Project: Food Printing Systems

Project Description

The Food Printing Systems project aimed to develop a system that enhances food accessibility for visually impaired individuals. Utilizing the Evebot Food-Grade Portable Printpen, A prototype was created that is capable of printing customized food labels on fruits. This project underscores my ability to innovate within the food industry and address accessibility challenges.

Objectives

1. Analyze a Food Industry Segment Using Systems Engineering Principles:
   - Conducted a thorough analysis of the food printing industry to identify potential areas for innovation.
   - Applied systems engineering methodologies to ensure a comprehensive understanding of the project's scope and requirements.

2. Develop a Working Prototype Demonstrating Key Features and Functionality:
   - Designed and built a functional prototype that integrates the Evebot system with a custom-developed funnel mechanism.
   - Ensured the prototype met all specified criteria, including food safety standards and usability for visually impaired users.

Project Focus: Evebot Food-Grade Portable Printpen
A handheld inkjet printer designed to customize food surfaces. This technology was leveraged to create a system that prints directly on food items, replacing traditional label stickers.

Exploratory Research

Starting off the project, exploratory research on food printing systems was first conducted. Food printing systems are split into two types, extrusion based and inkjet based.

S/N	Extrusion-based food printing system. [1]	Inkjet-based food printing system[2][3]
1	Extrude food materials through the extruder.	Eject food ink through the nozzle.
2	Manipulate raw food materials before extrusion.	
3	Move the extruder in the X, Y, and Z axis.	Move the extruder in either the X or Y axis.
4	Communicate with external devices to retrieve user input.	Communicate with external devices to retrieve user input.
5	Transforms user input into machine actions.	Transforms user input into machine actions.

The table above shows the functionalities of the two different printing systems. Following this, the conclusion of food printing systems was made, which is that **food printing systems will perform customization towards the shape, color, or texture of food materials**. Next, research on some potential problems faced by the food industry was conducted.

Print labels on food

Food labels are regularly pasted on food products to convey product information to customers, and for stock tracking. These single use food labeling has seen prevalent usage in the logistics sector of food industries such as supermarkets. The labeling on these products helps enable customers to make informed decisions and builds trust between customers and brands. However, the present method of labeling serves more contradictions than positivity.

Context

In grocery stores, print labels are commonly used for stock counting and expiry. This solution replaces the labels with direct prints on food items using the Evebot system, eliminating the need to peel off stickers before consumption.

Traditional stickers on ready-to-eat food items can be inconvenient and pose a contamination risk. These plastic labels are also torn off before consumption, which creates inconvenience for

both the customer, and the environment.

Waste Type	Total Generated ('000 tonnes)	Total Recycled ('000 tonnes)	Recycling Rate	Total Disposed ('000 tonnes)
Ferrous metal	1,296	1,289	99%	7
Paper/Cardboard	1,251	387	31%	863
Construction & Demolition	832	828	99%	5
Plastics	957	48	5%	909
Food	755	132	18%	623
Horticultural	256	218	85%	38
Wood	447	299	67%	149
Ash & sludge	231	32	14%	199
Textile/Leather	211	5	2%	206
Used slag	176	173	98%	3
Non-ferrous metal	106	105	99%	1
Glass	75	6	8%	69
Scrap tyres	27	26	95%	1
Others (stones, ceramics, etc.)	238	6	N.A.[1]	232
Overall	**6,859**	**3,553**	**52%**	**3,306**

Year	Waste Generated ('000 tonnes)	Waste Recycled ('000 tonnes)	Waste Disposed ('000 tonnes)	Overall Recycling Rate	Overall Recycling Rate w/o C&D waste
2013	7,851	4,826	3,026	62%	51%
2014	7,515	4,471	3,043	60%	51%
2015	7,673	4,650	3,024	61%	52%
2016	7,814	4,769	3,045	61%	51%
2017	7,704	4,724	2,980	61%	51%
2018	7,759	4,790	2,969	62%	52%
2019	7,278	4,293	2,984	59%	49%
2020	5,880	3,040	2,841	52%	44%
2021	6,944	3,826	3,118	55%	47%
2022	7,385	4,188	3,197	57%	46%
2023	6,859	3,553	3,306	52%	45%

The two tables above show the overall number of waste generated, and the overall recycling rate in the past decade. Although green washing is not the objective of this project, the numbers left much room for improvement.

