zero.

armando rodríguez pérez

final bachelor project

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coach: stephan wensveen

Fig. 1: Final carry bag

index

prologue

The current political climate has made me rethink the purpose of my role as a designer. Up until the point of starting my Final Bacholor Project, my process relied heavily on experimentation, leading to a bottom-up approach. While this approach fit my hands-on approach and lead me to the broadening the design opportunities, I noticed it often lead me to outcomes that contributed to incremental progress rather than radical design. For my Final Bachelor Project, I wanted to test my skills through a different way of working, a more context-driven and bottom-up approach.

While I considered Transformative and Inclusive Practices for my project due to the systemic nature of their projects, I believed that I would miss out on my strengths on crafting as part of my process. Crafting Everyday Soft Things, fit me best in this regard, as the focus on making and reflecting on every step would help keep me grounded through the process.

introduction

More plastic in the ocean than fish. This is the reality we will be facing in 2050, if we don't take action and change the role of plastic in our economy(Sheppard et al., 2016). Approximately 8 million tonnes of plastics leak into the ocean every year. One of the biggest contributors to this amount is plastic packaging as it represents 26% of the plastics used and is mainly single use. While recycling promised to take a toll on the impact of plastics, only 14% of plastic is collected for recycling and only 5% of the material value is retained. The zero-waste movement aims at tackling this problem. However, following a zero-waste lifestyle only has an impact on the packaging that is visible to consumers, and ignores waste generated during the packaging, transport, and processing of consumer goods. Furthermore, zero waste demands time, effort, and money as it is challenging for people to follow in our current economy where plastic is so ubiquitous.

This project aims at reimagining the business practices, user journey, and experiences in a packaging-free supermarket, as it is an important source of single-use plastic waste. How can we use technology in supermarkets to tackle waste production rather than incentivize consumerism? Can we look back at past grocery experiences before plastic and reimagine them in a plastic-free future?

zero.

zero. is a zero-waste supermarket that aims to reduce the environmental impact of grocery shopping. All items are sold packaging-free. To ease the shopping experience, the store has a series of sensors that track the product that users pick up and put in ther basket. This means that weighing containers or scanning labels is no longer necessary. After users fill up their containers they can head to the checkout to pay directly.

Fig. 2: Station with different dispensers for whole goods, dry bulk goods and liquids

zero app

Packaging doesn't only serve as a way to carry and preserve products but also as a way to deliver information. The app takes on this role by giving users information about nutritional values, expiration dates, and cooking instructions. Furthermore, the app also serves as a platform to share information about sustainable habits by suggesting recipes using seasonal, local products, giving tips about sustainable alternatives to other products, and providing information about producers. Together, these features aim to incentivize responsible consumption rather than incentivize consumption.

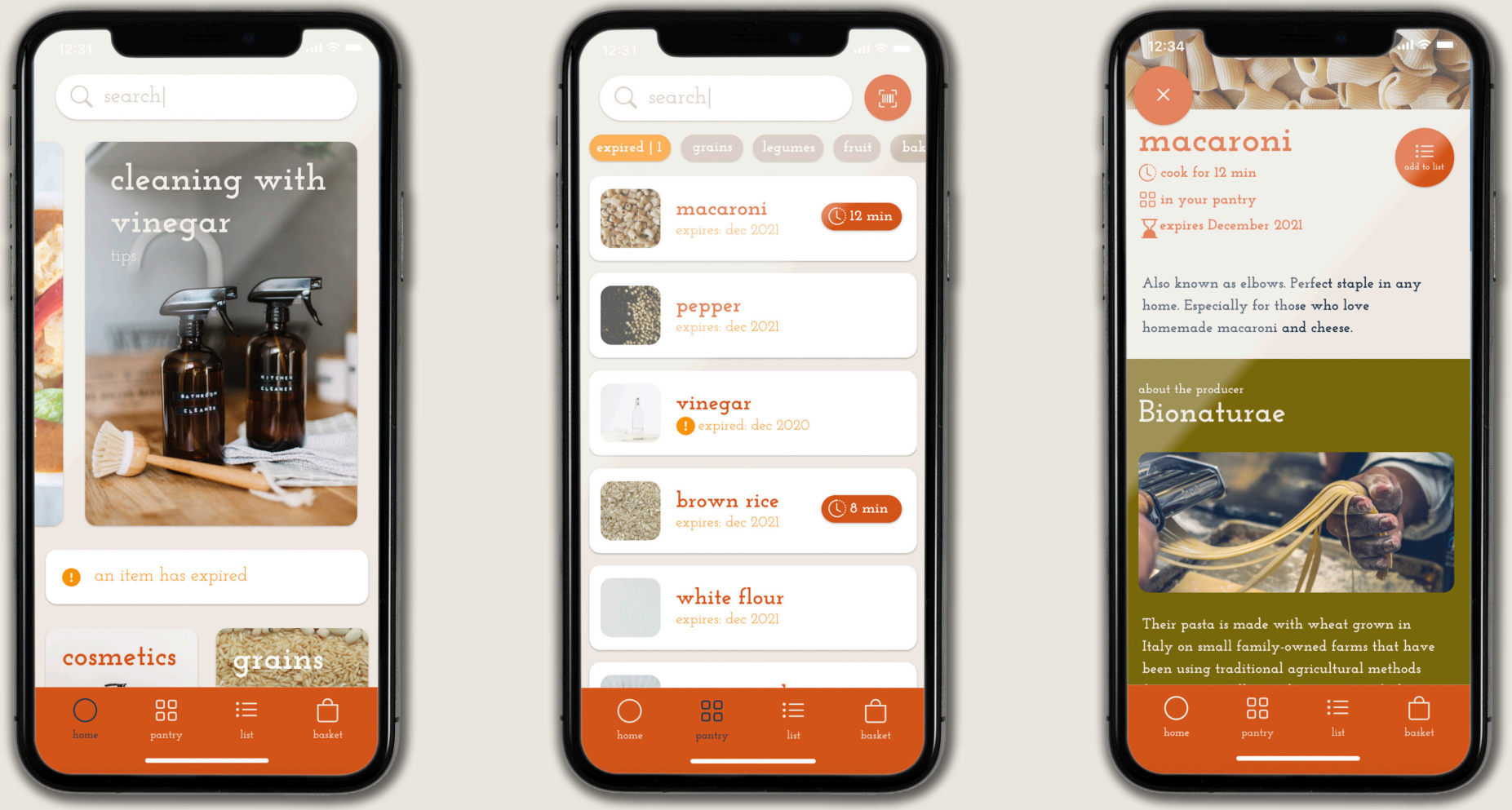

Fig. 3: Home page, pantry page and product page from the app

zero packaging

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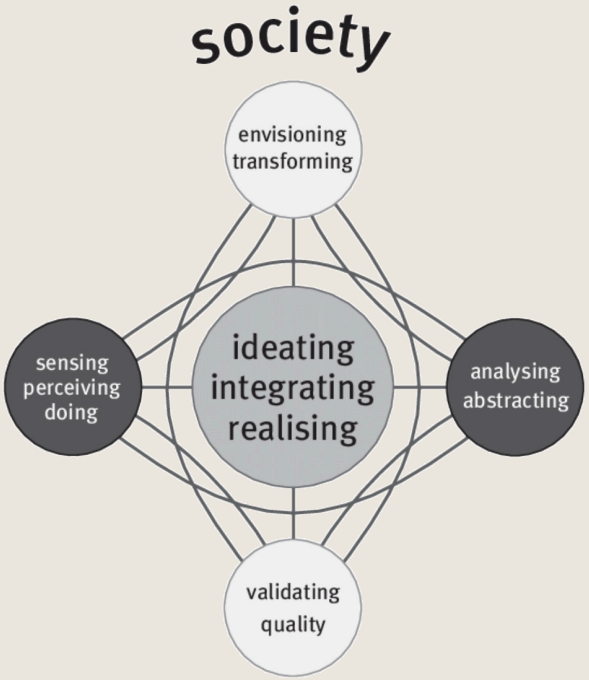
Fig. 4: Carry bags with their corresponding storage jars

process



To arrive at these results this project relied on a flexible structure that involved reflecting at every step taken. The Reflective Transformative Design Process (Hummels & Frens, 2009) gave me the flexibility to direct the following steps of the process based on every step I took along the way. I engaged in the different design activities through the different perspectives (Tomico et al., 2012):

First person

This lens was especially useful under the current circumstances and restrictions. I observed through this lens by evaluating my own past experiences, doing embodied ideation, taking on aspects of the zero-waste lifestyle, making and evaluating my prototypes through sensing.

Second person

I took this lens by observing beheaviors during my trips to the supermarket, by organizing a co-creation session and by talking to zero-waste shoppers and shop owners. It helped me analyse, abstract beheavior and to validate design decisions.

Thrid person

Due to the systemic nature of the challenge this lens was of primary importance. I look through this lens by looking at the historical, political and local components of the regime, analyzing competitors and trying to abstract how the political context fueled their values. This contextual analysis helped fuel the vision for the project.

Fig. 5: Node map illustrating the connections between the aspects of the projects

The findings I gathered through these lenses made me reflect and influenced other aspects. The integration of these finding created a tightly woven series of connections (figure). This report will further elaborate the design actions and how they contributed to the final outcome.

context

This chapter aims at explaining the foundation of this project. In this phase, I focused on getting as much information as possible. The following observations are a compilation of my first-person experiences, observations at supermarkets, research, and interviews with a zero-waste store owner and a zero-waste store shopper.

Fig. 6: A jar containing two years worth of trash (Dokiupil, 2015).

In the past 6 years, I have become increasingly conscious of the environment and have tried to minimize my impact on it. Some of these attempts include minimalism, veganism, or trying to lower my electricity consumption. Despite the varying degrees of success, most of them resulted in frustration and left me wondering how the defenders of these movements had the willpower to commit to them.

A few years ago I came across the image of a mason jar full of garbage (Dokoupil, 2015). It contained a person's two years' worth of trash. This jar turned out to be the archetype of the zero waste movement, which aims to reduce an individual's waste to a negligible amount. Just the thought of the amount of struggle and commitment necessary exhausted me.

After moving to the Netherlands and started living by myself, I became more aware of how much trash I produced every week. The image of the mason jar would come back to my mind, but the bar had risen even higher due to the amount of plastic packaging present in dutch supermarkets.

Now that the attention has been brought back to this issue thanks to initiatives like Fridays for Future(Fridays For Future, n.d.) and organizations like the plastic soup foundation(Fighting Plastic Pollution in the Oceans, n.d.) or the ocean cleanup project(The Ocean Cleanup, n.d.), I want to revisit this topic for my final bachelor project.

the plastic soup

It is becoming increasingly apparent that we have to change the business-as-usual model to aim for a sustainable future. The human enterprise currently demands 1.56 times more than the amount that Earth can regenerate(Almond et al., 2020).

The plastic that washes up on shores daily around the world is a constant reminder of our current relationship with the environment and its resources. We recklessly consume with no regard to the byproduct of our activity.

In 2050 there will be more plastic in the ocean than fish if we don't take action and change the role of plastic in our economy (Sheppard et al., 2016). Approximately 8 million tonnes of plastics leak into the ocean every year. One of the biggest contributors to this amount is plastic packaging as it represents 26% of the plastics used and is mainly single use.

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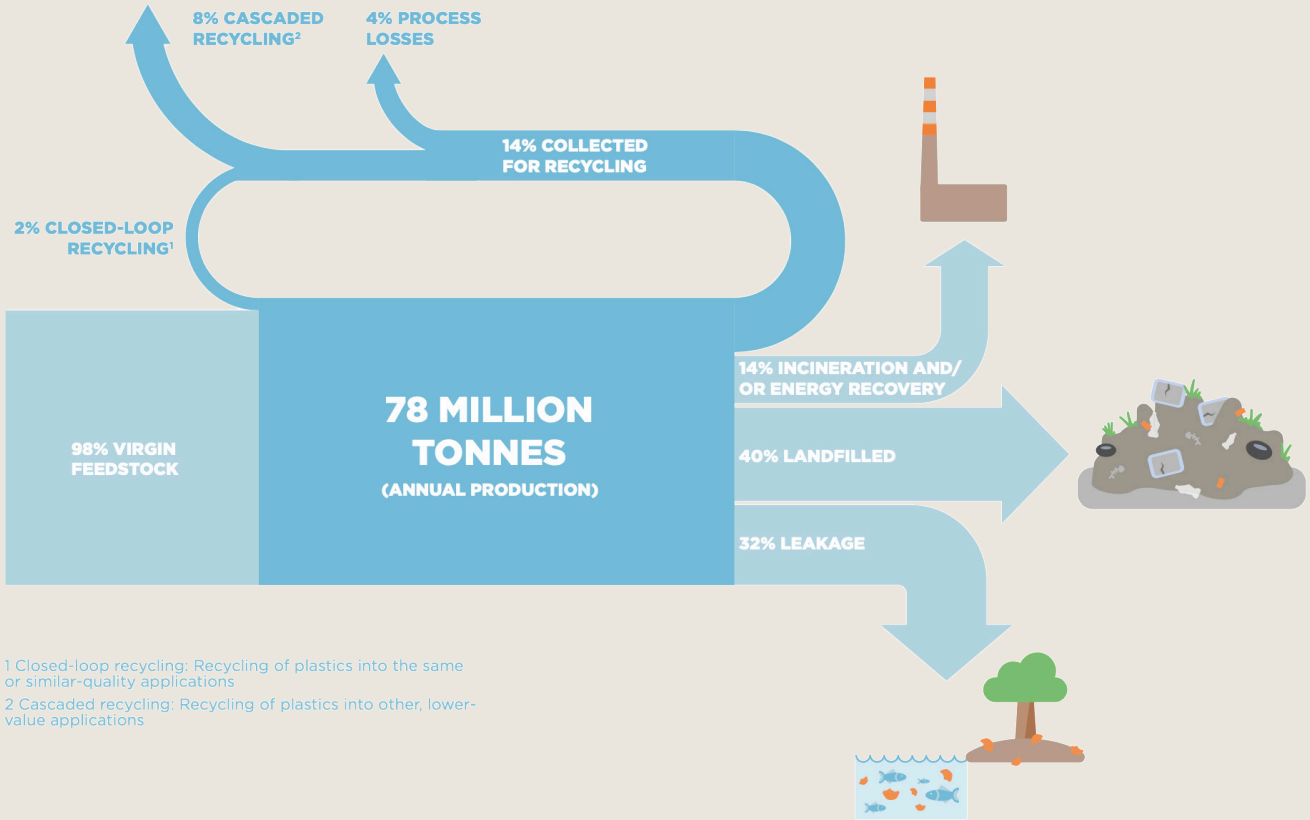


Fig. 7: Current plastic material flows (Sheppard et al., 2016)

Fig. 8: Customer journey based on ideos and interviews.

the zero-waste movement

The zero-waste movement aims at addressing the environmental issues caused by packaging by eliminating it. Followers of the movement often shop at bulk stores which have become increasingly popular in the last few years. These stores usually sell dry goods and some products in bulk. They encourage customers to bring their containers and fill them up with the desired products. Modern technologies do not aid this process and it closely resembles the shopping experience before the introduction of the UPC and is very inefficient compared to today's standards. To show the process and use it as a tool for comparing the following journey was mapped out from interviews and youtube videos explaining the process (Living Waste Free, 2017; Sustainably Vegan, 2017).

