

The De-CAN-Taminator: Technical Report

THE DE-CAN-TAMINATOR



By The Doorstoppers

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Course: GEEN 1400

I. ABSTRACT

In a time when environmental concerns and sustainability are becoming increasingly prevalent, the mission of The Doorstoppers is to make the recycling process more engaging, informative, and uncontaminated. The group chose to prioritize recycling aluminum cans among consumers in the local community because aluminum is extremely cost-effective, infinitely recyclable—a “true closed loop” material—yet only recycled 45.2% of the time. The design of The De-CAN-Taminator, which is inspired by the shape and colors of a retro jukebox, consists of two main sections, a lower section that contains an informational light display and a main recycling bin where cans will be collected, and an upper section that houses a load cell and most of the user interface. The cans collected must be uncontaminated, which means they need to be empty of any liquid, and the load cell is used to guarantee this. The device identifies this using the load cell and this input triggers a trapdoor to drop and for colorful LEDs to turn on, providing the user with immediate feedback and a sense of accomplishment for recycling correctly. This positive feedback and sense of fun will encourage users to continue recycling correctly even with standard recycle bins, in addition to spreading information about how and why to recycle aluminum, contributing to the effort to reach 100% consumer aluminum recycling rates.

II. INTRODUCTION AND BACKGROUND

To achieve the ever-important goal of reducing the carbon footprint as laid out by Mission Zero, The Doorstoppers chose to tackle the issue of low aluminum recycling rates among consumers which is currently only 45.2%. This translates to over \$800 million in landfills each year, a national gap in sustainability and efficiency. Aluminum is a “true closed loop” material which means it can be infinitely recycled. It is the most prevalent beverage package in the United States. Additionally, it only takes 5% of the original production energy to recycle and is 90% more expensive to make new, so the lack of proper aluminum recycling by consumers represents a gap in global efficiency and sustainability. When addressing this issue, it is imperative to prevent recycling contamination which undermines recycling efforts, hurts machines at the recycling plant, can be unsafe for recycling workers, and devalues the recyclables.

To raise the consumer recycling rate of aluminum to 100%, The Doorstoppers created The De-CAN-Taminator, a collection device that spreads awareness, succeeds at uncontaminated recycling, and does so in a fun and engaging way. The aesthetic design also incorporated aluminum cans to represent their versatility and a form of upcycling. This project marks a step towards increased consumer aluminum recycling rates and simultaneously a scalable success at reducing the carbon footprint. The final design is scalable and through education, has the effect of changing aluminum recycling habits through awareness, bridging the gap between current recycling systems and the future of AI sorting bins.

OVERVIEW

III. DESIGN REQUIREMENTS

The primary goal of the group was that the device be fully functional (over 90% accurate), easy to use, and effective in its task of accurately collecting empty cans. In addition, the team wanted to engage and educate the public through the collection device. Constraints included a 10-week time frame, a \$300 budget, as well as the priorities of safety, sustainability, and scalability. It was necessary to have calculation-based schematics, data-driven decisions, and critical thinking when it came to pivoting from original design ideas to new, better ones.

In general, recyclables have to be empty to prevent cross-contamination with other recyclables in the collection truck and at the recycling processing center. For example, if soda leaks onto any paper, the paper is no longer recyclable. Similarly, most recycling centers want to limit the amount of sugar residue left in the cans as it is bad for the machines. CU's Grounds & Recycling Center (GROC) also specifically requests cans be empty of liquids and uncrushed, so these requirements drove the initial weight-sensor design. From this requirement came the critical component of the load cell to measure cans and make sure they are liquid-free.

To achieve the goal of entertainment and education, the group eventually decided that lights would be the most effective and cost-efficient way to do so. This also aligned with the priority of safety, which influenced the design to eliminate too many moving parts and anything that might be dangerous to users. The second critical component of the trapdoor was designed to increase user safety and keep the collected recyclables uncontaminated. The \$300 budget impacted the teams' materials choices and the time frame came back to prevent too many last-minute changes, keeping the overall device design the same throughout the whole process and contributing to a post-prototype pivot to a new entertainment/education system that was more affordable. The team also wanted the created solution to save energy and money which was considered in the choice of electronic components. For optimization purposes, calculations included dimensions, cost analysis, and energy efficiency.

IV. DESIGN ALTERNATIVES AND PROCESS

The De-CAN-Taminator was designed to include a variety of engineering components: wood manufacturing, electronics, circuits, and laser cutting. Throughout the design process, these elements were improved by user testing and reiteration. After the group identified all the components necessary for the design, each team member focused on one specific component of the machine: the frame, load cell, trapdoor, lights, and entertainment/educational piece.

For the frame, The Doorstoppers chose to manufacture The De-CAN-Taminator out of wood. This manufacturing choice was made due to the ease of working with wood, cost efficiency, and the rigidity that wood provided to the full design which can be seen in Figure 1. The frame was built out of ½ inch plywood purchased from Home Depot and was cut with the various machines in the Manufacturing Center of the ITLL to fit around a 21x10x30-inch recycling bin. The prior calculations for the woodcuts were based on the dimensions of the original CAD design (Figure 1) and can be seen in Figure 2. The top arc in the design was also made from wood and was created to be detachable due to space limitations in the Project Vault storage lockers as well as to provide accessibility to the electronic-filled top section.