Problems and opportunity

Problem: Breakdown of disposable plastics creates microplastics, which creates microplastics, which causes harm to wildlife and humans
Opportunity: Replace the present method of food labeling with an alternate solution that does not involve the use of plastic

This project is significant for several reasons:

1. Systems Engineering Application:
   - Demonstrated ability to analyze, design, and implement complex systems, a key skill for any engineering role.

2. Innovation:
   - Identified gaps in the food printing market and developed creative solutions to address them.

3. Technical Skills:
   - Showcased proficiency in research, prototyping, and integrating new technologies.

4. Inclusivity:
   - Focused on developing accessible solutions that cater to diverse user needs, particularly the visually impaired.

Existing solution: Laser marking system

Functionalities of Laser Marking Systems:

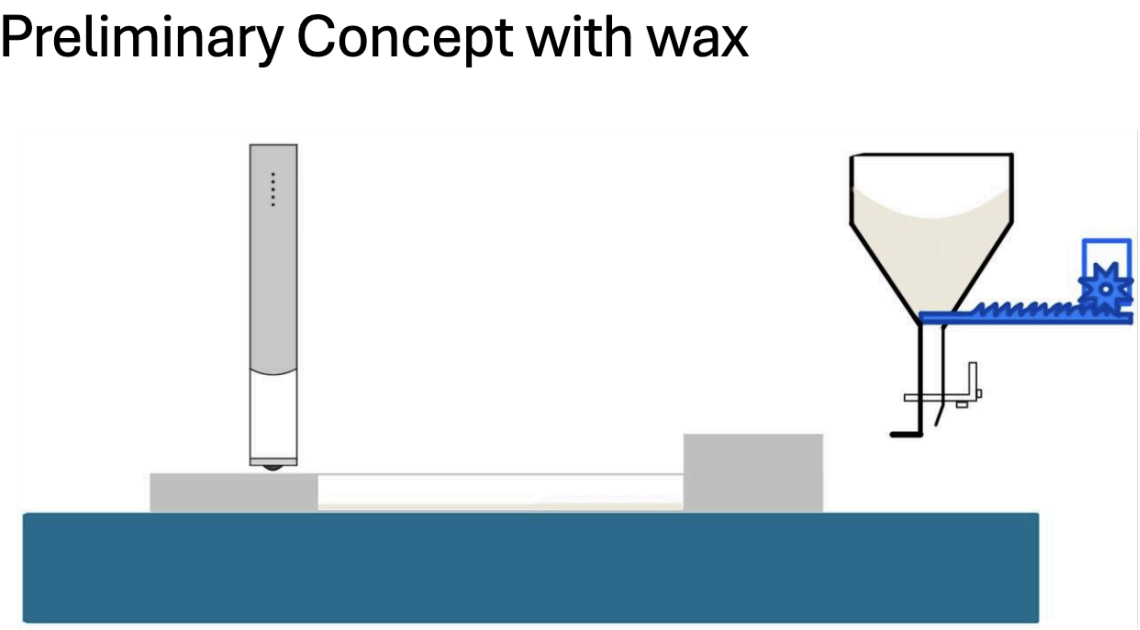
- Emits laser beams on food surfaces to cause localized heating.
- Communicate with external devices to retrieve user input.
- Transforms user input into machine actions.
- Move the laser head in a 3-dimensional axis.

Laser marking system is an existing solution used to engrave words or images onto food surfaces. This system is ideal for large scale engraving and speed. However, it is noted that the laser engraving method is not suitable for every surface, most notably brittle surfaces. In addition, Its high upfront cost does not entice smaller distributors to adopt it, making it catered to mainly huge enterprises. Finally, laser engraving essentially burns the surface of the product, which might affect the quality of the end product.

S/No	Functionalities of Laser Engraver	Functionalities of Food Printing Systems (Inkjet-based Food Printing Systems)
1.	Emits laser beams on food surfaces to cause localized heating.	
2.	Transforms user input into machine actions.	Transforms user input into machine actions.
3.		Eject food ink through the nozzle.
4.	Communicate with external devices to retrieve user input.	Communicate with external devices to retrieve user input.
5.	Move the laser head in a 3-dimensional axis.	Move the extruder in either the X or Y axis.

The functionalities of the laser engraver and inkjet food printing systems were compared to find the similarities between the two, thereby crafting a complete set of functionalities.