The movement has been heavily criticized for relying on individual action to tackle a systemic issue (Our Changing Climate, 2019). It often makes the movement less impactful as it only eliminates the waste that is visible to the user and not the one produced from farms to supermarkets. Furthermore, it places the responsibility on the consumer rather than on businesses. A common criticism that I found is how time demanding it is. As zero-waste influencer who is dedicated to this lifestyle described it:

"I have committed my career to [zero-waste] and it is still super difficult for me. That is when you know that there are some flaws in the system." (Christina, 2020)

For zero-waste to become competitive with the current alternatives, it has to address this lengthy and complicated user journey. It should improve the shopping experience for users and make the system more efficient to reduce costs(Gleim et al., 2013). Furthermore, the zero-waste has to push to make a greater impact on the food supply chain. During an interview with a zero-waste store owner, she explained her struggles in finding cooperation with suppliers:

"It is difficult to find a supplier who will send you products without plastic. So we always fight for it, but sometimes you cannot avoid it. Sometimes I fight a lot with their suppliers and if they send me plastic bags are just covering, I send them back".

the supermarket industry

If businesses should take responsibility and innovate to solve this issue, what are the challenges and opportunities that supermarkets face to embrace the movement?

To answer this question it is necessary to look into how we got here in the first place and to understand the importance and the role of packaging in supermarkets.

Before 1916 grocery stores were arranged as a service-desk. Customers would bring their shopping lists to the service desk at the stores. Employees would bring the items that the customer requested and write them down on their bill.

To cut down costs and make the system more efficient Piggly Wiggly introduced the self-service grocery store format in 1916 (Ellickson, 2016). In this store, customers would pick up the products themselves and bring them to the counter where an employee would write their bill and calculate the total. This process was facilitated by packed products as employees and customers did not have to weigh them, removing a step from the process.

Many innovations followed to make this process more efficient. The shopping cart, introduced in 1937, helped customers carry their packaged products to the register. The universal product code (UPC) together with the barcode scanner was introduced in 1974 (Ellickson, 2016). It sped up the checkout process by allowing employees to scan the products rather than having to type item numbers at the register. This innovation also led to the development of data-enabled marketing and self-scan systems, introduced in 1992. This way of shopping simplifies the system to a point where the employee no longer needs to intervene, increasing efficiency, and lowering employee costs for supermarkets.

The latest innovation and perhaps the blueprint for future supermarkets is the Amazon Go stores. It uses machine vision and hundreds of cameras and sensors to keep track of what customers pick up at the store. This way customers no longer need to scan their items and can leave the store with their bagged items. (Coldewey, 2018)

These incremental innovations have been built on the introduction of pre-packaged products. Therefore packaging has become a vital part of these systems.

service-desk

self-service
1916

shopping cart
1937

self-scan
1992

no-checkout
2016

scanning register
1974

online groceries
1997

Through this historical analysis, I gained an understanding of the critical role of packaging in making food retailers more efficient.

Fig. 9: Supermarket evolution based on the work of Ellickson(2016).

current solutions

As consumers become increasingly aware of environmental issues the market has slowly turned its efforts into addressing these issues.

Many retailers have shifted their efforts to recycling. However, as I found while researching the impact of plastic, recycling comes with several challenges. For once, all kinds of materials have to be properly separated. This is costly in terms of infrastructure. Most plastics are downcycled and result in lower grade material as they cannot be properly assorted. Besides, up to 95% of the European Union's recyclable plastic was sold to China for recycling until 2018, when China banned plastic imports (Katz, 2019). Europe does not possess the right infrastructure to process that amount of waste and has turned to restrict plastics further to limit its disposal.

Another popular strategy in the industry is paper packaging. This presents an alternative to plastic that is recyclable but also biodegradable if it ends up in the landfill. While the end-of-life seems more appealing, paper production emits 3 times the amount of greenhouse gases and requires 4 times more water than their plastic alternative(Bell & Cave, 2011). Similarly, other biomaterials have a higher impact in terms of manufacturing and require dedicated infrastructure to properly compost the material.

Fig. 10: Paper packaging alternative.
Source: Albert Heijn

Fig. 11: Worker sorting through plastic imports in Vietnam (Katz, 2019)

concepting

This chapter narrates the steps taking to arrive at a first prototype based on the problem statement.

concept

Based on the information discussed in the previous chapter, the task was: to create a technological system to make zero-waste shopping easier and faster. It should address the biggest barriers to green consumption: high costs, inconvenience, and disinformation (Gleim et al., 2013).

As seen from the customer journey many of the unnecessary steps relate to identifying the products and the quantities. A system that could compete with the current alternatives should keep track of these during the shopping experience rather than at the checkout. Albert Heijn does this by having users scan their products as they go with their smartphones or scanners, Amazon Go (Amazon Go, n.d.) achieves it by using hundreds of cameras and computer vision technology (Coldewey, 2018).

Taking this idea to zero-waste stores takes a different approach. Items are not individually packaged but stored in bulk bins. Furthermore, customers can choose how much of the product to buy.

This exploration includes some options that could detect how much of each product has been removed from the system.

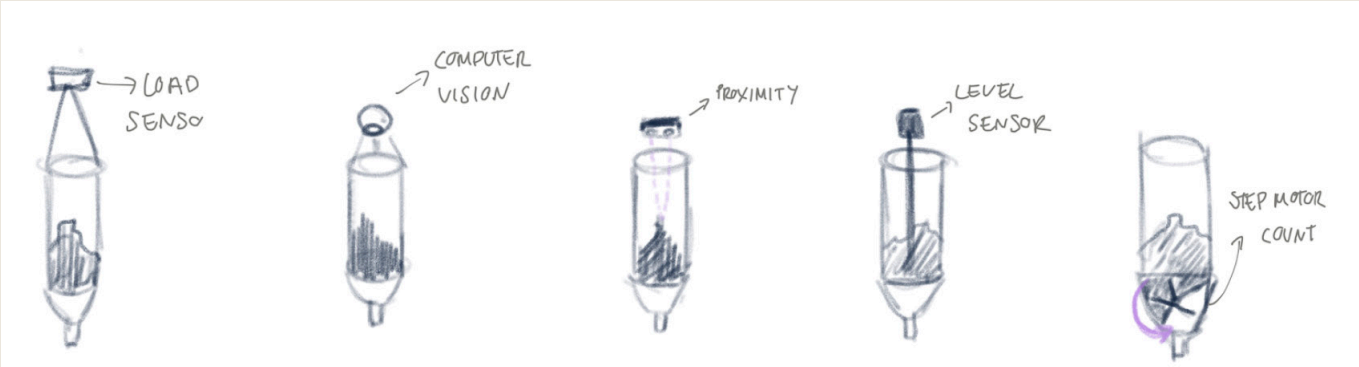


Fig. 13: Exploring different options for detecting products

However, this is not sufficient as the system also has to identify what consumer has removed this item from the system. Albert Heijn achieves it by storing the list on the scanner/smartphone linked to a customer card and Amazon by linking the customer in the store to an Amazon account and following the customer through the store with computer vision.

Some of the first concepts included physical identifiers or tokens that would be scanned next to each item. However, after roleplaying these interactions and exploring them through a first-person perspective, it became apparent that this action felt redundant and difficult as a two-hand operation is often needed to fill a container. Computer vision was also discarded as it is expensive and due to privacy concerns as seen in the case of Amazon Go (Coldewey, 2018).

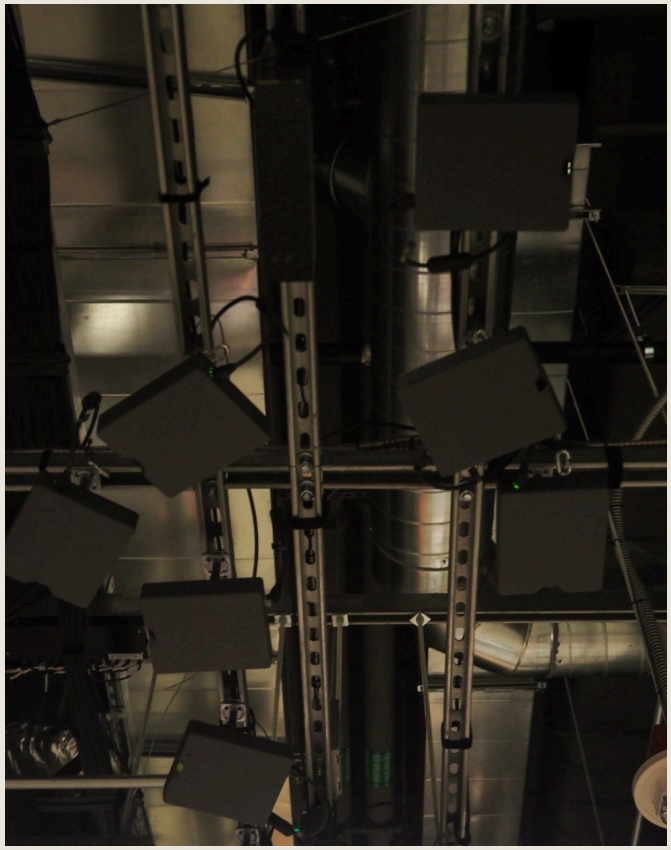


Fig. 12: Cameras at Amazon Go (Coldewey, 2018)

The prototype uses the physical basket at the store as the identifier for the digital basket that is created as the customer shops. When the customer places down the basket on a surface to fill up the jars (as I observed in multiple zero-waste shopping videos and by visiting a zero waste shop) the system identifies the digital basket that the product needs to be added to. These platforms are an affordance(Norman, 2013) as they are the only surfaces where users can place the items. The two-handed operation is a limitation(Norman, 2013) that may make the user place down the basket in the platform.

To understand how this interaction would feel I roleplayed it with a tray and some objects in my rooms. It became apparent that there couldn't be an identifier for every product as this would require switching the basket from the surface to the surface unnecessarily. By embodying the interaction I determined that one identifier could be used for the products that lay at an arms reach from it. These groups of products linked to a single identifier will be known as a station. These stations could contain products belonging to a category but this will be determined at a later stage.

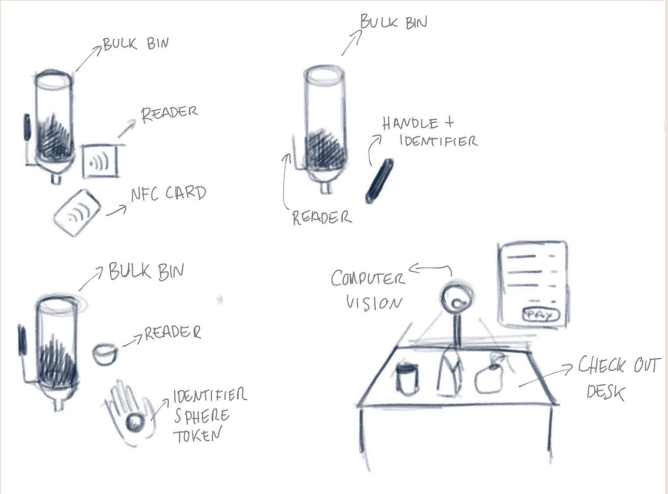


Fig. 14: Explorations of idenification options

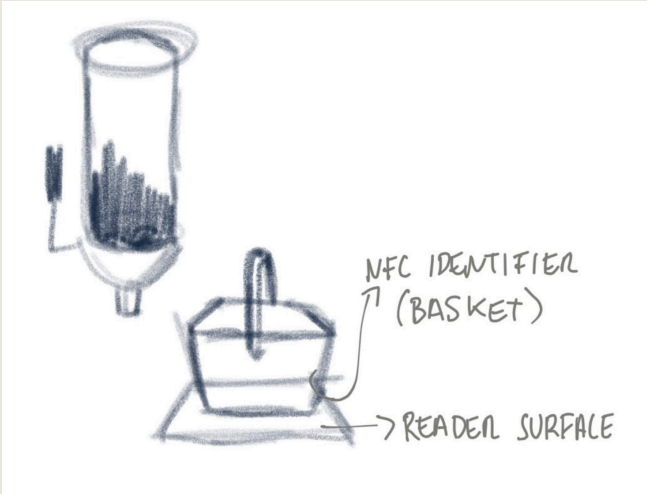


Fig. 15: Selected idenification option

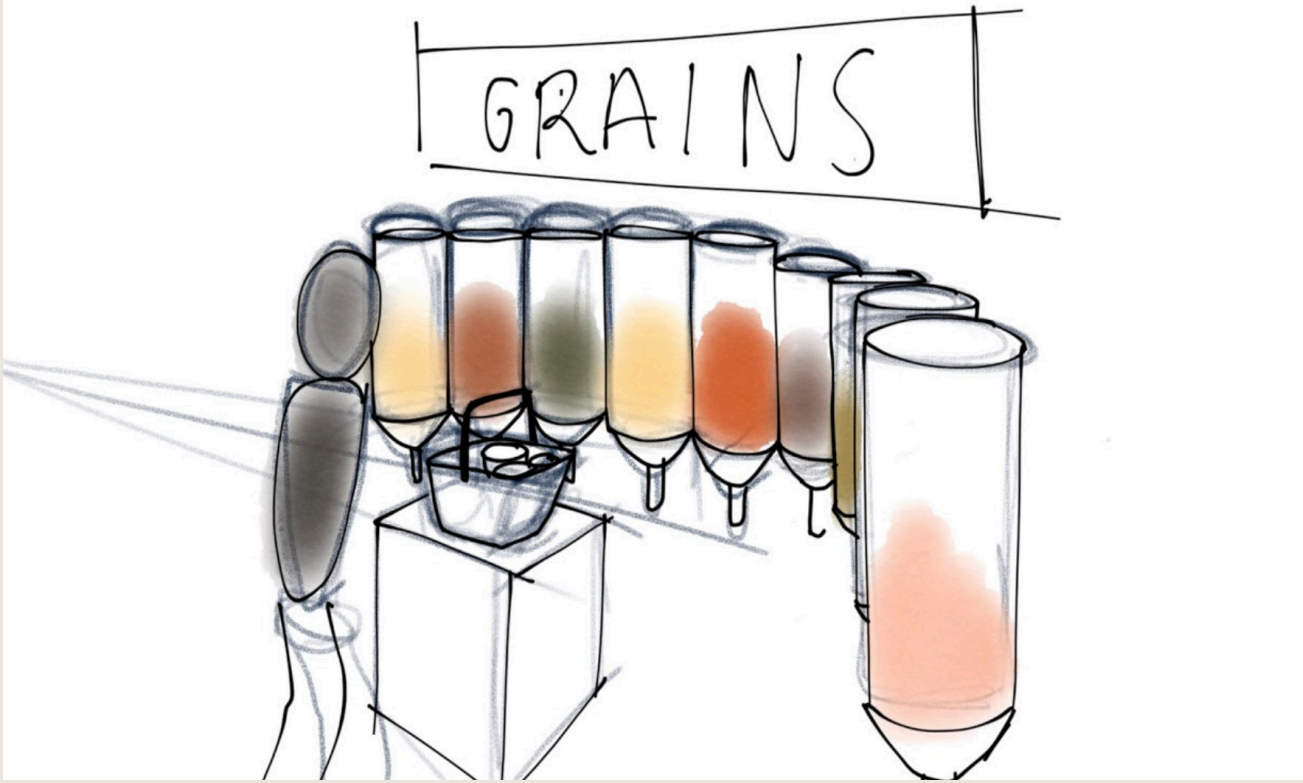


Fig. 16: Sketch of a station with its bulk bins and basket identifier

prototype

As I proposed during the ideation phase, there were multiple options for keeping track of the products at the store. For this first version, I chose to use load sensors as they measured weight directly and were fairly simple to use to evaluate the interaction and correct functioning of the system.

