

# GROW KIT DESIGN PROCESS DEVELOPMENT



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# EXECUTIVE SUMMARY



The project commissioned by VodafoneZiggo aimed at finding new solutions to mitigate current detrimental effects of the fresh food industry on the environment and help combat the upcoming food crisis. Framed within the urban farming movement, the proposed solution is a sensor stick that can measure key plant care properties such as moisture, light and temperature and communicate the information to an accompanying app that can provide tailored recommendations for optimal growth.

Building upon last semester's initial efforts to develop a solution to raise awareness about sustainable and responsible food production in an urban context by harnessing the opportunities offered by the internet of things, the team created a fully functional prototype. The product, aims to help individuals gain the confidence, no matter their level of knowledge in gardening, to grow their own food and create a community around these habits and support trade of excess produce.

As millennials and Social Media are currently considered industry drivers for the home plant industry, the team focussed its design to decisions to cater to this market while emphasizing the aesthetics of the product. While the entire design process followed a human centric approach by applying various empathetic design methodologies, the project also consisted of intensive market research, problem definition, strategic business development and experimentation with recycled plastics.

For more information please visit <https://letitgrow.launchaco.com/>



## CHAPTER 1 : THE PROBLEM

### Background : Sustainable food for everyone?

Worldwide population is expected to grow to nearly 10 billion by 2050<sup>1</sup> - but agricultural lands won't be able to follow the same pace. Although fertility levels worldwide are declining, life expectancy is increasing - and therefore, the global population keeps growing. The United Nations estimates that the world's population is increasing by more than 80 million people every year with forecasts indicating a nonstop rise: The global population is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion by 2100<sup>2</sup>.

On top of that, it's estimated that two-thirds of the world's population will be city dwellers. About 54% of the population lives in cities today, and about 66% are expected in 2050<sup>3</sup>. Urban areas require a massive quantity of goods, services and resources, which are causing many problems for citizens. Human activities generate externalities costs, and the transport sector is one of the main causes of these..

The Food and Agricultural Organization of the United Nations (FAO) forecasts that global food production will need to increase by 70% if the population reaches 9.1bn by 2050<sup>4</sup>. With so many more mouths to feed agricultural yields are going to have to catch up.

New agricultural practices have taken a toll on the planet resulting in a plethora of detrimental effects. From the colossal amount of water needed, pollution caused, energy use, and destruction of natural habitats, the problem is clear: something has to change.<sup>5</sup>

But how can we feed all these billions without destroying the Earth?

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<sup>1</sup> <https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html>

<sup>2</sup> <https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html>

<sup>3</sup> <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>

<sup>4</sup> <https://www.foodnavigator.com/Article/2017/11/10/Population-growth-a-threat-to-food-quality>

<sup>5</sup> <https://www.eolss.net/sample-chapters/c07/e5-17-02-03.pdf>

## Existing challenges in fresh food production practices

### Agricultural chemicals, fertilisers, antibiotics and food additives

As overpopulation takes hold, producers find themselves under pressure to meet amplified demand for food, thus placing vast constraints on production and distribution channels. For example, as crop yields grow in size, producers cut corners and attempt to inflate their production line through the use of chemicals and other synthetics during the production process.<sup>6</sup>

These synthetics commonly include chemical fertilizers and pesticides and additionally, producers can also modify inorganic food items at a molecular or genetic level<sup>7</sup>. Although agricultural chemicals in the production of inorganic food items helps control contaminations, enhance growth and fertility of their land enabling cheaper production costs, evidence suggests that these substances can cause health and environmental problems:

- The toxic chemicals found in synthetic substances can cause long-term damage to the land, ultimately making the land less fertile or non-fertile<sup>8</sup>. Some Fertilizers remove the nutrients of the soil, damaging the soil and the local environment, gradually reducing the fertility of the soil.
- Chemicals are absorbed into the plants and enter the food chain via vegetables and cereals. However, the largest health risk is when the chemicals flow into ground-water, which is then extracted for drinking. Example of toxic effects include gastrointestinal symptoms, kidney damage, liver disease, impairment of the nervous system, or DNA damage, which could cause cancer (Synthetic fertilizers increase over six times the risk of dying of cancer types including brain cancer, lymphoma, prostate cancer, leukemia and large intestine cancer)<sup>9</sup>

As a result, studies indicate that the greatest risk to food quality posed by a rising population is declining production standards as producers seek out short-cuts to higher yields.<sup>10</sup> Moreover rising demand also enhances the risk of food fraud within the supply chain as the highly competitive nature of the fresh food industry leads to operators working on very small profit margins.

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<sup>6</sup> <https://www.foodnavigator.com/Article/2017/11/10/Population-growth-a-threat-to-food-quality>

<sup>7</sup> <https://www.bigoven.com/organic-vs-inorganic-foods>

<sup>8</sup> <https://lettucegroup4.weebly.com/effects-on-human-health.html>

<sup>9</sup> <https://www.rivm.nl/en/food-safety/chemicals-in-food>

<sup>10</sup> <https://www.foodnavigator.com/Article/2017/11/10/Population-growth-a-threat-to-food-quality>

## The food mile problem

Food miles refer to the distance food has travelled to get from where it was produced to where it is sold. Much the food that are sold in local stores are grown in other countries where the climate is different, and are sent abroad to be processed after harvest.<sup>11</sup> This further adds miles to the journey of an item of food and therefore means more transport costs and more pollution. This has led to growing concerns about the environmental impact of transporting goods over great distances and how much carbon is used in the production and transportation of fresh food products. Overall, the food mile problem encompasses a range of related problems that are rooted in current global logistical systems:

Lower wages	Companies aim to reduce prices to remain competitive which often leads to cut the cost of production. Benefitting from cheaper labour costs abroad, some companies do not pay fair wages to their employees, provide terrible working conditions and may not give any breaks during the day. <sup>12</sup>
Food waste	The causes of food waste occurs at every stage of the supply chain, from producing, processing, retailing and consuming. According to food waste expert Toine Timmermans of Wageningen University, the entire food chain in the Netherlands - consumers, supermarkets, restaurants, and other institutions - throws away around 5 million kilograms of food every day. <sup>13</sup> Studies have shown that with the rise of more resource-consumptive Western diet, in addition to trends towards online food purchases results in more waste as consumers feel less invested in their food as they expend less effort to attain it. <sup>14</sup>
Plastic waste	Plastics has been known to protect our food end extend its life, making it easy to store and transport. Though it is expected that the longer shelf life of products would therefore allow to reduce food waste, it has merely lead to an extreme increase in food and plastic waste. <sup>15</sup> In fact the two go hand in hand. More food wasted leads to more food production, which in turn leads to more production of plastics. By wasting millions of tons of food annually, we're wasting millions of tons of plastic, which overall leads to exponentially increase the carbon footprint of the entire industry. Nowadays, producers mostly use plastic packaging to advertise their products, to transport food across long distances and to decide how much customers should buy at one go.
Last Mile and pollution	The Last mile distribution encompasses any movement of product between a distribution center and the end point at which the consumer, whether it be a retail store, a restaurant, or a home, receives it. In other words, it is simply the last leg of the food's journey within a city . Transport accounts for 26% of global CO2 emissions and is one of the few industrial sectors where emissions are still growing. <sup>16</sup> Car use, road freight and aviation are the principal contributors to greenhouse gas emissions from the transport sector and new trends focused on finding new approaches to reduce emissions from these three problem areas. There are countless problems that last mile delivery faces. As shopping online has increasingly become more convenient and practical, the shift from brick and mortar to online stores has also been increasing. Research has shown that 28% of total delivery cost comes from the implementation of the e-commerce last mile delivery. This is mainly due to the inefficiency of delivering goods. Factors such as incorrect address, difficulty finding locations,

<sup>11</sup> <http://www.pollutionissues.co.uk/food-miles-environmental-impact-food.html>

<sup>12</sup> <https://www.bbc.com/bitesize/guides/zf6fr82/revision/1>

<sup>13</sup> <https://nltimes.nl/2019/02/05/netherlands-throws-away-5-million-kilos-food-every-day-report>

<sup>14</sup> <https://www.sciencedirect.com/science/article/pii/S0969698917302990>

<sup>15</sup> <https://www.plasticsoupfoundation.org/en/2018/04/food-waste-and-plastic-waste-go-hand-in-hand/>

<sup>16</sup> <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.469.7623&rep=rep1&type=pdf>

	traffic or no one at home to receive orders, all add up to the environmental cost involved in last mile delivery.
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All these are the result of direct effects caused by the food mile which present serious global challenges that lie at the heart of many of the Sustainable Development Goals. Though most emphasis has been on mitigation of current systems, such as food recovery or development of less environmentally-harmful bottles, more solutions need to tackle the problem at its core to reduce food and plastic waste.

## CHAPTER 2 : THE SOLUTION

### Urban agriculture

With half the world's population living in cities, modern farmers have found new approaches to farming. New technologies are changing the equation, allowing people to grow food in places where it was previously difficult or impossible, and in quantities superior to traditional farms. These new-fashioned farmers lean on hydroponics (growing plants in a mineral solution) and vertical farming (farming in stacks or vertical surfaces) to get the most bang for their land-strapped buck.<sup>17</sup>

Urban farms can be as simple as traditional small outdoor community gardens, or as complex as indoor vertical farms in which farmers think about growing space in three-dimensional terms. These complex, futuristic farms can be configured in a number of ways, but most of them contain rows of racks lined with plants rooted in soil, nutrient-enriched water, or simply air. Each tier is equipped with UV lighting to mimic the effects of the sun. Unlike the unpredictable weather of outdoor farming, growing indoors allows farmers to tailor conditions to maximize growth.



With the proper technology, farming can go anywhere. That's what the new trend of urban farming shows — these farms go beyond simple community vegetable gardens to provide food to consumers in surrounding areas. All vertical farmers need is some space and access to electricity, no special facilities required. Farmers can buy everything they need to start and maintain their farms online as easily as shopping on Amazon which is why these innovative solutions are starting to gain traction all over the world.

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<sup>17</sup> <https://www.hpe.com/us/en/insights/articles/how-technology-is-enabling-urban-farming-1810.html>



Farmshelf offers personal hydroponic farms to enable anyone to grow their own food.