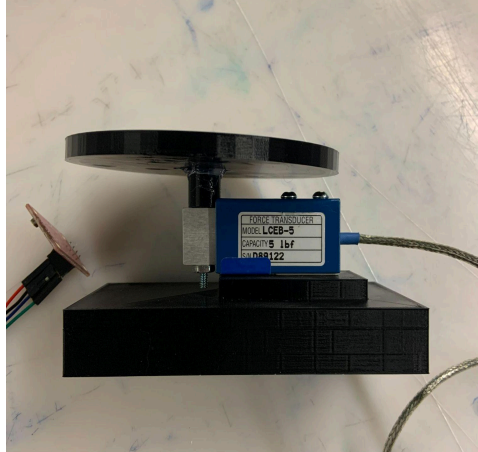


Figure 3. Pictures of the prototype, 3D printed load cell separate from the frame.

The trapdoor mechanism was designed using a linear servo actuator 3D print found on Thingiverse, which controlled the arm that held up the trapdoor (Potent Printables). The linear servo actuator utilized a continuous rotation servo borrowed from the ITLL and consisted of a base, gear, and rod as shown in Figure 4. The rod detracts and retracts to move the trapdoor when the load cell is activated by the correct weight.

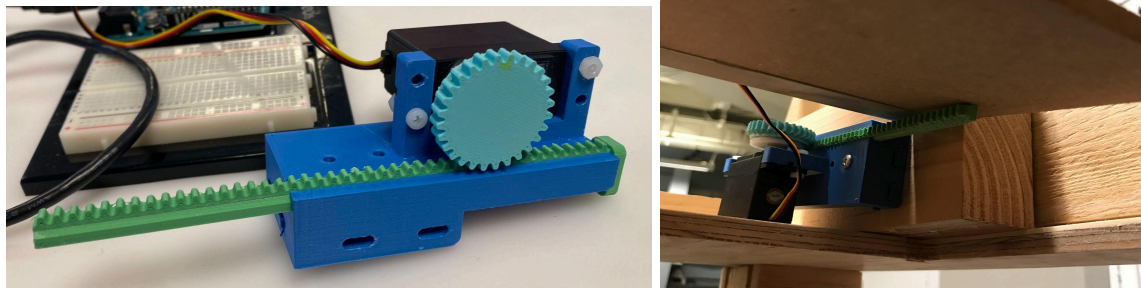


Figure 4. The prototype version of the 3D linear servo actuator and inside view.

Along with having a functional trapdoor, The De-CAN-Taminator was designed to have an entertainment reward system to incentivize users to use the machine. In the initial prototype phase, the group decided using a decision matrix that a Rube Goldberg machine would attract the most attention while remaining easy to incorporate into the front panel. The design (Figure 5) incorporates a motor-operated chain lift which would carry marbles from a collection basin to the top of the Rube Goldberg machine. The marble would enter the Rube Goldberg, passing text panels with aluminum recycling facts and rolling down a fun course for the user to watch. The chain lift would activate if an aluminum can was accepted, rewarding the user for their positive environmental impact.

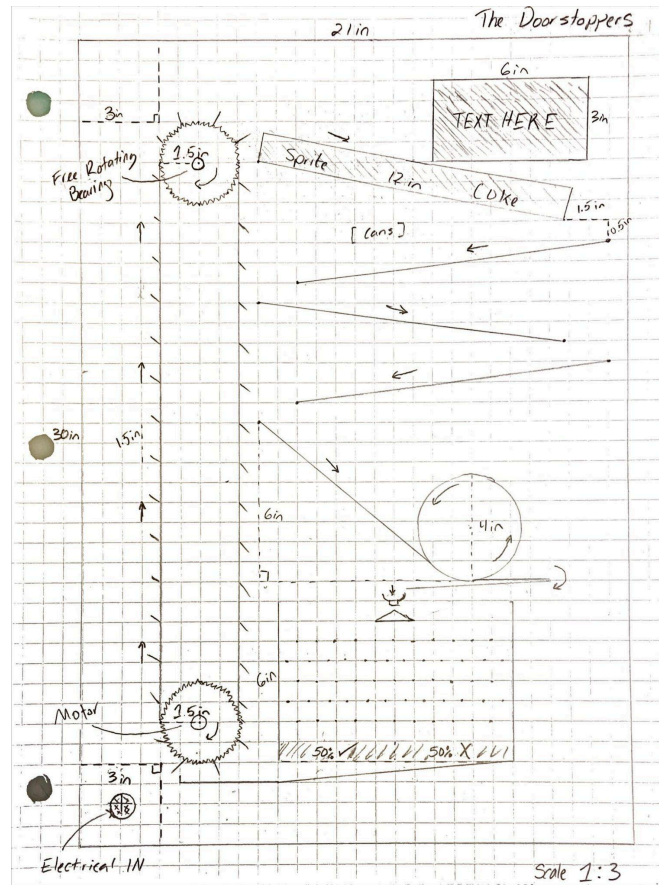


Figure 5. Drawing of Rube Goldberg design.

In designing and prototyping the initial concept, The Doorstoppers realized there were some significant advantages and disadvantages associated with the first iteration. In the first prototype, the load cell was housed outside of the frame which placed less stress on the servo arm, prioritized stability, and could potentially be waterproofed easier. Although these advantages were ideal, the disadvantages of separating the load cell outweighed the advantages; the most obvious disadvantage was the absence of a fully automatic system. Essentially, the can needed to be manually transferred to the trapdoor after it was accepted which the group believed would reduce user satisfaction and ease of use. The load cell was determined to be the most critical component because it was the singular way the device checked cans for contamination, so its orientation within The De-CAN-Taminator was integral. In the prototype, the trapdoor and load cell were separate, but it was decided that for the final interaction, both should be combined into the same component.