The component tracking the weights at the stations concise of two loadcells connected to HX711 signal amplifiers which were connected to an ESP8266 (Figure 17).

The second component of the station is the basket identifier, which consists of an MFRC522 RFID reader that updates the ID of the present basket through another ESP8266. I housed the reader in a platform I prototyped using foam core, which has the same shape as the bottom as the basket to act as an affordance(Norman, 2013)

To manage the information sent from the station I created a database using Firebase following a non-relational data structure (Figure 18).

To inform users of what products were picked up I created an interface using HTML, CSS, and Javascript which could read information from the database and display it on a screen. For the prototype, I designed the interface to resemble the ones present in online and physical supermarkets. The shopping list includes the product name quantity, price, and total.

Fig. 17: Prototype of a station with two load sensors

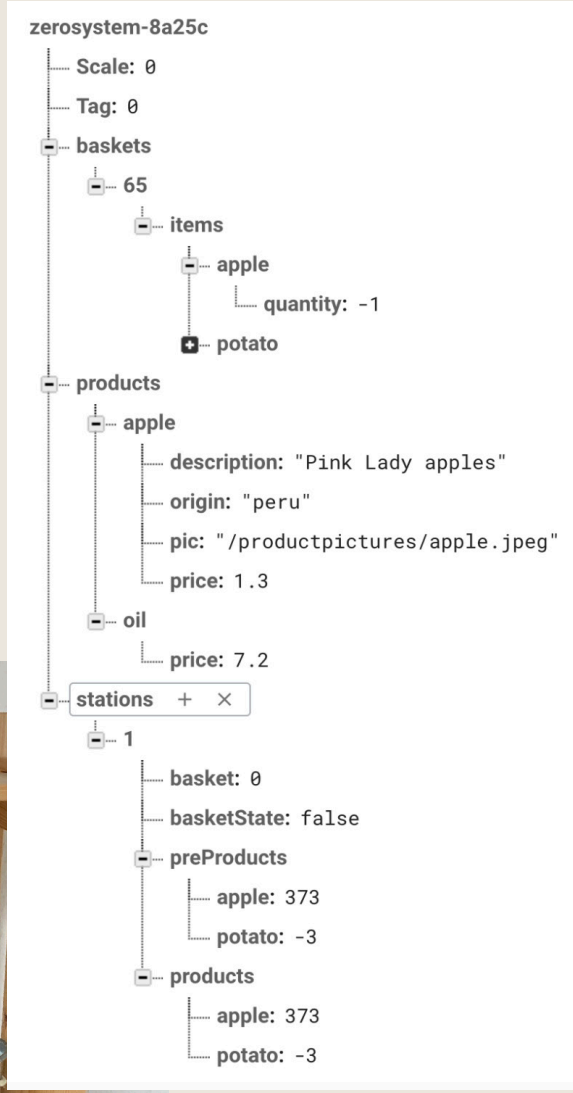


Fig. 18: Database

probes

With this prototype, I continued on to plan a user test to have an understanding of what were the barriers to these kinds of products and whether the concept helps remove any of those barriers.

The test consisted of a short interview to have an idea of the user's shopping practices and understand whether they considered packaging-free options. As a follow up they would test the prototype by picking up a few products and putting them in their baskets. It also included a card sorting exercise to get an understanding of what users looked for at the store (Appendix I).

While role-playing the user test, it became apparent that I wouldn't be able to get much valuable information with the proposed setup. Through related work on the topic, I already had an idea of the barriers to green products: pricing, convenience, and information (Gleim et al., 2013).

The test should evaluate the customer experience which would determine how convenient it is for the user but also how efficient the system is, resulting in lower prices. However, the small scale version of the current prototype was not sufficient for customers to express their comfort using the system nor sufficient for me to evaluate whether it is more efficient than conventional grocery shopping. Furthermore, the concept shares many similarities with systems currently used in stores, and the innovation partially lies on the back-end which the user can't address.

Second Probe

From this point, I decided that to get more valuable feedback on the prototype I would have to scale it up to be able to get a sense of how to design for other product categories and the flow in between them.

I designed an experience to resemble more a regular shopping experience. The task consisted of shopping for different products to complete a recipe. The participants would get the shopping list and proceed to use the prototype to shop for them. The list included:

- Rice
- Chickpeas
- Eggplant
- Bell pepper
- Garlic
- Coconut milk

This more complex list would also take a look at different ways to shop for different products. Whole products: bell pepper, garlic, and eggplant. Dry bulk products: chickpeas and rice. Bulk liquids: coconut milk. These products require different considerations.

For this prototype, I had to create bulk bins for dry bulk products. I also used a liquid dispenser for coconut milk and made a bulk bin for chickpeas (Appendix H). As for the interface I used to update the web app I had developed and edited the values front the database live to "wizard of oz" the experience.

However, making this prototype and the version used in the mid-term video helped me materialize it and experience it from a first-person perspective. I noticed how there should be an aid to help users fill their bag with one hand while they use the other to push the lever. I also posed the question of how people can make decisions on how much to get from each item in their lists. To what extent are they specific and defined amounts? To what extent can they make an approximate decision based on the offered options in current supermarkets?

I realized that there were too many aspects

to polish still on a very big scale to be able to assess the “efficiency” of the system. While I could have focused on improving the experience at the store, due to the timeframe, it would have limited the scope of the project and would have ignored many aspects that are vital to tackle such a systemic issue. Despite the presence of the user in the system, the issue I aimed to tackle in this project was not one that could be addressed through user-centered design.

Fig. 19: User experiencing the wizard of oz prototype

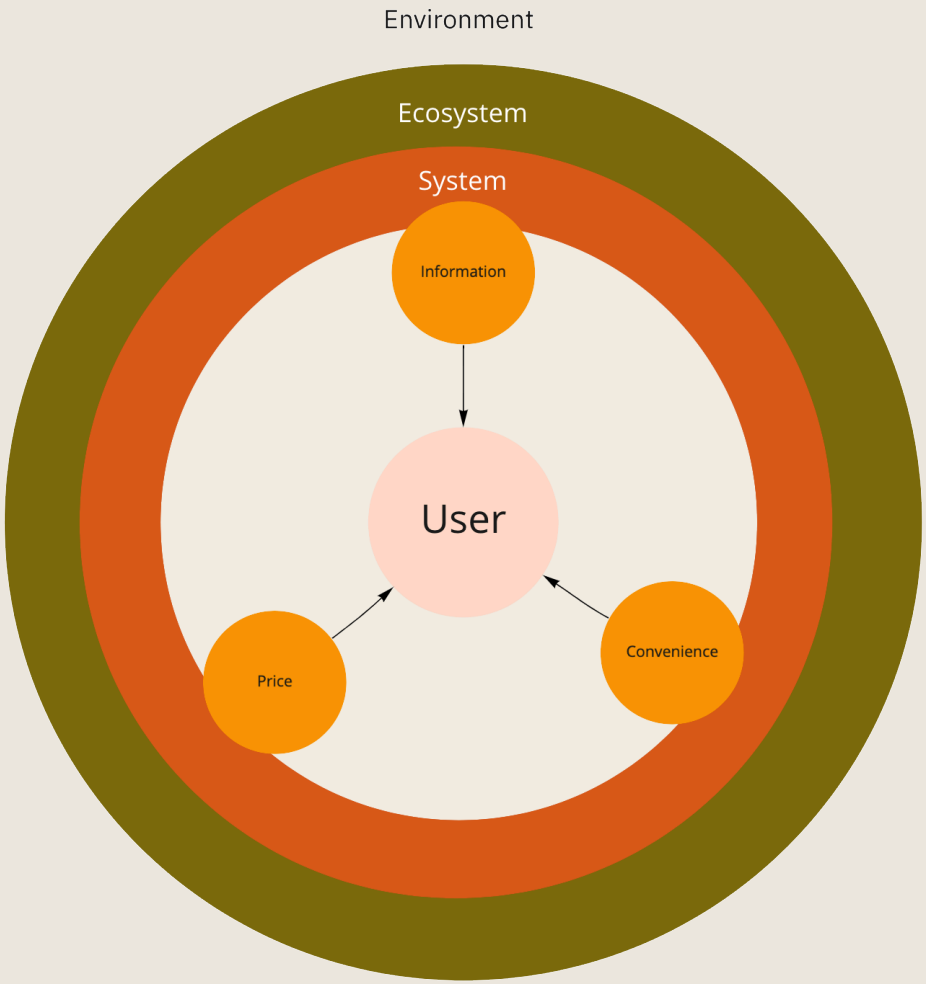
framing

After realizing that I couldn't just focus on the customer experience at the store as an outcome of my project, I decided to map out the different layers it should tackle to focus on its systemic nature.

The "system" layer is the first iteration of the project, it is the store and the business around it.

At the core is the end-user. It is the smallest unit but also the core, as their decision to use the system is going to determine it's viability and success to have a positive impact on the environment. The power of the user lies in its purchasing ability, which is delegated to users rather than society as a whole in our society.

To address the user, the system has three focus areas: price, convenience, and information. These are based on the barriers to green consumption (Gleim et al., 2013) which the system must address to reach the user.



Outside the system is the ecosystem. These are the other actors in the food supply chain such as farmers, producers, and food processors. These actors also play an important role in the impact on the environment. Users also can't often demand change at this level directly, so the system must adopt a stewardship role (Bocken et al., 2014) to help combat the negative impact at the ecosystem level.

Despite the user being in the center I would like to emphasize that this is not the main focus or the driver of the decisions.

business model

This chapter narrates the steps taking to arrive at a first prototype based on the problem statement.

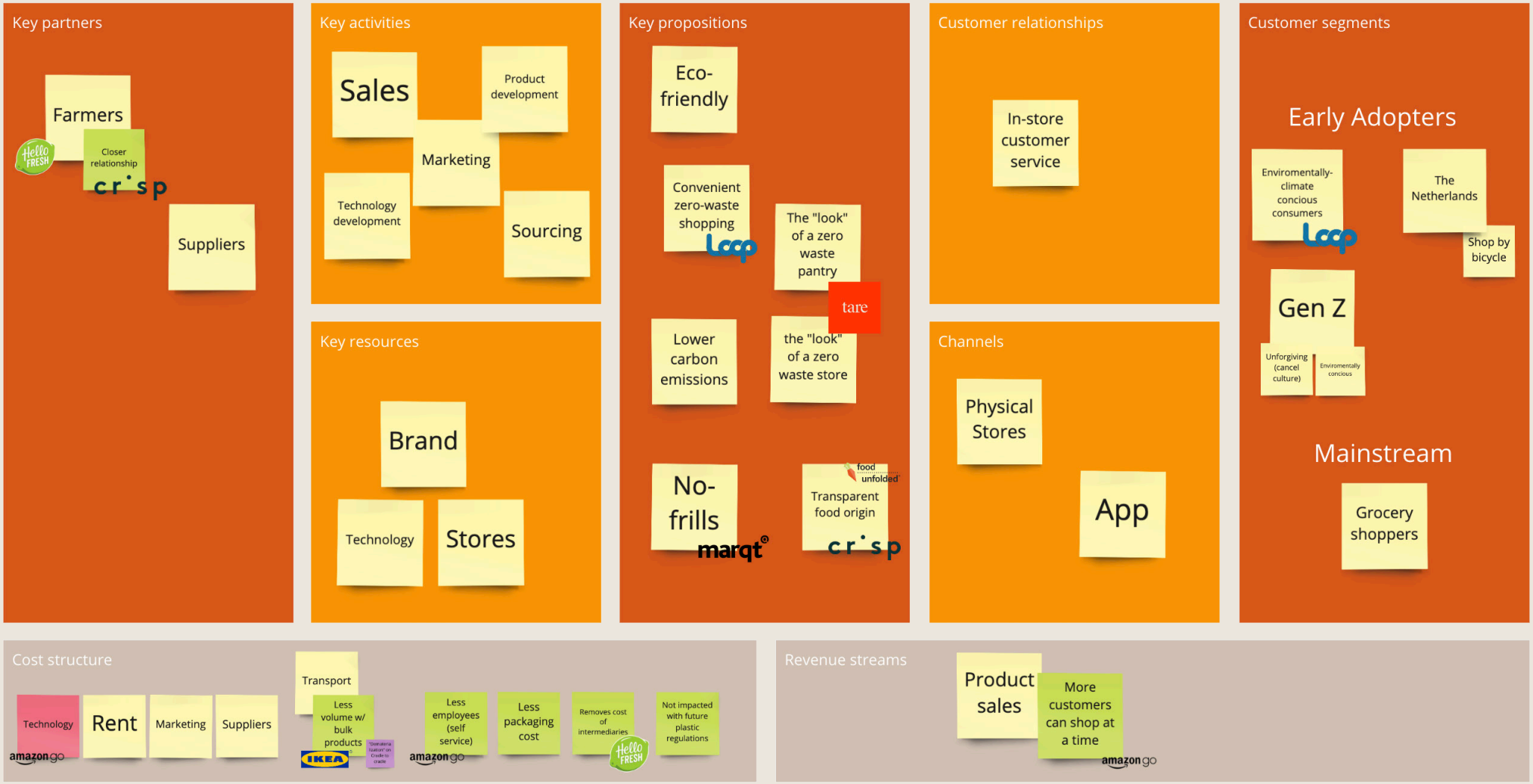


Fig. 20: Business model canvas

To develop and map out the relationships between the customer interface (the user), the system, and the value creation stream (ecosystem).

