Smart Cooking

Final report Engineering Design (4WBB0)

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1. Group effectiveness

The team consists of people from multiple backgrounds, majors and interests. The diversity of the group meant that there were a lot of individual strengths that could be combined. It also meant that the group had a lot different views on certain topics, which allowed us to come up with some creative ideas.

One of the most notable strengths of the group is the general coding experience. While not everyone had an extreme amount of coding experience using Arduino, everyone had at least a general understanding about coding. This meant that if someone encountered some troubles with the code, there was always someone else that could assist them. The group also had a couple of members with medical backgrounds, which sparked interest in helping people suffering from certain illnesses. Another strength was that most people were quite used to working in groups, which streamlined the overall process very well. Everyone in the meetings participated in an equal amount, which provided some interesting ideas and topics. Overall, the group was very interested in designing and developing a creative aid that could help improve people's lives. Everyone participated well in both the meetings and the individual research, which is another major strength of the group.

A weakness was that only a few people in the group were familiar with 3D drawing and designing new products. However, they were able to guide the group through the process. Because of this guidance, the whole group was able to make the envisioned prototype for the design, or at least could understand the design process. Another challenge was that while everyone had participated in group projects before, this project was the first where it was required to present a physical and working prototype for some of us.

After some brainstorming, people in an early stage of Alzheimer's disease seemed an interesting target group, because they can still do relatively much themselves and could become significantly more independent with a bit of help. We wanted to create something to help these people from a medical perspective, and because of our coding strength we wanted to create something that required code as well.

Later on in the project, because the product is split into two separate parts, the bracelet and the kitchen hub, there were two separate designs that had to be created and built. These two parts needed to communicate with each other as well, which is where the group's coding strength came into play. Multiple people were able to do research on the code, so when one person was stuck or couldn't progress past a certain point, someone else was able to help them or pick it up themselves.

Due to the lack of experience with 3D design and building, not everyone was able to effectively work on the assembly part. To resolve this issue, two teams were made halfway through the project, one team that mainly focused on testing the components and assembling the device, and one team that kept working on the report. During meetings problems found by a member or team would be discussed with everyone to reach the best solution. These teams were kept mostly the same for efficiency, because while everyone always knew and understood what was going on with both teams, the team that worked on the report previously would know the most about it, and the same went for the team working on the construction of the device.

In general the group's strengths were used to resolve or work around all of the weaknesses, which allowed us to work together efficiently.

2. Design goal

Worldwide, around 50 million people are suffering from dementia, with nearly 10 million cases arises every year. The World Health Organization (WHO) even projects the total number of people with dementia to be around 82 million in 2030 and 152 million in 2050. Alzheimer's disease is the most common form of dementia and may contribute to between 60 and 70% of all cases.[1] People that suffer from Alzheimer's disease can experience a loss of memory, difficulty thinking and behavioral changes, with the severity of the symptoms increasing as the disease progresses. It cannot be cured. As the disease progresses, patients will eventually be asked to move in with relatives or move to a residential care setting. As the amount of people suffering from dementia grows, so does the stress to have available spaces in these care settings for the increasing number of patients. Therefore, it is beneficial to create technology to help patients stay independent and live at home for as long as possible. [1]

The rate at which Alzheimer's disease affects a patient's health can vary greatly. On average, people live for another 3 to 11 years after diagnosis, but some survive for 20 years or longer. Many sources use different stages to describe the process, but in general the disease can be summed up in three or four, including pre-diagnosed stages. The early stage, including mild cognitive impairment and mild dementia, the middle stage, including moderate dementia, and the late stage, including severe dementia.[1][2][3] The product is focused on people in the early stage of this disease, as people in the middle stage or higher will generally not be able to perform tasks by themselves anymore and will need a roommate or caregiver to assist them.

Mild dementia is also the stage where the disease is often diagnosed, as this is where the memory issues become more significant and more noticeable to family members. In this stage patients may find it difficult to remember recent events, have difficulty with complex tasks, undergo changes in personality and more.

People suffering from an early stage of Alzheimer's disease can function mostly independently at first. This beginning stage can last for years. While a caregiver is preferred, patients will be able to do most things by themselves, and not all patients have family available to assist or help them. People in this stage can often do all daily tasks, but can suffer from memory lapses, where they momentarily forget what they were doing. In the kitchen, this can especially be a problem. A patient could become distracted while cooking a meal, after which they could forget that they were cooking something. This could end up with the patient leaving the stove on, which presents a potential fire hazard and could be very dangerous. [6]

The device aims to help people with Alzheimer's disease stay independent for longer by giving them an aid to bypass this cooking risk. This would be a useful innovation because being able to cook a meal for oneself is a very important task that needs to be executed daily, but it would become irresponsible to do so if it led to a potential fire hazard every day. If people cannot live on their own anymore, they require aid from a professional if family members are not available, or they will need to be taken into a residential setting, all of which require attention from other people and can put more stress on the health care system. For this reason, we wanted to create something that can assist people with staying independent for longer, as this is often a better solution for all involved. Medical settings become less crowded, and patients will be able to stay independent for longer.

This independence is especially important as sometimes patients become uncooperative towards a caregiver or they outright refuse help because they feel ashamed or want more control in their life. [4]

Because the symptoms of Alzheimer's disease will vary, the product focuses on a group that can still do most things by themselves but are prone to memory lapses where they could walk away from something they were doing and forget to return. This could lead to the stove being left on and the food becoming burnt, which could lead to a fire. Currently, automatic stoves already exist which turn off the stove after a certain amount of time, preventing a fire from happening [5]. However, the patient will still need to eat on that day, so this isn't an ideal solution. While the fire is prevented, the patient didn't eat, or they will return to the kitchen after an hour to find a ruined meal.

The main goal was to create something which not only provided safety but would also allow the user to continue cooking by alarming them via a signal. The intention was to send a signal to inform patients that walked out of the kitchen, wherever they were, that they were cooking something to give them the opportunity to return and continue. If the user would then not return, safety measures would be taken to ensure there wouldn't be a fire.

The group also had people with medical studies, which is why it was decided to create something to help people with a certain illness to stay home for as long as possible. Our group's strength involved creative design and thinking, which is why creating something new was the goal and creating for people suffering from the beginning stage of Alzheimer's disease seemed an appropriate target group for this. Our group had some coding experience, but not a lot regarding this subject, so we were interested in learning more about it and facing the challenge it could bring with it as well.

3. Functional design and solutions

The product must be easy to use for people with Alzheimer.

This specification is a must have for the product, since the goal was to enable people with Alzheimer to live independently for a longer period. This means that there will be no extra help available, so the user must be able to use the product to its full extend without any problems. Because the user will tend to forget things and have memory lapses, it is important that the product will not be confusing and easy to interpret. Not only the interpretation must be easy, the setup and startup must be easy to non-existent for the user as well.

- The product will be set up by us, which will make sure that the product will be installed correctly and can be used to its full potential.
- The product will not require any direct action from the user to turn on, so the product will always be turned on when needed and cannot be forgotten by the user. This will be done by making out product turn on automatically when the stove is on and is turned off when the stove is turned off.
- The bracelet must fit nicely on the users' arm.
- The bracelet produces a very noticeable alarm, using sound and vibration. This minimizes the chance that the user misses it, and a caregiver needs to be notified.

The product must prevent dangerous situations when the user forgets that he is cooking, without disturbing the cooking process.

The aim of the product is to enable the user to live independently for a longer period by offering aid that prevents dangerous situations in the kitchen while the user is cooking. Stoves already exist that turn off after a specific amount of time, but the product stands out with the feature that the cooking process is not disturbed.

- The user is alarmed with signals when the stove is left on.
- The stove will be left on and the user will be instructed to go back to cooking or turn the stove off.
- An alarm will be sent to the users' caregiver if the user does not react to the signals.
- The alarm will stop when the user gets back to cooking
- The user is not able to deny the signals with a button or other form of input.

The product must ensure the safety of the user, regardless of the situation.

The user must be protected whatever happens, so that the user does not need any extra help from a caregiver when cooking. This will give them more freedom and independency, while making sure that the patient is always safe.

- The system will be usable at any time of the day, so that it will work even when the user were to start cooking at night.
- The kitchen module will be on and connected 24/7.
- The bracelet must be worn and not be charging or out of power when the user starts cooking, otherwise the caregiver can be alarmed.
- Both the bracelet and kitchen module must be able to communicate with each other, if this is not the case the caregiver will be alarmed.
- If the user is not wearing the bracelet, when they start cooking, it will still go of in case the person leaves for too long and a caregiver can also still be notified.

The product should give easily recognizable signals to the user.

It is important that the signals that are given to the user are clear and recognizable, so the user will easily be able to see that there is something wrong and what should be done to tackle this problem.

- A buzzer can be used in order to catch the user's attention.
- A vibrating module can be used in order to make the user feel that something in wrong, which will catch the attention regardless of any surrounding noise.
- An RGB diode can be used in order to catch the attention with light signals and combine these signals with colors to specific objects in the users' kitchen.
- An MP3 module can be used to give the user spoken instructions on what to do.
- Sound and lightning signals can also be used in the kitchen module in order to make it clearer what the user must do.

The product could have a switch to determine the length of the cooking process.

Different meals require different cooking techniques and times. Some need to be watched closely, while other can be left on for hours. Therefore, the product could have an option to select the duration of the cooking process.

- A potentiometer will be attached to the kitchen module to allow the user to select different time values for the cooking process.
- A regular 2-step switch allows the user to select one of two different pre-programmed time values.
- A number pad allows the user to type in the expected cooking time.
- A button can be used to select two different time values.
- The user can indicate what he is going to cook, standard time values will be assigned per type of meal.

The product could offer aid in other places of the kitchen as well, like the water outlet and oven.

The stove is not the only place where dangerous situations can present themselves in the kitchen. The product could be improved by adding different modules for other object in the kitchen, for both safety and financial purposes.