Urban farms have the potential to change the world’s agricultural landscape. They can bring greater yields in smaller areas, increase access to healthy options in urban food deserts, and mitigate the environmental impact of feeding the world. Moreover city farming enables more people to eat as “local” as possible and making it easier for urban populations to get the freshest food possible. By growing food closer to those who will eat it, “food miles”, or the long distance transportation needed, is substantially decreased. When food doesn’t need to be transported, a lot of plastic packaging can be cut out of the equation, too.

The benefits of urban farming practices extend beyond the tangible aspects of growing food in underserved areas — there’s also a fortunate side effect of cultivating community. In cities where it’s unlikely that you’ll know your neighbors, urban farming harnesses community interaction and connections.<sup>18</sup> Moreover Urban farms add much-needed greenery to the concrete jungles that are big urban agglomerations. Plants act as a natural air-filters in the fume-filled cities. More plants mean better air quality and decreased ozone levels.<sup>19</sup>

Lastly interacting with nature also helps people to reconnect to the Earth. Numerous studies have shown that being exposed to plants can have a positive effect on mental health.<sup>20</sup> When people have a greater appreciation for nature and understand where their food comes from, they are more likely to want to safeguard the environment. Urban farming helps to eliminate the disconnect that comes with having access to a supermarket where you can get everything from quinoa to dragon fruits at any given time of the year.

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<sup>18</sup> <https://edgy.app/urban-farms-are-the-future-of-food-production>

<sup>19</sup> <https://edgy.app/urban-farms-are-the-future-of-food-production>

<sup>20</sup> <https://ellisonchair.tamu.edu/health-and-well-being-benefits-of-plants/>

## Internet-of-Things and Smart agriculture

The rise of more-efficient industries, connected cars, and smarter cities are all paramount components of the IoT world. However, the application of technologies such as IoT in agriculture could have the greatest global impact.<sup>21</sup> Smart agriculture denotes the application of IoT solutions in agriculture. Similarly, Smart Farming is a farming management concept using modern high technology that sustainably increases the quantity and quality of agricultural products.<sup>22</sup> In other words, data and IoT-based smart farming is enabling the future of agriculture.

Data and analytics have many benefits, and agriculture has more data than almost any other industry. Farmers around the world are using data and analytics to increase food production to help meet the ever-growing global demand. According to Beecham Research, by embracing IoT, food production could be increased by 70 percent by enabling farmers to reduce waste and enhance productivity as they are able to monitor their urban farms more accurately.<sup>23</sup>

Intelligent Connectivity enables increased crop yields, crop quality, and livestock management through enhanced monitoring of soil conditions, better use of pesticides and fertilizers, improved animal welfare, and more accurate prediction of weather conditions. Big data platforms, assisted by Artificial Intelligence (AI) use multiple real-time data feeds to make more informed food production decisions. Connected drones are used for crop spraying, land management, and aerial surveillance.<sup>24</sup> Through machine learning and data analysis, AI-assisted agricultural platforms will continue to enable long-term improvements to production through enhanced understanding of the whole agricultural process.

Moreover IoT system can be connected to a cloud server so that all information can be accessed remotely. The cloud server also enables data processing and lets farmers control actions. This eliminates the need for constant manual monitoring and limits the need for manual intervention making the process highly efficient and farming precise and profitable when compared with the conventional approach.

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<sup>21</sup> <https://www.iotforall.com/iot-applications-in-agriculture/>

<sup>22</sup> <https://dzone.com/articles/iot-in-agriculture-five-technology-uses-for-smart>

<sup>23</sup> <http://www.beechamresearch.com/files/BRL%20Smart%20Farming%20Executive%20Summary.pdf>

<sup>24</sup> <https://dzone.com/articles/iot-in-agriculture-five-technology-uses-for-smart>

## CHAPTER 3 : THE BUSINESS OPPORTUNITY

### Bringing smart agriculture to new stakeholders

While more people are talking about urban farming these days, planting vegetables in a city setting isn't anything new. Over the last decade, though, there's been an expanding movement to bring food production back into the metropolis. More people want to know where their produce is coming from and they want to reduce the amount of carbon that it takes to make and ship fresh food into the city. In addition to this trend, within big cities, where space in urban centres is limited, an increasing number of new buildings and apartment blocks are installing green space on their rooftops, many of which include a spot for a garden.<sup>25</sup> Many homeowners, churches and other organisations are also incorporating farms into their yards, the Food is then sold at local markets or by other companies.



Furthermore, although there have been significant advances in the fields of smart agriculture and the development of new alternative solutions to combat current challenges, most products are intended for medium and large scale food production and remain out of the hands of the everyday consumer. Though these new smart systems are incredibly important to shift current production practices to a more sustainable future, more people need to be involved in urban farming and allow individual consumers to do their part.

This is why we want to introduce a product that should be able to help any individual grow food at home in a fun and easy way, no matter their level of gardening knowledge, by providing easy to use technology, and allow them to connect to like minded individuals in order to share knowledge and experience, as well as strengthen their relationship to nature. **This will not only help reduce food was, but also prevent the needless production of millions of tons of plastic.**

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<sup>25</sup> <https://bit.ly/2YNDbD3>

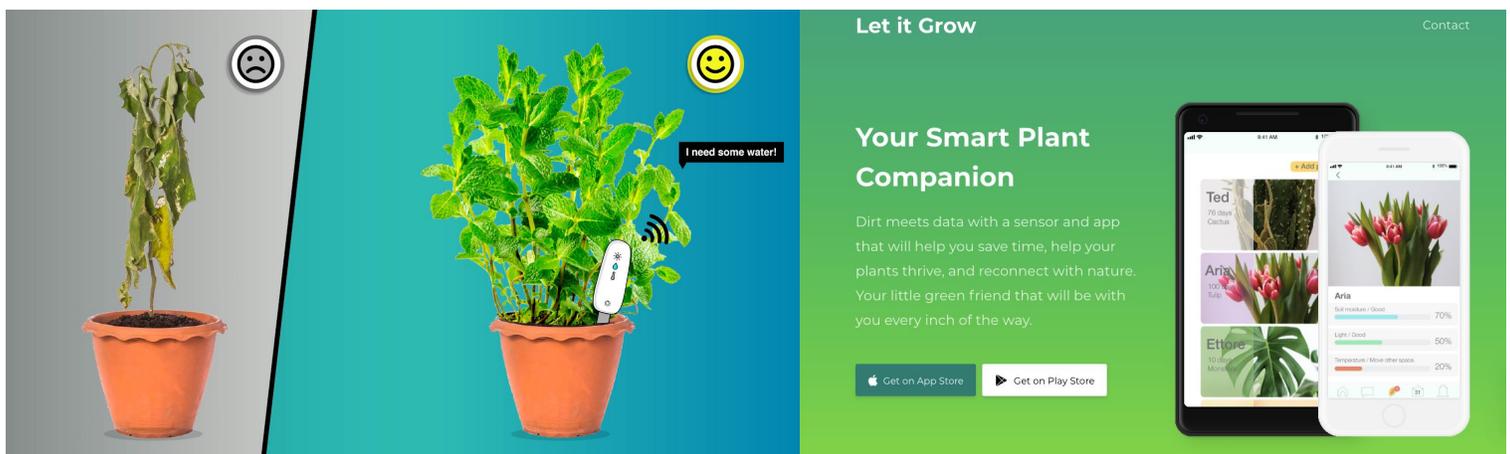
## The Grow kit Solution

Building upon last semester's initial efforts to develop a solution to raise awareness about sustainable and responsible food production in an urban context, we aim to further develop smart sensor kit. Here the goal is to design a toolkit for individuals no matter their level of knowledge in food production, gardening or technical skills. This aims to increase interest in monitoring the health of their plants as well as encouraging greater engagement in sustainable food production.

We therefore aim to introduce a sensor system that helps people monitor the health of their plants and receive recommendations into optimal growing methods to encourage indoor farming so that people can grow their own food, create a community around these habits and help minimize the negative impacts of the current food industry.

Moreover, the tool also aims at nurturing the relationship between owners and their vegetation in order to revive a greater appreciation for nature. Through gamification, friendly notifications and other interactive design decisions, we plan to enhance the plant-owner relationship by not only facilitating the maintenance process, but also by making it fun and enjoyable.

The sensors will be able to track three distinct factors that are crucial for the optimal growth of a plant: Moisture, Light and Temperature. We envision a future where individuals, business owners, schools, farmers and whole countries are able to grow everything they need at easy to live their healthiest and happiest lives, regardless of time, knowledge, or location in a way that is good for our environment.



<https://letitgrow.launchaco.com>

## Added value for the users

**Value proposition:** The goal is to create a fun, educational and meaningful experience, that allows any individual to easily cultivate food at home and optimize the maintenance of their plants. The product aims at nurturing the relationship between owners and their vegetation as well as strengthening communities by encouraging the exchange of knowledge, experience and trade.

GrowKit could thus provide key benefits to anyone seeking to grow food, but also to everyone who wishes to provide better care to their plants. GrowKit's smart system could continuously monitor conditions about the health of their plants and alert users on their smartphone when to take immediate action for optimal growth. Moreover, as people tend to keep their plants at different locations (e.g home or office), the product could help users to keep a better overview of their different plants.

In a larger context, GrowKit provides key opportunities to support positive food consumption practices and minimize the negative impacts of the current food industry by :

- Empowering any individual to become an urban farmer
- Encouraging sustainable food production
- Encouraging the production of organic foods
- Reduce the need for plastic packaging
- Reconnecting with Nature

Moreover the tool provides key value adding properties to any plant owners:

### ➤ **Time saving**

By being notified about when to cater to your plants and how, users will be able to save time on research as well as misinformed or mistimed decisions that could lead to the death of their plant. By providing continuous monitoring of their personal plants, GrowKit will optimize the maintenance process of the plant

### ➤ **Cost saving**

By being continuously well informed regarding various factors about their plants maintenance needs, users can take better care of their vegetation and avoid unnecessary deaths of their plants. Not only will this avoid repeated purchases of plants but also will allow users to reduce Wasted Water by getting it precisely where and when plants need it.