Furthermore, I could address some viability concerns which were raised during my mid-term presentation through the profit equation.

The business model contains some companies and organizations as examples for successful implementation of certain aspects.

value proposition

Convenient zero-waste shopping

As shown through the first designs of the system, the main value for the customer is making zero waste shopping easier through the experience in-store. Furthermore, the lack of brands at the store reduces the amount of choice at the store, making the retailer an advisor for good quality and environmentally responsible products following the growing "Prescription Supermarket" trend (Hawkins, 2019). Furthermore, the reduction of choice in the same product category makes for easier decisions with a lower environmental impact, much like Marqt stores (Over Marqt, n.d.)

Aesthetics

Due to the lockdowns in the current pandemic, people have been putting more care into their homes (IKEA Life at Home 2020, 2020). Having a beautiful and functional home is becoming increasingly important. These values are growing in interest as the recent pantry porn trend shows (Morris, 2019). The hashtag on social media showcases organized pantries which usually feature clear containers and bulk products.

The zero-waste pantry not only makes pantries more beautiful but also more functional. The use of reusable containers for grocery shopping fuels the aesthetics of the trend. This aspect could be an advertising tool for the business.

Fig. 21: Products in zero-waste packaging

cost structure

One of the biggest concerns compared to current supermarkets is the cost of the technology involved. Is there a return on such a large investment?

While such a system requires a big capital expense to start up, the technology could greatly increase the revenue. Wal-mart calculated that they save 12 million dollars for every second that they cut the check-out process (Desai et al., 2017). The system then, not only increases the value for customers but also increases the capacity of customers that can shop at a store resulting in higher revenue.

Amazon has invested in this cashier-less model and is planning to have 3000 stores by 2021(Cheng, 2019). Their investment in technology is around $1 million per store and it takes them around 2 years to break even on the investment. The investment for "zero." could be a similar figure. The costs could also be cut as the Amazon Go system relies on cameras for computer vision while "zero." would use more ordinary sensors such as proximity, flow, and weight sensors.

Furthermore, such a system would reduce the number of intermediaries in the supply

chain. This not only leads to higher margins but also to fresher products and a reduced carbon footprint for shipping the products. This disruption in the food supply chain has allowed companies like HelloFresh to create a successful business model(Post, 2018). "zero." would also disrupt the traditional chain by removing the packaging and processing companies (i.e. the food brands) from the ecosystem.

The system could also benefit from lower shipping costs. Since the food is shipped in bulk the volume is optimized since there is less air in the containers. Much like IKEA has lowered their shipping impact and prices thanks to their compact flat-pack furniture(Amory, n.d.).

Furthermore, the disruption of the regime could bring a fiscal advantage to the business. The proposed system would offer an alternative to single-use packaging, a product category that the European Union and local governments are actively targeting. So far, the bans have affected products for which alternatives are fairy accessible such as plastic bags, straws, and more recently single-use plastic cutlery (Parliament Seals Ban on Throwaway Plastics by 2021, 2019). Bringing an alternative to a different kind of single-use plastic on a mass level would increase the likeliness of them being banned or more heavily taxed. If this were the case, the business would have a competitive advantage over the "traditional" business models due to the regulatory pressures (O'Rourke, 2014) and alterations in the regulatory regime by following a "stretch and transform" strategy(Huijben et al., 2016). This strategy is based on changing mainstream conditions in the regime to improve the selection criteria for the niche innovation.

partners

The disruption in the supply chains also facilitates a direct connection with food producers. This helps in having an overview of the sustainability practices of the producers and increases food traceability, which is currently difficult due to the long supply chains in today's ecosystem (O'Rourke, 2014). In doing this the company also takes on the "stewardship role" which is necessary to implement green initiatives in an ecosystem(Bocken et al., 2014).

customer segment

Green Consumers

The initial customer segment would be environmentally aware consumers and zero-waste shoppers. The lack of zero-waste options is a real struggle as I found through interviews. For example, there is only one zero-waste store in all of North Brabant. This however is not due to a lack of a big enough customer segment but rather an untouched territory for retailers. The commitment to this mission is apparent in the rise of stores such as Loop, a refill service for branded products. Its success in the United States has sealed them deals to expand to France, the United Kingdom, and Germany.

However, what Loop fails to deliver is transparency to customers, as the environmental commitment can seem like a greenwashing campaign. As their commitment goals state, the goal is to "enables our brand partners (CPGs) and retailers to meet their reuse target within their sustainability goals" (Loop & Ellen MacArthur Foundation Commitments, n.d.). However, they promote single-use products such as zip-lock plastic bags and don't provide any information about the impact of shopping and centrally cleaning their packaging.

Gen Z

The focus on transparency is increasingly important in the age of information. As potential consumers have grown with the internet and are used to

"Gen Z consumers are mostly well educated about brands and the realities behind them. When they are not, they know how to access information and develop a point of view quickly(...)The search for the truth is at the root of all Gen Z's behavior".(Francis & Hoefel, 2018)

Combined with the growing interest in sustainability companies need to show how they are achieving their sustainability goals.

The Netherlands:

The system is envisioned around the dutch way of shopping and its culture. The supermarkets are small, local, and reachable by bike. As a result, the grocery lists are smaller and baskets are preferred over grocery stores. This way of shopping resembles the global past of grocery stores before the automobile pushed the supermarkets to the suburbs and outside residential areas (Ellickson, 2016). The accessibility also allows users to shop for fresh products as the visits to the store are more frequent.

The system has been designed around these customs, as sustainable systems need to cater to a region's characteristics since global solutions fail at achieving this(McDonough & Braungart, 2002). However, there is a global push for a model that could make shopping habits more similar, the 15-minute city. This model aims at bringing amenities closer to people so that they can reach all they need within 15 minutes. This would in return reduce the presence of the car in cities and incentivize other forms of transportation. This is the case in The Netherlands, as the use of the bike makes the whole country a 15-minute city (van Rest, 2020)

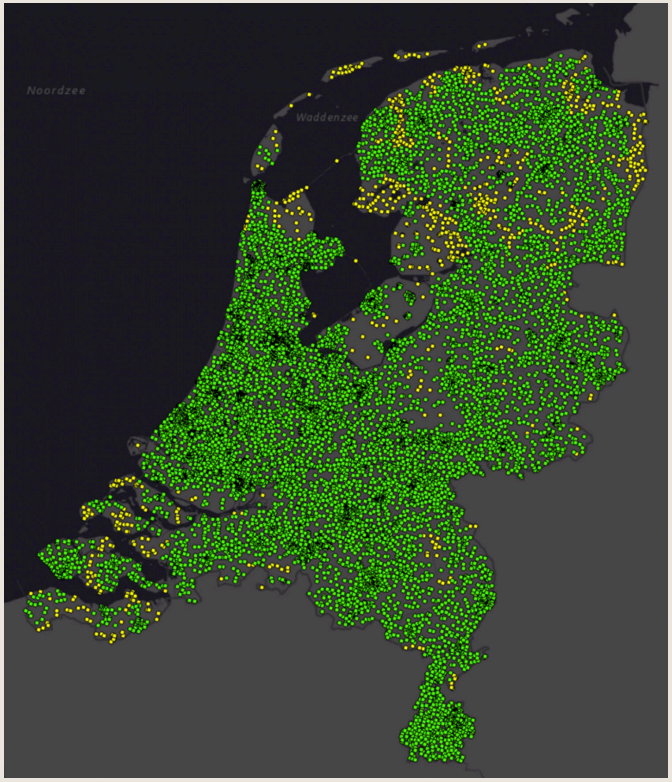


Fig. 22: Towns in the Netherlands (in green) that follow the 15-minute city model (van Rest, 2020).

diverging

To map out the connections in the frameworks rather than elaborating on the first prototype, I planned three short “mini-projects” to address other aspects of the first iteration. The outcomes from these mini-projects would help tell the story of the connections in the framework and also inform the system. They touch on other aspects outside of the customer experience at the store

The three mini-projects were based around the three areas of focus: convenience, information, and convenience. And also included other aspects that had emerged through my first-person perspective on engaging with zero waste and the first prototype and also from conversations about my project.

information

At the start of the project, while sensitizing to the zero-waste movements and their practices, I started storing my own food in clear jars. Shortly after storing my macaroni I realized that the cooking time for my pasta was gone with the packaging. Going through this first-person perspective in part fo the zero-waste process made me realize that packaging didn't just protect and help carry products, it is also used as a place to deliver information to the customer such as expiration dates, nutritional values, allergens, cooking instructions and even suggested recipes. All of this information would be gone with packaging.

Zero-waste stores have this information available on request from customers. However, as the owner of zero waste zone in Eindhoven shared with me, many customers just google this information. This is possible due to the fact that most products sold at these stores are single ingredient, such as lentils, or rice, so the nutritional values and cooking instructions can be found online. Expiration dates are also not often a concern, as these are dry goods and often have long shelf-lives.

However, if zero-waste stores were to expand their offer to more perishable goods, products made out of multiple ingredients or with more complex cooking instructions (for example a cake mix) the information should be more easily accessible to users.

To address the issue, I prototyped an app to take on packaging's role of providing information. Due to the short time frame, I opted for following design pattern's from supermaket apps.

In the app, users have access to a search bar to find information about individual products. In order to have a better overview of the products they have in their pantry only, they can scan the code shown at checkout at the store or in their receipt to log all of the products they have purchased to the pantry list on the app. This also allows the app to send push notifications when a product has expired.

In developing these features I wanted to use the opportunity to deliver more functionality beyond "fixing" what had been broken by removing packaging. An opportunity arises with the data that is gathered to notify expiration dates, as there could be a register of what kinds of products each customer likes. However, as discussed in the context section there is a risk of fueling surveillance capitalism by using this data to increase consumption to drive profits. Increasing (unecessary) consumption is against the goal of this project so the aim would be to incentivize green consumption instead. To achieve this I prototyped a home page with suggested sustainability tips and recipes using seasonal and local products. The aim here is to recommend options that lead to a lower environmental impact rather than to recommend options that are more likely to be purchased based on the products users have previously bought.

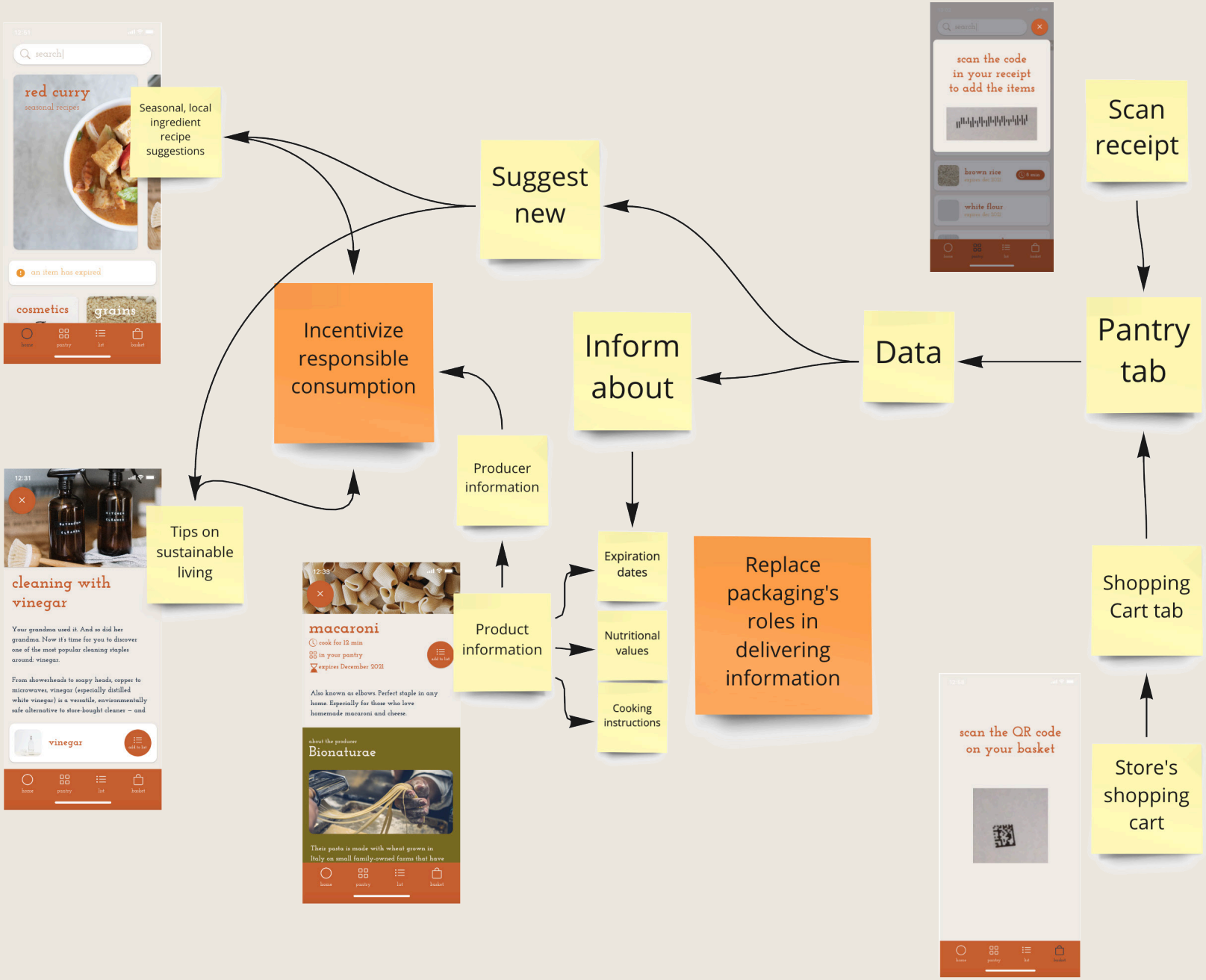


Fig. 23: Relationships between the app's functions.