Preliminary Concept



The concept will be Incorporating a printpen to create food safe labels to replace traditional plastic labels, and creating a coating layer using wax to ensure the print does not fade.

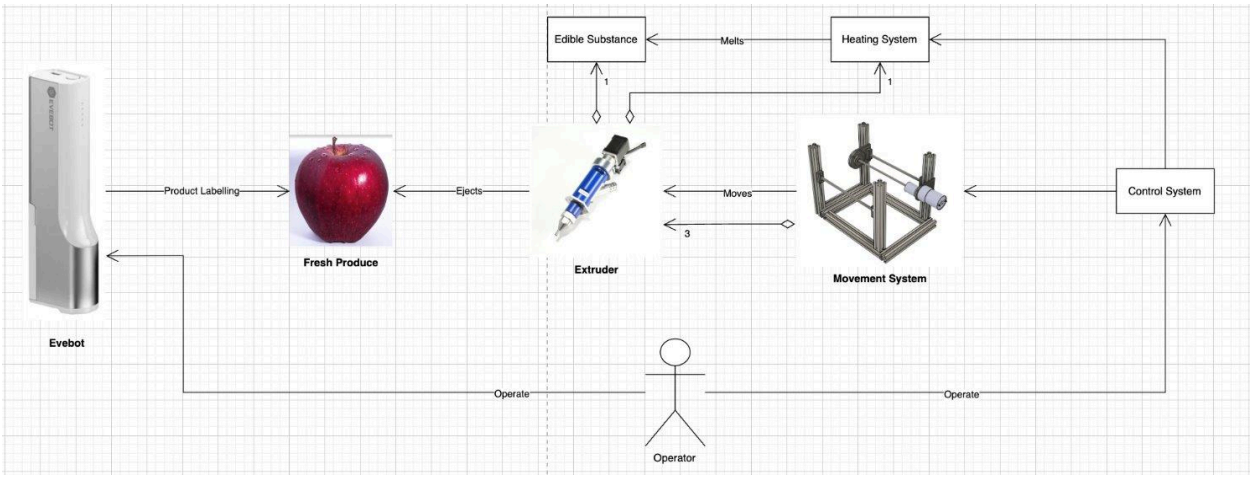
Concept of operation: Stakeholders involved