## Market exploration

Very early in the process, numerous possible markets and strategies were identified. GrowKit could be for all gardeners and small farmers, beginners to professionals. Moreover, it would not only aimed for anyone seeking to grow food, but also to everyone who wishes to provide better care to their plants. However several potential promising strategies and markets were identified

### B2C Home environment (families, millennials, vegans, digital natives)

As the product aims at allowing any individuals to easily cultivate food at home and optimize the maintenance of their plants, as well as nurturing the relationship between owners and their vegetation and encouraging the exchange of knowledge, experience and trade within communities, any people who hold plants could be interested in the product. Several customer segments could be interested in the product :

- Millennials and all digital natives could have particular interest in the product due to their possible lack of knowledge on optimal farming practices and overall forgetfulness regarding their plants
- Vegans could find a platform to demonstrate they knowledge and possible plant based recipes, as well as learn new recipes and various other sustainable practices.
- Families could be greatly interested in the tool to encourage family time with interactive educational content for the children. Moreover, as parents are generally already extremely busy with other activities, it will be a helpful tool to monitor the number of plants around the house and remind them of their maintenance needs.

Strength	Weakness
<ul style="list-style-type: none"><li>- Promote good nutrition</li><li>- Promote the benefits of indoor farming</li><li>- Reach wider audience with similar interests</li><li>- Helpful tool for busy lifestyle</li><li>- Maintain house decoration with little effort</li></ul>	<ul style="list-style-type: none"><li>- Several substitute products</li><li>- Unfocussed market</li></ul>



## CHAPTER 4 : STRATEGIC ANALYSIS

Understanding the industry the product would be set in was paramount in this project in order to gain insights into the competition in the industry, the exact extent of the impact that external factors have in order to anticipate significant changes, identify threats and opportunities, identify potential unique value propositions to differentiate the product from its main competitors and finally ensure that the design process would end up in a good product market fit. This involved closely analysing customer and market segments, their needs, major competitors, market growth rate and other behaviors, and the environmental uncertainties.

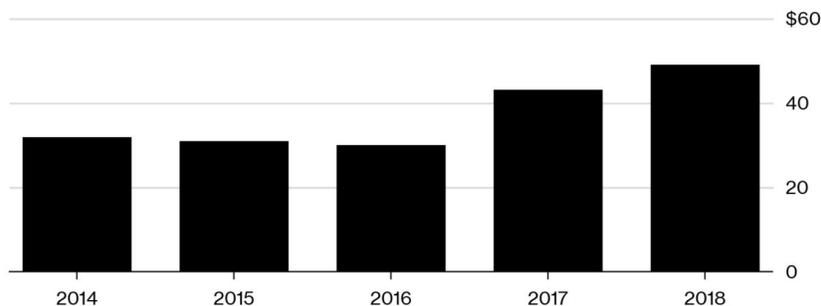
### Millennials and home Plants

As our product would be focussed on plant care, it was extremely important for us to understand current dynamics within the plant industry. Our research quickly indicated that urbanisation and the resulting limited availability of space have strongly contributed to the rise of indoor/ house plants. As a result, in the U.S., houseplant sales have increased 50 per cent in the last three years to \$1.7 billion, according to the National Gardening Association with Millennials being responsible for 31 percent of recent house plant sales.<sup>26</sup>

#### **Plant Power**

Social media sites like Instagram have fueled a resurgence in sales of indoor plants

■ Average annual household spending on indoor plants



Source: National Gardening Association's GardenResearch.com

**Bloomberg**

<sup>26</sup><https://www.bloomberg.com/news/features/2019-04-11/the-one-thing-millennials-haven-t-killed-is-house-plants>

## Focus on health and wellness

With many people losing access to outdoor gardens, more time is spent inside. The 2019 Garden Media Trend Report stated that 90 percent of people spend nearly 22 hours inside every day with Americans allegedly spending 93 percent of their time inside<sup>27</sup>. People have biophilic needs however ( innate and genetically determined human tendency to interact or be closely associated with other forms of life in nature) pushing them to put more greenery in their homes.

This is especially important considering that recent trends indicate a much deeper focus on wellness and self-care especially amongst millennials. Research about the health benefits of plants has been around for decades — popularized by the NASA Clean Air Study published in 1989, which concluded that common indoor plants like Dracaena, Sansevieria and Spathiphyllum could remove trace toxins from the air.<sup>28</sup> Moreover indoor plants have also been shown to help improve test scores in classrooms, lower blood pressure in hospitals and increase productivity in the workplace.<sup>29</sup> This is why many people turn towards houseplants, as they want to incorporate more wellness in their space.

## Instagram of plants

One of the main drivers of this surge appears to be closely linked to millennial's obsession with social media platforms. Though many advocate for plants for their utilitarian purpose (food, air quality, nurture), there is no denying that Millennials are probably more inclined to associate gardening and plants with a certain look or design aesthetic and that social media and interior design blogs play a big role.

Social media has fueled the current craze, sending buyers to e-commerce sites like Etsy Inc.<sup>30</sup>, better known for handcrafted items, and EBay Inc. Even Amazon.com Inc. joined last year with a dedicated site<sup>31</sup> for plants and other startups like the Sill<sup>32</sup> focussed on online sales. Instagram could be next, as it recently added a shopping feature to its app. Searches on Etsy for “live plants” increased 82 percent year over year.<sup>33</sup>

## Ease of growth

The research, conducted by Common Sense Gardening, also found that 84% of millennials would not garden unless it was simple to do, their gardens were easy to maintain and they would appreciate gardening being made easier.<sup>34</sup>

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<sup>27</sup> <https://bit.ly/2B8So75>

<sup>28</sup> <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19930073077.pdf>

<sup>29</sup> <https://bit.ly/2YQ8Zai>

<sup>30</sup> <https://www.etsy.com/uk/search?q=plants>

<sup>31</sup> <https://www.amazon.com/b?node=15280263011>

<sup>32</sup> <https://www.thesill.com>

<sup>33</sup> <https://bloom.bg/2KyPxMx>

<sup>34</sup> <https://bit.ly/2LMNoff>

The survey of 1,003 UK adults aged 22-37 who engage in horticulture found <sup>35</sup>:

- 81% of millennial gardeners grow produce to cook with almost half growing tomatoes, strawberries, carrots and potatoes. More than a quarter grow their own herbs.
- 53% said they grow their own produce as a cheaper alternative.
- 45% grow their own produce for health reasons.
- 60% garden as a hobby and to improve their wellbeing.

## Ease of gardening

The research also showed the need for simplicity, ease of garden maintenance and gardening in general to be made easier. The finds backs up the statistics which came out of The Common Sense Gardening initiative's 2018 research which showed <sup>36</sup>:

- 40% would like to spend less time weeding their gardens.
- 25% believe that garden care products are fundamental to the proper maintenance of their gardens.
- 37% need a faster impact on remedying problem areas.

With reports stating that the overall UK garden market is now worth over £5bn annually mainly driven by millennials engaging with gardening <sup>37</sup>, it is important to empower them with the tools to help them gardens successfully and how they want.

## Plant care apps and plant sensors

It was therefore crucial to look at current trend in smart technology specifically for the garden, in order to gain a good understanding of the demand and what the product would be up against. Consequently early on in the project it was determined that the product would be categorized as Consumer Smart-Plant Sensors which are sophisticated devices which guide you in taking care of plants. They measure parameters like the amount of sun plants are exposed to, how much water they need, etc. and give advice on what to do to cultivate healthier plants. Thanks to wireless connection and smartphone apps, they're able to precisely communicate how plants are doing and send out notifications to the gardeners.

During the research of other plant sensors, we were quickly able to categorise them in two main segments: Plant care apps and plant sensors

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<sup>35</sup> <https://bit.ly/2LMNoff>

<sup>36</sup> <https://garden-care.org.uk/news/2019/majority-of-millennials-want-gardening-to-be-simple-and-easy/>

<sup>37</sup> <https://www.airtasker.com/uk/blog/uk-gardening-trends-are-evolving/>

Plant care apps	Plant sensors
<p><b>GARDEN ANSWERS</b><sup>38</sup></p> <p>One of the most useful tools for any gardener is a plant identifier, helping you become a walking encyclopaedia of all British garden plant species. Garden Answers is an easy-to-use and incredibly popular identification app that can instantly define over 20,000 plants, coming with some very useful information. Take a snap of the plant you want to identify, press 'submit' and you'll have the answer.</p>	<p><b>Xiaomi 4 in 1 Plant Flower Care Smart Monitor</b><sup>39</sup></p> <p>A plant sensor isn't the first thing that comes to mind when you think of renowned cellphone manufacturer Xiaomi. Nevertheless, they've created an affordable and accurate plant monitor for your potted plant needs. It is straightforward to set up, has a minimalistic yet functional companion app, and the measurements it provides let you take concrete steps to improve the health of your plants.</p> <p>The Flower Care Smart Monitor suffers from frequent connection issues. It will refuse to sync with the app for no apparent reason. Luckily, the data it records is stored on the device itself and can be transmitted when the connection is eventually established. The app only serves as a monitoring tool and doesn't send any messages or warnings when the moisture or humidity levels are low.</p>
<p><b>SMARTPLANT</b><sup>40</sup></p> <p>Not only does the SmartPlant app help you identify plants but also provides a 'Digital Care Calendar' to reveal everything your garden, and the plants within it, need. You can personalise the app by adding the specific plants you have in your garden and the app will notify you of their requirements.</p>	<p><b>Gro Water Sensor Starter Kit</b></p> <p>The Gro Water Sensor Starter Kit contains three water sensors which work both indoors and outdoors. However Using a sensor that measures nothing but soil moisture paints an incomplete picture of your plants' needs. Each sensor is completely reliant on the Gro Hub to work. If that malfunctions, you'll need to buy another starter kit. It would be nice if you could connect the sensors to your phone directly or get a warning light if the moisture is too low independently of the hub.</p>
<p><b>GARDENING COMPANION</b><sup>41</sup></p> <p>The Gardening Companion app can help you track your garden's progress, care for your plants and access a wealth of gardening knowledge. It's certainly a useful friend to the green-fingered.</p>	<p><b>Parrot Flower Power</b><sup>42</sup></p> <p>Following Parrot Pot's app you can get the same features from Parrot's other plant-oriented product, the Flower Power! This capable sensor measures the same parameters as the Parrot Pot and makes use of the same app as well. Its robust design makes the Flower Power suitable for outdoor use.</p>
<p><b>GARDEN PLAN PRO</b><sup>43</sup></p> <p>Gain expert knowledge and help with planning a vegetable, herb or fruit garden with Garden Plan Pro. The simple tools aid layout designing, plant arrangement, and tracking garden progress.</p>	<p><b>Click and Grow Smart Garden</b><sup>44</sup></p> <p>The Click and Grow Smart Garden is a new and effective tool which helps you grow edible plants or flowers with minimal interaction. As long as you remember to refill the water, you can look forward to home-grown greens in a matter of weeks.</p> <p>Seed pod refills are expensive. One refill contains three pods and costs \$10, which quickly adds up if you use the Click and Grow all the time. The space each plant gets to grow in is limited by the tiny pots.</p>
<p><b>GARDENTAGS</b><sup>45</sup></p> <p>Offering plant advice, inspiration and gardening tasks, the GardenTags app allows gardeners to share helpful information and tips between each other. Your plant care will be sorted with this app, which can also suggest ways to deal with weeds and pests.</p>	<p><b>Edyn</b></p> <p>Edyn rolled out a plant sensor with a slick look from award-winning designer Yves Behar. The sensor measures how much light, water, and fertilizer your plants are receiving, collecting this data via a long metal probe that you stick in the ground in your garden. The system uses Wi-Fi to send all that data up to the cloud, where it's analyzed along with the data you entered into the Edyn app about what you've planted, and weather data based on your location.</p>