- An extra module can be added which signals the user when the oven is left on, this can work almost the same as the stove module with a temperature sensor.
- An extra module for the water outlet can be added, which measures whether the tap is left open.
- A module can be added if the lights are left on at night or when the person leaves the house.
- The different objects can be linked to a color which can be shown on the bracelet when the user gets a signal.
- All different signals can have different sound and vibrating patterns on the bracelet, to indicate what the user has forgotten.

4. Design concepts

Design concept 1 – Activity sensors

One design concept that came to mind, was to place a visual sensor that detects the user's presence in another place in the house, apart from the kitchen (e.g. the front door). Another sensor which detects the stove being turned on is placed in the kitchen. The idea behind this concept is that when the sensor in the kitchen detects that the stove is turned on, and one of the presence-sensors in another room detects a form of presence simultaneously, it gives a signal to the user. This signal should make the user return to the kitchen where he or she was cooking a meal. The goal of this system is to prevent the users from wandering off to another location while forgetting they were cooking a meal.

Figure 1: Requirements to send a signal

The kind of sensor that would be used would be an ultrasonic sensor for presence detection. The signals that are provided would be sound and vibration signals. These will be provided with the help of a wearable device, preferably a bracelet.

This concept asked for wireless communication between three stations (the bracelet, the presence sensors and the sensor at the stove). This also means that there should be three different hubs with each one needing their own power supply. This is, in contrast to the other concepts, not very cost-effective, as for these concepts only two stations need to communicate and have a separate power supply.

Another problem with this concept is that it does not take activity of other people into account. Someone else could pass by the ultrasonic sensor while the user, the one with the bracelet, is still in the kitchen. This would result in the user receiving a signal for no reason at all. Because the user has beginning Alzheimer's this could result in them becoming confused.

One of the main positives of this design concept was that it required no input from the user. This concept prevents the user from leaving a certain area, so no timer is used to measure the time the person spends away from the stove. This means that no input is needed regarding the time interval that the person could spend in another location.

Design concept 2 – GPS location

One function that was difficult to figure out was how to measure when someone has stopped cooking and has left the stove. This is a must in the final design, otherwise it becomes impossible to check whether the user is still cooking or not. One of the initial proposed solutions was to measure the distance from the hub by GPS. At first this seemed to be a relatively cheap option which could measure the distance reliably. The GPS unit would keep track of the exact latitude and longitude of a custom bracelet the user would wear.

The GPS had some flaws as well. It uses significantly more power than the other possible solutions. It also required an almost constantly active two-way communication between the hub and the bracelet, which would require quite a lot of energy. When deciding on how to measure the distance from the stove, two-way communication posed another challenge as well. Solving that challenge would require time and most likely take up more room and cost more. Some alternatives only required one-way communication, so this design concept seemed to bring more problems than it would solve. While this design concept technically met all the requirements, it was later discovered that a GPS would not measure precise enough, because it does not take height into account. This seems trivial at first, but if a person were to go into a room located above the kitchen, it would be registered as the person being at the stove. This would be a critical problem in the final design as people could go do something completely different if it is approximately on the same latitude and longitude as the kitchen. In other designs this problem didn't exist.

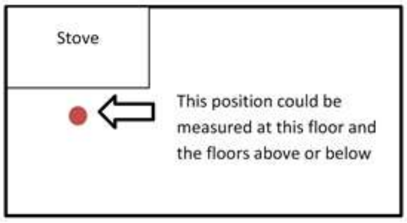

Figure 2: Top view of how a gps could wrongfully measure the user's location

Design concept 3 – Power saving

Another challenge that needed solving was the power management. Leaving the whole system on the entire time would use a lot of unnecessary power. It would be best to avoid this to increase the longevity and sustainability of the product. Seeing as the product is designed for elderly with Alzheimer, ideally the device would turn on on its own. Otherwise the risk of them forgetting this or not understanding it would arise. However, having every sensor on always would require a lot of power. Therefore, the choice was made to only have one sensor on the entire time, namely the heat sensor. This is like putting a computer or tv on standby to limit the amount of power used while maintaining a certain amount of ease for the user. The heat sensor can detect when the stove is turned on and, when the temperature reaches a certain threshold, turn on the rest of the system as well. When the temperature drops below this threshold again after cooking, the system will also automatically revert to its "standby-state". The elderly would not have to understand or remember anything, making it as easy as possible for them to use. There would only need to be some extra features in the code to make this possible and someone to help them install it, however this is only a one-time action. It does not have any impact on the budget or the room required for the system to be put inside of. All other options with a switch or a button would make it more difficult to use and meant that the users would have to turn it off themselves as well. This still leaves the chance that they will forget to do this and it will remain turned on for longer periods than necessary. So, the most reliable option with the target group is to make it automatic.

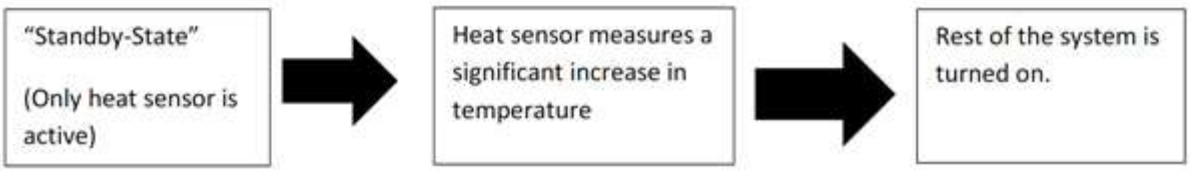

Figure 3: The steps taken to save power

5. Final design concept

To select the final design concept, all considerable options were compared to find the one that suited our design goal the best. The exact technical specifications of each concept as well as how they would work in combinations with the patients were compared to choose the best option.

It was decided to make use of a bracelet to create the part of the device which the patient will always carry with them. The idea behind this concept was that while it would be easier to create an app for a mobile phone, the device needed to be as easy to use as possible. The use of a mobile phone may not be accessible to all patients suffering from beginning Alzheimer’s, and it brought another unwanted layer of complexity to the use of our design. Furthermore, the mobile phone would bring the risk that patients could easily place it on a counter somewhere and forget about it. The bracelet was designed to be something the patient puts on their wrist, and then doesn’t have to think about anymore. It shouldn’t be taken off or put away, it should always be worn.

The final concept makes use of sounds and vibrations to alert the patient. These were chosen over the use of lights and screens because those provide signals that could still be ignored. While a patient could choose to look away from a certain screen or a light source, this is not possible for sounds or vibrations. These kinds of signals will always be felt or heard if the device is worn and are therefore the best choice for the product. Because the bracelet sends the signals, the user will always be alarmed regardless of where they are in the house.

An addition to the previous designs was to place the kitchen hub in a location where it could then be solidly attached to either the counter or a wall. This prevents users from removing the hub when they are confused, which could otherwise result in the sensor being ripped off the stove. Attaching the hub to a solid surface also prevents it from falling off the counter or into a sink.

To save power and create a longer battery lifetime while also making sure the device would always stay on to prevent the user from accidently forgetting to turn it on, the decision was made keep the heat sensor active. The heat sensor will remain powered to detect whether the stove is in use or not, while the others components stay in a low battery mode to preserve the battery. The only component that will be active in the bracelet is the WiFi-shield. This component will remain in a ‘sleep’ status, where it will consume the least power while still being able to receive a signal from the kitchen hub. Once the heat sensor measures an increase in temperature, the rest of the system will activate.

Our final design is user-friendly because it provides patients with an easy-to-use device that requires almost no input from them. It creates a safer environment in the kitchen for the users with beginning Alzheimer’s, because they will be alerted when the stove is left on, which mitigates the risk of a fire. Furthermore, because the device alerts the user in real time, the user gets the opportunity to return to the kitchen to finish their meal, so that they do not forget to eat either. This enables people to safely start cooking and helps them with reminders to ensure they finish cooking their meal so that they get to eat it as well.

Figure 4: Overview of the full process

6. Technical specification

The design consists of two separate elements, the bracelet and the kitchen module. These elements are only connected via Wi-Fi and therefore a separate MoSCoW method prioritizations was created for both elements. The most important components have been summarized in a table for the stove and one for the bracelet.

Table 1: Important components of the stove

Component	Details
Temperature sensor	TMP36GT9Z
Ultrasonic Distance Sensor	HC-SR04
Arduino with WiFi	ESP8266MOD, Wemos D1 Mini
Cable and powerbank	Micro USB
Potentiometer	Alpha RV16AF20KB100KM turning potentiometer Mono 200 mW 100kOhm

Table 2: Important components of the bracelet

Component	Details
Vibrating motor	1034
WiFi shield with IFTT	ESP01 / ESP8266EX
Battery	CR2032
USB to ESP01 Adapter	USB to ESP-01
Buzzer	zo Buzzer
Resistor	220Ohm
Resistor	100Ohm
Battery holder	PCB
Voltage regulator	3.3V step-up/step-down regulator

Bracelet

The bracelet must:

- be able to communicate with the kitchen module throughout the entire house using a Wi-Fi connection.
- be powered by a small 2000mAh, 3,7 V battery which lasts for at least 24 hours.
- have a maximum budget of 70 Euros combined with the kitchen module.
- have a vibration motor to signal the user.
- have a sound emitter to signal the user.
- have a way to signal and consistently get the attention of the user.

The bracelet should:

- have a wristband that is adjustable to fit most wrist sizes.
- have a diameter of 5cm and a height of 3cm.
- be smaller than 20 cm3 (excluding the wristband).
- have a vibration motor capable of vibrations of 200Hz with a maximum size of 1cmx1cmx0.5cm.
- have a sound emitter capable of sounds of 2000 Hz with a maximum size of 1cmx3cmx1cm.
- have a detachable lid to swap the battery if it’s empty.

The bracelet could:

- have an mp3 module capable of transmitting custom spoken instructions.

The bracelet won’t:

- have the ability to send visual signals such as LED lights.
- have an LCD screen with instructions.