convenience

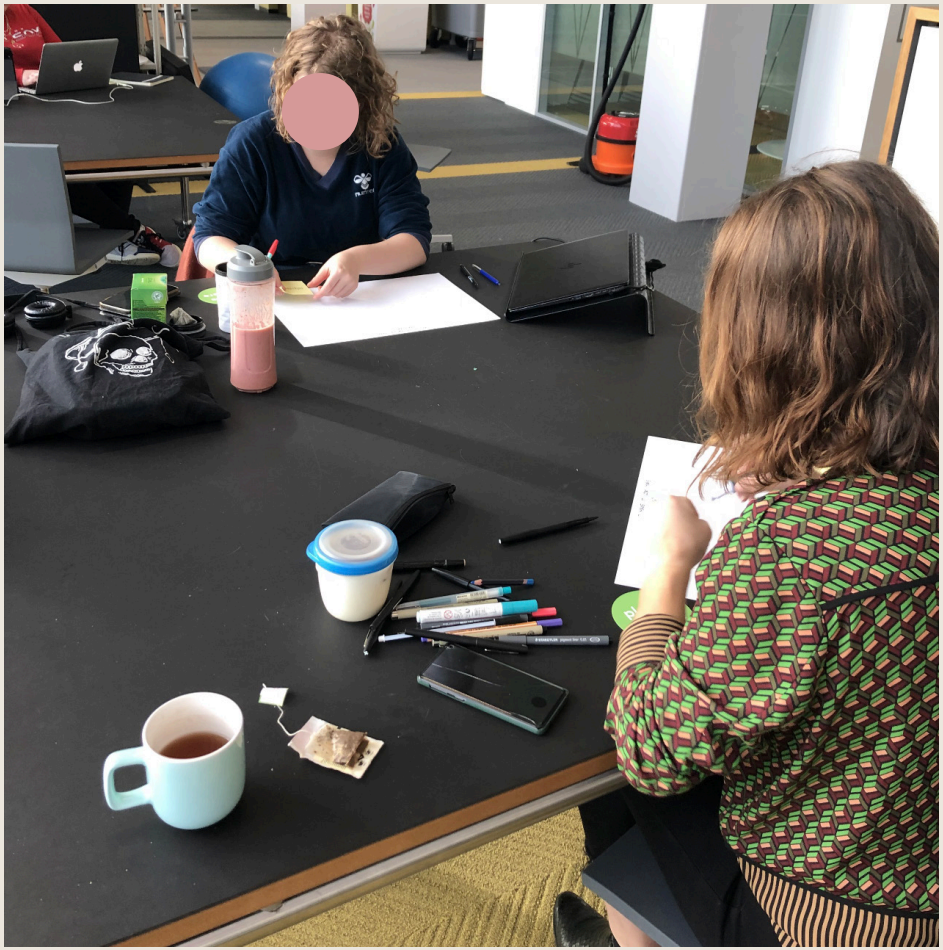


Fig. 24: Participants in the co-creation session

Fig. 25: Findings of the co-creation session

Adopting this way of shopping would also require changes in user's habits. In this case, the decision on how much of the amount of a product to buy lands on the user rather than on the packaging plant. Users have to decide whether they want 300gr or 400gr of a product rather than going for the amount in a package. To explore these thoughts and conventions with quantities of food I held a small session with fellow ID students (Figure 24). To start the conversation I asked them to write down their favorite recipe to cook and to write the ingredients down as if they were going to shop at the supermarket.

By going through the "units" they used and talking about packaging in an open-ended conversation I came to the realizations shown in figure 25.

As a result of this, I envisioned how the packaging and quantities would be handled.

The packaging is split into two: one for carrying(cotton) and one for storing(glass) (Figure 27).

The use of cotton or mesh bags at the store and glaas at home is widely adopted by zero-waste shoppers. However, these two parts that work together are often designed and bought separately. I experienced the issues of this through a first person perspective while testing out my prototype and while storing my food items in clear jar as I mentioned in the previous section(Figure 26).

While looking at the recipes of the participants it became apparent that packaging often acts as a unit of measurement. Therefore I created reusable packaging resembles existing "units" that have been adopted through single-use packaging such as a pack of pasta (Figure 28) or a can (400ml). This also helps with another issue I found while testing the prototype: calculating amounts at the store. I found that the big square mesh bags that are often used for bulk products make it hard to estimate how much product you are actually getting.

Borrowing the shapes and volumes from standard packaging can help customers get an idea about how much they are actually getting.

While pouring my food into glass containers I also noticed that the amount I had bought did not fit entirely in the container I had for such a product at home. This is another issue of having such dependent object designed separately. To aid in this process I made cottong bags so that the content of one fits perfectly into the glass one so you know that what you get at the store will fit in your container at home. This also helps in making the decision of how much to get at home, by picking the cotton bag for the container you want to refill.

Furthermore, this way of shopping and using clear containers fuels a clean aesthetic that resembles that of the "pantry porn" trend (Morris, 2019). In doing this, the products themselves become self-evident, expressing themselves through their actual shape and color rather than through packaging.

Fig. 26: Filling a jar with an ordinary bag

Fig. 27: Filling a jar with the zero bag

Fig. 28: Plastic and cotton spaghetti bag.

price

As mentioned in the discussion about the profit equation section, the proposed system requires a substantial initial investment for the hardware involved. It is therefore imperative to reduce costs where possible to keep the products competitive. One area for opportunity is in the technology used to measure the stock of products. Amazon Go uses cameras and computer vision to detect packaging which is expensive in terms of hardware and computing power necessary. The advantage of many bulk products is that they are contained in a bin which means the stock can be detected through other means.

While load cells would be a sensible way to do this by measuring the weight, they pose a number of challenges. For one, they need to hold all the bin's weight at one point. Load-cells that can support a large weight and have the precision needed are expensive. Secondly, the force that the user applies on a lever, button to dispense the product would affect the reading.

Another option would be to detect the stock by measuring the level on the bin with a distance sensor. This would require a model to estimate the weight output based on the level. To explore this possibility I trained a machine-learning algorithm to achieve that goal.

To train such a model, I put together a small circuit to gather data. It consists of an Arduino Uno board, a data-logging shield, two buttons, an HC-SR04 and a load cell with an HX711 signal amplifier (Figure 29). The wiring diagram and code can be found in appendix F. Using this circuit together with the the bulk bin I made, I was able to log data to an SD card.

The variables I was tracking were the initial level of the bin, the final level of the bin and the resulting weight. At first I considered a simpler model using only the height difference as an input but due to the tapered shape that bulkbins often have, this would not be possible as the same height difference in two different areas of the bin would have different volumes.

To log the data I filled the bulk bin with cheapeas and dispensed different amount of products, pressing the button inbetween to log the three points of data. I logged 100 lines of data to have enough for training and an additional 50 for out-of-data testing(Figure 32).

Fig. 29: The data-logging system with inputs and outputs.

For the training I used some code facilitated by Rong-Hao Liang from the course Intellignt Interactive products(Liang, 2020). Due to the numerical nature of this problem I chose two regressors: a linear support vector regressor and a kernel support vector regressor. On the first run, neither model yielded acceptable results with correlation coefficients of 0.4. However, I discovered this was due to a systematic error caused by some cables that were interfering with the load cell's readings. After training the models again, I achieved much better results with an out-of-sample correlation coefficient of 0.88 using the kernel support vector regressor due to the non-linear nature of the problem.

Though this model would not meet legal requirements regarding the tolerable negative error, it goes to show how a high accuracy can be achieved using ordinary sensors with machine learning. While a higher accuracy could be achieved with more data, better models, better hardware or the introduction of a second distance sensor, a positive error could be programmed in in the meantime.

This prototype goes to show the opportunity bulk shops have to automate their checkouts through more cost effective means. Also, in not using cameras and computer vision it eliminates the chance for surveillance, which customers can find "creepy"(Coldewey, 2018; Machkovech, 2020). Furthermore, this design decision limits the chance of using beheavioral data, which is often used to stimulate consumption through surveillance capitalism (Zuboff, 2019).

Fig. 30: Visualization of the final model. X-axis: initial level. Y-axis: final level. Shade: output weight

Fig. 32: Logging data to train the model

Initial level(mm)	Level difference (mm)	Weight(kg)
200.30	72.00	0.82
198.30	52.80	0.70
251.10	24.00	0.17
197.60	7.50	0.14
205.10	22.70	0.17
227.80	8.20	0.16
236.00	22.60	0.18

Fig. 31: Snapshot of some of the gathered data

validation

The validation of this project proved to be a challenging aspect due to it's scope. The complexity in achieving this is two-fold:

The first challenge is the size of the system itself. The experience at the shop, as described in the probe chapter, requires a significant amount of work to convey a realistic picture of the store. Furthermore, the zero-waste shopping experience also has significant implications outside of the store, and requires the slow adaptation of new habits which is also hard to to convey in a short focus group.

Secondly, the validation of the project should not land on the hands of the end-user. The user-centered design approach did not fit with the goal of this project. While I have taken the end-user's perspective into account for my design decisions throughout the process, the environment had a bigger stake.Therefore, for a final evaluation of the prototype I decided to interview someone with a more holistic view, a zero-waste store owner.

Fig. 33: Zero waste zone in Edisonstraat and its co-owner Darin Arouri.

Zero Waste Zone is the only zero waste store in North Brabant. Their owners Darin Arouri and Valeria Kochyna, were inspired to start the business after seeing the amount of plastic present in the Nethrelands compared to their home countries. While I got the chance to interview Valeria Kochyna for the contextualization of the project, this time I got the chance to discuss the outcomes with Darin Arouri.

Darin understood the concept of the store through my pitch and presentation of my demo day materials. She appreciated the integration of the sensors into the bulk bins directly as currently, customers have to weight their containers when they get to the store and then again with the products. This makes the process more complicated and customers usually need guidance and supervision. Darin also shared that for their store, only one customer can really shop at a time while the rest have to wait. This description matched the parallel I made between zero-waste shopping and the old-school service desk food store format.

Darin believed that my concept had potential in increasing the flow of customers at the store and of making the process easier for customers. However the investment in such technology would probably not be possible for such small business owners.

"I think that we are still in a long way until everybody understands why we shouldn't do certain things, even though they are more comfortable. So I think your concept, I don't think it's a threat. It may facilitate things for the consumers who are not aware that it's such a big issue."

discussion & conclussion

The food retail industry is a highly competitive market. The threat of new entrants is relatively low. However, retailers with new value propositions have flourished in the past few years such as Crisp, Picnic or HelloFresh. Zero's value proposition is particularly different since it places the environmental value at it's core.

As I have seen from studies on the organic food industry, ecopreneurs are in constant tensions between making profit and staying fully sustainable companies (Jolink & Niesten, 2015). Therefore, this project does not try to enforce a vision on the present. It suggests a series of steps to take direction in that vision. In trying not to be reductionist the concept becomes less clear the further it reaches into the future. The dialog with the real world and the opportunities and challenges it faces will bring clarity as it moves along. The outcome of the project paint a picture of the space of opportunity, but only engaging with the real world will stablish the path.

Future steps

As I discussed with the zero-waste store owner, this solution is too expensive for small shop owners and would do better as a start-up. The first step in achieving this would be to find shareholders. Luckily, as sustainability issues have increasingly come forward, so have the angel investors interested in sustainability initiatives(Sustainability Angel Investors, n.d.). Finding an angel investor that truly believes in the project could provide some seed capital, and guidance in finding partners and experts to fuel the initiative.

On the first stage, the startup could focus on creating a prototype for the concept store. This would help, refine design decisions, assess the technology readiness level and secure more investors. The app would also be a top priority and a legal team would have to verify the legality of the alternative way of delivering nutritional information.

Depending on the amount of funding the first flagship stores could contain a limited assortment of products of non perishable goods, to limit the losses at the early stages. Gradually, more product categories could be added. Based on the success, a product development team could be started to offer zero waste options that are not readily available such as detergents or cake mixes.

Perhaps one of the aspects the business could leverage its financial success would be its commitment to local products. At first, these might be too expensive, but if the bargaining power grew with the company or it developed its own products, this focus area could be brought back into the core of the concept.

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reflection

Integrating expertise

This project has given me the chance to fully integrate all of my expertise areas in a different way. Often before, my focus was on experimentation on exploring the possibilities that data or technology bring by using them as tools for design. In this approach, I noticed how my emphasis relied on Technology and Realization; Math, Data and Computing and Creativity and Aesthetics. As a result, my expertise areas of User and Society, and Technology and Entrepreneurship were somewhat neglected until the end of the process where they served as tools of validation.

During this project, I wanted to further integrate these two expertise areas further in my project. I also wanted to put to use the skills I have learned in these domains through courses like Trends and Forecasting, Green Business Models, or the Technology Entrepreneurship USE line I have followed.

Thanks to the strong focus on the context I have been able to find real problems in the environment and for users (User and Society) the risks and opportunities in the current regime (Business and Entrepreneurship) using these two inputs to leave space to

create opportunities (Creativity and Aesthetics) using data and technology (Math, Data and Computing, and Technology and Realization). In turn, I have been able to let contextual factors play a bigger role in my design decisions while still making use of my hands-on and experimental approach in the field of technology. One of the contextual factors I have found a new appreciation for thanks to this project has been history. It helped me see how the design decisions taken in the past, were shaped by political views and have an influence on how we see the world today. In addition, reading "To Save Everything, Click Here" by Evgeny Morozov, also helped me see how history can also be used to draw out false parallels to convey a certain narrative, such as technologists comparing the internet to the printing press. This appreciation for context is definitely something I will carry through in my practice.

Switching perspectives

In the current situation and with the current restrictions I have had the chance to explore forms of validation beyond user-testing. By picking a topic that has been vastly homogenized on a global scale, I have had the chance to reflect on how local circumstances influence and create space for opportunity. I have been able to do this by observing -through a second person prospecting- differences in supermarkets both in the Netherlands and in Spain but also experiencing these differences myself - through a first-person perspective-. Furthermore, this project has made me realize some issues with user-centered design. Particularly, in the fact that they focus on users' immediate problems which may just lead to incremental innovations. This is particularly problematic in tackling systemic problems that require, among other things, the partial sacrifice of individual interests for the common good. In my case, having to bring containers to the store is obviously not in the interest of the end-users when compared to the current conventions, but this is the decision I took by placing the importance on the environment's needs rather than the user's needs. I noticed how solutions that tried to partly fix the environmental issue while respecting the user's notion of convenience failed in delivering environmental value. This project has made me more confident in taking these kinds of decisions and risks.

