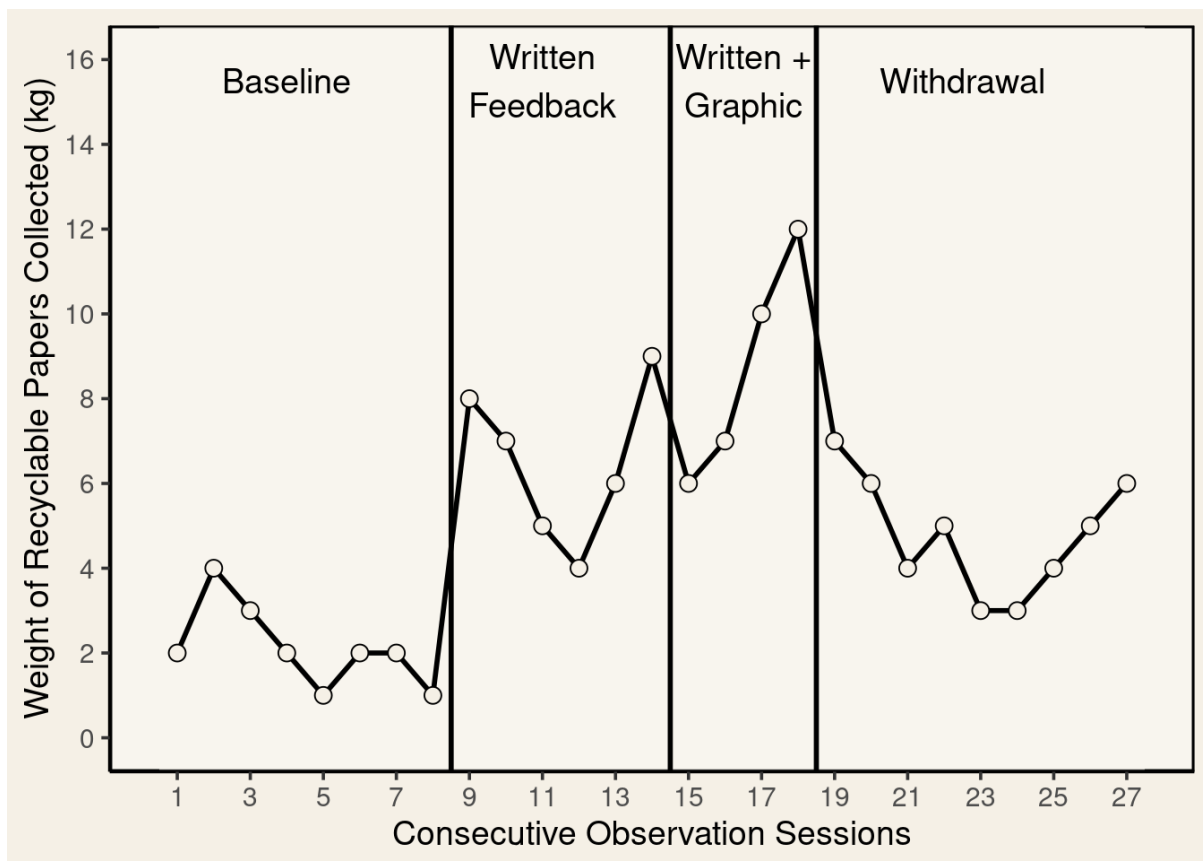

Figure 3: The Result of Implementing Written Feedback and Written Feedback + Graphics, compared to no instructions on recycling. (Fritz et al., 2017)

The core justification for implementing Visual Graphics Boards lies in the proven efficacy of public feedback as a behavioural modifier. The proposed plan models its success on findings by Kim et al. (2005), which showed that when written feedback is combined with graphic displays of performance, recycling behaviours are not only initiated but sustained at higher levels than with written feedback alone or no signage at all. Therefore, by displaying real-time data on waste generation and recycling rates, the university can promote "self-determined motivation," a psychological state, as Cho described, where "individuals feel their actions have a tangible impact" (Cho, 2019). If done correctly, this will lay the foundation for a strong predictor, leading to a positive outcome in waste reduction.