Kitchen module

The kitchen module must:

- be able to communicate with the bracelet throughout the entire house using a Wi-Fi connection.
- have a minimum battery life of 24 hours.
- have a maximum budget of 70 Euros combined with the bracelet.
- have a sensor to detect people in front of the stove.
- have an internal timer.
- be able to alert a caregiver in case of an emergency.
- have a temperature sensor to detect heat near the stove.
- have its wires protected to withstand heat up to 100 degrees Celsius.

The kitchen module should:

- have an ultrasonic sensor capable of detecting movement in a range of 2 meters in front of it and with an angle of 30 degrees.
- have a temperature sensor on the stove capable of detecting when the temperature goes above 40 degree Celsius.
- have a timer that detects how long it’s been since a person was detected by the ultrasonic sensor.
- have two different timer intervals, short (3 minutes) and long (12 minutes) that can be switched manually via a switch on the module.
- be able to send the caregiver a message via Wi-Fi in case of an emergency.
- have a detachable lid to swap the power source if it’s empty.

The kitchen module could:

- have a switch with only two options to make it clearer which time interval is selected.
- have more than two time intervals.

The kitchen module won’t:

- have an LED screen with the current timer / time interval on it.

7. Detailing

Battery

One key component in the current design is the battery in the bracelet. This is because the battery needs to deliver enough energy for at least one extensive meal. If it could not keep the bracelet running for this amount of time, the bracelet would lose a big part of its purpose and only be usable when cooking shorter, more regular meals. Preferably the battery could last for a whole week or even more before needing to be replaced. The battery needed to deliver 3.3 volts. Knowing this, it was calculated how long the battery would last. First with 3V the capacity of 225mAh gives 675mWh. This means that the capacity goes down with 3.3V (675/3.3= 204.5) to 204mAh. If everything is running at max capacity, the bracelet uses 245 mAh. This means that the bracelet could do that for (204/245=0.83,0.83hours=50min) 50minutes. Of course, the buzzer and vibrating motor are not working all the time. Also, the Arduino is never at a full capacity. It is more likely that the Arduino runs at 50 mA. Its energy usage would then be 125mAh and it's time capacity (204/125 = 1.632) 1.632 hours equals 1 hour and 37 minutes. This means that it should be sufficient to cook a normal to more extensive meal. The battery would need to be replaced after every more extensive meal and should last about 3 regular meals, (a regular meal is considered to be made in about 30 minutes.). It was unsuccessful to extend this time within the current project. If a similar product were to be developed, a LiPo battery would probably be the ideal solution. These can often last longer and when they are empty, they can simply be charged instead of replaced. This would make it more environmentally friendly and eliminate the process of fiddling with a small battery for the elderly users. In the current circumstances a LiPo battery seemed too great a risk and therefore a choice was made to use a C2032 battery. This choice of battery also greatly reduces the cost and keeps the bracelet relatively small. To improve the lifespan, parts are kept on standby as much as possible.

Buzzer

Another key component is the sound of the buzzer, because this is supposed to alert the elderly and warn them that they have left the stove for too long. The buzzer must therefore attract attention and immediately incite the user to return to the cooking, otherwise the product would be of no use at all. The code (see appendix C detailing) shows how this is accomplished. By creating a rhythm in the signal, it resembles an alarm. This should give the user a feeling of alertness and thus make them take action to get back to cooking if possible. Another important aspect of the buzzer is the frequency of the sound. The target group is almost exclusively elderly people and these people often suffer from hearing problems. This means they can't hear soft or high-pitched noises. The frequency of 4Hz has been chosen, because according to the functional design for elderly and people with functional limitations, most elderly should still be able to hear this. This has the additional benefit that low-pitched noises are better associated with alarms or imminent dangers. The frequency makes it suited for the target group and strengthens the feeling that immediate action needs to be taken. Eventually this is safer for the user, because they are more inclined to stop the problem, which obviously reduces risks such as fires. Because the alerting function is crucial, a buzzer was chosen with a maximum loudness of 80dB. 80dB roughly equals the sound of a typical doorbell. This amount of noise on the arm should be practically impossible to ignore, even for people with hearing problems. Louder than 80 dB should be avoided, because anything louder could damage the hearing. The alerting function should not be harmful to the users, but loud enough to be heard clearly.

Ultrasonic Sensor

The ultrasonic sensor is another key component. Without this, it would be uncertain whether the user is cooking or not. The purpose of the whole system is defeated when there is no way to determine if the person is cooking. The ultrasonic sensor will detect a person in front of the stove when they are in a range of 2 meters and when this is not detected a timer will start. This is chosen to make sure people don't just walk by accidentally and reset the timer. If the timer reaches a certain threshold, either 3 or 12 minutes dependent on the current setting of the Arduino, contact will be made with the bracelet. 2 meters are chosen, because this seemed a reasonable distance to be away from the stove to do something else related to the cooking. Getting something from a refrigerator for example. The ultrasonic sensor is not measuring constantly to reduce the amount of power it uses and limit the amount of data processing necessary.

Modelling

The modelling as a group was started by thinking about how the product should look and what was technically required for the product to work. The product consists of 2 elements, a bracelet and a hub. The hub is stationed at the stove, where it houses an Arduino, a switch, and various sensors. Since the hub does not need a custom design, it was decided to buy a container and no modelling was needed for this component.

The bracelet is a part for which there is no container or product that can just be bought, so it was decided to 3D print it. To do this a clear representation of how the group wanted it to look was needed first. A sketch was made and then a CAD design to add details. These sketches allowed the group to work out what the final product had to look like. Also, the sketches provide the measurements that are needed, considering everything that needed to fit into it.

After the first sketches, Siemens NX was downloaded to create a 3D printable model. Using the predetermined measurements, the main cylinder of the case is made first. Using the extrude function, a main cylinder is made first. This cylinder is hollowed out using the hole function. Next a fixed bottom of the case is placed at the bottom of the cylinder. To this bottom an attachment is added, which is a rectangle with a slit in it. The rectangle is rounded off with the cylinder, so it does not stick out. The slit in the rectangle will allow the strap to go through, which will allow the user to wear it around their wrist. Lastly, the thread function is used to create a thread at the opening of the cylinder. This thread has a length of 3mm and a pitch of 2mm.

The cap of the case consists of two flat round surfaces, one smaller than the other. The top part has the same diameter as the main cylinder, allowing it to lay on to top neatly. The bottom part is a flat cylinder with the diameter of the hole in the main cylinder allowing it to slide in. To create a seal on the cap a thread to the bottom cylinder of the cap was added. This thread also with a length of 3mm and a pitch of 2mm.

These parts have separate NX files (.prt) and are put together in the Ultimaker Cura program. The Ultimaker Cura program allows estimation of the print time of the design. The file is then also saved in Ultimaker Cura, creating a ".3mf" file. All these files were sent to the Engineering Design workshop to be 3D printed.

Programming

The code is built up as follows: The temperature sensors is always measuring. As soon as it measures a temperature that is higher than 40 degrees Celsius, the ultrasonic sensor starts measuring. As soon as the distance is bigger than 2 meters – this means the person is not watching the stove – the timer starts. If the potentiometer is turned to the left – short – and the timer exceeds a time of 3 minutes, a signal is sent via WiFi to the bracelet and the buzzer and vibration motor start working. If the potentiometer is turned to the right – long – and the timer exceed a time of 12 minutes, a signal is also sent to the bracelet and the buzzer and vibration motor start working. As soon as the timer exceed 8, respectively 17 minutes, the caregiver will get a notification saying: 'The person needs help.'

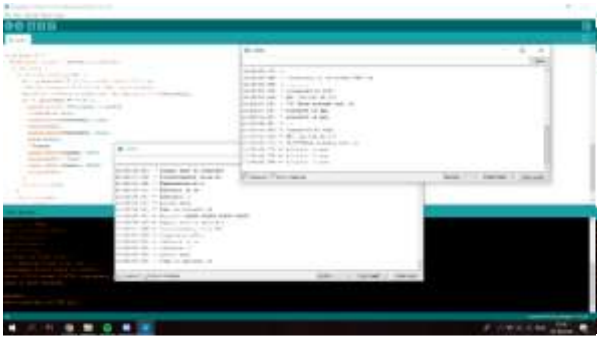

Figure 5: Results on serial monitor

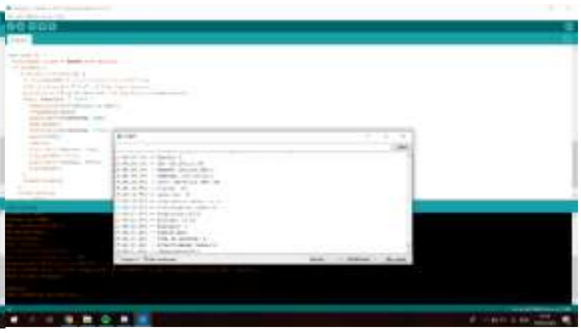

Figure 6: Results on serial monitor WiFi connection

8. Realization

Bracelet

The bracelet consists out of a case, strap, Arduino, battery, battery holder, buzzer and vibration motor. The case is a 3D printed cylinder with a diameter of 5 cm and a height of 3 cm. There is a slightly thicker part of plastic at the bottom of the case with a slit in it, through which the strap goes. This strap goes around the wrist and is connected using a simple buckle. The buckle makes the strap resemble that of a watch, which is something most people are familiar with. Also, if the bracelet resembles a watch, people might feel more like they are wearing an accessory instead of a medical device.

Since the case consists of a main cylinder and a cap, it is easier to first put all the functioning part together and then put them inside the case. It also allows easy access when the battery needs to be replaced or in case maintenance is needed. The cap is connected using a screw thread, this makes for a secure seal. The screw thread is also relatively short which means that, if something were to be placed on the cap, the wires connecting that part do not tangle too much. If wires do tangle or spin too much, they could break or be torn from one of the parts.