<sup>38</sup> <http://www.gardenanswers.com>

<sup>39</sup> <http://www.huahuacaocao.com>

<sup>40</sup> <https://www.smartplantapp.com>

<sup>41</sup> <https://apps.apple.com/us/app/gardening-companion/id968479901>

<sup>42</sup> <https://www.parrot.com/global/connected-garden/parrot-pot>

<sup>43</sup> <http://gardenplanpro.com>

<sup>44</sup> <https://www.clickandgrow.com/products/the-smart-garden-3>

<sup>45</sup> <https://www.gardentags.com>

## Main conclusions

Our research also found other sensor kickstarter project that never successfully manage to collect all the funds needed for launch. However certain key patterns emerged from this competitive research :

### **Lack of plant care education**

With so many different options on the market, it can definitely be confirmed that people are in need/ are interested in smart plant care companion. In the larger context, this emphasizes a key problem : lack of education about plant care requirements. Though there has been a spike in interest for houseplants, it hasn't necessarily correlate to a spike in knowledge about them. A lot of the questions that users post on platforms such as GrowIt are focused on, 'What's wrong with my plant?' or 'How do I take care of it?' There's an overwhelming amount of basic information that people are looking for. The biggest difference today is the new digital channels where consumers can find information. That's why apps like GrowIt and SmartPlant exist to answer basic questions — and it's why growers and retailers would greatly benefit for a supporting system that combines the power of technology with the wisdom of a community.

### **Features : Main Plant parameters, identification and community help**

One of the main insights from this research are the identification of key popular features that could be regarded as required for both app and sensor. Firstly, sensors are expected to measure multiple key properties of plant care that go beyond just moisture. Secondly it appears that people value being able to identify their plants using the app either through augmented reality features or relying on community help. Lastly, the research also brought out that people truly value the community aspect of these apps, as it promotes the sharing of knowledge and experience.

### **Design of product**

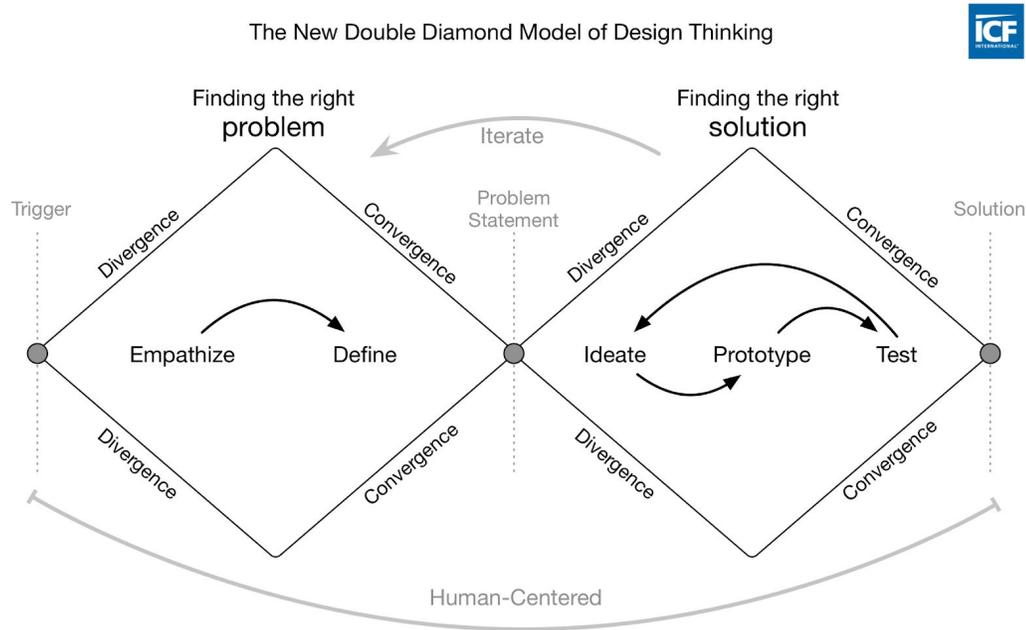
In regards to the very design elements used in these products, some conclusions could be made. Firstly a major flaw of most of the sensor sticks on the market is that they do not have any elements on them that can provide key information about the plant straight away. They all require the app in order to show the user any kind of info regarding the plant' s needs creating unnecessary steps in between.

Lastly, in regards to the apps, a lot of them serve more of a plant calendar in the sense of providing only scheduled advice. Moreover, most sensor accompanying apps appear very basic on their UI, making these apps less aesthetically pleasing. However our research also indicated that plant care app are popular UX/UI case studies to enrich people' s portfolio, however never end up malog it on the market.



## CHAPTER 5 : THE DESIGN PROCESS

Though the solution and initial designs were already formulated by the previous group, we were still convinced to make this project our own and develop it to its best potential. With the digital society school introducing principles of design thinking, the design process followed a human centered approach to the development of the product as it allows to ensure that the product integrates the needs of people, the possibilities of technology, and the requirements for business success.



Design thinking is a non-linear, iterative process which seeks to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test. The method consists of 5 phases—**Empathize, Define, Ideate, Prototype and Test** and is most useful when you want to tackle problems that are ill-defined or unknown.<sup>46</sup> Two different types of cognitive thinking can also be brought together to optimize the approach to think about a problem and come up with a perfect fit solution.

As a result, we were able to make use of the Design Method Toolkit that enabled us to kickstart and enrich our design process and utilize it to plan and execute your design research, ideation, experimentation and creation within short iterations.

<sup>46</sup> <https://www.interaction-design.org/literature/topics/design-thinking>

## Empathy and User-centered design

Empathy is crucial to a human-centred design process such as Design Thinking, and empathy helps design thinkers to set aside their own assumptions about the world in order to gain insight into their users and their needs. This process involves observing, engaging, and empathising with the people who are designing for in order to understand their experiences and motivations, as well as immersing oneself in the topic to have a deeper personal understanding of the issues, needs and challenges involved. It involves learning about the difficulties people face, as well as uncovering their latent needs and desires in order to explain their behaviours. To do so, we need to have an understanding of the people's environment, as well as their roles in and interactions with their environment.

The Design Method toolkit introduced numerous methodologies that were particularly useful at this stage of the process. As our project was framed within the urban farming context, we had to first explore how people view and use plants in an urban context.

### Design method : 5 W

This is why the beginning of the project consisted of various research into various topics within urban farming, plant care technologies and products, new trends agriculture in order to be able to apply the **5 W methodology (Who, What, Where, When, Why and How)** and obtain a thorough understanding of the problem, current solutions put into place and identify new trends.

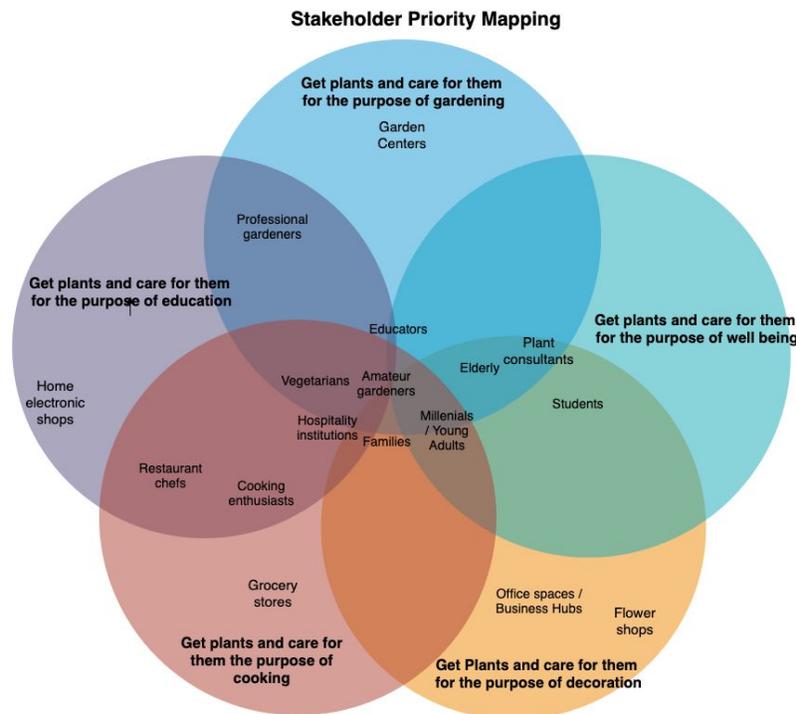
<p><b>What problem are we trying to solve?</b></p>	<p>Rapid growth in global population predicted to reach 9.6 billion by 2050 and trends indicating that half the world living in cities, agricultural practices involving chemicals and pesticides have taken a toll on the planet resulting in a plethora of detrimental effects and concerns over the ability to feed every mouth.</p> <p>Current trends indicate that the urban farming movement is the solution to this arising issue by harnessing the power of technology to maximize efficiency of space and plant growth. Though this allows to scale local fresh food production within urban agglomeration, most solutions within this movement remain costly, complex and out of the reach of the everyday consumers.</p>
<p><b>How are we going to solve the problem ?</b></p>	<p>We want to empower home gardeners to grow their own food by facilitating the plant growing process by harnessing the power of IoT and providing a platform to connect and grow a community of gardeners and encourage the exchange of knowledge, materials and production.</p> <p>As every plant requires unique and complex care requirements, our product can help growers provide adequate care recommendations and allow for plant care to shift from a scheduled maintenance activity to predictive plant care. Moreover by encouraging this community exchange we can help not only strengthen community relationships but also broadening awareness of the benefits of growing food at home and encourage participation.</p>
<p><b>Why does our product solve the problem?</b></p>	<p>We are convinced that our product can play an instrumental part in shifting consumer behaviour and reshape current systems by reviving an appreciation of food, the process of life and nature. We envision a future where everyone will be able to grow their own food, no matter their gardening skills and alleviate current needs for unethical and unsustainable practices within the food industry.</p> <p>Our product aims to build up the people's confidence in their own gardening abilities by providing easy to use technology, and allow them to connect to like minded individuals, to share knowledge and experience, as well as strengthen their relationship to nature.</p>
<p><b>Who is the customer?</b></p>	<p>As the activity of plant care remains universal, our product intends to appeal to the widest audience of plant growers across age, ethnicity and gender. However, research has shown that Millenials are the current drivers of the home plant industry, primarily driven by their interest in health, well being and lifestyle.</p>
<p><b>Where does our product solve the problem?</b></p>	<p>As the primary stakeholder of this project is VodafoneZiggo in the Netherlands, the product will initially be targeted to the dutch consumers. As one of the largest agrarian powerhouses in the world, employing the most advanced technologies in agriculture the Netherlands has widely become a leading example in showing what the future of farming could look like.</p> <p>As the netherlands works towards developing a circular economy by 2050, new consumer innovations will lead the way towards more participatory systems where every person will be empowered to contribute towards a brighter future.</p>