As illustrated in *Figure 3*, empirical studies, as addressed by Kim et al. (2005), have examined the impact of this specific intervention on waste streams, revealing positive effects. In a study examining paper recycling (Kim et al., 2005), the introduction of written feedback resulted in a "statistically significant increase in the weight of recyclables collected compared to the baseline"; furthermore, when graphic feedback was added to visualise this progress, the positive behaviour was not only maintained but saw an even bigger improvement. This visual evidence confirms that when students and staff are presented with a graphical representation of their collective efforts, the "value-action gap" diminishes. The graph clearly demonstrates that the withdrawal of this feedback results in a decrease in performance, further justifying the need for a permanent, installed solution, such as the proposed Visual Graphics Boards, rather than temporary campaigns.

In addition to the implementation of graphical feedback, the methodology incorporates a rigorous data collection component, not merely for administrative tracking, but also as a "pedagogical tool" to foster "place attachment" and "interpersonal altruism" (Chao et al., 2020). Research suggests that when students are emotionally connected to their community environment, they are more inclined to engage in self-sacrifice for the collective good, such as taking the extra time to sort waste correctly. By employing student researchers to conduct the "weigh-and-measure" protocols, the project adopts an archaeological approach to contemporary waste (Camp, 2010), a method that has been proven by Kim et al. (2005), Fritz et al. (2007), and Hansen et al. (2008), successful in highlighting the increasing disconnect between perceived and actual waste behaviours. This granular data collection from a survey of over 3,000, essential for validating reduction targets (Ghazvinei et al., 2017), enables the identification of specific "hot spots" of contamination, allowing for visual displays that provide targets as well as relevant information for specific campus sectors or high-traffic buildings, such as Tillet Hall. This combination of precise measurement and public visibility creates a social norm of sustainability, shifting the campus culture from one of indiscriminate disposal to one of informed, altruistic environmental stewardshi

Plan of Action

To overcome these barriers and limitations, it is imperative to implement programs that integrate two highly successful, research-backed models for changing the behaviours of students, faculty, and staff. This is a highly cost-efficient solution that can be integrated across all our campuses, delivering noticeable improvements in recycling rates.

Implementation of a Visual Graphics Board Model

To effectively increase recycling participation and reduce waste contamination at Rutgers University, the plan centres on the strategic implementation of a Visual Graphics Board Model, specifically targeting high-volume generation points to maximise behavioural impact. Based on the successful experimental design by Kim et al. (2005), who achieved significant results by placing feedback mechanisms in a university lounge containing vending machines, these boards will be installed in analogous high-traffic zones across the Rutgers campus. Specifically, the boards will be mounted directly above or adjacent to centralised waste stations in student centre lounges (such as the Busch Student Centre), the exit vestibules of major dining halls (like Livingston Commons), and the primary lobby areas of high-density dormitories. The selection of these specific locations is driven by the necessity to intervene at the exact moment of disposal; research indicates that students are unlikely to carry a recyclable item for an extended period to find a bin, making the immediate availability of guidance crucial. By placing these boards in communal areas where consumption occurs—such as the lounge setting in the Kim et al. study—we ensure the intervention is visible to the specific population generating the waste, thereby facilitating the social contingencies that support the desired behaviour.

The necessity for such prominent, "flashy" placement is evidenced by the findings of the Campus Trash Project, which revealed that standard receptacles often blend into the landscape and are ignored by students. Camp (2010) observed that even when disposal units (such as cigarette "butt pipes") were located mere feet away from users, they were underutilised if they were not visually inviting or explicitly distinct. Therefore, we know that subtlety fails in a campus environment. To counter this, the Visual Graphics Boards will function as dynamic, high-visibility information hubs that disrupt the habit of indiscriminate tossing. Following the protocol established by Fritz et al. (2017), who successfully increased recycling by centralising bins in hallways and removing them from classrooms, these boards will serve as the focal point for waste disposal in academic buildings. Rather than hiding waste collection in corners, these boards will command attention in corridor intersections, utilising the physical environment to guide students toward the correct decision.