Inside of the case the working parts of the bracelet are found, as seen in the list of parts, consisting of an Arduino WIFI shield, vibrating motor, lithium battery, battery holder, and a buzzer. All of these components are soldered to short wires. These wires can be connected to the pins on the Wifi shield. It is possible to take the wires of the pins to allow the ESP01's program to be adjusted if needed. The system is then put inside the casing. The vibration motor will stick to the casing so that everything vibrates in case of an alarm, making it very noticeable for the user.

The Arduino is connected to the battery holder, in which the battery will be placed. After that the buzzer and vibration motor are connected to the Arduino. These two actuators are both connected to the Arduino using one parallel circuit, as seen in the Fritzing diagram. The parallel circuit allows the bracelet to vibrate and buzz at the same time, which is useful since it is needed for them to go on and off with intervals to make the alarm more noticeable. All these parts are connected by wires that we soldered together.

Furthermore, the Arduino will be programmed to be in a type of sleep state in which it can receive messages from the hub located near the furnace, if it receives such a message it can play the alarm by activating the other parts connected to the Arduino. It will also be able to receive a message telling it to turn off again, when the person returns to the stove. To program the ESP01, first a USB adapter is connected to it, which allows us to connect it to the computer.

Figure 7: Fritzing drawing bracelet

Hub

The hub consists of a plastic case containing the Wemos D1 mini, a power bank, a temperature sensor, an ultrasonic sensor and a potentiometer. All parts of the hub were not self-made. The dimensions of the case are 160*95*55 mm. The plastic case contains a hole for the wires of the sensors and the power bank to pass through and a hole through which the potentiometer can be accessed by the user. This potentiometer can be used by the user to set the time which they can spend away from the stove.

For the case of the hub, a plastic container with a screw on lid was used, so the parts could easily be inserted into the case while avoiding that the user will accidentally damage something. Just like with the bracelet, this case can easily be opened in case of a drained battery, or for maintenance purposes. Since the hub will be stationary and stick to the wall with Velcro, no internal parts will be secured onto the case itself, other than the potentiometer. The reason behind this is that parts can be replaced more easily when broken. no internal parts will be secured onto the case itself, other than the potentiometer.

All parts of the hub were tested individually as well. The conclusion of these tests was that all parts worked properly. The specific results of these individual tests are to be found in the tables in Chapter 9. More details on the testing will follow in chapter 9. After the individual testing, the assembling part started.

The hub assembly was made via the following schematic:

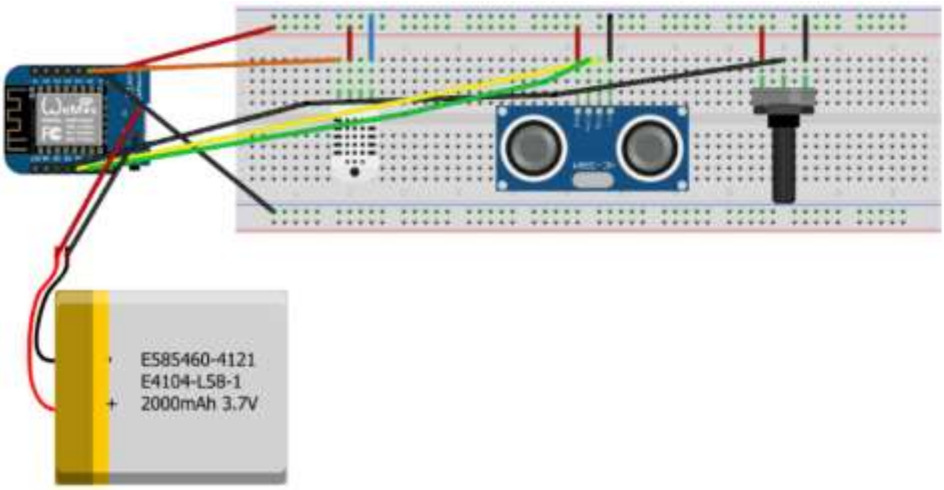

Figure 8: Fritzing drawing hub

First, the power bank was connected to the Wemos D1 via a USB to micro-USB cable. After that the temperature and ultrasonic sensor were connected separately to the Wemos D1 unit. The last thing that was connected to the board was the potentiometer. Just as in the bracelet, all the parts are connected via wires which are soldered into their respective ports. A worked-out assembly without the case can be seen in the figure below.

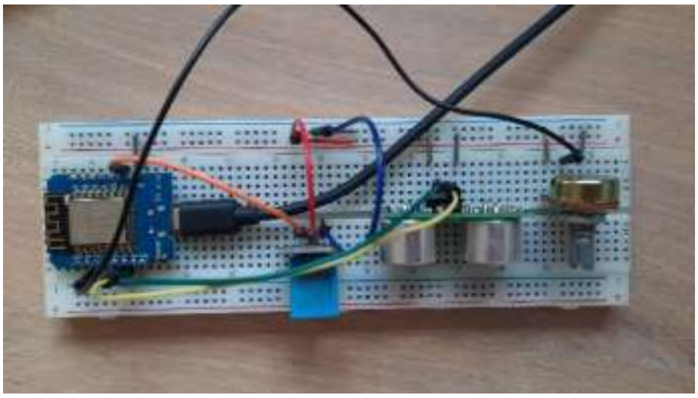

Figure 9: Electronics hub

All parts for the hub and bracelet of the design are tested separately. This way, errors could be prevented since the potential not working parts can be found. Below the results of the testing can be found.

For the vibration motor the desired frequency is 200 Hz. This is a frequency that can still be perceived by elderly people. The vibration motor has a maximum frequency that is equal to the desired frequency:

Table 3: Specifics of the vibration motor

[1]	**Frequency (Hz)**
Lowest	0 Hz
Highest	12000rpm = 200 Hz

For the buzzer the desired frequency is lower than 2 kHz. This is a frequency that can still be perceived by elderly people. The buzzer has a maximum frequency that is lower than the desired frequency. Moreover, the desired volume is 80dB. This is a volume that can be perceived easily and is often used in alarms but doesn't immediately lead to hearing damage.

Table 4: Specifics of the buzzer

[2]	**Volume (dB)**
Lowest	0dB
Highest	80dB
	Frequency (Hz)
Lowest	0
Highest	2000 Hz

For the temperature sensor the desired temperature is 50 degrees Celsius. The temperature sensor can measure a temperature that is as high as the desired temperature to detect when a person is cooking.

Table 5: Specifics of the temperature sensor

[3]	**Temperature (degrees C)**
Lowest	0
Highest	50

For the batteries the desired voltage is 3V and 5V. These are the minimum voltages needed for the WiFi shields, respectively ESP01 and WEMOS D1 MINI. Moreover, the desired lifespan of the Lithium cell battery is 7 hours. For the hub, the WEMOS D1 MINI is connected to a power bank. Therefore, the lifespan doesn't play a role since it's rechargeable and can be powered while working. The batteries do reach this desired voltage and lifespan:

Table 6: Specifics of the batteries

[4]	**Voltage (V)**
Lowest	-
Highest	5V | 3.2V
[5]	**Lifespan (hours)**
Lowest	
Highest	1245 (for 2V)

Plan for production

- Upload the code to the corresponding Arduinos
- Solder male-male wires to the sensors and potentiometer (temperature sensor-65cm, ultrasonic sensor-80cm) and male-female wires to the actuators and battery holder (10cm)
- Pin the Wemos D1 Mini into the breadboard
- Put the wires of the sensors and potentiometer into the corresponding pins on the breadboard (see fritzing drawing)
- Put the pins of the WIFI shield into the corresponding wires of the sensors and the battery holder (see fritzing drawing)
- 3D-print the case and attach the band
- Make holes in the project box to allow the wires of the sensors and the cable from the powerbank to go through
- Insert the powerbank into the project box and align the output with the holes
- Insert the Wemos D1 Mini into the project box on top of the powerbank
- Connect the Wemos D1 Mini and the powerbank with a USB to micro-USB cable
- Insert the WIFI shield into the 3D-printed case and stick the vibration motor to it

Table 7: BoM of the stove

Part	Details	Cost (€)	Shop
Temperature Sensor	DHT11	2.50	TinyTronics
Ultrasonic Sensor	HC-SR04	3.00	TinyTronics
Arduino with Wifi	ESP8266MOD, Wemos D1 Mini	5.75	TinyTronics
Wires	Different sizes	4.00	TinyTronics
Breadboard	170 points	2.40	TinyTronics
Project Box	160*95*55 mm	6.35	OpenCircuit
Voltage Regulator	3.3V up/down	0.60	TinyTronics
Powerbank	10.000 mAh, 5V	9.98	Action

Table 8: BoM of the bracelet

Part	Details	Cost (€)	Shop
Vibrating Motor	1034	1.00	TinyTronics
Wifi Shield with IFTT	ESP01/ESP8266EX	8.76	Antratek Electronics
Battery	CR2032	1.50	TinyTronics
USB to ESP01 Adapter	USB to ESP-01	2.50	TinyTronics
Buzzer	Piezo Buzzer	1.50	Kiwi Electronics
3D-Printing		5.00	TU/e
Battery Holder	CR2032	0.50	TinyTronics
Transistors	PNP	0.30	TinyTronics

Table 9: Delivery costs of BoM

Shop	Delivery Cost (€)
TinyTronics	2.50
Antratek Electronics	1.65
Kiwi Electronics	2.50
Open Circuit	2.50

The links to the products can be found in the appendix D

9. Test plan and results

Wemos D1 mini

To let the system receive the information of the potentiometer and to let it control the input of the ultrasonic sensor and the temperature sensor. Therefore, a connection should be made as shown in figure 10 and 11

Figure 10: Wemos D1 mini blinking

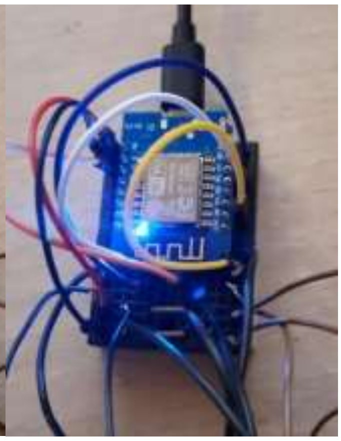

Figure 11: Wemos D1 mini Testing

Ultrasonic sensor

For the ultrasonic sensor the desired distance is 2m. This is a distance at which the person can stand from the stove and still is able to see what's going on. The ultrasonic sensor is able to perceive movement from this distance.