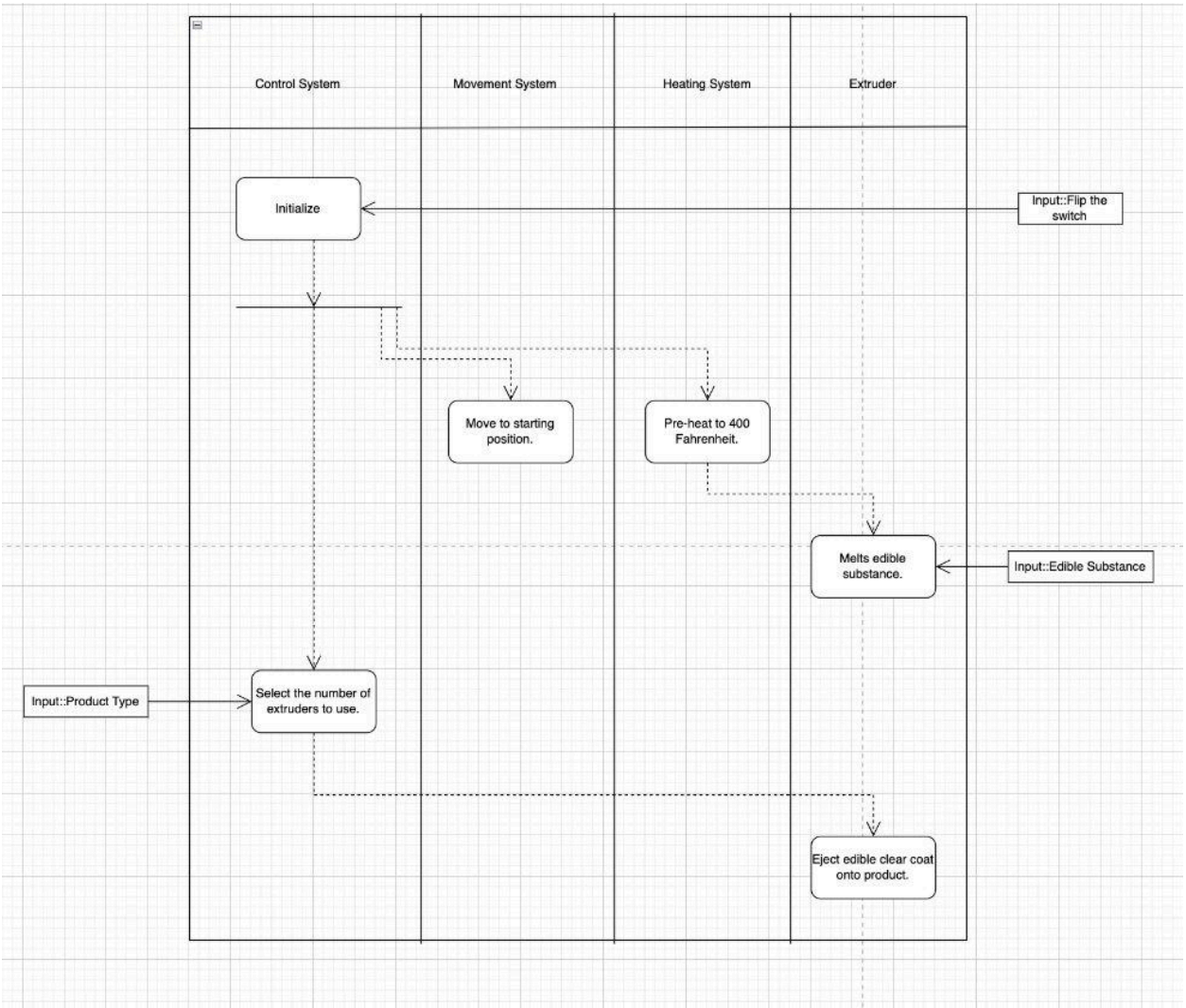
Stakeholder	Involvement	Desired Outcome	Classification
Supermarket(FairPrice)	Purchase of SOI	Provide Feedback	Participate
Customers	Benefits from SOI	Provide Feedback	Influence
Government Agencies (NEA)	Sponsor and Regulator	Promote reduction of waste	Vested, Influence
Employees	Operators	Provide Feedback	Influence

Concept selection

Functionality	Test Description	Pass/Fail
Printing on different types of surfaces	Food printer will print a QR code on a smooth flat surface.	
	Food printer will print a QR code on a non-smooth flat surface.	
	Food printer will print a QR code on a smooth curved surface.	
	Food printer will print a QR code on a non-smooth curved surface.	
Extruding materials on food surfaces	[material] should be extruded onto the surface where QR code will be and be left to harden.	
	[material] should be observed for transparency.	
	Verify that printed QR code can be scanned by an external device.	

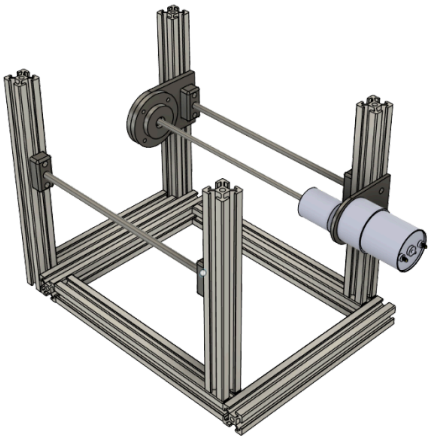
The material (wax) is validated against the above set of criterias and after clearing the test, the concept model and operation of concept is made to find the link between each component, and how the operation will be performed.