The content displayed on these boards addresses the specific "knowledge barrier" identified by Hansen et al. (2008), where students expressed confusion over plastic codes and item eligibility as the primary reason for non-participation. To mitigate this, the boards will feature extensive, simplified photographic sorting guides for everyday campus items—such as coffee cups and clam-shell containers—alongside the dynamic feedback data. As demonstrated by

Kim et al. (2005), providing specific weekly data on the weight of recyclables collected and contamination rates yields statistically significant increases in correct separation compared to baseline conditions. We know this approach works because the introduction of graphic feedback in prior studies resulted in higher performance means than written feedback alone, maintaining the behaviour over time. By visualising the collective progress of a specific dorm or building, the boards will foster a sense of efficacy and community responsibility, directly linking individual disposal actions to the university's broader sustainability goals.

Implementation of a Data Collection Model

The second integral component of this plan is the establishment of a rigorous, practical, and much-needed Data Collection Model, which serves the dual purpose of monitoring system efficiency and promoting engagement between students through active learning. As outlined by Ghazvinei et al. (2017), "a comprehensive understanding of solid waste composition is essential for designing an effective management system". This model aims to address the exponential problem. Furthermore, noted by Leah Filho et al. (2023), "many universities fail to measure the amount of food waste, and other refuse generated by their canteens", which makes it nearly impossible to put a number on the full extent of this waste dilemma. To rectify this, my plan implements a "weigh-and-measure" protocol, where student research assistants majoring in Data Science or Statistics can utilise the important information and research high-traffic buildings to promote further ideas to minimise this issue. Furthermore, there can be collaborations between teachers and student researchers, as well as the custodial staff, to record the weight of recyclables and trash from designated stations, which aligns with Ghazvinei's idea to study the information. By categorising waste at the sources— separating domestic waste, electronic waste, and recyclable materials—we can identify specific "hot spots" of contaminated waste or high generations, which will allow for targeted interventions.

The data collection model is not intended solely for operational purposes, but also serves as the foundation for the visual graphics board model. The data gathered will directly correlate with the graphics boards, ensuring the feedback is accurate and relevant to all parties of the University. Moreover, this model incorporates the statistical methodologies that were suggested by Hansen et al. (2008) and Camp (2010). This model is designed to go beyond quantitative weighing, as the plan includes periodic waste audits and observational studies to understand the 'how' and 'why' of disposal behaviours. For instance, Camp (2010) previously utilised archaeological methods to map trash deposition, which revealed "strong disconnects between where bins were placed and where waste was actually accumulating". Repeating this approach in relation to Rutgers University, we can identify if current bin placements are optimal or if they contribute to littering behaviour, as seen in Camp's study, where "butt pipes" were ignored despite being nearby. By approaching this model from both quantitative and qualitative viewpoints, we can ensure that Rutgers can adopt an agile management style, where bin locations and signage can be adjusted based on empirical evidence rather than assumptions.

Evaluation

Evaluating the success of this initiative will require both the objective changes in waste diversion rates and the subjective shifts in student attitudes. According to Liu et al. (2024), "a lack of knowledge is often the primary obstacle to effective waste separation". Therefore, the University must strive for improvement in "Knowledge, Attitude, and Practice" (KAP) scores among the student body (Camp et al., 2010). It is also crucial to assess the effectiveness of the models at Rutgers University, which can be done by conducting pre- and post-implementation surveys to measure the gap between the visual boards and actual knowledge. The goal is to identify a reduction in contamination rates as a surrogate for improved knowledge, as discussed in Davison et al. (2022), where interventions resulted in significant waste reductions. Suppose the data shows an increase in recycling weight but no decrease in contamination. In that case, it suggests that while motivation or attitude has increased, the specific knowledge required to sort correctly is still lacking, necessitating a redesign of the visual prompts. Transparency is essential when conducting this survey.