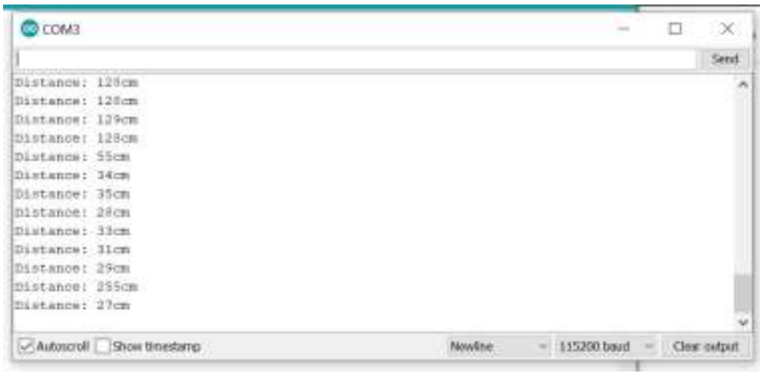

Figure 12: Distance Ultrasonic Sensor Test

Temperature sensor

For the temperature sensor the goal is to let the Wemos D1 mini decide whether the temperature is below or above 40 degrees Celsius. Therefor the temperature should be able to be measured as shown in figure 13 and 14

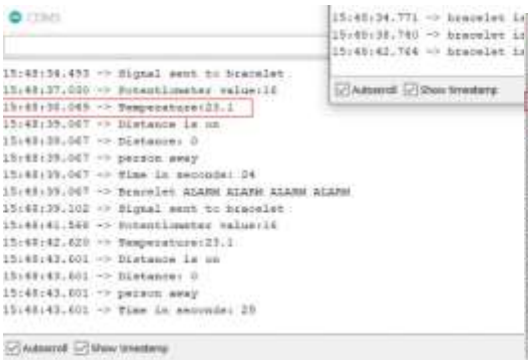

Figure 13: Temperature low

Figure 14: Temperature high

Potentiometer

For potentiometer, the goal is to let the Wemos D1 mini decide whether it's turned to the left or to the right, therefore the values need to be indicated. Turning the potentiometer all the way to the left should give a value of 1024 where turning the potentiometer all the way to the right should give a value much lower than 1024. The tests are shown in the serial monitor that can be seen in figure 15 and 16

Figue 15: Potentiometer short *Figure 16: Potentiometer long*

ESP01

For the ESP01 the goal is to let it connect with the Wemos D1 mini. This is tested by letting is blink as soon as there is a connection as shown in figure 17 and 17

Figure 17: ESP01 Testing *Figure 18: ESP01 Testing blinking*

Battery

For the battery the goal is to power the ESP01. Therefor the voltage should be high enough – 3.3V. But not too high so that the ports of the ESP01 get overpowered – 3.6V. The real value is 3.00V as shown in figure 20

Figure 19: Voltage battery of the bracelet

Buzzer and vibration motor

The goal for the buzzer is to send a signal of 4 kHz. Moreover, the volume should be 80dB. There is a circuit and corresponding code used to test. The goal for the vibration motor is to vibrate with a frequency of 200Hz.

Signal to Phone

The goal is to let a signal be send to the phone via IFTTT. There is a link used to test the working.[1] The result is shown in figure 20.

Figure 20: Signal to Phone

Results

The results of the design are shown in the images below. More images of the design and building process can be found in the appendix.

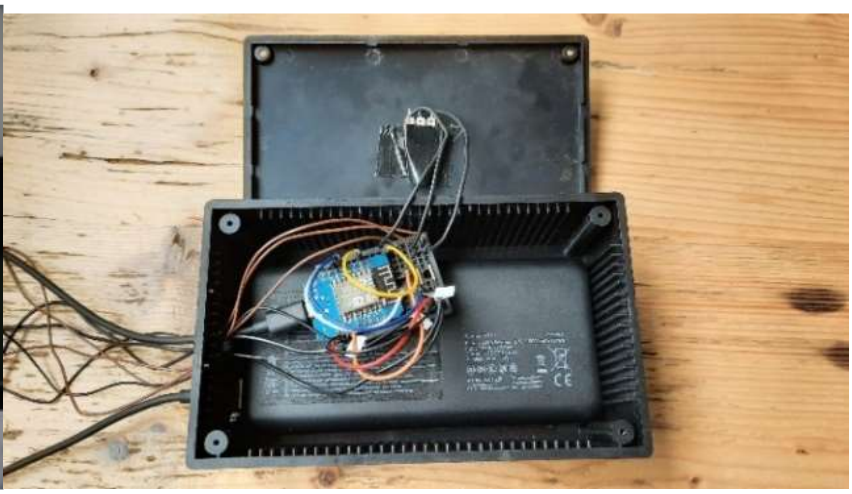

Figure 21: Hub places near stove

Figure 22: Hub with electronics

Figure 23: Bracelet open

Figure 24: Bracelet closed

[1] https://maker.ifttt.com/trigger/Notificatie/with/key/fvrhYQw_Vt2DQrVPdA-W62wqJxqlUUQkUlR5__hFLmw

10. Design evaluation

Evaluation

The question is of course whether this design is a result that satisfies the design goal that was intended. The design goal was to create a device that would help people in the beginning stages of Alzheimer's disease to live independent for longer by creating a cooking aid. This aid was not only intended to increase the safety of the user while cooking, but also to allow them to continue cooking independently. It is rather hard to give a clear answer to whether the final design is completely fulfilling the entirety of the design goal. However, all things considered, the conclusion is that the design that was made is very much in line with the design goal that was stated.

In a design cycle, each phase has its own purpose, and all phases are important towards the creation of a final product. However, this does not mean that all phases are of equal importance to the project. This is because every project is different, and therefore every project has its own distribution of importance regarding the design phases. In the case of this project, the most critical design step was the realization. In all the phases up to the realization phase, an open field was kept with respect to the solutions to different problems that the design tackles. Because the budget allowed it, sudden changes about the design could easily be made when problems occurred. However, this would not be the case during and after the realization process, because then all the parts that were chosen would be irreversibly connected. It was vital for this project to not make any crucial mistakes during this step.

Possible improvements

There are some improvements that still could be made to the final design. For instance, this design still involves contacting a caregiver of some sort. This happens when there is too long of an absence by the user from the stove. The fact that there still is a need to contact a caregiver implies that complete independence is ruled out, and therefore that aspect of the design goal is not satisfied completely. This aspect could be bettered by finding a solution to the problem of a too long absence from the stove, other than one that involves contacting a caregiver. An example is let the hub turn off the stove automatically. The part of the design cycle that this should be implemented is the design concepting phase.

Another improvement that could be made is the usage of batteries throughout the design. At this moment, the type of battery in the bracelet is not compliant with the purpose of its power. The original voltage of the battery is too low to keep the Wi-Fi shield running properly. To be more power-efficient, and with that also more cost-efficient, another type of battery could be used in the bracelet. The design phase in which this improvement could be made is the detailing phase.

One final improvement that the design could use is the frequency of the buzzer in the bracelet. One of the signals that the bracelet ejects is a sound signal. For this, the design makes use of a buzzer that produces a noise with the frequency of 2 kHz. However, this is a constant tone with the same frequency, which could result in it being harder to hear for certain people, especially elderly with hearing problems. Therefore, it is better for the bracelet to produce a two alternating sounds with one having a frequency between 300 and 750 Hz and the other with a frequency between 500 and 3000 Hz. Just like the previous improvement, this improvement can be made in the detailing phase of the project.

11. Special topics

Special Topic - Design Sketching

To be able to create a common interpretation about how the design looks, 2- and 3D sketches are made. This was done after coming up with the visual representation of the design and before the 3D modelling of the design in SolidWorks and Siemens NX Design. Moreover, the results of these sketches and its dimensions were helpful for creating the 3D model.

The design itself consists of two parts, the hub and the bracelet. Since the hub is only functional and used to store the electronics parts in the decision is made to only make sketches of the bracelet.

It started with sketching the 3D design of the bracelet to create an overview of all the parts and details of the design. The 3D sketch is shown from a top/front angle. This way, most of the distinctive elements of the design are shown.

In the same figure, the intersection of the tray with its content on the bracelet is drawn. These contents are the buzzer, some wires to connect the buzzer to the Arduino shield ESP01, the Arduino shield itself, a lithium battery and the vibration motor. In the sketch is shown how these parts fit in the tray using dimensions.

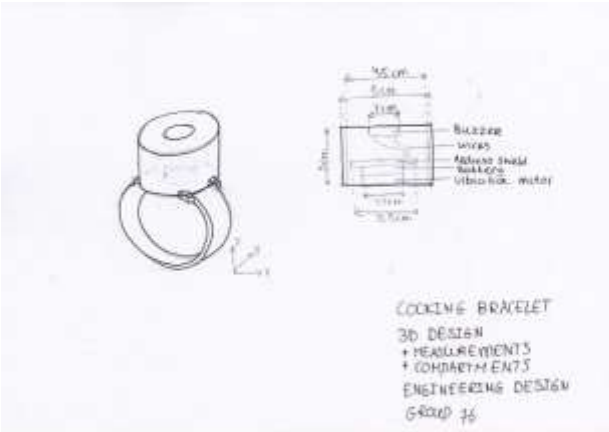

Figure 25: 3D sketch bracelet with dimensions

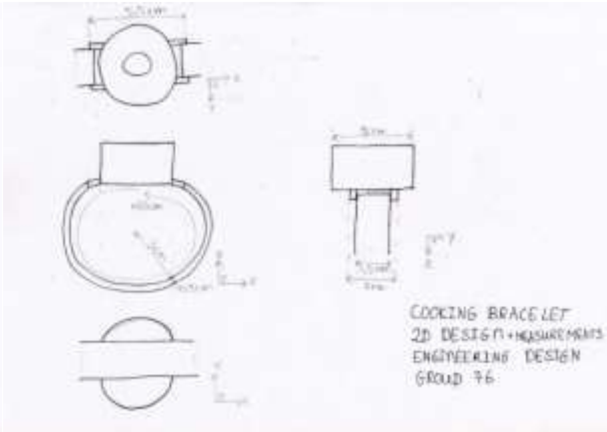

Figure 26: 2D sketch bracelet with dimensions

Next to that, the four other views of the bracelet, the top view, the front view, the side view and the bottom view are visualized. All the measurements together, provide a complete indication of the dimensions of the bracelet and its tray. To be able to make these sketches, the course Training technical design skills 4ONLOO is done. The skills developed are visualizing ideas, drawing and estimating proportions. Moreover, the skill of knowing what to put where on the paper is gained. This contains the placement of the individual sketches itself, the dimensions and the text. Making these sketches helped the group getting a common interpretation of the design of the bracelet.