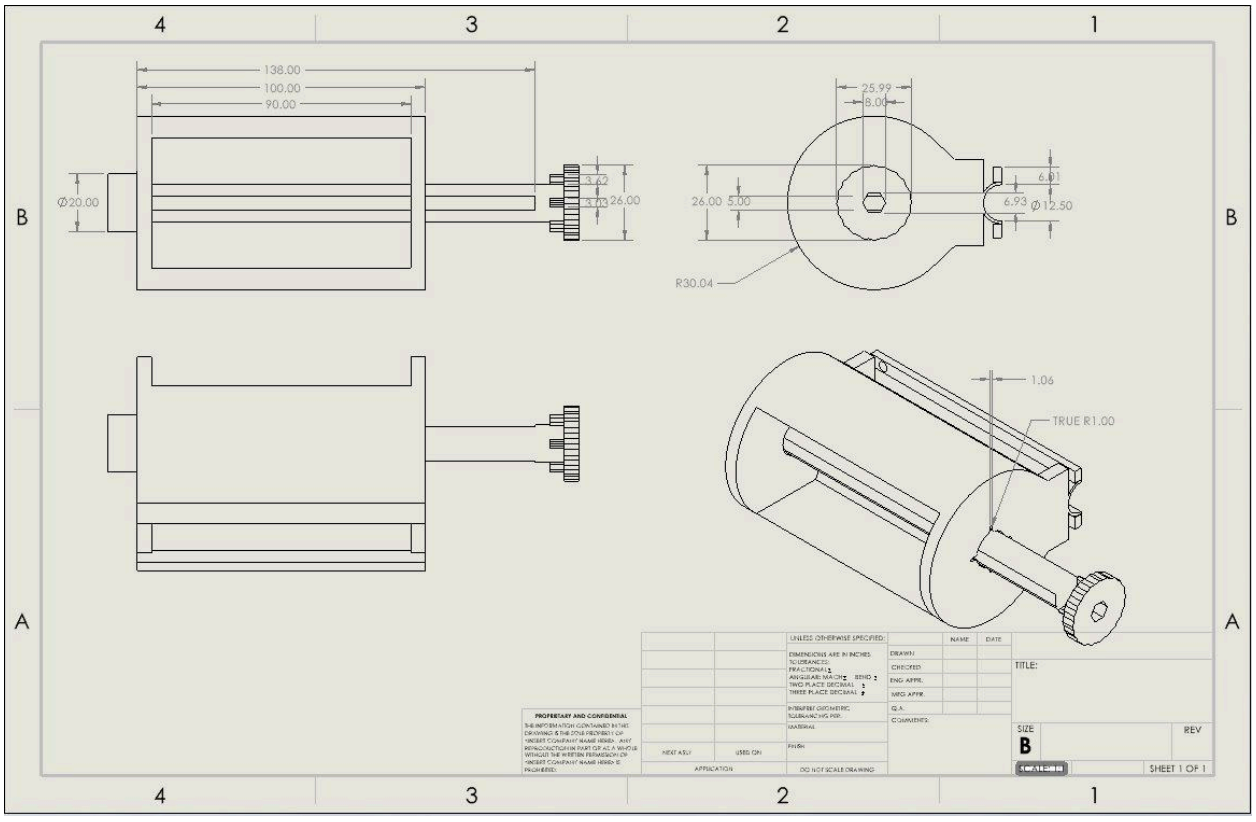

Edible Substance
Melts
Heating System
1
1
Product Labelling
Ejects
Moves
3
Control System
Fresh Produce
Extruder
Movement System
Evebot
Operate
Operate
Operator


Control System
Movement System
Heating System
Extruder
Initialize
Input::Flip the switch
Move to starting position.
Pre-heat to 400 Fahrenheit.
Melts edible substance.
Input::Edible Substance
Input::Product Type
Select the number of extruders to use.
Eject edible clear coat onto product.

Design Output Specifications

In design output, the CAD drawing of the body frame, and the different methods of extrusion was drawn





Plunger mechanism	Linear Displacement mechanism
Precision Control - precise control over amount of material dispense	Consistent Control - same pressure and flow, allowing for uniform dot size and spacing
Simple and ease of use - ideal for small scale application	Easier to automate
Small volume - might require frequent refilling for larger projects	Larger volume - suitable for larger projects

In architecture tradeoffs, the plunger vs linear displacement mechanism was compared, with the chosen concept being the plunger mechanism due to its precision control and the scale of project.

Solution Concept

The image above shows the prototype created. The prototype will then be validated with different test cases to determine the feasibility of it.