Additionally, we must also assess the program's impact on the psychological aspects of recycling. Cho & Kim (2017) proposed an integrated model in which "self-determined motivation" serves as a good foundation for predicting recycling behaviour. Furthermore, the evaluation must assess whether the program fosters internal motivation or relies on external pressure in decision-making. If the visual boards are viewed by students solely to trigger compliance through subjective norms, the behaviour will be adapted once the novelty wears off. As Cho & Kim (2017) noted, "whilst subjective norms are important, perceived behavioural control and attitude are stronger predictors". Therefore, the introduction of evaluation in this plan will qualitatively assess whether students feel more capable (i.e., increased perceived control) and more positive towards the act of recycling. Additionally, the "value-action gap", as described by Chaplin and Wyton (2014), will be closely monitored to ensure that the heightened awareness of sustainability is translated into consistent physical actions, rather than just performative agreement with environmental ideals.

Budget

The funding needed for the launch of this plan is approximately $23,500. The price accounts for the necessary recycling hardware upgrades, including centralised stations and classroom bins, as well as the funding needed for the labour involved in producing and updating the visual graphic materials. Additionally, this includes the funding needed for precise data measurement tools, such as digital scales and logging software, as well as the costs associated with signage and public feedback displays essential for the behavioural intervention. This money will help ensure a reduction in solid waste and an increase in recycling rates among Rutgers Students. A reputable source for distributing these funds would be the Rutgers University Environmental Health and Safety Board. The departments and hierarchies of Rutgers University possess the necessary infrastructure to oversee the procurement of hardware and manage student research assistants, establishing them as the ideal sponsors of the funds.

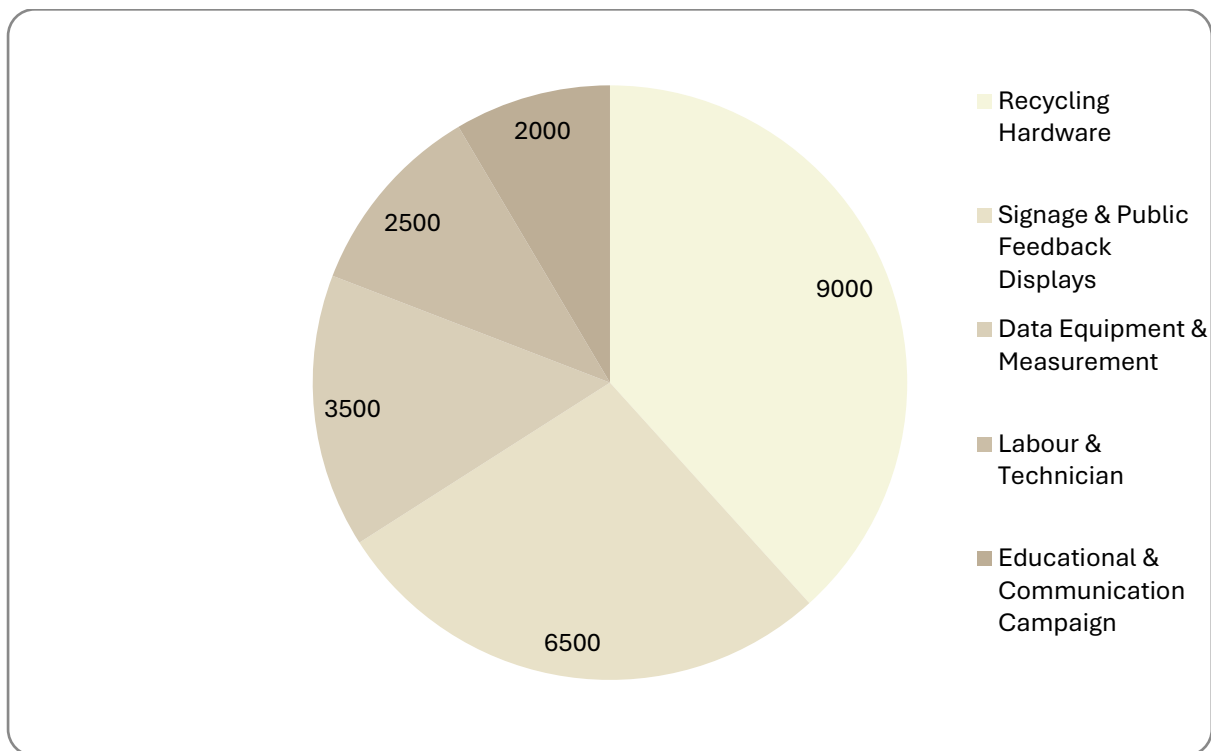| Item Category	Description	Cost
Recycling Hardware	Purchase of centralised waste stations (combined trash + recycling units), additional labelled bins for classrooms, and mounting hardware.	**$9,000**
Signage & Public Feedback Displays	Printing large-format laminated signage for every floor, and weekly-updated feedback display boards.	**$6,500**
Data Equipment & Measurement	Portable digital scales for measuring the weight of recyclables, a journal for input of weekly numbers, and a data logging software license.	**$3,500**
Labour & Technician	Custodial training hours to reconfigure bin arrangements, and student research assistants to collect/analyse data.	**$2,500**
Educational & Communication Campaign	Posters, QR code stickers linking to sorting guides, targeted email graphics, and brief orientation scripts.	**$2,000**
Total Cost		**$23,500**