Special Topic - CAD Design

For the prototype of the design, the choice is made to 3D print the tray of the bracelet. The complete system consists of a hub and the bracelet. However, since the size of the hub will be relatively big, we chose not to 3D print that part. Also, because it's relatively easy to make from other materials using other techniques.

The bracelet consists of the tray and the wristband. Since a requirement for the wristband is to let it be flexible in order to let if fit around any writs, this part won't be made using a 3D printer. However, to visualize the connection between the tray and the wristband, both are visualized in the 3D model together in some of the figures.

Moreover, a transparent figure of the 3D model is added to visualize the inside of the tray.

Figure 27: 3D model bracelet

Figure 28: 3D model bracelet transparent

Visualizing the sketches in a 3D modelling software helped the group to get an interpretation about the estimated and measured proportions. Another example, the group got the insight of the need to discuss about whether to make holes in the top and bottom of the tray for the buzzer and vibration motor.

In order to create these 3D models the course Training technical design skills 4ONL00 is completed for the parts 1: Basic modelling in NX and part 2: Assemblies in NX. For these models the software applications SolidWorks and Siemens NX are being used.

The skills developed while studying these materials and creating the models are, spatial thinking, working with SolidWorks parts and assemblies and working with Siemens NX parts and assemblies.

The development of the 3D models is done after the 2- and 3D sketches are made, but before the 3D printing of the model started.

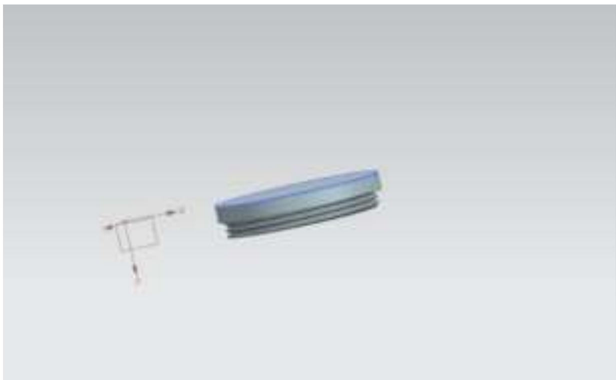
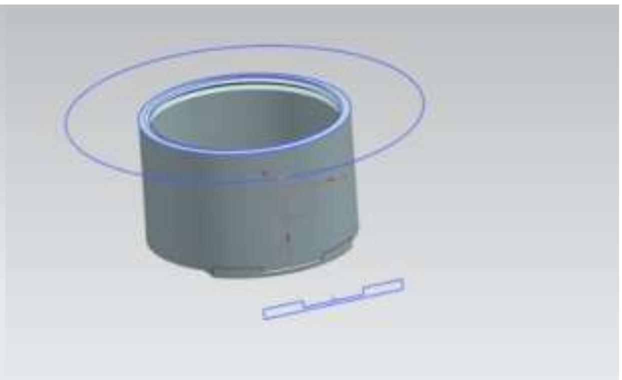

Figure 29: The cap of the tray *Figure 30: The cup of the tray*

The tray consists of a cup and a cap. These two elements attach to each other by screwing. Moreover, there is a slit in the bottom of the tray through which the wristband of the bracelet goes. This way, the wristband can be made from one piece which makes it firmer.

The buzzer and vibration motor are the actuators located in the tray. They don't need to be in contact with the skin of the person or with the air since the vibration and sound can go through the 3D printed tray.

Special Topic - Project Risk

One special topic that was chosen was that of project risk. This special topic was chosen because it seemed valuable for our project to create a good view of what risks are being faced during this project. In this way eventual risks can be avoided, or a mitigation of a risk is already thought of when this risk occurs. This helped the project group to become more aware of the risks faced during the project and helped the group to become more time and cost-effective.

Study material

For this special topic chapters 5 and 8 of the book Project Risk Management [1][2] and a video lecture [3] were studied. In this material certain methods for risk-identification and risk management are given. The assignment states that a fishbone diagram and at least one other management tool from the given literature must be applied to the project. The management tool that was chosen was the risk matrix in combination with a traffic light model.

Risk identification

First comes the step of identifying risks. This step was carried out during the concepting phase of this project. Before risk identification starts, the definition of success is being stated for our project. To make this definition more specific, the following issues were being considered: stakeholders, goals and interests, and constraints. For this project the following definition of success was made: Success is designing a cooking aid to help people with Alzheimer's live independent for a longer period.

One tool that was used for risk identification was the creation of a so-called fishbone diagram. It creates a systematic and clear view of the kinds of the nature of the risks this project faces. These diagrams are frequently used for a cause-and-effect situation to illustrate which factors have an influence on a certain outcome. The outcome in this case is an unsuccessful execution of the project. The fishbone diagram for our picture can be seen in figure 35. The diagram can also be seen in the appendix

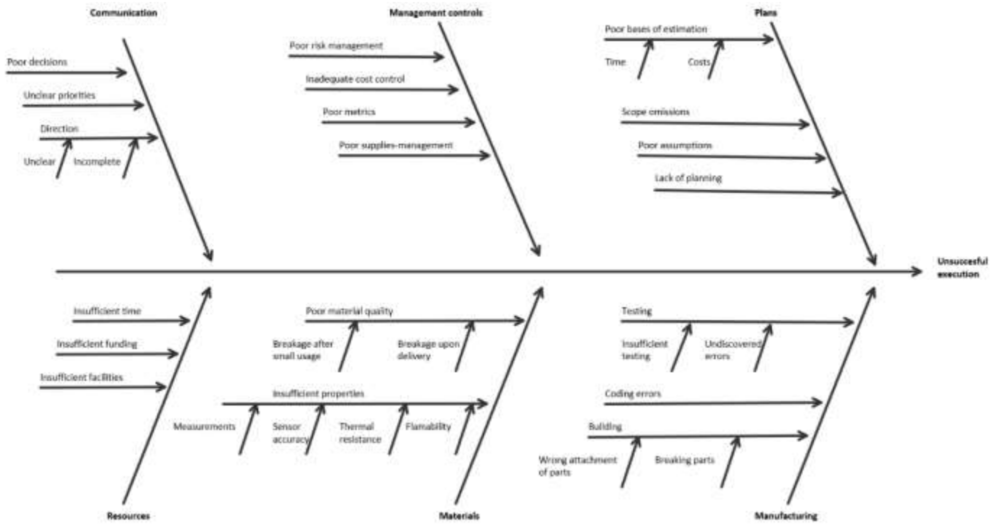

Figure 31: Fishbone diagram

Risk management

The tool that was chosen from the literature to manage the risks this project faces is the combination of a risk matrix in combination with a traffic light scheme. This method was chosen because it provides a good combination of being reliable and effective, without the method being too time-consuming and complex. This can be seen in figure 38 The chosen method falls under Formal Risk Planning.

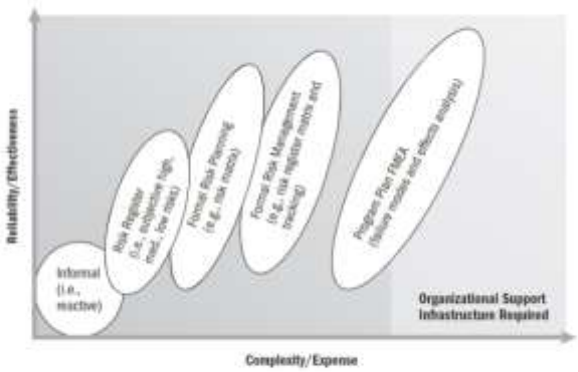

Figure 32: Classical project risk management tools and techniques

The risk register is a register containing 18 risks stated, each with their own severity score and mitigation method. Most of the risks from the risk register were added during the concepting phase, however some risks were added later, so it can be said that during almost the whole course of the project additions were made to the register. The top row of the register can be seen in table 10 to give an indication of the aspects considered while stating the possible risks. The full risk register can be found in appendix A

Table 10: Risk register (top row)

A risk matrix with a traffic light scheme was made from the risk register. This matrix shows all the risks along with their likelihood and impact scores. There are three zones in the matrix: a red zone which contains all the risks that must be avoided at all costs, an orange zone with risks that need a solution should they occur, and a green zone with all the acceptable risks that can be faced during the project. The risk matrix can be found in the figure below and in appendix A.

