MESA Mathematics Engineering Science Achievement
JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY

R^3

(Reduce Reuse Recycle)

Technical Presentation

Patapsco Middle School - 6th Grade
Designed by: The RoboKnights
2017-2018
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Project Objective

Core Objective : Develop a device to efficiently identify recyclable items to reduce landfill Recyclables and minimize environment pollution.

Problem statement : Currently lot of recyclable items are being thrown into the trash and being sent to landfills everyday, this creates toxic chemicals that heat up the earth and contributes to global warming.Another issue with recyclable items in landfills is that they don't biodegrade quickly. In fact, it takes an average plastic water bottle 500 years to completely biodegrade.

About Our Client
- Gemma Evans

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Experience:
- Planning Specialist
- Recycling Coordinator
- Assistant Manager
- Schoolyard Habits Intern
- Assistant Director of Special Events

Education:
Warren Wilson College

Honors/Awards:
Employee of The Year for October 2010

Accepting the award is Branch Manager, Susan Stonesifer (Middle). Presented by MRN Vice President Gemma Evans and MRN Awards Chair, Bob Stumpf.

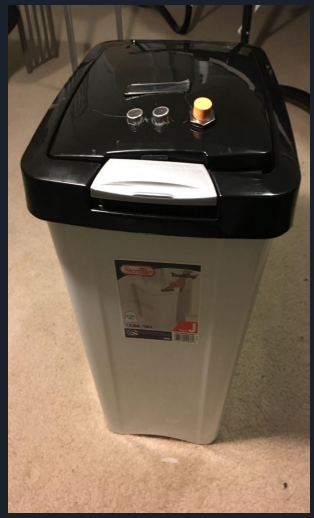
Client Requirements

Client needs:

- Need a tool to identify recyclable items and restrict recyclable items to be intermixed with the trash
- Efficient Proximity sensing of recyclable items
- Needs to be weatherproof and avoid damage from trash inside the container
- Needs to have display panel for friendly usability and buzzer prompting
- Scope is limited for home usage - Needs further improvements for commercial usage

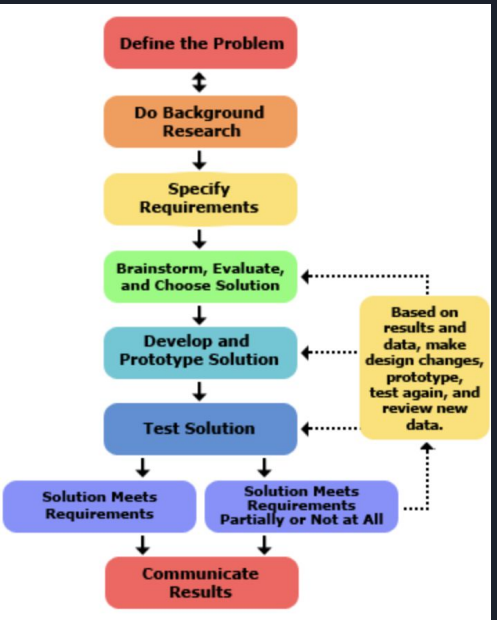
Constraints:

- The object the should not be more than 8mm away from the proximity sensor on the device.
- The trash should not be filled over the device, which is attached inside the trash bin.
- The user has to check the power supply (batteries) on a regular basis.



Engineering Design Process

- We followed standard engineering design process as our methodology with steps that includes
  - **ASK** → **IMAGINE** → **PLAN** → **CREATE** → **IMPROVE** → **SHARE** solution
  - Engineering standard: 3-5-ETS1-2 ; 3-5-ETS1-3
  - Program Coding standards for arduino e.g.naming convention, single line comments etc.
- We did some background research if there any products in market that can efficiently identify recyclable items to avoid intermixing trash, to minimize recyclable items in landfills, and reduce generation of toxic chemicals
- We did some brainstorming and came up with 3 different solutions and decided on one final solution
- The selected solution for device design has been split into 3 different modules- metal detector, motion detector, and Display Panel
- We first built and tested the 3 modules separately then integrated them and tested the integrated device
- We had a couple of bugs along the way with both the separate modules and the integrated device which we persevered to fix then test again



Major challenges and correlating solutions

Currently there is no single device in the market that can efficiently identify all recyclable items from trash and user friendly.