Additionally, the initial prototype had some durability concerns with the 3D-printed servo rod which was later continuously improved until fixed for the final design. The servo worked as intended; upon receiving the input data, it always released the trapdoor when a can was determined to be within the fixed load cell acceptance range of 11-16g, which is the weight range of all empty aluminum cans used in the beverage industry. The load cell was determined to weigh accurately within $\pm 0.5g$ which is demonstrated in Table 1, and so the acceptance range was changed to 10 -17g.

Table 1. Data of empty can weights used to calculate the load cell weight acceptance range.

Volume (mL)	Empty Weight (g)	Average Load Cell Reading (g)
Monster: 473 mL	15 g	14.92 g
Coca Cola: 355mL	13 g	13.32 g
Redbull: 250mL	11 g	10.87 g

Final considerations from the prototyping experience included decisions about the design aesthetic, including confirmation that the team wanted to layer the frame in used aluminum cans, paint visible wood sections, and add wheels to the base. More importantly, the original idea for a Rube Goldberg machine as the entertainment element was swapped for that of a poster and LED display due to space, budget, and time constraints. The team decided that the new design choice would be more efficient at informing users and so was not afraid to pivot.

V. FINAL DESIGN

As in the prototype phase, the team used a divide-and-conquer approach to the final build process, splitting up tasks for individuals or pairs, but always reconvening as a whole group to understand each component, integrate elements, and problem-solve trouble spots. In the final design, when the load cell detects the can to be of acceptable weight, it signals the motor of a linear servo actuator which releases a trapdoor under the can and drops it down into the recycling bin. Simultaneously, the light display directs attention to an informational poster positioned right in front of the recycling bin which can be observed through a clear piece of acrylic. As the can drops, additional LED light strips stationed on either side of the device diffuse through the acrylic, rewarding and encouraging the user to continue recycling correctly.

One major change made in the final iteration was integrating the load cell onto the trapdoor. This featured a design with the load cell embedded in the middle of the trapdoor, allowing for cans to be weighed and admitted into the trash can, all without the need for additional user input as seen in Figure 6. This piece was then attached to a hinge within the frame. Another change that was made was the strengthening of the 3D-printed arm for the trapdoor. There were concerns that the arm for the trapdoor lacked rigidity and may snap during consumer use. This was proven by evidence of the trapdoor sagging, even without the presence of the updated combined trapdoor and load cell design. Therefore, the final design featured a 3D-printed arm with greater infill density to support the newly redesigned trapdoor. Figure 7 shows the primary integration of different components.

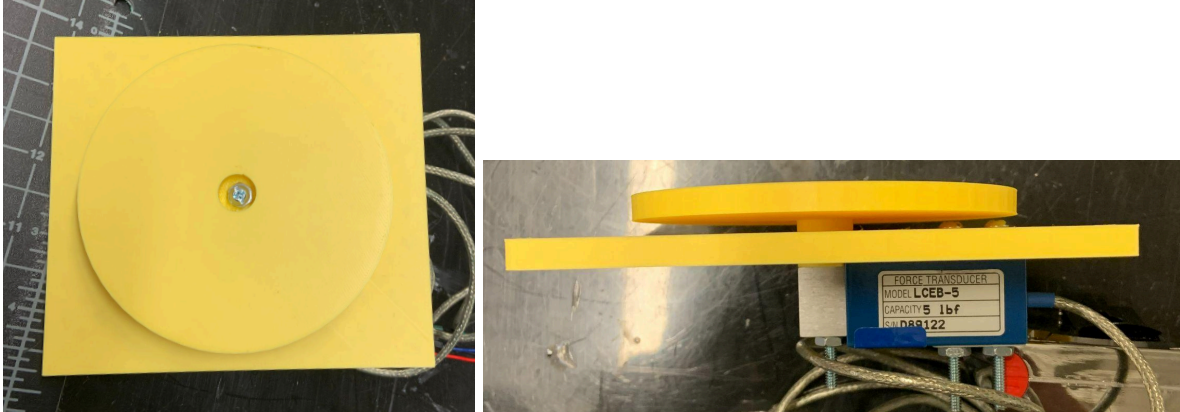


Figure 6. Pictures of the 3D-printed load cell integrated into the trapdoor.



Figure 7. The first stage integration of parts.

After trials and tribulations with the Rube Goldberg machine, The Doorstoppers realized the initial design was too ambitious to complete with the budget and time requirements. After periods of brainstorming, the team opted for a stationary entertainment piece that would be both educational and attention-attracting. The new entertainment piece was made to detail the life-cycle of an aluminum can as seen in Figure 8, as well as containing an LED light panel recycling symbol to attract users.