Table 1

Figure 4: Pie Chart of the Costs

The budget is strategically allocated to prioritise the promotion of physical infrastructure as well as the communicative tools necessary for behavioural change. The most significant proportion, $9,000, is being allocated to Recycling Hardware. The $6,500 for signage and public feedback displays is critical for the "Visual Graphics Board Model" portion of the plan. This will cover the material costs of the board itself and the ongoing printing needs to keep the data fresh and relevant, satisfying the requirement for public feedback supported by Kim et al. (2005).

The Data Equipment & Measurement ($3,500) ensures that Rutgers University will have the technical capacity to accurately audit the waste streams, as emphasised by Leah Filho et al. (2023) for validating reduction targets. Labour & Technician ($2,500) covers the human capital required to gather this data and reconfigure the physical space. This is relatively low because, as suggested by the Campus Trash Project (Camp, 2010), much of this work can be integrated into student service-learning. Finally, the $2,000 for Educational & Communication Campaign supports the visual boards with broader messaging, utilising digital and print media to reinforce the "knowledge" component of the KAP model described by Liu et al. (2024).

Discussion

This plan will ensure that the critical need for a systematic approach to waste management is thoroughly addressed, and it goes beyond simple bin placement. As highlighted by Chao et al. (2020), factors such as concerns for the environment and interpersonal altruism play a significant role in shaping the adolescent mindset on recycling behaviour. Therefore, by implementing a system that visualises the collective impact of individual actions, we can tap into these altruistic psychics. The point of a visual board is not just to inform the general public but also to connect their own action to the overall community goal, fostering a sense of "place attachment" (Chao et al., 2020) where the students feel a responsibility toward their shared campus environment. This correlates with the findings of Zhang et al. (2021), who similarly note that the characteristics of the dining environment and peer behaviours heavily influenced overall wastage generation. By making waste data public, we can promote a shift in the social environment of the campus to one where sustainability is the norm.

Furthermore, the integration of student research into the data collection process transforms waste management from a hidden facility operation into an active educational opportunity. This will reflect the "pedagogical benefits" which were seen in Camp's (2010) archaeological approach, where students learned critical thinking and responsibility by handling waste data directly. However, it is equally important to maintain transparency in this plan and address the challenges highlighted by Hansen et al. (2008), specifically the "institutional barriers" and lack of administrative support that can stall these initiatives. Therefore, there must be consistent coordination between the student body, faculty, and the facilities staff. If successful, this model could serve as a blueprint for other universities and institutions, demonstrating that a relatively low-cost approach combining behavioural psychology with data analysis can yield significant environmental and educational benefits.