- We considered the following solution choices for protype and selected option 1
  - Option 1: A device to identify trash and recyclable items throwing into the trash bin with lid
  - Option 2: A device to identify recyclable items throwing into (free flow) the trash bin without lid
  - Option 3: A device to identify recyclable items from the settled items of the trash bin

  But after our brainstorm discussions, we found it is practically difficult to identify settled recyclable items from trash bin and also for free flow items without lid. So finally we chose option 1 as viable solution.

- We considered the following capabilities for this iteration but it has foundational framework that can be extendable
  - Identification of few selected recyclable items - metal detection scope only, individual loading of the items in trash bin, LCD display for prompts along with buzzer, Lid auto open/close, residential usage only.

Modules Implementation

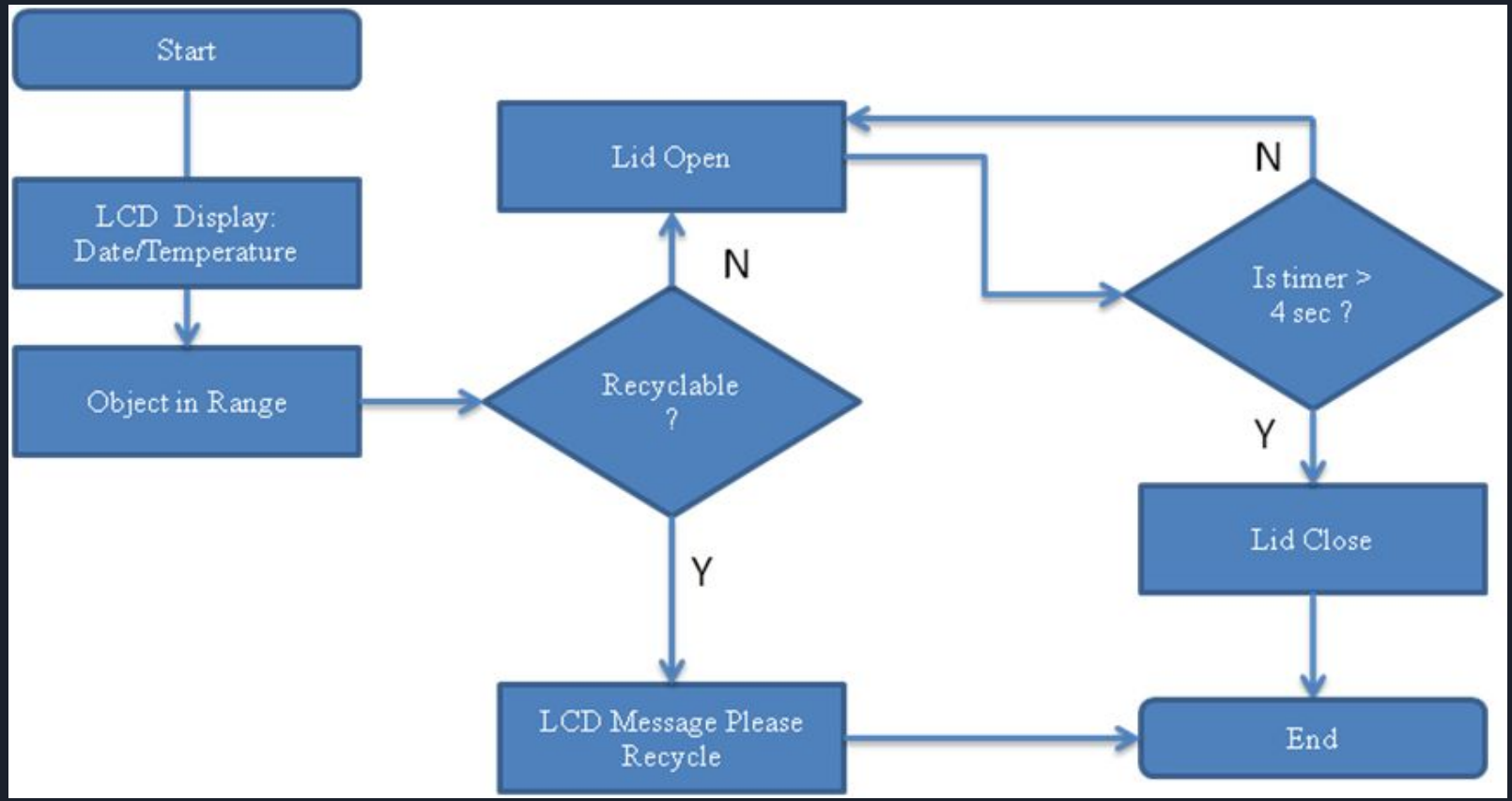
Design and development work has been split into 3 modules:

- 1. Metal Detector : Metal Detector is the inductive proximity sensor for detecting the metal items. Metal detector module upon identification of metal sends signals in a serial fashion to the code deployed on the arduino board and LCD.

- 2. Motion and Temperature Detector : Motion Detector is an Ultrasonic sensor to detect the motion of objects within proximity of 5cm to 15cm and sends serial signals to the arduino board that is programmed to open /close the lid. This also uses Temperature sensor and Real Time Clock (RTC)

- 3. Display Panel : Based on signals received from metal detector module Liquid Crystal Display (LCD) panel displays “Please Recycle” prompts, if metal is detected and produces buzzing sound.

R^3 Flow Diagram



Materials Needed

Materials Finalized:

- 1 Arduino Mega ATmega2560
- 1 Inductive Proximity Sensor(NPN type)
- 1 Ultrasonic Sensor (HC-SR04)
- 1 Liquid Crystal Display (HC1624 LCD)
- 1 Device holding box
- 1 RTC and Temperature Sensor (DS3231)
- 1 Battery holder
- 1 Trash bin for prototype
- 1 Buzzer
- 1 DC Servo (55g)
- 6V battery (Quantity 4)
- Miscellaneous

Prototype Demonstration

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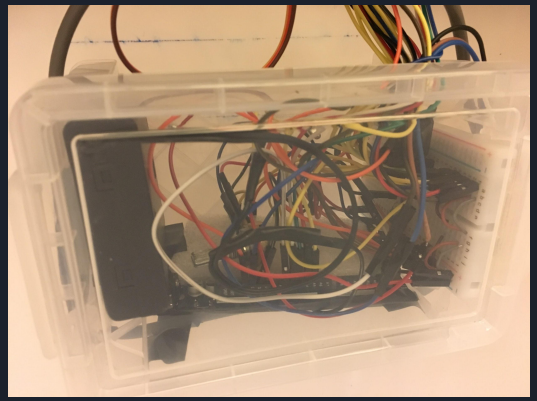