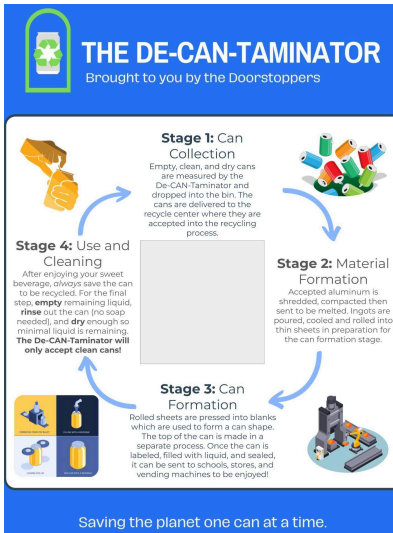


Figure 8. The informational poster about the lifecycle of a can used on the front of the device.

The poster was complemented by a custom-coded LED recycling sign and the side, juke-box style lights. In the final design, the light strip and panel are WS2812B, individually addressable LEDs. The load cell, linear servo motor, and lights are all connected by an Arduino and are activated by the code when the load cell reads a weight within 10-17 grams, the weight range of all empty aluminum cans. When the weight goes over 17 grams, red flashing lights display to the user that The De-CAN-Taminator will not accept the can or item. The Arduino model is shown in Figure 9 [1]. The front LED panel is powered by a separate, secondary Arduino since there were too many components on the first Arduino. Each LED is always on through an array in the panel coding [2]. The code for a successful can activation within the range is randomized with four different light sequences which can flash white, blue, purple, or rainbow.

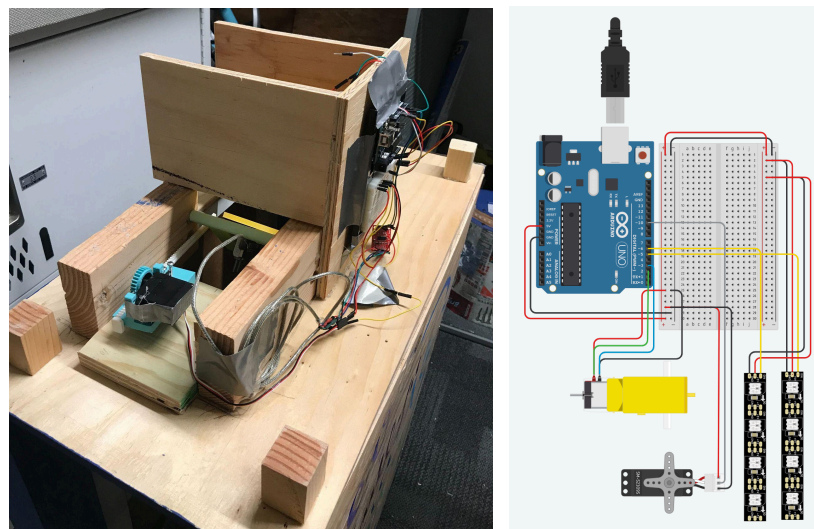


Figure 9. Connection of electronic components to the primary Arduino Uno.

Aesthetics were finished in the final design by painting the box blue as well as layering flattened, used aluminum cans on the sides to contribute to the theme of sustainability and tie

back to the jukebox theme. Once the informational poster and the LEDs were installed, sheets of clear acrylic were laser cut [3] and mounted on top using hot glue and thumb tacks shown in Figure 10. Figure 11 shows examples of the negative and positive inputs. Each component of the project came together to complete The De-CAN-Taminator.



Figure 10. Finalized aesthetics of The De-CAN-Taminator with paint, acrylic, and lights.



Figure 11. The De-CAN-Taminator rejecting and accepting a can (which already dropped).

VI. TESTING

The group's goal for testing was to validate the overall functionality and user satisfaction of The De-CAN-Taminator. The testing phase focused on three critical components: the load cell, the trapdoor mechanism, and the entertainment reward system. The load cell plays a vital role in checking the weight of the cans. It ensures that only empty cans are accepted, contributing to the overall efficiency of the recycling process. The trapdoor mechanism is responsible for the smooth disposal of cans. It opens from underneath, allowing the cans to drop into the recycling bin seamlessly. Finally, the entertainment reward system features lights that illuminate the machine. While not essential for functionality, this element enhances the user experience, making recycling more engaging. The testing of these components ensured that they aligned with the intended design, emphasizing precision, accuracy, and user satisfaction, offering valuable insights into its effectiveness at recycling and engaging/educating the user.

The objective of the load cell testing is to evaluate its accuracy in identifying can weight. The testing procedure used five different cans types, each subjected to ten repetitions. The percent accuracy of the load cell in correctly identifying cans was then recorded. For the trapdoor, the objective was to assess the precision of the mechanism. The testing procedure consisted of fifty tests, recording if the angle of the trapdoor returns to the expected 0° angle in reference to the horizon. Finally the objective for testing the entertainment reward system was to evaluate the effectiveness of the two light displays. The testing procedure consisted of fifty tests, recording the percent success of both LED panels turning on when the can is accepted. In addition, a brief user number-rating questionnaire was administered to 31 people to survey satisfaction, desire to use the machine, and learning outcomes. This data was then used to quantitatively measure success in exciting and educating users.

VII. ANALYSIS

This section documents how the team evaluated the data collected above

- **Load Cell:**

Method/Theory: Utilize statistical measures to assess the accuracy of the load cell.

Equation: Load Cell Success Rate = (Number of Correct Cans admitted / Number of Cans Tested) * 100

Load Cell Success Rate = (47/50) * 100 = 94%

- **Trapdoor:**

Method/Theory: Analyze the trapdoor's angle checking it in comparison to the expected 0°.