Breaking and fixing

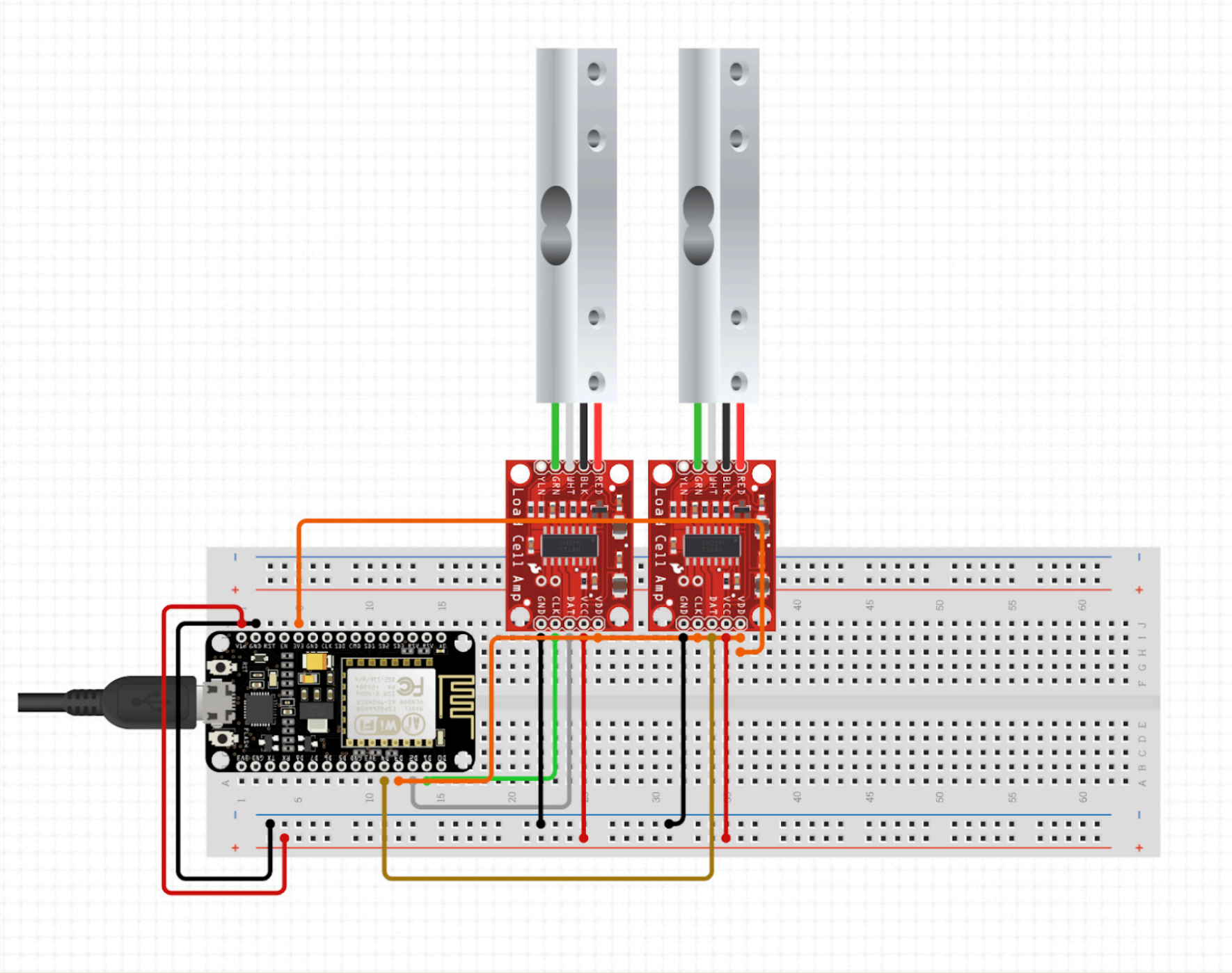
In my effort of "breaking" with established practices, I also found spaces for opportunities while trying to "fix" them. For example, when I noticed that legally required information like expiration dates would be missing if I removed the packaging, I "fixed" it through the app. However, this fix also opened up new opportunities, such as notifying people when an item is about to expire. Had I just looked at the previous option and my proposal just by how they addressed the initial concern, I would have gone for the first one; however, by considering what opportunities arise with change things changed.

All in all, this project has helped me further integrate my skills as a designer, changing the way I work and the way my design work contributes to society.

appendix

appendix A - weight tracker

```
#include “FirebaseESP8266.h”
#include <ESP8266WiFi.h>
#include <HX711.h>

#define FIREBASE_HOST “zerosystem-8a25c.firebaseio.com”
#define FIREBASE_AUTH “2VcPrCV1oKelVd7SkIzdu7SX6AVryAHFATVXW8n2”
#define WIFI_SSID //wi-fi name
#define WIFI_PASSWORD //wi-fi password

FirebaseData firebaseData;

String station = “/1”;
String product1 = “/apple”;
String product2 = “/potato”;

#include <SPI.h>
#include <MFRC522.h>
constexpr uint8_t RST_PIN = 5;
constexpr uint8_t SS_PIN = 4;

// HX711 circuit wiring
const int LOADCELL_DOUT_PIN = 12; //D6
const int LOADCELL_SCK_PIN = 14; //D5

const int LOADCELL2_DOUT_PIN = 13; // D7
const int LOADCELL2_SCK_PIN = 5; //D1

HX711 scale;
HX711 scale2;

float calibration_factor = 415;
float calibration_factor2 = 373;

void setup()
 {
  Serial.begin(115200);

  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  Serial.print(“Connecting to Wi-Fi”);
  while (WiFi.status() != WL_CONNECTED)
  {
   Serial.print(“.”);
   delay(300);
  }
  Serial.println();
  Serial.print(“Connected with IP: “);
  Serial.println(WiFi.localIP());
  Serial.println();

  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);
  Firebase.reconnectWiFi(true);

  scale.begin(LOADCELL_DOUT_PIN, LOADCELL_SCK_PIN);
  scale.set_scale();
  scale.tare(); //Reset the scale to 0

  scale2.begin(LOADCELL2_DOUT_PIN, LOADCELL2_SCK_PIN);
  scale2.set_scale();
  scale2.tare(); //Reset the scale to 0

 }

void loop()
{
  scale.set_scale(calibration_factor);
  long reading = scale.get_units();
  Firebase.setInt(firebaseData, “/stations” + station + “/products” + product1, reading);

  scale2.set_scale(calibration_factor2);
  long reading2 = scale2.get_units();
  Firebase.setInt(firebaseData, “/stations” + station + “/products” + product2, reading2);

  Serial.println(“data uploaded”);

 }
```

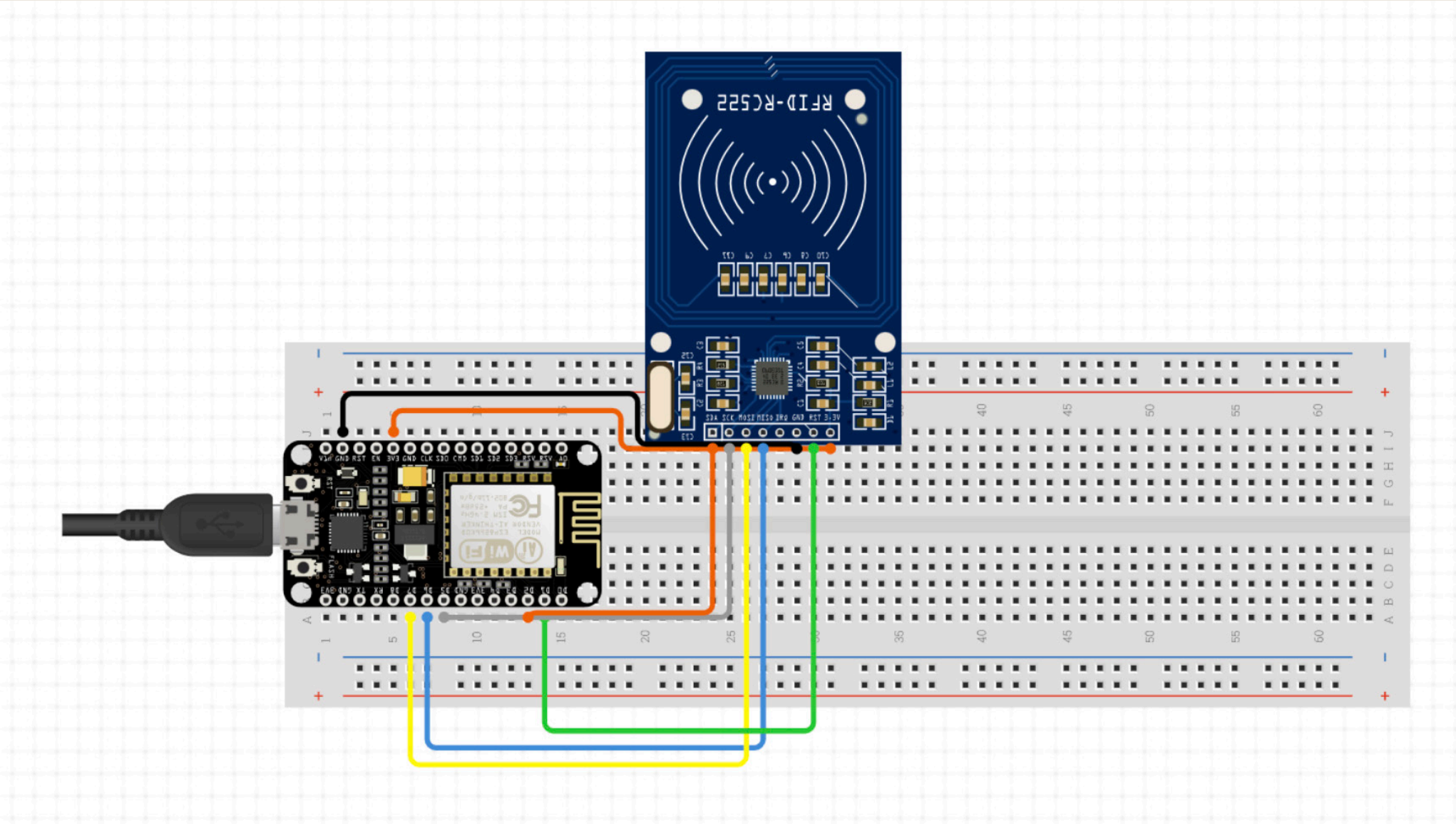

Load Cell Amp
YLW
GRN
WHT
BLK
RED
GND
CLK
DAT
VCC
VDD
Load Cell Amp
YLW
GRN
WHT
BLK
RED
GND
CLK
DAT
VCC
VDD

appendix B - basket reader

```
/*
  NUID reader code based on K. Suwatchai's (Mobizt) code
  Email: k_suwatchai@hotmail.com
  Github: https://github.com/mobizt
  Copyright (c) 2019 mobizt
*/

#include "FirebaseESP8266.h"
#include <ESP8266WiFi.h>

//1. Change the following info
#define FIREBASE_HOST "zerosystem-8a25c.firebaseio.com"
#define FIREBASE_AUTH "2VcPrCV1oKelVd7SkIzdu7SX6AVryAHFATVXW8n2"
#define WIFI_SSID  // wi-fi name
#define WIFI_PASSWORD  // wi-fi password
FirebaseData firebaseData;

#include <SPI.h>
#include <MFRC522.h>

constexpr uint8_t RST_PIN = 5;     // Configurable, see typical pin layout above
constexpr uint8_t SS_PIN = 4;     // Configurable, see typical pin layout above

MFRC522 rfid(SS_PIN, RST_PIN); // Instance of the class
MFRC522::MIFARE_Key key;
byte nuidPICC[4];
bool state = false;
String station = "/1";

void setup()
{

  Serial.begin(115200);

  WiFi.begin(WIFI_SSID, WIFI_PASSWORD);
  Serial.print("Connecting to Wi-Fi");
  while (WiFi.status() != WL_CONNECTED)
  {
    Serial.print(".");
    delay(300);
  }
  Serial.println();
  Serial.print("Connected with IP: ");
  Serial.println(WiFi.localIP());
  Serial.println();

  Firebase.begin(FIREBASE_HOST, FIREBASE_AUTH);

  Firebase.reconnectWiFi(true);

  SPI.begin(); // Init SPI bus
  rfid.PCD_Init(); // Init MFRC522
}

uint8_t control = 0x00;

void loop()
{
  delay(50);
  // Look for new cards
  if ( ! rfid.PICC_IsNewCardPresent())
    return;

  // Verify if the NUID has been readed
  if ( ! rfid.PICC_ReadCardSerial())
    return;

  Serial.print(F("PICC type: "));
  MFRC522::PICC_Type piccType = rfid.PICC_GetType(rfid.uid.sak);
  Serial.println(rfid.PICC_GetTypeName(piccType));
    Serial.println(F("A new card has been detected."));

    // Store NUID into nuidPICC array
    for (byte i = 0; i < 4; i++) {
```

```
    nuidPICC[i] = rfid.uid.uidByte[i];
   }

   printDec(rfid.uid.uidByte, rfid.uid.size);
}

while(true){
//digitalWrite(Green,HIGH);
   control=0;
   for(int i=0; i<3; i++){
    if(!rfid.PICC_IsNewCardPresent()){
     if(rfid.PICC_ReadCardSerial()){
      //Serial.print('a');
      control |= 0x16;
     }
     if(rfid.PICC_ReadCardSerial()){
      //Serial.print('b');
      control |= 0x16;
     }
     //Serial.print('c');
      control += 0x1;
    }
    //Serial.print('d');
    control += 0x4;
   }
  delay(50);//Delay to let the ESP run the Wi-Fi functionalities
   //Serial.println(control);
   if(control == 13 || control == 14){
    //card is still there

   } else {
      if (Firebase.setInt(firebaseData, "/stations" + station + "/basket", 0)){
       //Success
       Firebase.setInt(firebaseData, "/stations" + station + "/basketState", false);
       Serial.println("Set int data success");
      } else {
       //Failed?, get the error reason from firebaseData

       Serial.print("Error in setInt, ");
       Serial.println(firebaseData.errorReason());
      }
```

```
     break;
    }
    yield(); //indicates that it is a purpuseful loop so that it doesn't time out the ESP
   }

   Serial.println("CardRemoved");

  // digitalWrite(Green,LOW);
  delay(50);



   // Halt PICC
   rfid.PICC_HaltA();

   // Stop encryption on PCD
   rfid.PCD_StopCrypto1();

}

void printDec(byte *buffer, byte bufferSize) {
  for (byte i = 0; i < bufferSize; i++) {
    Serial.print(buffer[i] < 0x10 ? " 0" : " ");
    Serial.print(buffer[i], DEC);
  }
  if (Firebase.setInt(firebaseData, "/stations" + station + "/basket", buffer[1]))
  {
    //Success
    Firebase.setInt(firebaseData, "/stations" + station + "/basketState", true);
    Serial.println("Set int data success");
  } else {
    //Failed?, get the error reason from firebaseData

    Serial.print("Error in setInt, ");
    Serial.println(firebaseData.errorReason());
  }
}
```