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Figure 1 Code

```
library(tidyverse)

raw <- matrix(c(
  135, 119, 254,  20, 10, 30,
   98,  56, 154,  17, 10, 27,
   70,  50, 120,  55, 25, 80,
  112, 114, 226,  38, 17, 55,
   76,  35, 111,  50, 40, 90,
   63,  36,  99,  19, 16, 35
), nrow = 6, byrow = TRUE)

colnames(raw) <- c(
  "Alu_Correct", "Alu_Incorrect", "Alu_Total",
  "Cup_Correct", "Cup_Incorrect", "Cup_Total"
)

df <- as_tibble(raw)
cond <- df %>% mutate(Session = factor(1:6))

long <- cond %>%
  pivot_longer(cols = -Session, names_to = "metric", values_to = "count") %>%
  separate(metric, into = c("Container", "Type"), sep = "_")

plot_data <- long %>% filter(Type %in% c("Correct", "Incorrect"))

beige_bg <- "#F5F0E6"
panel_bg <- "#FBF7EE"
accent1 <- "#CBB79B"
accent2 <- "#8C6A45"
text_col <- "#3E3A36"

p <- ggplot(plot_data, aes(x = Session, y = count, fill = Type)) +
  geom_col(position = position_dodge(width = 0.8), width = 0.7, color = NA) +
  facet_wrap(~Container, nrow = 1) +
  labs(
    title = "Correct vs Incorrect — Aluminium cans and Paper cups",
    subtitle = "Without Proper Instructions/Signages",
    x = "Session",
    y = "Count",
    caption = "Generated with tidyverse & ggplot2"
  ) +
  scale_fill_manual(values = c("Correct" = accent1, "Incorrect" = accent2),
              name = NULL) +
  theme_minimal(base_family = "Helvetica") +
  theme(
    plot.background = element_rect(fill = beige_bg, color = NA),
    panel.background = element_rect(fill = panel_bg, color = NA),
    strip.background = element_rect(fill = "#EFE6D8", color = NA),
    strip.text = element_text(color = text_col, face = "bold"),
    panel.grid.major = element_line(color = "#EFE6D8"),
    panel.grid.minor = element_blank(),
    axis.text = element_text(color = text_col),
    plot.title = element_text(size = 16, face = "bold", color = text_col),
    plot.subtitle = element_text(size = 11, color = text_col),
    plot.caption = element_text(size = 8, color = text_col),
    legend.position = "top",
    legend.text = element_text(color = text_col)
  )

p <- p + geom_text(aes(label = count),
            position = position_dodge(width = 0.8),
            vjust = -0.4, size = 3, color = text_col)

print(p
```