Equation: Trapdoor Success Rate = (Number of Successful Returns to 0° / Number of Tests) * 100

Trapdoor Success Rate = (50/50)*100 = 100%

- **Entertainment Reward:**

Method/Theory: Evaluate the success of the entertainment reward system based on observed performance rates.

Equation: Entertainment Percentage Success = (Successful Performances / Total Performances) * 100

Entertainment Percentage Success = (49/50)*100 = 98%

- **User Feedback:**

Method/Theory: Qualitative and quantitative analysis of survey responses to gauge satisfaction, desire to use the machine, and learning outcomes. Averaging of scores on scale-based questions.

Total Responses: 31

Question 1:

On a scale of 1-10 how entertaining is the De-Can-Taminator?

31 responses

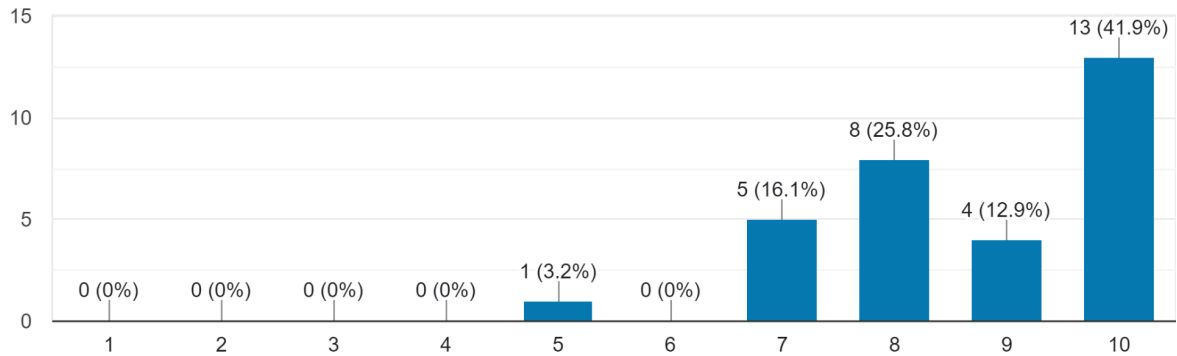


Figure 12. Bar chart representing participants' ratings of the entertainment scale (1-10).

On average, the device received a high rating of 8.71, indicating that users found it to be highly entertaining. This positive response suggests a favorable user experience with the entertainment features of The De-Can-Taminator, contributing to its overall appeal in the recycling process.

Question 2:

How informative is the De-Can-Taminator?

31 responses

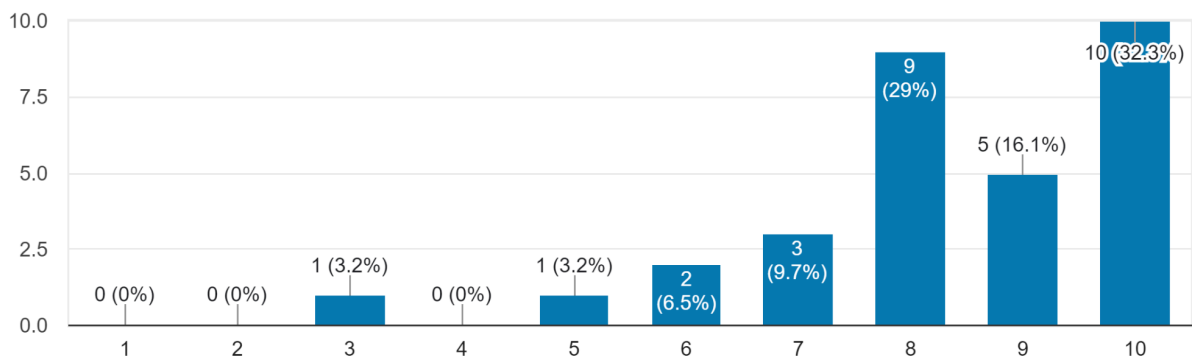


Figure 13. Bar chart illustrating participants' ratings on the informativeness scale (1-10).

The average rating of 8.32 suggests that users found the device to be highly informative. This positive response indicates that The De-Can-Taminator effectively conveyed valuable

information during the recycling process, contributing to its perceived educational value among users.

Question 3:

How easy to use is the device?

31 responses

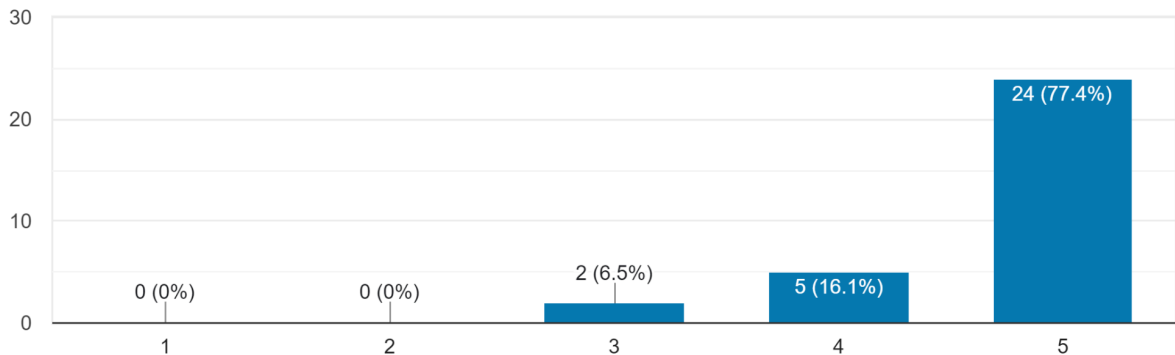


Figure 14. Bar chart representing participants' ratings on the ease of use scale (1-5).