## Outcome

Though concept was already established from the prior semester, the team sought to impose their own mission, vision and strategic objectives for the product. This allowed for the project to have an innate direction, align all of the team's understanding and expectation of the problem and finally ensure that we can bring in our values into the development of the product.

## Stakeholder analysis and priority mapping

In order to have a good understanding of all stakeholders involved, an initial stakeholder analysis was performed. Stakeholder Analysis is an important technique for stakeholder identification & analysis of their needs and used to identify all key (primary and secondary) stakeholders who have a vested interest in the issues with which the project is concerned. It allows to develop a strategic view of the human and institutional landscape, and the relationships between the different stakeholders and the issues they care about most.



## Outcome

As a result, after identifying the most relevant stakeholders, a deeper analysis was performed on each stakeholder segment in order to more effectively understand their needs, interests and problems. This allowed to position the stakeholder within a stakeholder priority map, enabling to gain a clear understanding of their motivations and needs and narrow down our target users. This method allowed to segment plant purchases in 5 different categories based on their purpose. Thus the research indicated that people purchase plants for primarily 5 reasons :

- For Purpose of gardening
- For the purpose of well being
- For the purpose of education
- For the purpose of decoration
- For the purpose of nutrition

We were then able to position the most relevant stakeholders within this priority map to further help the team identify the optimal target market and their primary concerns. Moreover, it helped

identify potential strategic partners and overall provide insights into potential users which helped in the further development of the design process.

## Customer experience map

A customer journey map is a visual representation of every experience a customer has before, during and after the interaction with a specific product. It is crucial to understand the essence of the whole experience from the user's perspective in order to understand pain points, design requirements and opportunities for the final product. As a result, the whole plant-purchase to plant-owner was mapped below.



## Outcome

By mapping the customer experience map, the team was able to better understand the plant growing process by analyzing every single stage ranging from purchase purchase, ownage and death of their plant. By decomposing every element of the process, the team was able to better understand the owner- plant relationship.

It can be seen that customers will invest a lot of time into research to find the right plant that would fit in their decoration as well as needing achievable care requirements. The following stages highlight the priorities after the plant purchase ranging from finding optimal place for it to provide the intended decorative benefits, but also allow it to receive enough amount of light. The map also highlights the relationship that is being built throughout this process. As caring for the plant will eventually evoke emotions in the owner by creating a sense of protecting the plant from insects and death and overall a deep desire for it to thrive. This is also reflected in peoples need to take a picture of them to display their pride in their own gardening abilities, but also tpide towards the plant itself.

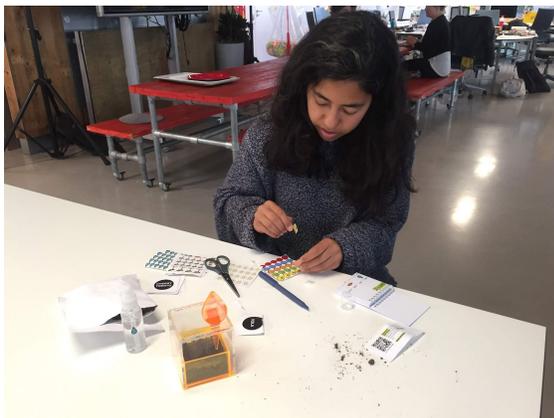
## Mobile diary study

In order to better understand the relationship between plant and owner, the team designed a low tech user test kit which were distributed to selected people in and outside of the digital society school. The kit consisted of :

- A little base to help the seed germ
- A little greenhouse that could be transformed into a bigger pot once the plant started to grow including self watering system
- A little diary of 30 days with the space to write the users emotion, how much they watered, and how much sun their plant got in the day
- Stickers to facilitate the process

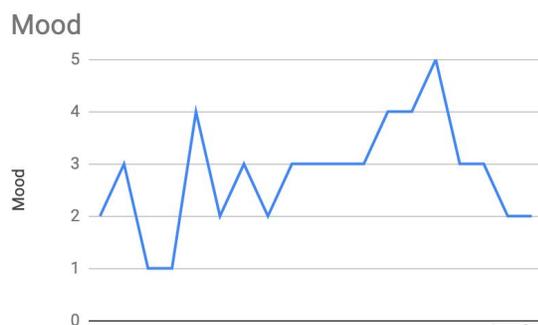
The goal of this experiment aimed at gaining insights into:

- How much gardening skills people have
- Understand basic emotions associated with gardening
- Insights in user engagement with growing a plant from a seed
- Insights into challenges people might face while gardening (ex: forgot to water, lack of knowledge on the plant)



## Outcome

Though participants were excited about the experiment in the early stages, many appeared to lose interest to monitor their progress and emotional state over time. As a result the experiment was not able to provide the desired and conclusive insights into the relationship between participants and plants. However some insights still remained useful:



Having provided stickers to allow participants expressed their mood, the data collected was then processed on a score from 1 to 5 (1 being happy and 5 very unhappy). Here we can see the results of one of the participants, clearly showing a wide range of emotions during the plant growing

process. **In the early stages of the process, the participant's lack of knowledge resulted in being very worried about their ability to grow a plant which is highlighted by their level of motivation in the beginning.** "I still have no clue what i' m doing (watering), still haven't googled anything but took a picture" (Participant 1).

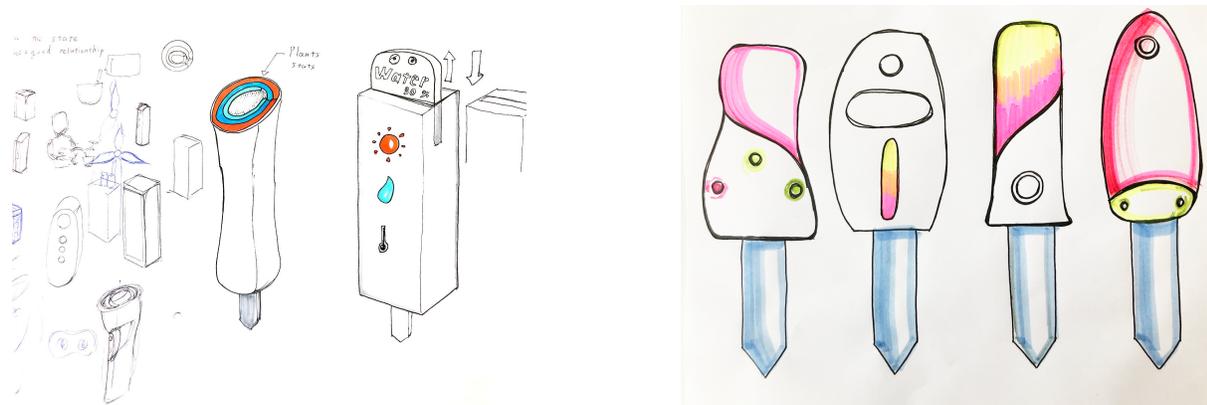
Furthermore, the participant' s lack of knowledge but feeling of responsibility strongly affected their mood towards the end of the experiment. As some of the seeds died during the process, the participant became strongly critical of their own abilities "I water it but i am tired of this responsibility. If only it was big already i could use it to decorate" (Participant 1).

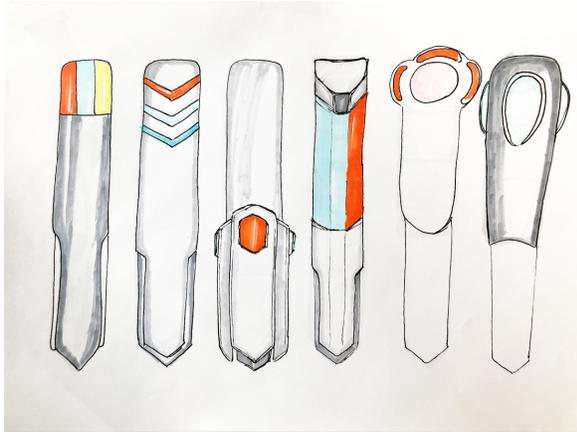
Lastly the experiment also showed that some of the participants had personified their plants by giving them names and sometimes talking to them. Not only does this show that the plant takes an integral part in the owners life, but also that they care about the plant similarly as they would with a human being "It's like a toddler if you'd like the human comparison" (Participant 1)

In conclusion, though this experiment was not able to deliver all the desired results it further highlighted the need for a product that can help amateur gardeners to grow their own food. **It can be seen that the very confidence in their own gardening ability has much greater importance in regards to how they feel throughout the plant growing process.** Not only is this result interesting from behavioral perspective, but also further validates the need for a product like ours.