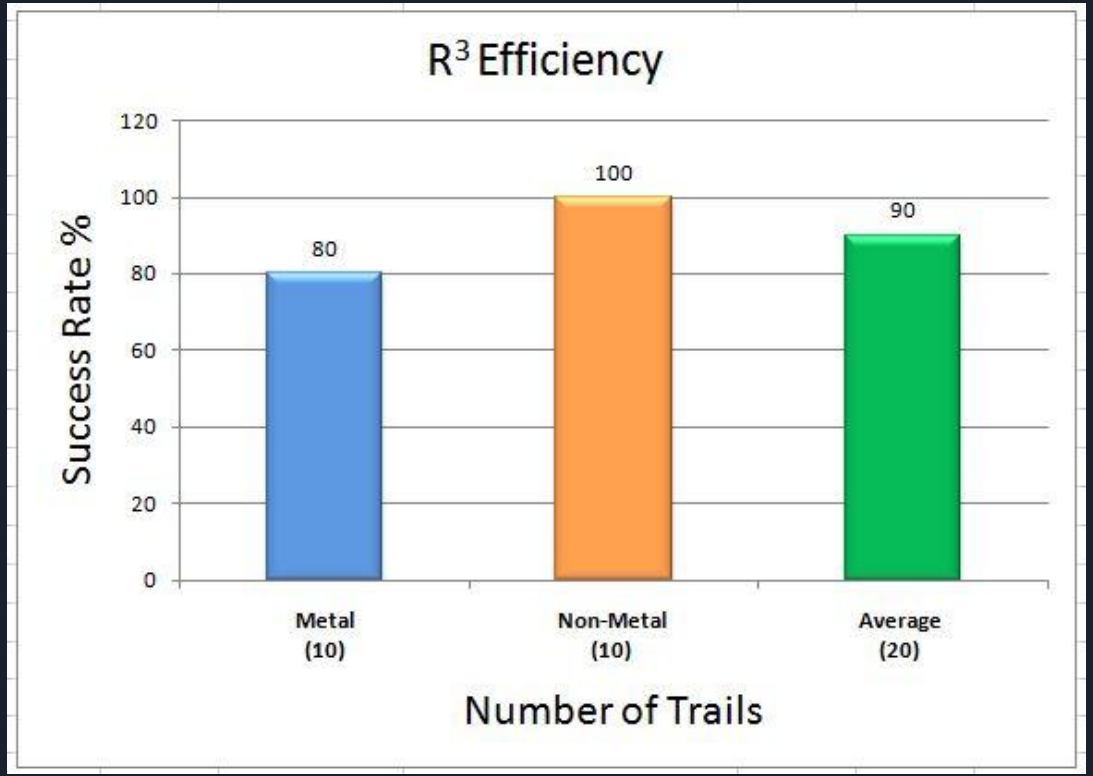
Testing approach and Results

We have conducted testing for our prototype in two phases:

- Unit Testing
  - Tested each of the modules separately soon after the module code is developed and the corresponding circuit is completed.
  -
- Integration Testing
  - Once all modules are passed unit testing, we integrated code for two Metal Detector module and LCD Panel module with the corresponding integrated circuit and then conducted testing.
  - Next we integrated Motion Detector module with the already above integrated modules along with the code and the circuit and finally conducted the integrated system testing.
  - Few of the Test Scenarios are as below:
    - Placed a metal soda tin in front of the device and the trash lid did not open with the message ‘Please Recycle’ on the LCD display panel.
    - Placed a non-metal soda tin in front of the device and the trash can lid was opened. No prompting to recycle with the text message on LCD display panel

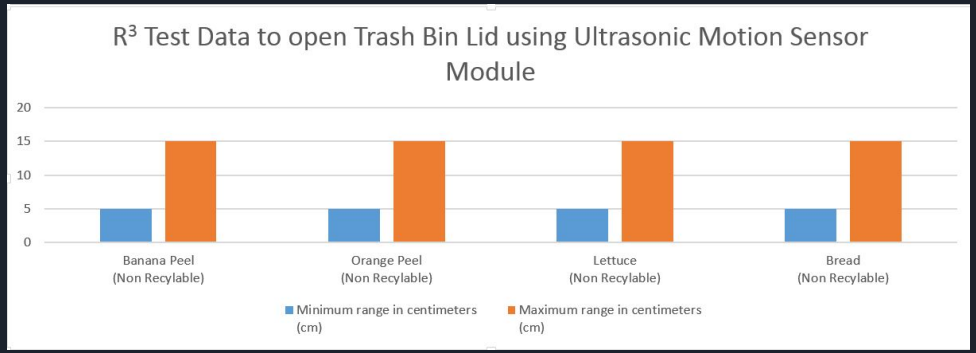
R^3 Efficiency

Trials	Metal/Non-metal	Worked/Didn't:
1	Metal (Stainless steel cup)	Didn't work
2	Metal (aluminum)	worked
3	Metal (stainless steel sciss	worked
4	Metal (steel key chain)	worked
5	Metal (aluminum)	worked
6	Metal (gold ring)	worked
7	Metal (iron screw)	worked
8	Metal (steel earring)	Didn't work
9	Metal (steel car key)	worked
10	Metal (steel pliers)	worked
11	Non metal (peanut butter ja	worked
12	Non metal (potato)	worked
13	Non metal (glass cup)	worked
14	Non metal (onion)	worked
15	Non metal (foam toy)	worked
16	Non metal (popsicle stick)	worked
17	Non metal (lemon)	worked
18	Non metal (rubber bouncy	worked
19	Non metal (pistachio shell)	worked
20	Non metal (pencil)	Worked