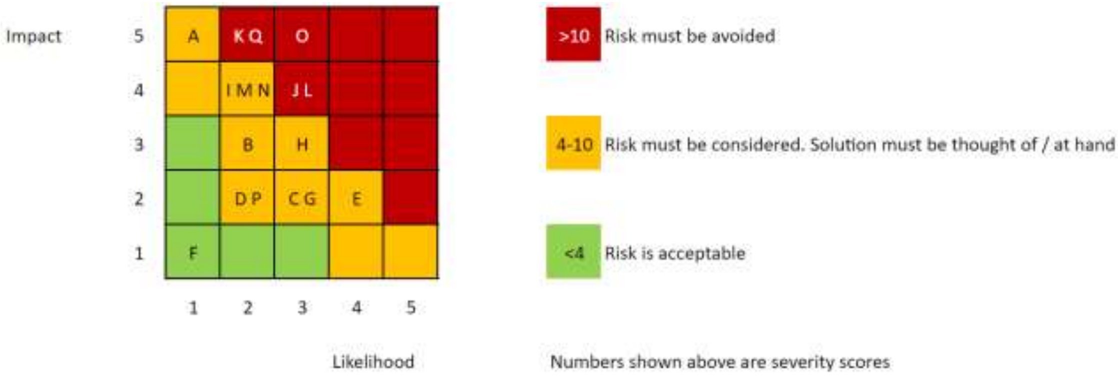

Figure 33: Risk matrix

This topic focuses on designing technology, which is usable, safe and desirable to improve the success of the product. It especially focuses on aspects of human perception that need to be considered when 'designing for people with special needs, such as individuals with functional limitations or elderly'. Because the device is aimed at people with Alzheimer's, we found this module to be very helpful while designing the more specific details of our product. These people are often suffering from limitations because of their affliction, but these patients are often elderly as well.

Special Topic - Human factors design

This topic focuses on designing technology which is usable, safe and desirable to improve the success of the product. It especially focuses on aspects of human perception that need to be considered when 'designing for people with special needs, such as individuals with functional limitations or elderly'. Because the device is aimed at people with Alzheimer's, we found this module to be very helpful while designing the more specific details of our product. These people are often suffering from limitations because of their affliction, but these patients are often elderly as well.

To make the product easy to interact with it needed to be as intuitive as possible. The three rules steps given to make sure interacting is easy are the following:

1. Eliminate interfaces where possible
2. Make interfaces as natural as possible
3. Adapt to people, don't make people adapt to the product

These were important to follow as we were working with mostly elderly people, who are often not experienced with interacting with technology. Elderly often have impaired senses, such as hearing, visual and physical impairments as well. The device aims to provide signals to alarm people if the stove was still on, which means that it was needed to ensure that these signals would be easily detectable for elderly. Because the product is aimed to help people suffering from beginning Alzheimer's disease, we needed to focus on what impairments these patients might have, and because it's more likely for elderly people to have this disease, elderly were a focus too. The device aims to provide signals to alarm people if the stove was still on, which means that it was needed to ensure that these signals would be easily detectable for elderly. Because the product is aimed to help people suffering from beginning Alzheimer's disease, we needed to focus on what impairments these patients might have, and because it's more likely for elderly people to have this disease, it was needed to keep that in mind as well to make our device useable for as many people as possible.

The information on Canvas [2] was studied and used to investigate the impairments of the target group more effectively. By watching the lectures and reading the material a clearer understanding of what problems could arise between the design and its users was achieved. By studying this module we learned how to detect and deal with these kinds of problems, allowing the group to make better choices for what kind of signals we wanted to send and it also helped to decide on the specific values of these signals, such as frequency and noise level.

The bracelet

This module was implemented when it was needed to choose and define the final design concept. Initially there were multiple signal concepts to choose from, including lights patterns, a small screen on the wristband, audio cues and vibrations.

During this module we stumbled upon the problem that a person's sight decreases with age, as well as the colors they perceive, with an increased overall yellow tone. Color coded messages would also require the group's attention, as they would need to be equally as helpful for people suffering from colorblindness [2]. This knowledge combined with the risk that a user might look away from the bracelet led to the decision not to use visual cues.

When it was decided upon the use of audio cues, this module was implemented again, this time to get a better understanding of the exact values these devices would need to work properly. Because the device is an alarm designed to always gain the user's attention, the choice was made to have the volume set at a predetermined level to prevent a confused user from turning it down and not hearing it anymore. Higher frequency alarms can be differentiated from background noises easier than the lower frequency alarms, but the frequency of these alarms should not exceed 4000 Hz [1]. People with hearing aids may still find it difficult to differentiate an audible cue from background noises, and auditory information that is not repeated or too short could be missed or misunderstood entirely. Research showed that most common smoke alarms have a frequency of 4000Hz [6], and a sound of 80dB is common for alarms. It also showed that ideally the frequency would be lower, somewhere between 500 and 3000Hz, and a 'pulsating' alarm instead of a steady alarm to attract attention. A pulsating alarm would ideally have one tone between 500 Hz and 3000 Hz and another tone between 300 Hz and 750 Hz. Another potential problem was that people with moderate hearing impairments are often not able to hear sounds in higher frequencies above 2000 Hz [7]. Most buzzers compatible with our device had variable frequencies but could only emit one tone constantly. For this reason, it was decided to use a steady alarm with 2000Hz, to ensure the elderly and most people with reduced hearing will still be alerted by the alarm and that they won't miss it.

To eliminate the risk of one signal being drowned out by the environment because of certain circumstances such as a loud radio, and to assist people who have difficulty hearing, we chose to add another signal in the form of a vibration motor. Unfortunately, the perception of vibration also becomes increasingly difficult for elderly [4], so this needed a significant vibration that would still be felt. Vibrations are easier to detect on the upper body, which worked out well because the bracelet will be worn on the wrist. One source of research also shows that the perception of vibration is relatively unimpaired at a low 25Hz and mostly declines at frequencies that are slightly higher [5]. However, further research proved that the vibration detection thresholds on the forearm in elderly people are significantly lower for 200Hz than 30Hz [4]. Because of this, it was decided to use a vibration motor with a frequency of 200 Hz.

The kitchen module

For the kitchen module a way was needed for the user to adjust the amount of time the sensor should wait for someone to come back to the kitchen before the alarm went off. Because of this, some form of interface in this part of the device was necessary. It was decided this interface would be most intuitive by turning a clock-like timer or by allowing the user to type a time. This presented the problem that older people tend to have trembling hands, making it harder to type. This could be fixed by including a keyguard to prevent them from typing in the wrong number.

The kitchen module then also needed a way to clearly indicate the function of the interface and what amount of time it was currently set to. Because the hub is placed a on the kitchen counter and because it wouldn't be very large, it proved difficult to create an interface which allowed the user to have a safe and large enough (readable) input screen. One considered option was using a small LCD screen to show current timer value, but eventually a switch system was implemented instead, where the user could choose between two clear time intervals, a 'short' time interval and a 'long' interval. The switch would remove the need for complex input from the user, as the user only needs to flick the switch either to the left or to the right. Furthermore, with only two possible time intervals it was much easier to clearly convey what setting the user had selected for the time interval.

Safety and risk analysis

General safety power

To supply the necessary power to the kitchen module, a power bank is used. The kitchen module is a stationary part of the device and is not worn by the user. It provides 3.7V, 10000mAh and 3.7W. This power supply was chosen to prolong the kitchen module's lifespan and ensure it has the required voltage to stay in contact with the bracelet, because the Wi-Fi shield necessary for this communication requires at least 3.3V. The power bank is a common product intended to be safely used by customers. It's placed inside of the kitchen module and will not be accessible to people unless they open the kitchen module, therefore it cannot be accidentally touched or interacted with. The maximum output of the battery is 5V and 2.1A, however because the device is not in contact with the user this should not be a problem.

When the power bank is completely empty it can be safely removed and charged in the charging station compatible with the power bank.

The bracelet has a buzzer which emits a loud tone. The buzzer emits a tone of 80dB with a frequency of 2000 Hz. Prolonged sounds above 70dB can damage hearing, and tones above 120 dB can induce immediate damage. While the buzzer cannot produce tones high enough for immediate damage, it can produce tones of around 80dB. Hearing loss may occur after listening to tones of 85dB for longer than eight hours [1]. The buzzer in the bracelet does not have the power necessary to emit a constant signal for so long, so it does not provide a threat. Furthermore, if the buzzer malfunctions and keeps emitting a signal, the bracelet can simply be taken off and put away.

Casing

The kitchen module shields the components within and is almost completely closed when in use. This protects the power source from getting into contact with splashing water or most other outside influences that could disrupt the system or create a dangerous situation. However, because the device has small openings to make room for wires leading out of it and to install the switch, it is not waterproof. While the casing protects the inside from droplets, if the module is submerged or exposed to a lot of water the risk of it getting inside and causing the device to short circuit is very high.

The same generally goes for the bracelet. While the bracelet does not have holes for electronics and wires, the cap can be screwed loose and is not airtight. The bracelet will shield the electronics from water, but if it would get submerged in water, the water could leak inside causing the device to short circuit.

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Design goal

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13. Appendices

A. Risk Management

Table 11: Risk schedule

Item	Risk	Objectives impacted	Impact (1-5)	Likelihood (1-5)	Severity (impact * likelihood)	Prevention / mitigation	Cost of response (time)
A	Prototype not delivered on time	All	5	1	5	Find an alternative to a physical prototype	2 weeks
B	Parts not delivered on time		3	2	6	Find alternatives for that part / implement other functions	1 week
C	Parts breaking or being broken upon delivery		2	3	6	Order new parts (if the budget allows it to) / implement other functions	1 week
D	Team member gets coronavirus		2	2	4	Discuss with course coordinator	2 hours
E	Code doesn't work properly		2	4	8	Rethink / remake the code	4 hours
F	Text message for caregivers is not clear enough		1	1	1	Rewrite the message	1 hour
G	Text message doesn't reach caregiver		2	3	6	Fix the code	3 hours
H	Ultrasonic sound sensor angle is too short to detect presence		3	3	9	Implement another way to sense presence	1 week
I	Sensors are not accurate enough		4	2	8	Implement another kind of sensor	1 week
J	Costs exceed budget		4	3	12	Make a thorough budget overview	3 hours