## Ideation

Ideation is the process where the attempted to generate quick ideas and solutions through sessions such as Sketching, Prototyping, Brainstorming, Brainwriting, and other ideation techniques. Though the concept of sensor stick was already defined in the previous semester, the team still wanted to explore alternative solutions, stick designs and information display.





## Design Conclusions

This initial design methodologies provided key insights into design requirements for the project. One of our initial challenges when designing the stick was the design choices between slick vs. cute, gamified vs social. Nonetheless the most important requirement is that it should be able to fit into people's existing decoration and display an "instagrammable" aspect. Though all concepts were played around with and prototyped, responses from initial user testing remained varied.



With VodafoneZiggo's design requirements being "Simple, fun and reliable" it was clear the final design of the app and stick had to be intuitive, easy to use and fun. It was clear however that the design process would have to focus on the MVP of the product. As such, most of the design process focussed on :

- The design of the stick
- The design of key wireframes in the app :
  - Plant Profile
  - My garden
  - Stick connection

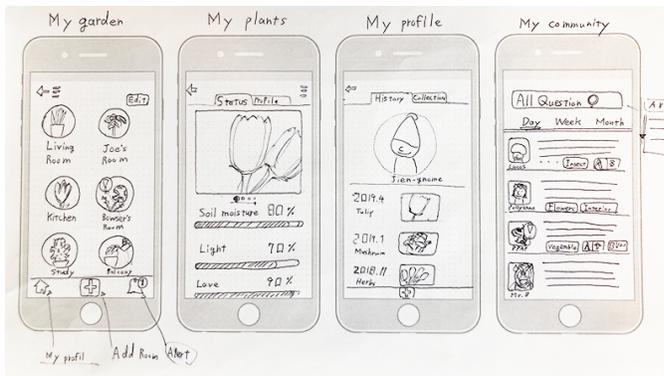
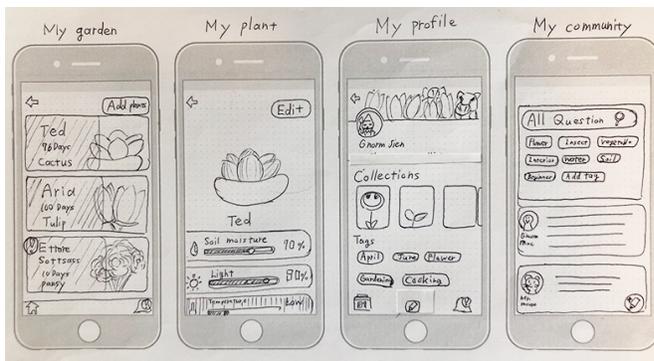
# CHAPTER 6 : APP DESIGN

## Ideation

### Sketching

The initial phase of the design process for the accompanying app, sketching provided a quick and cheap way to generate and translate multiple ideas. It provided a good way to align the team's vision, reveal key insights into the expected user experience, assess the validity of ideated features and begin exploring user friendly information architecture. As the expected MVP focussed on the development of key tabs in the app, the team focused their efforts on the design of :

- Plant Profile
- My garden
- Stick connection
- Community

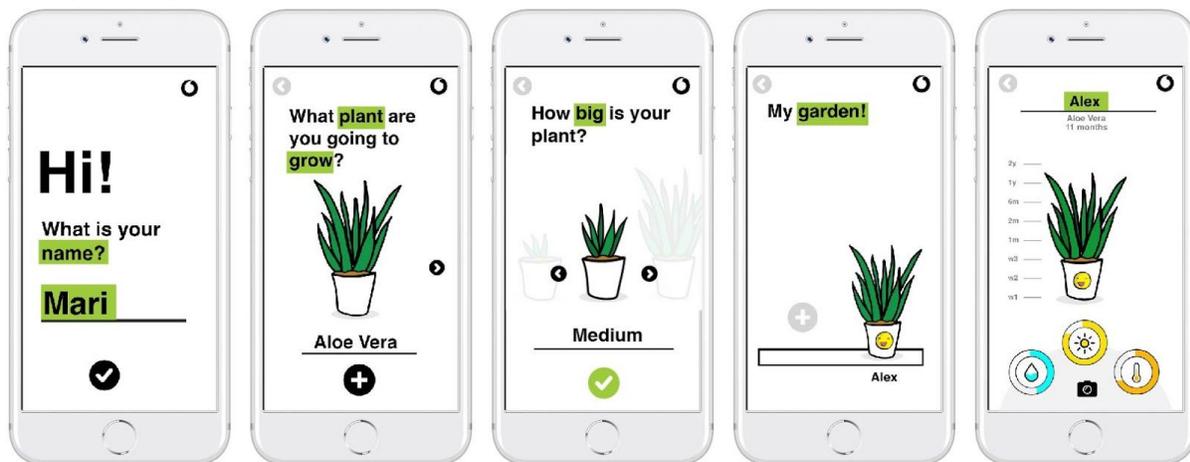


## Prototyping

The goal was to create a user friendly and personalized app where user could have quick access to his plants needs and have the opportunity to strengthen its bond with the plant. As the user research indicated that people often personified their plants by naming them, sometimes talking to them and overall being proud of their achievements to keep the plant alive and thriving. The team therefore played around with the concept of the plant itself being one the main user of the app that wants to inform his owner of his needs in the most comprehensible way and display its own progress.

As the project consisted of creating a new consumer IoT device for their plants, ease of use when connecting a new plant to the app was key. This is why the team created an intuitive platform that guides new users every step of the way. Numerous designs were sketched , prototyped and tested.

### Fast prototyping



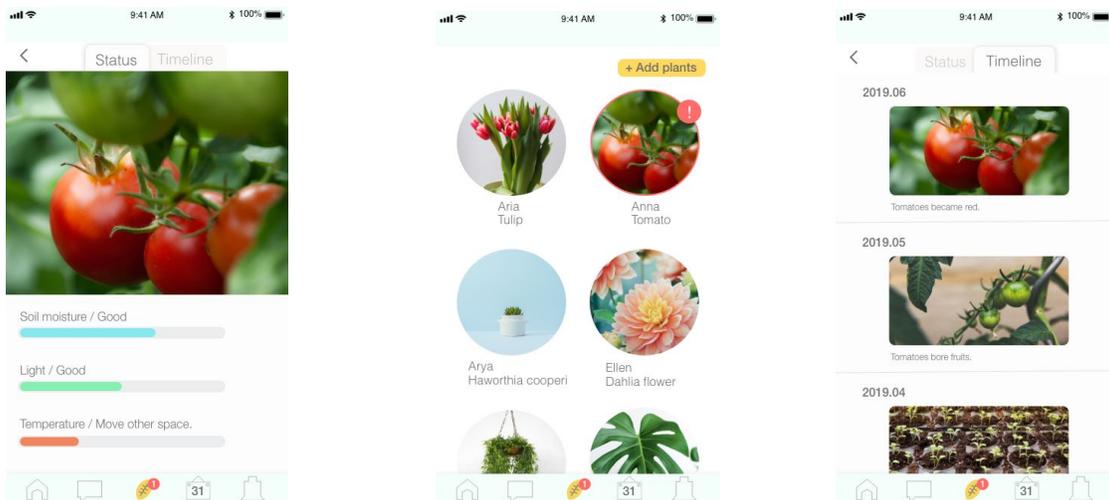
Market research also indicated that millennials often take pictures of their own plant to display their pride in their achievement to keep it alive and thriving. This is why we also wanted to emphasize the possibility of recording milestones of the plant itself that, similarly to popular social media platforms such as Facebook and Instagram. By displaying key growth stages of the plant, the owner can reminisce about his own achievement which at the same time will strengthen its bond to it. By giving plants their own personal social media presence, the design further highlights the personification concept that was explored in the user research.

### Design decisions

Several alternatives were prototyped and tested to find the most comprehensible and user friendly way to understand the plants health levels. The team played around with different ways of displaying the required information ranging from bar charts to progress bars in the form of circles.

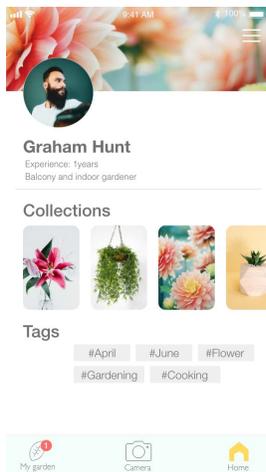
Moreover in regards to the plant's profile picture, a lot of discussion revolved around providing users with the choice of either selecting stock pictures, take their pictures themselves or even select icons. As millennials are a large varied group that emphasize individuality, it was important to cater all personality types.

An additional design challenge was to create a user friendly interface for the overview of the garden. The team played around with different concepts and designs that allowed to display different amount of plants on the page. As the initial strategic vision was to distribute the sticks in packs of three, it was deemed best to select a card interface.



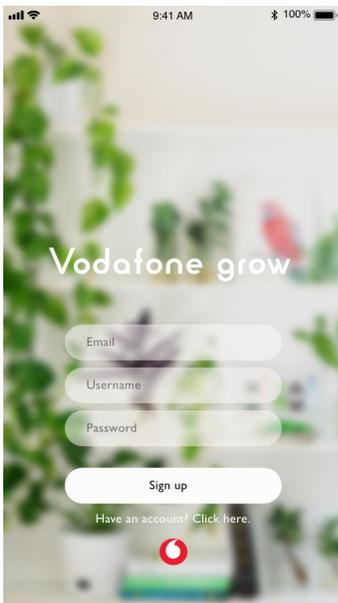
Early prototypes

## Social Media for plants

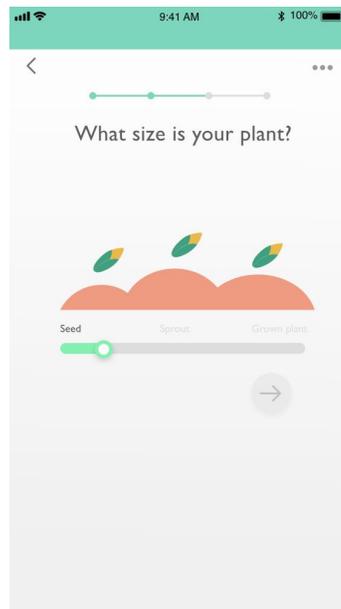


Finally as a driving concept in the team's vision for the product was to deliver a social media platform where the plant would be a main user itself, we wanted to facilitate the possibility to share the milestones of the plant with a community, and enable the possibility to ask questions and recommendations. Though these elements were outside of the main MVP, the team still prototyped early possible versions of the tabs. Inspired by other social media platforms, the interface remains intuitive and slick.