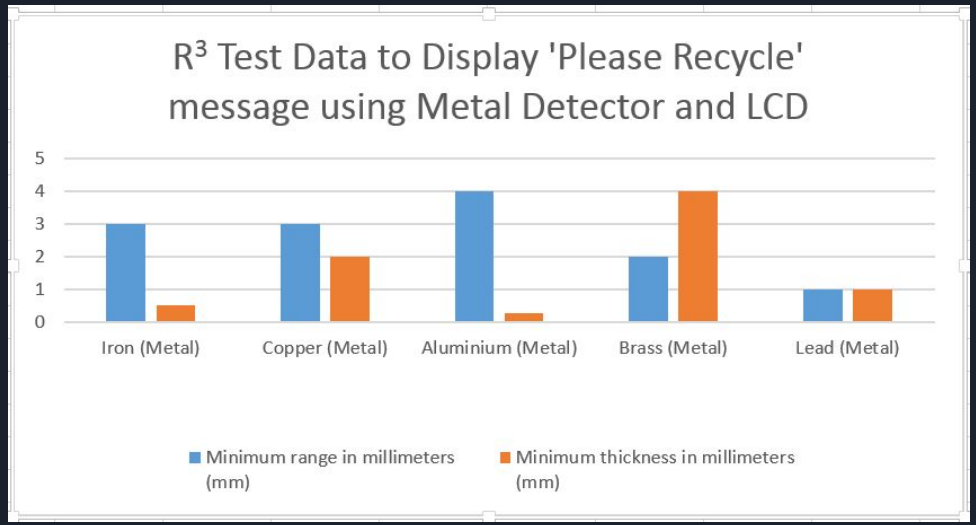
Test Data and Graphs for Non-Metal

Type of Material	Minimum range in centimeters (cm)	Maximum range in centimeters (cm)
Banana Peel (Non Recylable)	5	15
Orange Peel (Non Recylable)	5	15
Lettuce (Non Recylable)	5	15
Bread (Non Recylable)	5	15



Test Data and Graphs for Metal

Type of Material	Minimum range in millimeters (mm)	Minimum thickness in millimeters (mm)
Iron (Metal)	3	0.5
Copper (Metal)	3	2
Aluminium (Metal)	4	0.25
Brass (Metal)	2	4
Lead (Metal)	1	1



Conclusion

The device has foundational framework that can be extendable and currently has following

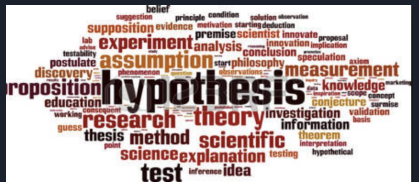
key features:

- ➢ Uniqueness of the product to deliver various capabilities like metal detection, LCD display, buzzer prompting and auto lid open/close functionality.
- ➢ Improves the efficiency of recyclable items identification.
- ➢ The product has foundational framework with focused capabilities but has potential to be fully extendable to meet broader diversified needs.

Limitations: Metal detection only, individual loading of the items in trash bin, inductive proximity sensor range is low

In **summary** the device minimizes intermixing of recyclable items with trash in turn helps

- ○ Reduction of chemical toxic gases generation from Landfills
- ○ Increased Opportunity on recycling and saves energy



Next Steps / Recommendations

Enabling below capabilities are been considered for future enhancements for multi iteration releases for full blown product:

- Can be enhanced with Plastic, paper and glass identification capabilities with corresponding sensors.
- Notification to user's phone with for each recycled item is a nice to have future.
- Extend product capabilities from residential to community common usage.
- Monthly reports to user telling them how much they have recycled
- Temperature sensor can be used to detect temperature over 80 degrees Fahrenheit to notify user with a message on LCD to empty trash from the bin

Any Questions?

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