Test Description	Pass/Fail
The food printing system will be used to print onto a bread. The prototype will extrude a clear layering onto the surface. The printed surface must be able to stick.	Pass
The food printing system will be used to print onto an apple. The prototype will extrude a clear layering onto the surface. The printed surface must be able to stick.	Pass
If the prototype can stick, a smartphone will be used to scan the code. The code must be readable and extrudes the information.	Pass
The material extruded will be tasted to test for food safe	Pass

Project management plan

S/no.	Item	Description	Material	Source	Measurement	Quantity	Unit Price	Delivery	SubTotal
1	Guiding Rod	guiding the linear movement	Aluminium	SUNHEE hardware Clementi	D6mm x 30cm	2	$ 1.50	$ -	$ 3.00
2	20ML Syringe	plastic syringe		Art friend	20ml	2	$ 2.15	$ -	$ 4.30
3	battery holder	18650 X3		continental electronics		1	$ 3.00	$ -	$ 3.00
4	SPST rocker switch			continental electronics		1	$ 2.00	$ -	$ 2.00
5	DC Motor	6V 12V Gearbox 319 rpm		Kuriosity		1	$ 14.00	$ -	$ 14.00
6	DC-DC Constant Current Step Down Buck Converter	4 - 38V to 1.25 - 36V 75W (5A) XL4015		Kuriosity		1	$ 7.20	$ -	$ 7.20
7	LCD Screen	LCD 16X02 Black on Green		continental electronics		1	$ 7.00	$ -	$ 7.00
8	Nichrome Wire			continental electronics	0.22mm x 1m	3	$ 2.00	$ -	$ 6.00
9	Rocker switch			Sun Light Electronics		2	$ 2.00	$ -	$ 4.00
10	Arduino Mega 2560 Rev 3	Microprocessor to control servo motor and TOF sensors.	-	https://sg.rs-online.com/web/p/arduino/7154084?gb=s	-	1	$ 58.17	$ 30.00	$ 96.11
11	Right Angle Geared TT Hobby Motor	Control open and close of locking mechanism	-	ps://sg.rs-online.com/web/p/stem-motion-components/2153179?gb	-	3	$ 3.87	$ -	$ 12.65
12	12V DC Gear-Box Motor	Provide rotational torque to move the platform.		Carousell		1	$ 20.00	$ -	$ 20.00
13	18650 battery			Shopee		6	$ 3.30	$ 1.99	$ 21.79
14	Linear Bearing	Smooth movement on guiding rods	stainless steel	shopee		3	$ 1.95	$ -	$ 5.85
15	Motor Coupler	Motor Coupler to threaded rod	stainless steel	shopee	ID:5mmx6mm OD:25mm L:30mm	1	$ 3.82	$ -	$ 3.82
16	HC-SR04 Ultrasonic Sensor	Tracking of distance from funnel to surface	-	https://sg.rs-online.com/web/p/bbc-micro-bit-add-ons/2153181?gb=s	-	2	$ 8.93	$ -	$ 17.86
17	Linear Bearing	Smooth movement on guiding rods	stainless steel	shopee		3	$ 1.95	$ -	$ 5.85
18	Motor Coupler	Motor Coupler to threaded rod	stainless steel	shopee	ID:5mmx6mm OD:25mm L:30mm	1	$ 3.82	$ -	$ 3.82
									$ 238.25

The bill of materials is crafted in accordance with the future system, which will serve as a reference to the budget necessary to make this system.

Risk	Likelihood	Impact	Risk Rating	Response Action
Heating Element exposed to air, risk of people touching getting shocked burn	4	3	Medium	Ensure that the wrapping of the heating element is not damage before each use.
No emergency stop	1	3	Low	Ensure the Emergency stop is in the product and ensure that it is working.
Employees with no training using the product get injured during the process	2	3	Low	Ensure that the person using the product have gotten training.

In risk management, the following mitigation plans were crafted to cover potential risk the system might face.

Personal Contributions

1. Research Lead:
   - Investigated existing food printing systems and accessibility solutions.

2. Concept Development:
   - Selected and developed the binder jetting solution, ensuring it met the project's requirements.

3. Prototype Design:
   - Designed and integrated a funnel mechanism with the Evebot system, enhancing the prototype's functionality.

Skills and Learning

1. Project Management:
   - Managed the project from concept to prototype, ensuring timely and effective execution.

2. Research and Analysis:
   - Conducted extensive research to identify the best solutions and validate the prototype's effectiveness.

3. Prototype and Design:
   - Applied engineering principles to design and develop a working prototype.

4. Collaboration:
   - Worked effectively with team members and stakeholders to bring the project to fruition.

Future Work

The next steps for this project include further testing and refinement of the prototype, conducting user trials, and exploring additional applications for printing food labels. The plan is to pitch this innovative idea to potential stakeholders, aiming to secure support for further development and commercialization.