RFID-RC522

appendix C - webapp

HTML code

```
<!DOCTYPE html>
<html>
 <head>
  <meta charset="utf-8">
  <meta name="viewport" content="width=device-width, initial-scale=1">
   <link href="https://fonts.googleapis.com/css2?family=Josefin+Slab&display=swap" rel="stylesheet">
    <link href="https://fonts.googleapis.com/css2?family=Be+Vietnam:ital,wght@0,100;0,300;0,400;0,500;0,600;0,700;0,800;1,100;1,300;1,400;1,500;1,600;1,700;1,800&display=swap" rel="stylesheet">

   <!-- Bootstrap CSS -->
    <link rel="stylesheet" href="https://stackpath.bootstrapcdn.com/bootstrap/4.5.2/css/bootstrap.min.css" integrity="sha384-JcKb8q3iqJ61gNV9KGb8thSsNjpSL0n8PARn9HuZOnIxN0hoP+VmmDGMN5t9UJ0Z" crossorigin="anonymous">
  <link rel="stylesheet" href="/css/boption.css">

 </head>

 <body>
  <div class="screensaver" id="screensaver">
   <h1 id="sstext">place your basket</h1>

  </div>
<div class="container">
 <div class="row justify-content-center">
  <div class="col-xl-6 listb d-flex flex-column">
    <div class="row listheader align-items-center">
     <h3 class="listheadertitle">Your basket</h3>
    </div>
    <div id="eggplantline" class="row align-items-center productline">
     <div class="col-8">
          <p><span class="itemname">Onion</span><span id="eggplantquantity" class="itemquantity">200gr</span></p>
     </div>
     <div class="col-4 itemsubtotal">
      <p>€<span id="eggplanttotal">2.99</span></p>
     </div>
    </div>
    <div id="bellpepperline" class="row align-items-center productline">
     <div class="col-8">
      <p><span class="itemname">Bell pepper</span><span id="bellpepperquantity" class="itemquantity">200gr</span></p>
     </div>
     <div class="col-4 itemsubtotal">
      <p>€<span id="bellpeppertotal">2.99</span></p>
     </div>
    </div>
    <div id="garlicline" class="row align-items-center productline">
     <div class="col-8">
    <p><span class="itemname">Garlic</span><span id="garlicquantity" class="itemquantity">200gr</span></p>
     </div>
     <div class="col-4 itemsubtotal">
      <p>€<span id="garlictotal">2.99</span></p>
     </div>
    </div>
    <div id="riceline" class="row align-items-center productline">
     <div class="col-8">
      <p><span class="itemname">Rice</span><span id="ricequantity" class="itemquantity">200gr</span></p>
     </div>
     <div class="col-4 itemsubtotal">
      <p>€<span id="ricetotal">2.99</span></p>
     </div>
    </div>
    <div id="chickpeasline" class="row align-items-center productline">
     <div class="col-8">
      <p><span class="itemname">Chickpeas</span><span id="chickpeasquantity" class="itemquantity">200gr</span></p>
     </div>
     <div class="col-4 itemsubtotal">
      <p>€<span id="chickpeastotal">2.99</span></p>
     </div>
    </div>
    <div id="coconutmilkline" class="row align-items-center productline">
     <div class="col-8">
     <p><span class="itemname">White vinegar</span><span id="coconutmilkquantity" class="itemquantity">200gr</span></p>
     </div>
     <div class="col-4 itemsubtotal">
```

```
        <p>€<span id="coconutmilktotal">2.99</span></p>
      </div>
     </div>
     <div class="row listtotal align-items-center">
      <div class="col-8">
        Total
      </div>
      <div class="col-4 itemsubtotal">
        €<span id="total"></span>
      </div>

     </div>
    </div>

   </div>
  </div>
</div>
```

CSS code

```
body{
  font-family: 'Be Vietnam', sans-serif;
  color: #d6571c;

}

.product{
  width: 75px;
  height: 75px;
}

.card-body{
  -webkit-transition: all 1s ease-in-out;
-moz-transition: all 1s ease-in-out;
-o-transition: all 1s ease-in-out;
transition: all 1s ease-in-out;
}

.screensaver{
  display: flex;
  align-items: center;
  justify-content: center;
  height: 100vh;
  background-color: #d6571c;
  transition: all 1s ease-in-out;
}

.hideSS{
  height: 0vh;
  color: #d6571c;
  font-size: 0pt;
}

h1{
  font-family: 'Josefin Slab', serif;
  color: #f1ebe4;
  font-weight: 700;
  font-size: 44pt;
}
```

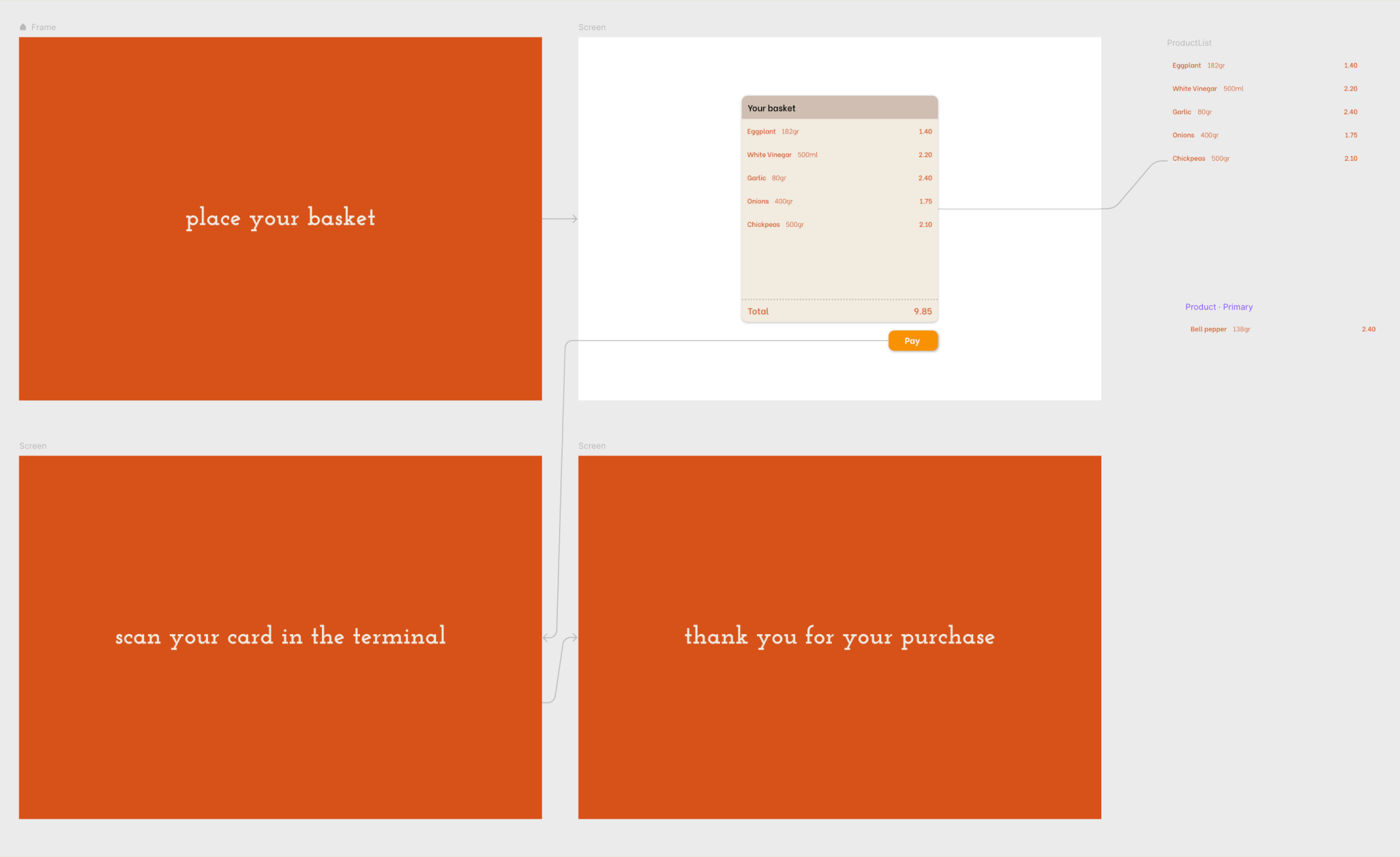
```
.listheader {
  height: 64px;
  background: #d1c1b3;
  border-radius: 16px 16px 0 0;
}

.listheadertitle {
  padding: 16px;
  overflow: visible;
  font-family: “Be Vietnam”, serif;
  color: #000000;
  font-size: 24px;
  letter-spacing: 0px;
  line-height: 1.2;
  font-weight: 500;
  font-style: normal;
}
.listb{
  margin: 60px;
  background: #f1ebe4;
  box-shadow: 0px 2px 5px 0px rgba(0, 0, 0, 0.25);
  border-radius: 16px;
  height: 540px;
}

.itemname{
  padding-right: 8px;
  font-weight: 400;
  font-size: 18px;

}
.itemquantity{
  font-weight: 100;
  font-size: 18px;

}
.itemsubtotal{
  font-weight: 400;
  font-size: 18px;
  text-align: right;
}

.productline {
  padding-top: 20px;
  height: 64px;
  align-items: center;
  transition: all 0.2s ease;
  opacity: 1;
}

.hide {
  opacity: 0;
  height: 0px;
  padding: 0px;
}

.container{
  height: 100vh;
}

.listtotal {
  margin-top: auto;
  font-size: 24px;
  padding-left: 0px;
  box-sizing: border-box;
  height: 64px;
  overflow: visible;
  border-style: dotted;
  border-color: #d1c1b3;
  border-top-width: 4px;
  border-bottom-width: 0px;
  border-left-width: 0px;
  border-right-width: 0px;
}
```

JS code

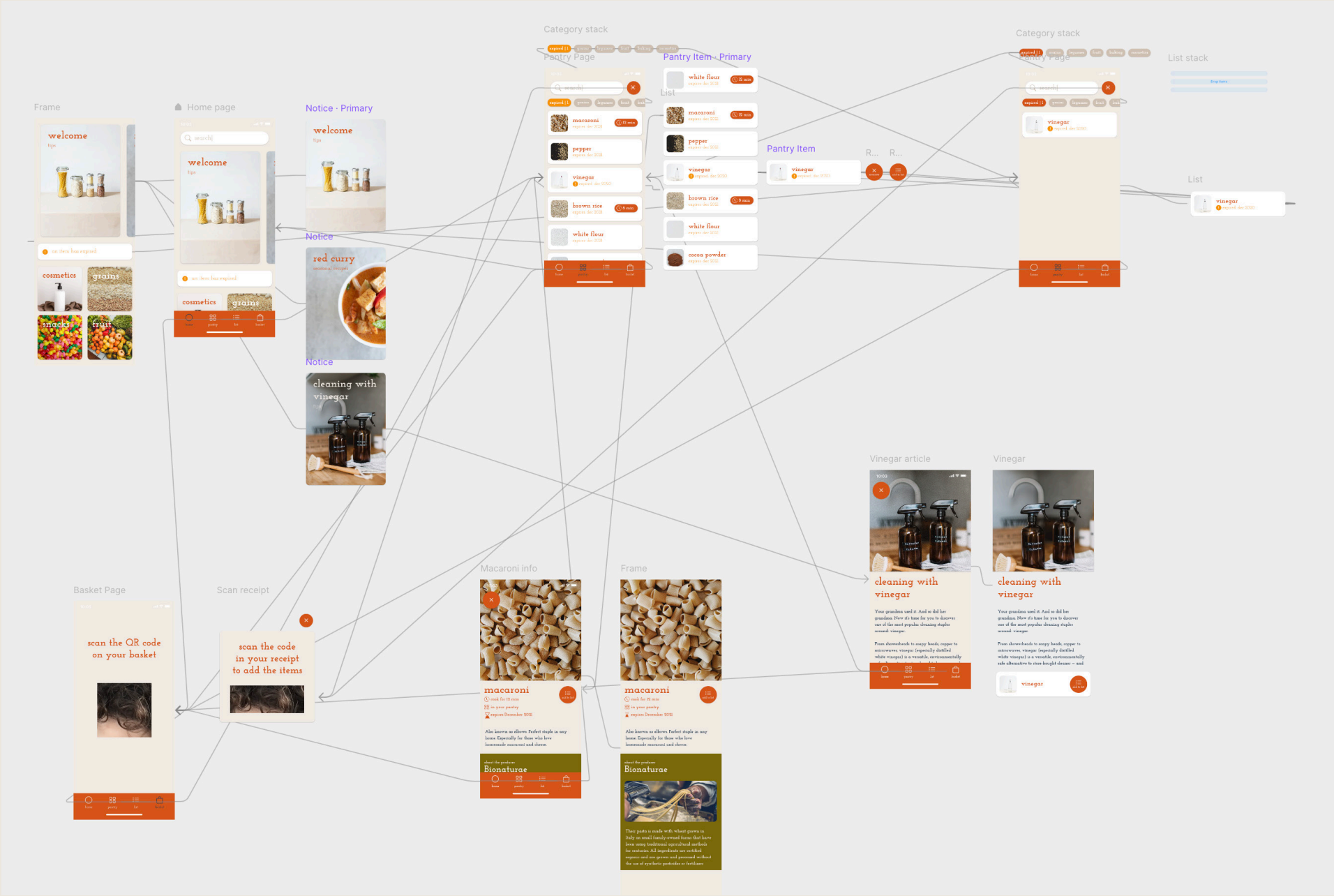
```
var firebaseConfig = { //data removed for security
  apiKey:
  authDomain:
  databaseURL:
  projectId:
  storageBucket:
  messagingSenderId:
  appId:
  measurementId:
};
// Initialize Firebase
firebase.initializeApp(firebaseConfig);
//firebase.analytics();

const database = firebase.database();
const station = '/1';
var basketRef = database.ref('stations' + station + '/basket');
var basketStateRef = database.ref('stations' + station + '/basketState');
var productsRef = database.ref('stations' + station + '/products');
var preProductsRef = database.ref('stations' + station + '/preProducts');
var basketID = 0;
var basketsRef = database.ref('baskets');

//when the basket number is updated:
basketRef.on('value', function(snapshot) {
  document.getElementById("basket1").classList.remove('squareb');
  document.getElementById("basket2").classList.remove('squareb');
  document.getElementById("basket3").classList.remove('squareb');
  document.getElementById("basket4").classList.remove('squareb');
  document.getElementById("basket5").classList.remove('squareb');
  var data = snapshot.val();
  //console.log(data);
  if (data == 65) {
    document.getElementById("basket1").classList.add('squareb');
    basketStateRef.set(true);
    basketID = 65;
  } else if (data == 67) {
    document.getElementById("basket2").classList.add('squareb');
    basketStateRef.set(true);
    basketID = 67;
  } else if (data == 204) {
    document.getElementById("basket3").classList.add('squareb');
    basketStateRef.set(true);
    basketID = 204;
  } else if (data == 111) {
    document.getElementById("basket4").classList.add('squareb');
    basketStateRef.set(true);
    basketID = 11;
  } else if (data == 142) {
    document.getElementById("basket5").classList.add('squareb');
    basketStateRef.set(true);
    basketID = 142;
  } else if (data == 0) {
    basketStateRef.set(false);
    basketID = 0;
  }

})

appleRef = database.ref('baskets/65/items/apple/quantity');
appleRef.on('value', function(snapshot){
  quantity = snapshot.val().toString();
  document.getElementById("basket1text").innerHTML = quantity;
})


//BACKEND

basketStateRef.on('value', function(snapshot) {
  var state = snapshot.val();
  console.log(state);
  if (state) {
    productsRef.off(); //stops listening
    productsRef.on('value', function(snapshot) {
      snapshot.forEach(function(childsnapshot) {
        var product = childsnapshot.key;
        var quantity = childsnapshot.val();
        var prevQuantity;
        var quantityInBasket;
          database.ref('stations' + station + '/preProducts/' + product).once('value', func-
```

```
tion(snapshot) {
        prevQuantity = snapshot.val()
        quantityInBasket = prevQuantity - quantity;
        console.log(quantityInBasket);

        if (quantityInBasket != 0) {
          //console.log(product);
          //console.log(quantityInBasket);
          ref = basketsRef.child(basketID).child("items");
          ref.child(product).set({
            quantity: quantityInBasket
          });
          //ref.child("items").child(product).set({quantity: quantityInBasket});
        }
      })


     })

    })
  } else {
    productsRef.on('value', function(snapshot) {
      var products = snapshot.val();
      preProductsRef.set(products);
    })
  }
})
```