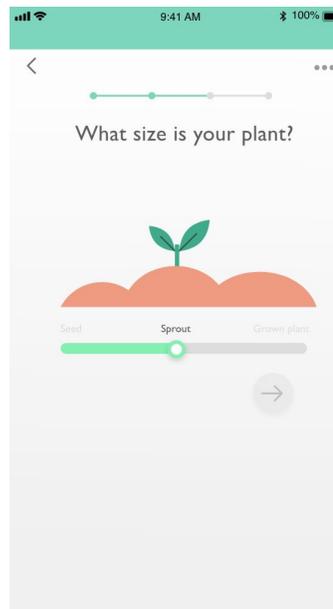
## Some final Designs



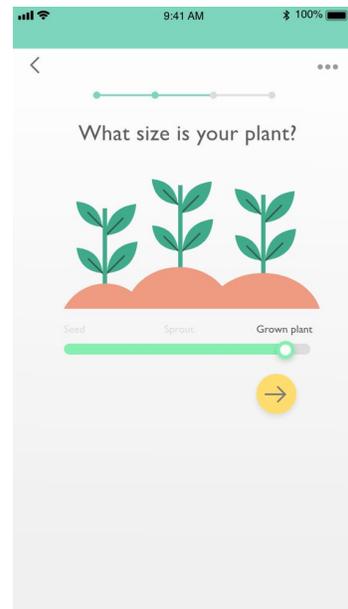
login



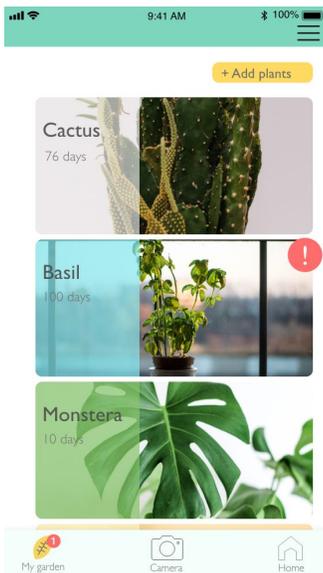
Registering plant 1



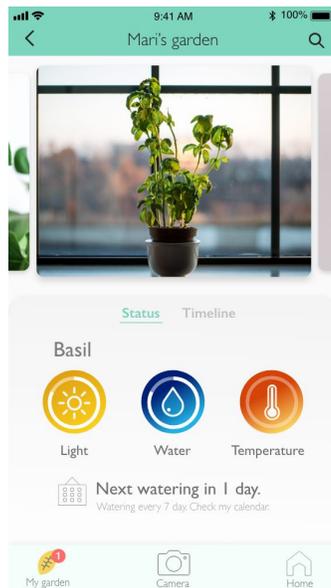
Registering plant 2



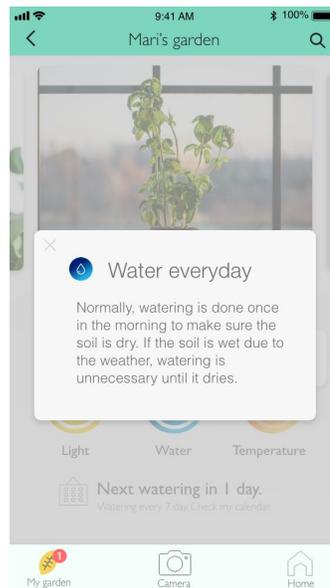
Registering plant3



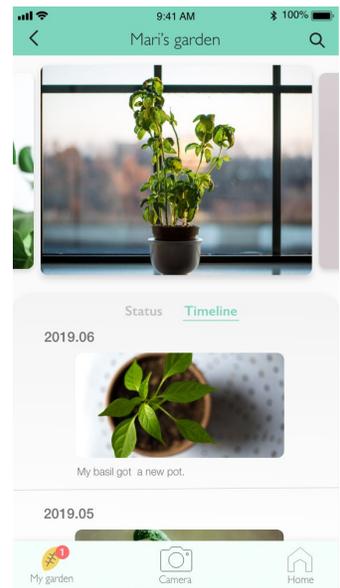
My garden tab



My plant tab



My Plant (watering info)



My plant' timeline tab



# CHAPTER 7: THE CASE OF RECYCLED PLASTIC FOR IOT

## The Problem with plastic waste

The global manufacturer of plastic has increased exponentially over recent decades, and there is no predicted decrease of this production in the foreseeable future. Consumers have become used to this useful and cheap material. Plastic has become a part of almost every consumer product. About 311 million tons of plastic is produced worldwide every year<sup>47</sup>. A quarter of this is for packaging purposes. Only 14% of packaging materials are recycled and almost a third leaks into the environment and pollutes our cities, beaches and oceans.<sup>48</sup>

According to the United Nations, the volume increased from 1.5 million tons of plastic in 1950, up to 300 millions tons of plastic in 2016.<sup>49</sup> Scientists have warned that, unless big global changes are introduced soon, the amount of plastic waste infiltrating the natural landscape will exceed 12 billion tons by 2050.<sup>50</sup> Huge quantities of it are either in landfill or in the oceans, in clusters the size of countries, such as the Great Pacific Garbage Patch.

Currently about 8-12 million tons of plastic enters our oceans every year<sup>51</sup>, including many plastic bottle caps that can be found at the North Sea in large numbers. Marine mammals, birds and fish see plastic bottle caps as food, which can lead to ingestion and potentially fatal consequences. In 2014, 530 billion PET bottles were produced worldwide. This number is expected to rise by 4.7% every year. In 2016, one of the world's largest cap manufacturers produced 78 billion caps; enough to cover the surface area of the Netherlands one and a half times.<sup>52</sup>

Past research on the issue of worldwide bottle cap pollution emphasized the urgency of the problem across the globe by uncovering very disturbing statistics<sup>53</sup> :

- Every year in the Netherlands alone, 1.4 billion plastic bottles gets consumed of which 750 million are small plastic bottles with caps
- bottle caps are among the top 5 items found during beach cleaning and beach litter monitoring around the world
- over the last 30 years, more than 20 million bottle caps and lids were found during beach cleaning activities around the world. Currently, it is unknown how many bottle caps actually enter our oceans and wash up on shore

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<sup>47</sup> [https://www.noordzee.nl/project/userfiles/SDN\\_Doppenrapport\\_EN\\_2017\\_DEF\\_small.pdf](https://www.noordzee.nl/project/userfiles/SDN_Doppenrapport_EN_2017_DEF_small.pdf)

<sup>48</sup> [https://www.noordzee.nl/project/userfiles/SDN\\_Doppenrapport\\_EN\\_2017\\_DEF\\_small.pdf](https://www.noordzee.nl/project/userfiles/SDN_Doppenrapport_EN_2017_DEF_small.pdf)

<sup>49</sup> <http://www.un.org/apps/news/story.asp?NewsID=56638#.Wm9lpZOFjOR>

<sup>50</sup> <https://www.dezeen.com/2018/02/02/recycled-plastic-only-choice-say-designers/>

<sup>51</sup> [https://www.noordzee.nl/project/userfiles/SDN\\_Doppenrapport\\_EN\\_2017\\_DEF\\_small\\_2.pdf](https://www.noordzee.nl/project/userfiles/SDN_Doppenrapport_EN_2017_DEF_small_2.pdf)

<sup>52</sup> [https://www.noordzee.nl/project/userfiles/SDN\\_Doppenrapport\\_EN\\_2017\\_DEF\\_small.pdf](https://www.noordzee.nl/project/userfiles/SDN_Doppenrapport_EN_2017_DEF_small.pdf)

<sup>53</sup> [https://www.noordzee.nl/project/userfiles/SDN\\_Doppenrapport\\_EN\\_2017\\_DEF\\_small.pdf](https://www.noordzee.nl/project/userfiles/SDN_Doppenrapport_EN_2017_DEF_small.pdf)

- over the last 12 years shows that on average, 19 bottle caps are found every 100 metres, mostly on non – touristy beaches
- plastic bottle caps are made of hard plastic and degrade very slowly
- plastic bottle caps are among the top 5 ocean trash items that are deadly for sea life.

In the summer of 2016, The North Sea Foundation and more than 2,000 volunteers picked up as many bottle caps as they could find along the entire Dutch North Sea coast and analysed them <sup>54</sup>. They managed to collect 19,230 kilos of litter was collected from the Dutch coastline, including 10,004 plastic caps and found that :

- More than 80% came from consumer drinks and food packaging
- The most common bottle cap colours that were found were blue and white
- 80% of the bottle caps had no brand
- More than 70% were damaged, ranging from slight to severe damage. This may indicate that the bottle caps had been floating at sea for a long time

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<sup>54</sup> [https://www.noordzee.nl/project/userfiles/SDN\\_Doppenrapport\\_EN\\_2017\\_DEF\\_small.pdf](https://www.noordzee.nl/project/userfiles/SDN_Doppenrapport_EN_2017_DEF_small.pdf)

## Towards a circular economy

The findings of these research underline the urgency with which we need a circular economy in order to tackle these problems. In addition to information, awareness and cleaning campaigns, the emphasis of these projects are about identifying the root of the problem and finding ways to approach the resulting problems and closing the loop. International cooperation is necessary, however it primarily relies on the cooperation between the private and public sector alongside a shift in attitude of consumers.

This is why the Netherlands have rolled out government-wide programmes to enable a circular economy in the Netherlands by 2050. The ambition of the Cabinet is to realise, together with a variety of stakeholders, an (interim) objective of a 50% reduction in the use of primary raw materials (minerals, fossils and metals) by 2030.<sup>55</sup> These objectives serves the higher goal of achieving a transition to a sustainable economy in which production and consumption cycles are closed and facilitate the transition “from waste to raw material”.