The average rating of 4.71 indicates that users generally found the device to be user-friendly. This positive response suggests that The De-Can-Taminator was perceived as accessible and straightforward in its operation.

Question 4: Did you know a lot about aluminum's recyclability before?

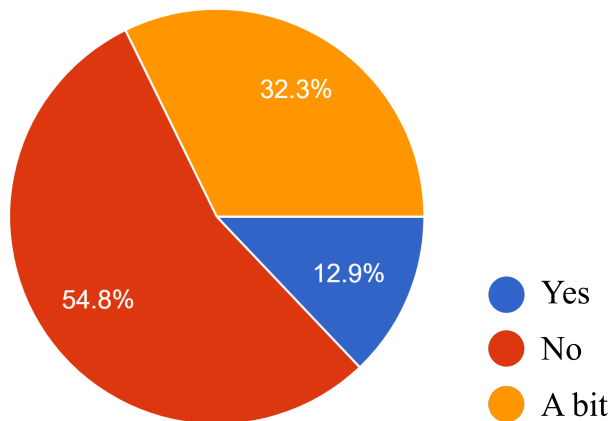


Figure 15. Pie chart illustrating participants' levels of prior awareness about aluminum recyclability.

A significant portion, 54.8%, indicated that they had no prior knowledge about aluminum's recyclability. About 32.3% mentioned having some awareness, while a smaller fraction, 12.9%, affirmed possessing substantial knowledge of the recyclability of aluminum. This distribution highlights the potential impact of educational initiatives to enhance public awareness about aluminum recycling.

Calculations were also performed to determine how much energy The De-CAN-Taminator was saving. Recycling one pound of aluminum (33 cans) saves about 7 kilowatt-hours (kWh) of electricity. With the energy it takes to make just one *new* aluminum can, 20 recycled aluminum cans can be created. Hence, about 0.2 kWh and 3 cents get saved per can recycled. Table 2 shows how the kilowatt-hours it takes to run the machine were found, which is 0.0935 kWh, and translates to The De-CAN-Taminator operating on less than 2 cents per hour, saving energy and money. A single can powers The De-CAN-Taminator for 2.5 hours, so if it collects 10 cans every 24 hours, the machine has paid for itself.

Table 2. Data of the power it takes to run The De-CAN-Taminator

	Voltage (V)	Current (A)	Power, P = IV (Watts)	Usage (hr)	Total Energy, P*Time (Wh)	Total Energy, P*Time/1000 (kWh)
Arduino	5	0.03	0.15	1	0.15	0.00015
Load Cell	5	0.01	0.05	1	0.05	0.00005
Servo Motor	5	0.65	3.25	1	3.25	0.00325
LED Lights	5	6	30		90	0.09
Total kWh =						0.09345
Electrical Rate =						\$0.15
Operating Cost per Hour =						\$0.0140175

VIII. CONCLUSION

The De-CAN-Taminator ultimately is a machine dedicated to the continued reduction of the global carbon footprint. The Doorstoppers approached the construction of this machine with the unique qualities aluminum has (true closed-loop recycling material) as core inspiration. Since aluminum is only recycled 45.2% of the time by consumers, the team designed The De-CAN-Taminator to address the widespread lack of aluminum recycling through the means of decontamination, education, and by making the process fulfilling and entertaining. The Doorstoppers succeeded at these original goals and that of being 90% fully functional, as proven by the testing, analysis, and user survey results. On a scale from one to ten, users, on average, rated the machine’s informative ability a 8.32, entertaining ability a 8.71, and ease of use a 4.71 (from one to five). The De-CAN-Taminator worked successfully—which the team defined as accepting or declining a can accurately and projecting an LED reward—94% of the time, which exceeds the initial benchmark of 90%. 54.8% of users reported having no prior knowledge of aluminum’s closed-loop nature and recycling specifications; the team hopes these users are now educated and will continue to recycle their cans responsibly in the future. It was also interesting to find that low consumer recycling rates were indeed reflected by the lack of public knowledge about aluminum recycling.

As The Doorstopper’s main initiative was to reduce the global carbon footprint, The De-CAN-Taminator was designed with sustainability principles in mind. Before construction, the team extensively drafted dimensions so no extra material would be wasted. In this design process, the team chose materials that could be borrowed (load cell and servo motor) or renewed easily (wood). The core concept of the machine was to improve the collection process of

aluminum cans and educate the public about the aluminum recycling process. This initiative correlates to a positive sustainable impact. The Doorstoppers believe both, a solid education and an open mind, can be the catalyst for progress.

In the future, The Doorstoppers wish to expand the positive influence The De-CAN-Taminator can have on aluminum recycling to multiple locations around the University of Colorado Boulder. If The De-CAN-Taminator can replicate its results at other locations on campus, the construction of more units may be considered. If the recycling effort, with more units, at the University of Colorado is successful, the team would encourage branching out to other university campuses or the broader community. To facilitate this expansion, construction manuals with building instructions, material lists, and electronic code would need to be drafted and optimized by The Doorstoppers. More than anything, the intended impact is to entertain and educate users so that they change their aluminum recycling habits even without The De-CAN-Taminator.