Figure 2 Code

```
library(tidyverse)
library(stringr)

data <- tibble(
  Item = c("Waste batteries are harmful garbage",
       "Spoiled sausages belong to kitchen waste",
       "Glass bottles are recyclable",
       "Chewing gum belongs to other garbage",
       "The leaves on the ground belong to kitchen waste",
       "Dust belongs to other garbage"),

  Percent = c(84.3, 73.6, 72.5, 28.2, 26.5, 34.1),

  Type = c("Highest Correct",
       "Highest Correct",
       "Highest Correct",
       "Highest Incorrect",
       "Highest Incorrect",
       "Highest Incorrect")
)

data$Item <- str_wrap(data$Item, width = 35)

data$Item <- fct_reorder(data$Item, data$Percent)

beige_palette <- c(
  "Highest Correct" = "#D8CFC4",
  "Highest Incorrect" = "#BFAE9B"
)

main_title <- str_wrap(
  "University Students' Waste Classification Knowledge",
  width = 40
)

sub_title <- str_wrap(
  "Highest Correct vs Highest Incorrect Responses",
  width = 50
)


ggplot(data, aes(x = Percent, y = Item, fill = Type)) +

  geom_col(width = 0.7) +

  facet_wrap(~Type,
         scales = "free_y",
         ncol = 1,
         strip.position = "top") +

  geom_text(aes(label = paste0(Percent, "%")),
        hjust = -0.1,
        size = 4.5,
        family = "serif",
        color = "#433A2F") +

  scale_fill_manual(values = beige_palette) +

  scale_x_continuous(limits = c(0, 105), expand = c(0, 0)) +

  labs(
    title = main_title,
    subtitle = sub_title,
    x = "Percentage of Students (%)",
```

```
  y = NULL
) +

coord_cartesian(clip = "off") +

theme_minimal(base_family = "serif") +

theme(
  plot.background = element_rect(fill = "#F6EFE6", color = NA)
  panel.background = element_rect(fill = "#F6EFE6"),
  strip.background = element_rect(fill = "#E7DCCF", color = NA),

  plot.title = element_text(
    size = 20,
    face = "bold",
    color = "#433A2F",
    lineheight = 0.95,
    margin = margin(b = 15)
  ),

  plot.subtitle = element_text(
    size = 14,
    color = "#6B5D50",
    margin = margin(b = 20)
  ),

  strip.text = element_text(size = 15, face = "bold", color = "#433A2F"),
  axis.text = element_text(color = "#433A2F", size = 11),
  axis.title.x = element_text(size = 12, color = "#433A2F"),

  panel.spacing = unit(1.5, "lines"),

  plot.margin = margin(40, 50, 30, 50),

  grid.major.y = element_blank(),
  grid.minor = element_blank(),
  legend.position = "none"

)
```

Figure 3 Code

```
library(ggplot2)
library(dplyr)

sessions <- 1:27
weight <- c(
 2, 4, 3, 2, 1, 2, 2, 1,
 8, 7, 5, 4, 6, 9,
 6, 7, 10, 12,
 7, 6, 4, 5, 3, 3, 4, 5, 6
)

phases <- c(
 rep("Baseline", 8),
 rep("Written Feedback", 6),
 rep("Written + Graphic Feedback", 4),
 rep("Withdrawal", 9)
)

df <- data.frame(sessions, weight, phases)

rects <- data.frame(
 xmin = c(0.5, 8.5, 14.5, 18.5),
 xmax = c(8.5, 14.5, 18.5, 27.5),
 phase = c("Baseline", "Written Feedback",
       "Written + Graphic Feedback", "Withdrawal")
)

beige_bg <- "#f5f0e6"     # whole-plot background
beige_panel <- "#f8f5ee"   # panel background
line_col <- "black"

ggplot() +

  geom_rect(data = rects,
       aes(xmin = xmin, xmax = xmax, ymin = -Inf, ymax = Inf),
       fill = beige_panel, color = NA, alpha = 0.6) +

  geom_line(data = df, aes(x = sessions, y = weight),
       color = line_col, size = 1) +
  geom_point(data = df, aes(x = sessions, y = weight),
        shape = 21, fill = beige_bg, color = line_col, size = 3) +

  geom_vline(xintercept = c(8.5, 14.5, 18.5), size = 1) +

  annotate("text", x = c(4, 11, 16.5, 22.5), y = 15.5,
       label = c("Baseline", "Written\nFeedback",
            "Written +\nGraphic", "Withdrawal"),
       size = 5) +

  scale_x_continuous(breaks = seq(1, 27, 2),
           name = "Consecutive Observation Sessions") +
  scale_y_continuous(limits = c(0, 16),
           breaks = seq(0, 16, 2),
           name = "Weight of Recyclable Papers Collected (kg)") +

  theme_classic(base_size = 14) +
  theme(
   plot.background = element_rect(fill = beige_bg, color = NA),
   panel.background = element_rect(fill = beige_panel, color = "black", size = 1),
   axis.line = element_line(color = "black"),
   panel.border = element_rect(color = "black", fill = NA),
   text = element_text(color = "black")
  )
```