Part of the problem is that people perceive plastic as a valueless disposable product. However numerous projects have since launched in amsterdam aimed towards the collection and sustainable exploitation of plastic found in the environment making the city a leader in the fight against plastic pollution:

<b>The Ocean Cleanup</b> <sup>56</sup>	The Ocean Cleanup is designing and developing the first feasible method to rid the world’s oceans of plastic. The Ocean Cleanup was founded in 2013 by Boyan Slat, after his TEDx talk about his proposed solution to the plastic pollution problem went viral and garnered worldwide support. Every year, millions of tons of plastic enter the ocean. A significant percentage of this plastic drifts into large systems of circulating ocean currents, also known as gyres. Once trapped in a gyre, the plastic breaks down into microplastics and becomes increasingly easier for marine life to mistake for food.
<b>Plastic Whale</b> <sup>57</sup>	Plastic Whale is the first professional plastic fishing company in the world running fishing tours in Amsterdam and Rotterdam. Founded by Marius Smit in 2011, the non profit is a social enterprise with a mission: make the world’s waters plastic-free and create value from plastic waste. It started five years ago with a single challenge to build a boat made of plastic waste. Their goal to go ‘out of business’ by fishing out all the plastic in the canals. In 2017, its Amsterdam fleet of nine boats took 6,000 people fishing for plastic, plucking 50-60,000 PET (polyethylene terephthalate) bottles out of the water and nearly three times this volume in other waste.
<b>Precious Plastic</b> <sup>58</sup>	Precious Plastic is a project trying to boost plastic recycling worldwide by providing tools and knowledge to people around the world for free in order to allow people, anywhere in the world to transform plastic waste into valuable goods. The project consists of demonstrating how to build of a set of plastic machines, developed to set up a small scale plastic workshop and shared open source online and improved by the community. The machinery is based on general industrial techniques, but designed to build yourself. The machines are easy to use and made to work with recycled plastic. Precious Plastic was started by Dave Hakkens in 2013 and has now reached a global community that creates a wide range of products – from jewellery and textiles, ceramics and homeware – and sells them through online retailers such as Bezar.

<sup>55</sup> [A Circular Economy in the Netherlands by 2050 - Government.nl](https://www.government.nl/topics/circular-economy/2019/04/23/a-circular-economy-in-the-netherlands-by-2050)

<sup>56</sup> <https://theoceancleanup.com>

<sup>57</sup> <https://plasticwhale.com>

<sup>58</sup> <https://preciousplastic.com>

## Designing with recycled plastic

For decades, "virgin plastic" has been used to produce everything from food packaging to furniture. But, as the environmental impact of this material becomes more apparent, an increasing number of designers are exploring alternatives. Not only does recycled plastic offer a more sustainable solution, it is a material that is often free to source, and can be produced in a wide range of colours, patterns and textures. This is why a new generation of sustainably minded designers is pioneering ways of using recycled plastic as a raw material, as concern over pollution increases.

Working with recycled plastic offers unlimited design opportunities, because of the variety of polymer compounds and processing techniques that can be used. Over the past few years, a range of new innovative recycled-plastic projects has since been launched by smaller and a number of well known designers and brands promoting the vast potential of recycled plastic.



### **WasteBoards<sup>59</sup>**

Dutch start-up company WasteBoards came up with the world's first environmental friendly skateboard. Using a special process, the company produces unique handmade skateboards using recycled plastic bottle caps. The caps are collected at music festivals or, with a little help of PlasticWhale, fished out of the Amsterdam canals. WasteBoards also buys plastic bottle caps from the Royal

Dutch Guide Dog Foundation (KNGF), paying KNGF double the price of what they normally would get from recycling companies. Even little kids donate their collected bottle caps to WasteBoards.



### **Gomi Speaker<sup>60</sup>**

Brighton-based design studio Gomi has created a portable bluetooth speaker using plastic waste that is deemed non-recyclable by local councils in the UK. Each Gomi speaker features a rectangular body formed from colourful marble-effect plastic. The equivalent of 100 plastic bags in non-recyclable – or flexible – plastic go into the body of each

speaker.

In most cases, these organizations either attempt to launch collective volunteering collection events or can partner with businesses that like to donate their leftovers for free. By experimenting with materials, colours and process techniques, these organisations not only create awareness about the problems we are facing because of plastic pollution, but also

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<sup>59</sup> <https://wasteboards.com>

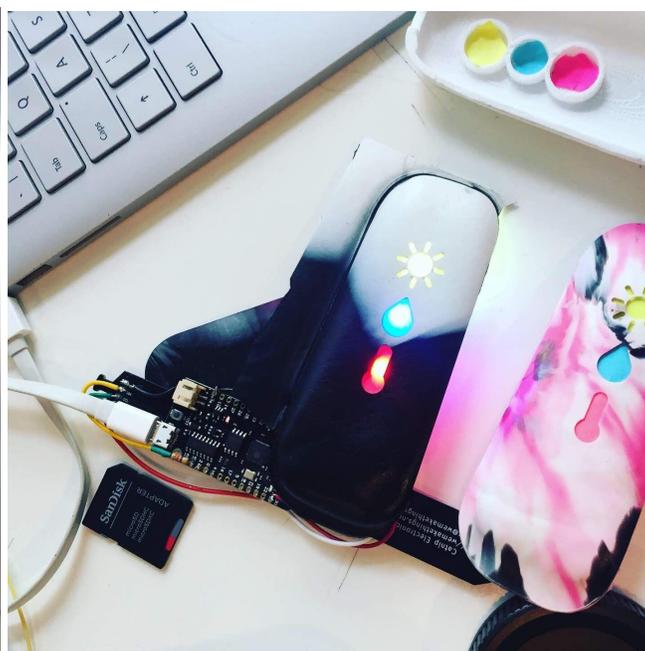
<sup>60</sup> <https://www.gomi.design>

exhibits solutions and inspires new ones. Moreover it emphasizes the feasibility and economic opportunities when adopting a circular mindset in the development of new product designs.

## Growkit and recycled plastic

During the course of the project, the team decided to experiment with in designing the sensor stick with recycled plastic. Though it did not yet succeed in completely designing the whole stick out of the material, the experiment showed promising results.

According to several user feedbacks, the unique colour patterns of the stick designs were a hugely attractive attribute that many people sought after as it provided them with the opportunity to buy their favourite colour combinations. Not only did they emphasize how much they like the colour patterns but also highlighted how they would be happy to show off the product on their social media or placing it in a prominent place in their house.





# CHAPTER 8 : USER TESTING

## User Test Protocol

The product aims at harnessing the power of IoT to empower home gardeners from any level to grow their own food, reconnect to nature and assemble a community that encourages the exchange of botanical knowledge, materials and production. The final product consisted of a sensor stick that can measure key attributes of house plant care, namely soil moisture, temperature and light variations that communicates with an accompanying app.

The tests were structured in the corresponding 5 phases and aiming to examine the following:

### Goals

- Examine preconceived expectations in a plant care app
- Examine aesthetic appeal of the app design
- Examine the ease of use of the app
- Examine usability and readability of the stick
- Examine aesthetic appeal of the stick case design

### Research Participants

- DSS trainees and Coaches
- Entrepreneurship minors
- HvA students

The process of the user test focussed on the app went as follows :

**Stage 1** : First participants were asked how they envisioned the app by drawing them

**Stage 2** : Similarly second stage consisted of allowing the participants to build their own app using preprinted graphics which contained icons and images to better understand their expected visual composition and intuitive interface.

**Stage 3** : Third stage consisted of showing the different iterations of our wireframes and letting the users choose their favourite one, as well as constructing their preferred UX flow.



The process of the user test focussed on the sensor went as follows :

**Stage 1** : Participants were asked to draw out symbols they associate with water, temperature and light

**Stage 2** : Participants were asked to draw out their expected product design

**Stage 3** : Showed current stick design and collected feedback

## **Outcome**

Several key findings came out of the user test:

### **Stick**

- Symbols for light, water and temperature were universally understood and interpreted as such by each participant.
- Some participants emphasized the importance of the tick to be discrete before being shown the prototypes as it would have to fit with the rest of their home decoration
- The stick designs were positively received and overall the current stick format was mostly appreciated. Participants did point out that the current prototype might be a bit big but liked our smaller low tech prototype.
- All participants positively reacted to the stick designs out of recycled plastic. The possibility of selecting the most matching colour patterns and the idea that each stick is unique was universally a highly attractive feature.

### **App**

- Overall the information hierarchy of the app was well understood and users confirmed that it was intuitive enough to understand how it works without any need for tutorials.
- In regards to the picture used for the plant profile and the one that is represented in the “my garden” page, responses of participants were quite varied. The main insight of this is that it should be customizable for every user. The app should give users the choice to choose between stock photos, personal photos and also possibly icons.
- Participants were presented with various formats of how to read the measurements of the plant, ranging from circles to bars. A key insight from this was to help make it more intuitive by showing some measurement lines to help users understand quicker what the right level of the measurement is. Some participants recommended looking into the measurements shown in cars such as with fuel, water and speed.



## CHAPTER 9 : FINAL CONCLUSION AND RECOMMENDATIONS

We are on the planet at an incredible period of time in human history. Never before have our challenges been so great. Yet, never before has technology been so powerful. With IoT, we can literally connect anything to anything.

Therefore when looking at the product, we are not just looking at it as a sensor but rather from an IoT perspective by asking, “What could this thing do if we were connected millions of gardeners by connecting of sensors?”. With the product’s primary purpose being to connect novice gardeners and empowering them with the confidence needed to attempt growing their own food, it is possible to successfully shift collective behaviours towards a more sustainable model by providing a platform in which everyone can grow their own produce, trade or give excess production.

In regards to the most promising markets, the Netherlands offers a logical choice for VodafoneZiggo. It is definitely recommended to initially deploy the product in selected cities where urbanisation and limited garden space is a current problem and therefore opportunity for the home plant industry.

Subsequently it is recommended to deploy the products in markets where indoor houseplants have gained a lot of traction, continue targeting busy urban cities with a large community of millennials. It is also additionally recommended to target people on large plant related instagram communities as it provides access to a large network of plant owners with a variety of gardening skills. With the research having indicated that these plants are primarily purchased for their aesthetic and decorative elements, as well as their instagrammability, it can be assumed that these users could still be struggling with keeping their plants alive and could benefit of the product.

Finally though focussing on the plant industry as a whole is a necessary step for a successful initial strategy in market penetration the project has to keep its ultimate goal of empowering people to harvest their own food.