IX. BUDGET/BILL OF MATERIALS

Construction Category	Item Aquired	Location Aquired	Price
Frame	1/2 in. 4x8ft Plywood	Home Depot	\$27.48
	Casters (wheels)	Home Depot	\$11.42
	Onyx Printed Rod	ITLL	\$2.30
	Fiberglass Reinforced Rod	ITLL	\$7.54
	Screws	Project Vault	\$0.00
			\$48.74
Electronics	Load Cell	Electronics Center	(Borrowed)
	Servo Motor	Electronics Center	(Borrowed)
	Arduino Uno	Electronics Center	(Borrowed)
	LED Light Strip (x2)	Amazon	\$18.81
	LED Light Panel	Amazon	\$18.89
	Power Adapter	Amazon	\$7.99
			\$45.69
Aesthetic	Acrylic	Amazon	\$54.78
	Thumb Tacks	Home Depot	\$5.08
	Paint	Michael's	\$2.17
	Aluminum Cans	Personal Donations	\$0.00
	Front Poster	ITLL	\$30.63
	Wood	ITLL Workshop	\$0.00
	Screws	Project Vault	\$0.00
			\$92.66
Display Poster	Display Poster	ITLL	\$22.78
		TOTAL :	\$209.87

X. TIMELINE

- 09/27 Need Finding and Brainstorming
- 10/12 Project Definition and Ideation (PDR)
- 10/26 Prototyping
- 11/02 Critical Design Review (CDR)
 - Integrate New Trapdoor & Load Cell & New Servo
 - Code Light Display
- 11/16 Functional Project/Testing and Analysis Report Due
 - Testing Data & User Survey
 - Finalize Aesthetics
- 11/30 Posters Due
- 12/09 Design Expo*
- 12/14 Final Design Report

*Everything was finalized the week before the exposition but because the LEDs and servo randomly stopped functioning the night before the expo (multiple separate issues), the team was still fixing components 24 hours before the event.

XI. APPENDIX

[1] First Arduino Code for the Servo, Load Cell, and LED strip

```
#include <Adafruit_NeoPixel.h>
#ifdef __AVR__
#include <avr/power.h> // Required for 16 MHz Adafruit Trinket
#endif
#define LED_PIN    6
#define LED_COUNT 300
Adafruit_NeoPixel strip(LED_COUNT, LED_PIN, NEO_GRB + NEO_KHZ800);

#include <Arduino.h>

#include "HX711.h"

#include <Servo.h>

// HX711 circuit wiring
const int LOADCELL_DOUT_PIN = 2;
const int LOADCELL_SCK_PIN = 3;
HX711 scale;

//Servo Setup
Servo swizzle; //declares servo
int angle = 0;
int increment = 1.5; // Change this value to control the speed

//For weighing cans
float total;
float reading;

void setup() {
  //Load Cell
  Serial.begin(57600);
  scale.begin(LOADCELL_DOUT_PIN, LOADCELL_SCK_PIN);
  scale.set_scale(2816.22265); //Calibration
  scale.tare();

  //Servo
  swizzle.attach(10);

  //Random LED Sequence
  randomSeed(analogRead(0));

  //LED Initialization
  strip.begin();           // INITIALIZE NeoPixel strip object (REQUIRED)
  strip.show();           // Turn OFF all pixels ASAP
  strip.setBrightness(50); // Set BRIGHTNESS to about 1/5 (max = 255)
}
void loop() {

  int randomNumber = random(4);

  float reading = scale.get_units(30);
  Serial.println(reading);

  //No can is detected
  if ((reading >= -1.0) && (reading <= 1.0)) {
```

```

    Serial.println("No can detected.");
}

//Too much weight
while (reading > 17.0)
{
    theaterChase(strip.Color(127, 0, 0), 50);
    strip.show();
    delay(1000);
    strip.clear();
    strip.show();

    break;
}
//If value is within range of 10g - 17g, print valid value
while ((reading >= 10.0) && (reading <= 17.0)) {

    //Write good reading
    Serial.println("This reading is correct. Can is valid");

    //Use Servo
    swizzle.attach(10);
    swizzle.write(0); // 0 degrees
    delay(1400);      // Wait for 1.4 seconds

    // Rotate the servo in the other direction
    swizzle.write(180); // 180 degrees
    delay(1400);      // Wait for 1.4 seconds

    // Stop the servo
    swizzle.detach(); // Detach the servo to stop moving

    if (randomNumber == 0) {
        theaterChase(strip.Color(127, 127, 127), 50); // White, half brightness
        strip.show();
        delay(1000);
        strip.clear();
        strip.show();
    }
    else if (randomNumber == 1) {
        theaterChase(strip.Color(127, 0, 128), 50); // Purple, half brightness
        strip.show();
        delay(1000);
        strip.clear();
        strip.show();
    }
    else if (randomNumber == 2) {
        theaterChase(strip.Color(0, 0, 127), 50); // Blue, half brightness
        strip.show();
        delay(1000);
        strip.clear();
        strip.show();
    }
    else if (randomNumber == 3) {
        theaterChaseRainbow(50);
        strip.show();
        delay(1000);
        strip.clear();
        strip.show();
    }
}