appendix D - UI design



appendix E - app design



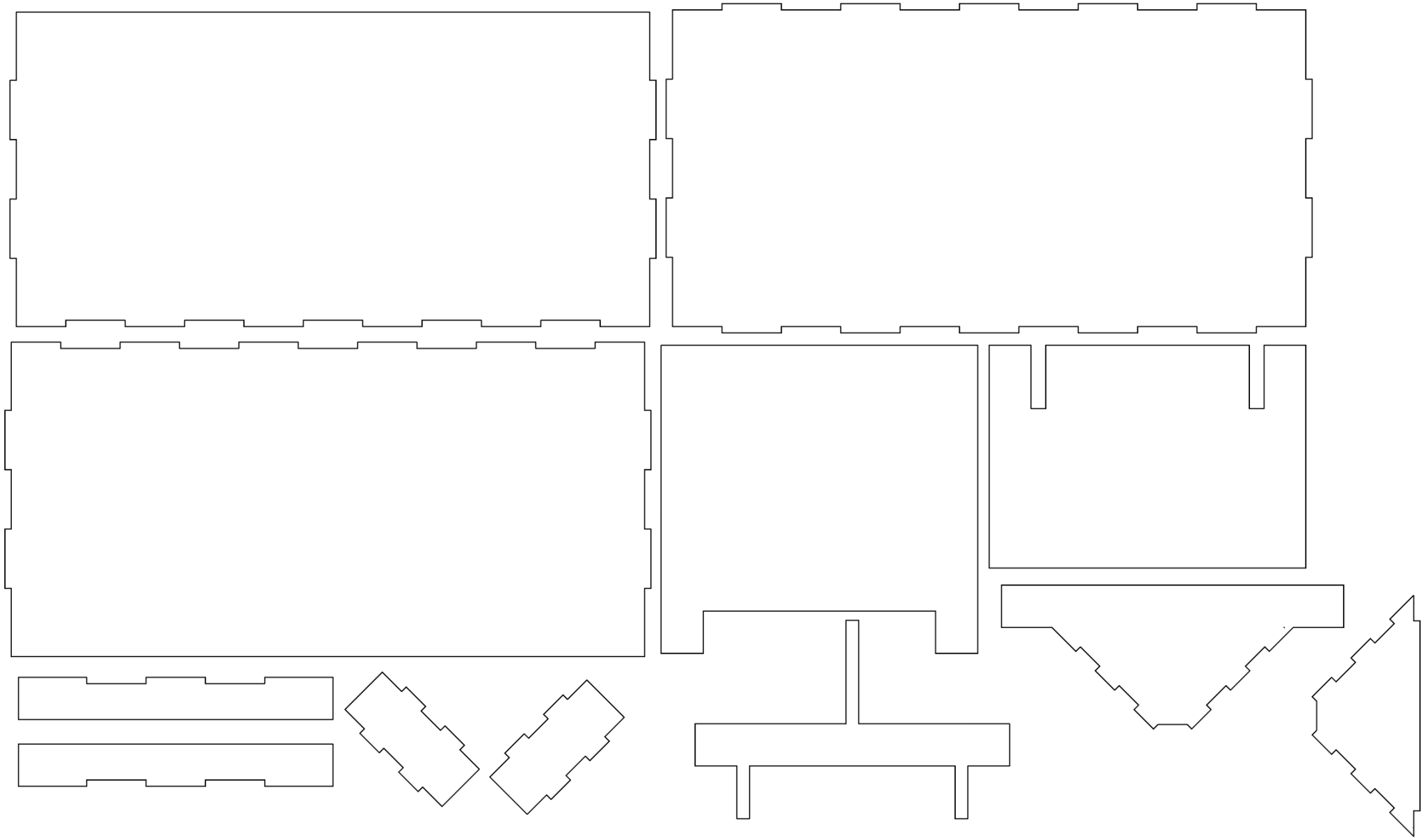
appendix F - data logger

```
/*   The circuit:
  SD card attached to SPI bus as follows:
 ** MOSI - pin 11
 ** MISO - pin 12
 ** CLK - pin 13
 ** CS - pin 9 for Robodyn board
 *
 * This is different for other boards such as Arduino Mega
*/

#include <SPI.h>
#include <SD.h>

File myFile;

const int chipSelect = 10;

#include <Wire.h>
#include <HX711.h>
#include <HCSR04.h>

int triggerPin = 3;
int echoPin = 2;

const int LOADCELL_DOUT_PIN = 4;
const int LOADCELL_SCK_PIN = 5;

HX711 scale;

#define btnPin 6
#define btnPin2 7

#define Debug_mode true

// Define pin for signaling avctivity

#define debugled 8

float prevdistance;

uint8_t btn_prev;
uint8_t btn_prev2;


void setup() {

  // Open serial communications and wait for port to open:

  blink1();
  if (Debug_mode) {
    Serial.begin(9600);

    while (!Serial) {}

    Serial.println("DS1307RTC Read Test");
    Serial.println("-------------------");
    Serial.print("Initializing SD card...");
  }
  delay(1000);
  pinMode(chipSelect, OUTPUT); // Set Chip Select pin to "output" otherwise the routine
will not work
  delay(1000);

  if (!SD.begin(chipSelect)) {
    if (Debug_mode) {Serial.println("initialization failed!");}
    while (1);
  }
  if (Debug_mode) {Serial.println("initialization done.");}

  // open the file. note that only one file can be open at a time,
  // so you have to close this one before opening another.
  myFile = SD.open("data.csv", FILE_WRITE);

  // if the file opened okay, write to it:
  if (myFile) {
    if (Debug_mode) {Serial.print("Writing to data.csv...");}
    myFile.println("Initial level, Final level, Weight");
    // close the file:
    myFile.close();
```

```
  if (Debug_mode) {Serial.println("done.");}
 } else {
  // if the file didn't open, print an error:
  if (Debug_mode) {Serial.println("error opening data.csv");}
 }

 scale.begin(LOADCELL_DOUT_PIN, LOADCELL_SCK_PIN);
 scale.set_scale(65479.00/174);
 scale.tare();
HCSR04.begin(triggerPin, echoPin);
double* prevdistanceb = HCSR04.measureDistanceCm();
prevdistance = prevdistanceb[0];

 if (Debug_mode) {
  Serial.println("-------------------");
  Serial.println("done.");
  Serial.println("-------------------");
  Serial.println("Starting data log");
  Serial.println("-------------------");
 }

 pinMode(btnPin, INPUT_PULLUP);
 btn_prev = digitalRead(btnPin);
  pinMode(btnPin2, INPUT_PULLUP);
 btn_prev2 = digitalRead(btnPin2);

 blink1();
 Serial.print("setup done");
}

void blink1() {
 digitalWrite(debugled, HIGH);   // turn the LED on (HIGH is the voltage level)
 delay(500);                     // wait for a second
 digitalWrite(debugled, LOW);    // turn the LED off by making the voltage LOW
 delay(500);                     // wait for a second

}

void printdist(){
 double* distances = HCSR04.measureDistanceCm();
 myFile.print(prevdistance);
 Serial.println("IL:" + String(prevdistance));
 myFile.print(" , ");
 myFile.print(distances[0]);
 Serial.println("FL:" + String(distances[0]));
 myFile.print(" , ");
 prevdistance = distances[0];

}

void printweight(){
 float weight = scale.get_units(4)/1000;
 myFile.print(weight);
 Serial.println("W:"+ String(weight));
 myFile.println("  ");
 scale.tare();

}

void loop() {
uint8_t btn = digitalRead(btnPin);
//Serial.print("digitalRead(btnPin)");
uint8_t btn2 = digitalRead(btnPin2);

if (btn == LOW && btn_prev == HIGH){
 // re-open the file for reading:
 Serial.print("button presed");

 myFile = SD.open("data.csv", FILE_WRITE);
 blink1();
 if (myFile) {
  printdist();
  printweight();
  myFile.close();
  // close the file:
  delay(1000);

 } else {
  // if the file didn't open, print an error:
 if (Debug_mode) { Serial.println("error opening data,csv");}
 }
 blink1();
```

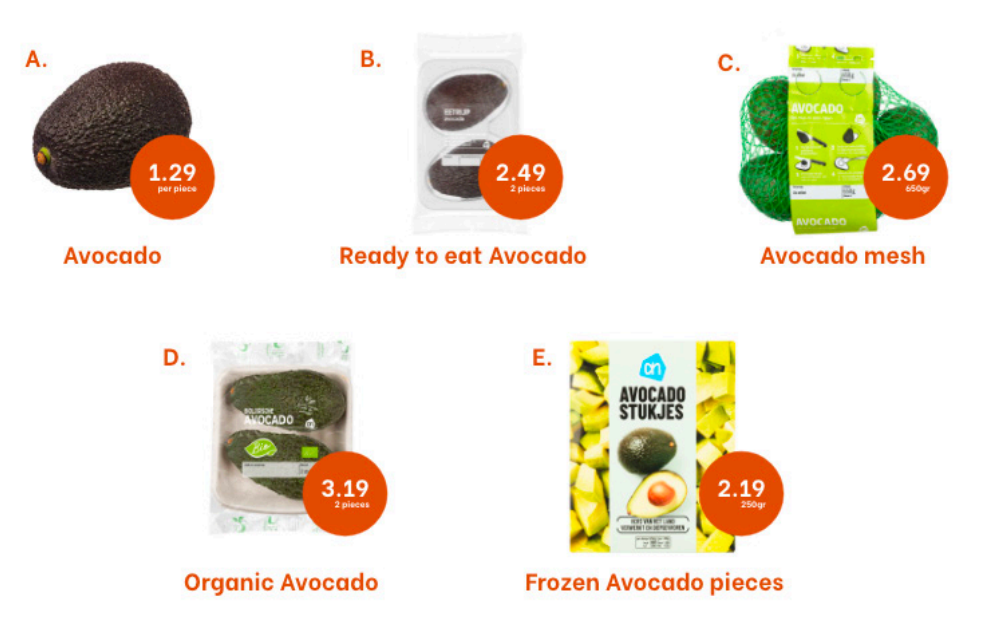
```
  btn_prev = digitalRead(btnPin);

}
btn_prev = digitalRead(btnPin);

if (btn2 == LOW && btn_prev2 == HIGH){
 scale.tare();
 double* prevdistancec = HCSR04.measureDistanceCm();
 prevdistance = prevdistancec[0];
 Serial.println("reset");
}
btn_prev2 = digitalRead(btnPin2);

}
```

appendix H - bulk bin

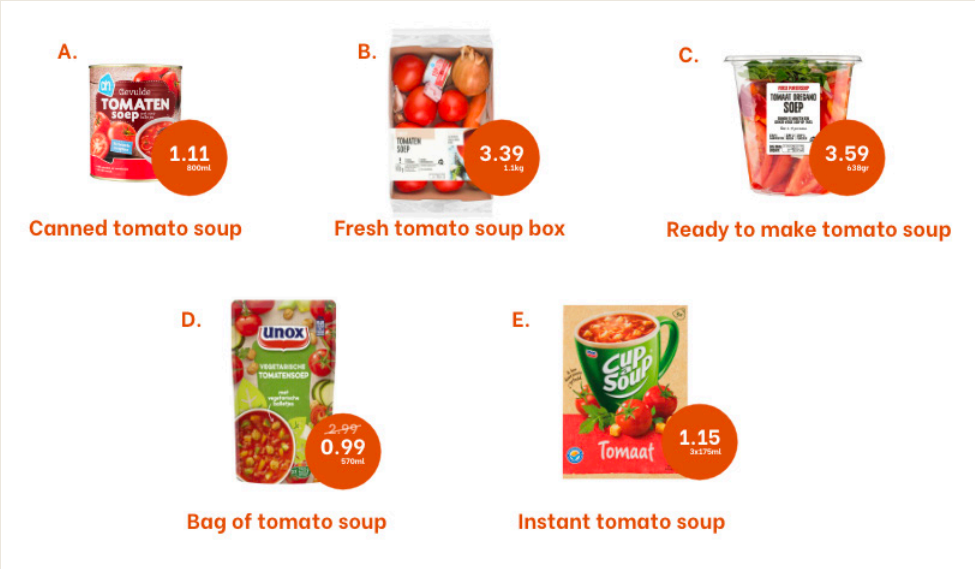


appendix I - card sorting

Stack A



Stack B



appendix J - first expert interview

Questions

When did you hear about zero waste?

How long ago did you start going zero-waste?

Why did you go zero-waste?

What was the hardest part about going zero-waste at first?

What is the biggest problem right now?

What are consumers least knowledgeable on?

What products are the most popular?

What products do you not have that your customers are demanding?

What products have you tried to sell and failed?

What are the biggest challenges in terms of available products in your store?

What do you think is the biggest challenge to make zero-waste mainstream?

What is the current journey for a regular shopper at your shop? (from when they open the door until they leave)?

How do your customers bring their products home?

How do you deal with someone who has poured something in a container and then realized its not what they wanted/too much?

What are the hardest challenges of making a zero waste store?

What is the market environment like?

How do you regulate nutritional info, allergens, expiration date... for bulk items?

Do you think you produce social value besides sustainability?

Do you support local agriculture?

In what other ways could you improve the sustainability of your business? What are the barriers to change those aspects?