```

```

    }
    break;
}
delay(150);
}

// Theater-marquee-style chasing lights. Pass in a color (32-bit value,
// a la strip.Color(r,g,b) as mentioned above), and a delay time (in ms)
// between frames.
void theaterChase(uint32_t color, int wait) {
  for (int a = 0; a < 5; a++) { // Repeat 10 times...
    for (int b = 0; b < 3; b++) { // 'b' counts from 0 to 2...
      strip.clear();           // Set all pixels in RAM to 0 (off)
      // 'c' counts up from 'b' to end of strip in steps of 3...
      for (int c = b; c < strip.numPixels(); c += 3) {
        strip.setPixelColor(c, color); // Set pixel 'c' to value 'color'
      }
      strip.show(); // Update strip with new contents
      delay(wait); // Pause for a moment
    }
  }
}

// Rainbow-enhanced theater marquee. Pass delay time (in ms) between frames.
void theaterChaseRainbow(int wait) {
  int firstPixelHue = 0; // First pixel starts at red (hue 0)
  for (int a = 0; a < 30; a++) { // Repeat 30 times...
    for (int b = 0; b < 3; b++) { // 'b' counts from 0 to 2...
      strip.clear();           // Set all pixels in RAM to 0 (off)
      // 'c' counts up from 'b' to end of strip in increments of 3...
      for (int c = b; c < strip.numPixels(); c += 3) {
        // hue of pixel 'c' is offset by an amount to make one full
        // revolution of the color wheel (range 65536) along the length
        // of the strip (strip.numPixels() steps):
        int hue = firstPixelHue + c * 65536L / strip.numPixels();
        uint32_t color = strip.gamma32(strip.ColorHSV(hue)); // hue -> RGB
        strip.setPixelColor(c, color); // Set pixel 'c' to value 'color'
      }
      strip.show();           // Update strip with new contents
      delay(wait);           // Pause for a moment
      firstPixelHue += 65536 / 90; // One cycle of color wheel over 90 frames
    }
  }
}
}

```

[2] Second Arduino Code for the front LED panel

```

#include <FastLED.h>
#define LED_PINS 6
#define NUM_LEDS 256
CRGB leds[NUM_LEDS];

void setup() {
  FastLED.addLeds<WS2812, LED_PINS, GRB>(leds, NUM_LEDS);
}

void loop() {
  // Clear the matrix
  fill_solid(leds, NUM_LEDS, CRGB::Black);
}

```

```

// Draw an arrow shape with green lights
drawArrow();
// Show the pattern
FastLED.show();
// Delay for a moment
delay(500);
}

void drawArrow() {
// Define the arrow shape using LED indices
int arrowIndices[] = {
    249, 250, 251, 233, 231, 230, 229, 228, 227,
    214, 215, 216, 217, 218, 219, 220, 221,
    201, 200, 199, 198, 197, 196, 195, 194,
    182, 183, 184, 185, 187, 188, 189,
    169, 168, 167, 166, 165,

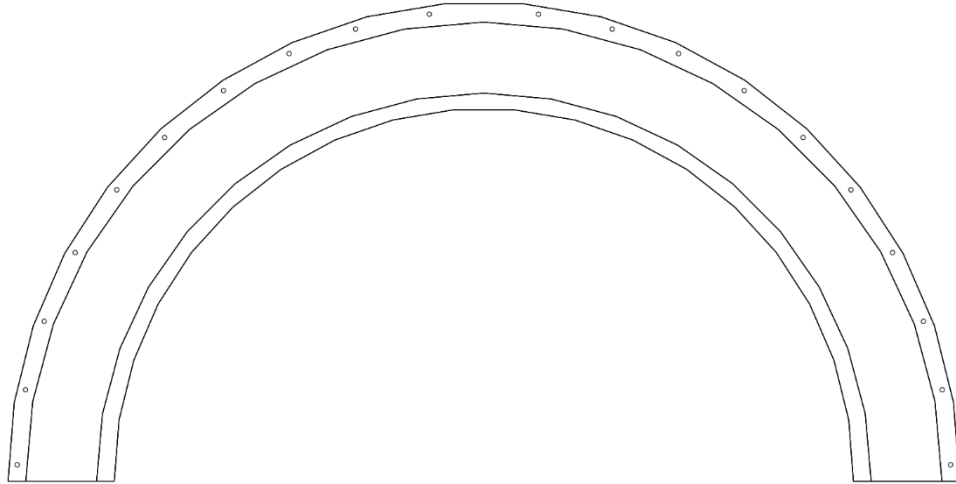
    178, 174, 173, 172,
    144, 145, 146, 147, 148,
    143, 142, 141, 140, 139, 138,
    112, 113, 114, 115, 116,
    111, 110, 109, 108,
    80, 81, 82, 83, 84, 85,
    78, 77, 76, 75, 74,
    50, 51, 52, 53,
    46, 45, 44, 43, 42,

    156, 132, 131, 130,
    122, 123, 124, 125, 126,
    102, 101, 100, 99, 98, 97, 96,
    91, 92, 93,
    68, 67, 66,
    70, 56, 57, 58, 59, 60, 61,
    40, 39, 38, 37, 36, 35, 34,
    24, 25, 26, 27, 28,
    6, 4, 5,
};

// Set LEDs in the arrow shape to green
for (int i = 0; i < sizeof(arrowIndices) / sizeof(arrowIndices[0]); i++) {
    leds[arrowIndices[i]] = CRGB(0, 0, 20); // Green color
}
}

```

[3] Acrylic Laser Cutting File



XII. REFERENCES

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