K	Electrical failure		5	2	10	Prevent the use of certain kinds of power supply	3 hours
L	User doesn't realize battery is empty / forgets to recharge battery		4	3	12	Create a better signal that clearly indicates battery is empty	2 days
M	Bracelet and / or hub run out of power too quickly		4	2	8	Minimize power cost or add power switches to both devices (will bring risk of forgetting to turn it on)	5 days
N	User doesn't notice the warning signals		4	2	8	Increase the intensity of the warning signals and/or lower the frequencies	1 hour
O	Usage of flammable materials near the stove		5	3	15	Use non-flammable materials near the stove / properly mount the materials so they won't move.	3 hours
P	The band of the bracelet breaks		2	2	4	use a durable material for the band and make to connection part bigger/stronger	3 hours
Q	Connection of housing to band breaks		5	2	10	make the connection big enough	1 week

Figure 34: Risk matrix

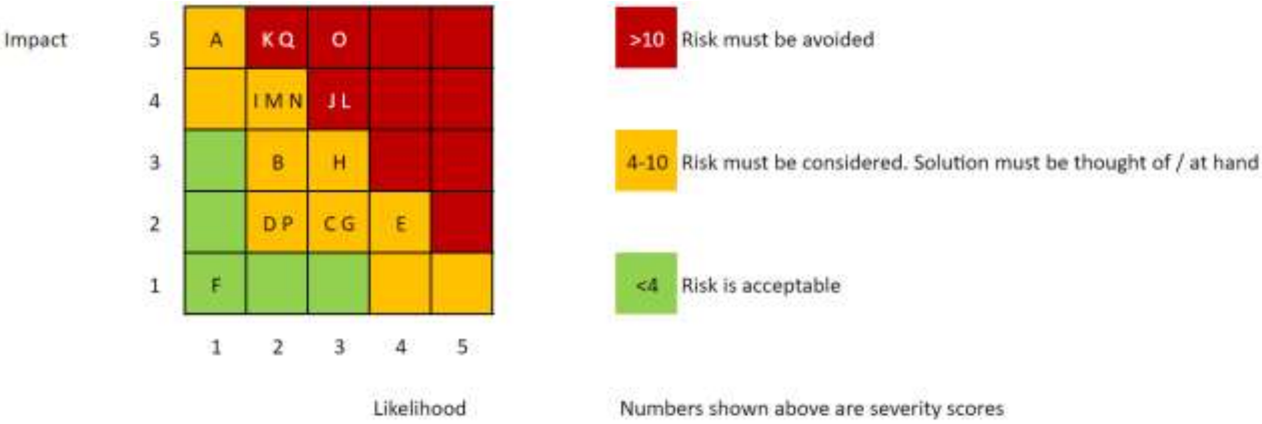
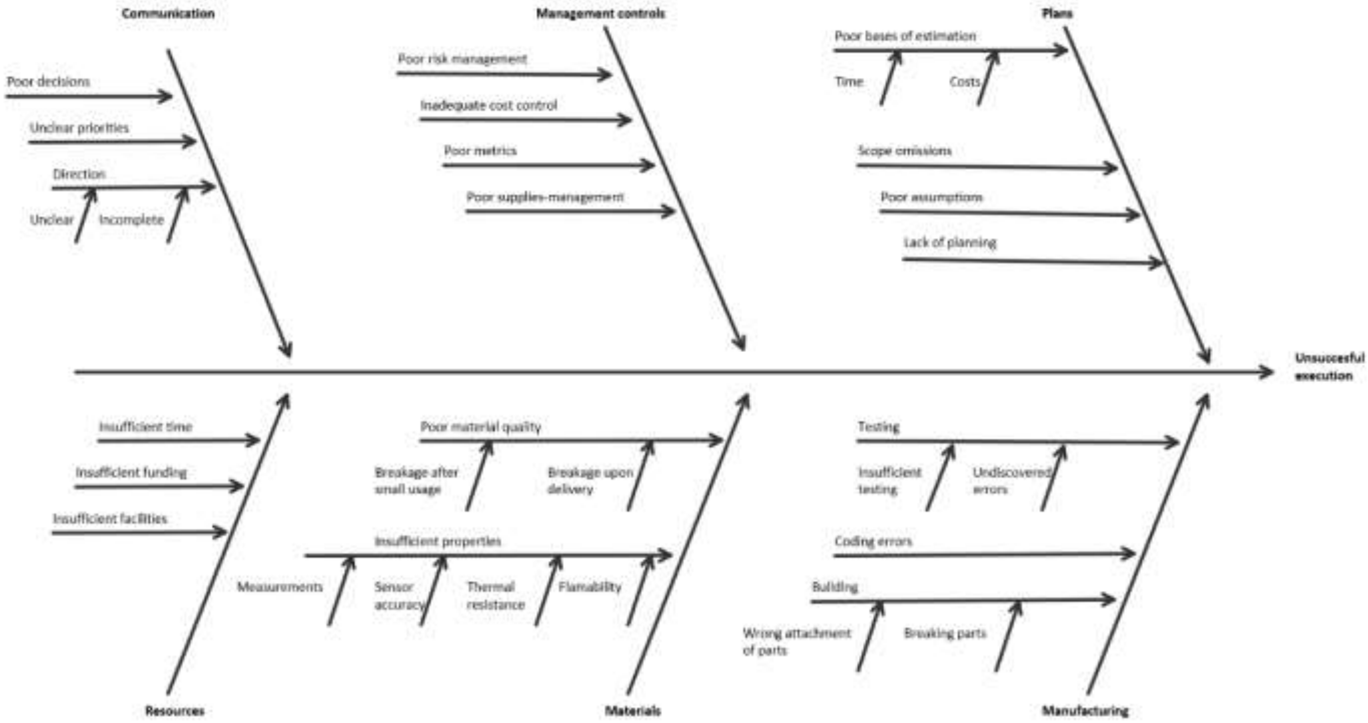
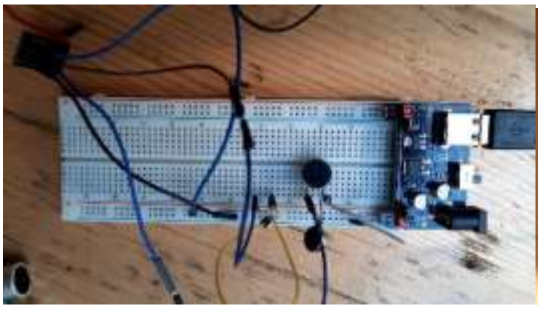


Figure 35: Fishbone diagram



B. Images final design and building process

Testing



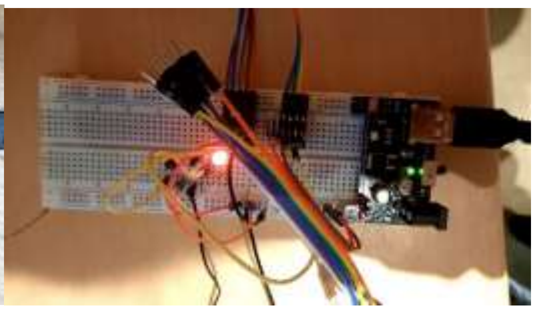


Figure 36: Test bracelet actuators

Figure 37: Test bracelet connection

The Hub

Figure 38: Front view hub

Figure 39: Inside hub with power bank

Figure 40: Side view hub

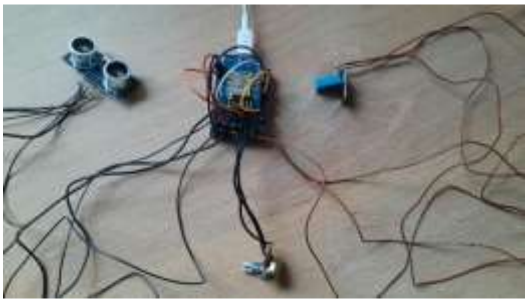


Figure 41: Electronics for in the Hub

Figure 42: Temperature sensor

Figure 43: Ultrasonic sensor

Figure 44: Outside view of the hub

The Bracelet

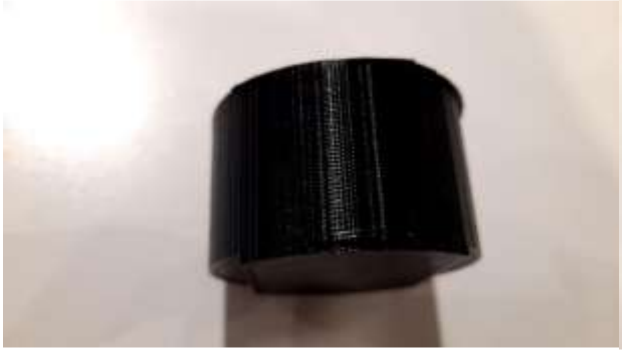


Figure 45: Side view of the bracelet

Figure 46: Side view bracelet 3D model

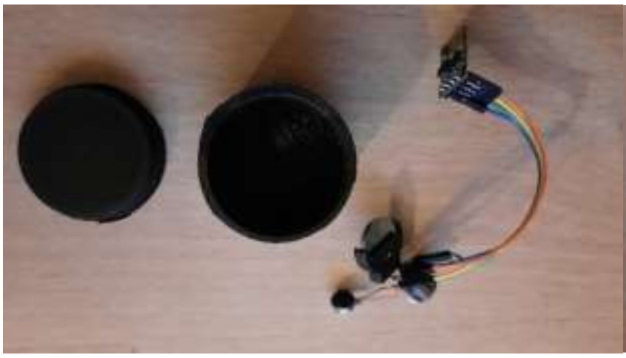


Figure 47: 3D model and electronics

Figure 48: Electronics for bracelet

Figure 49: Electronics in 3D model

Figure 50: Empty 3D model

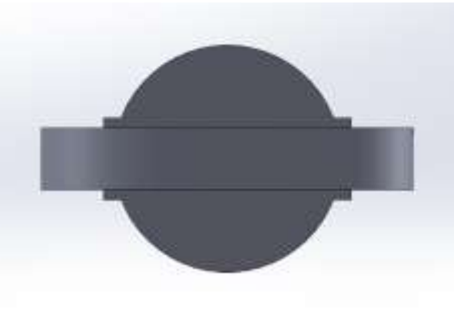


Figure 51: 3D model bracelet bottom

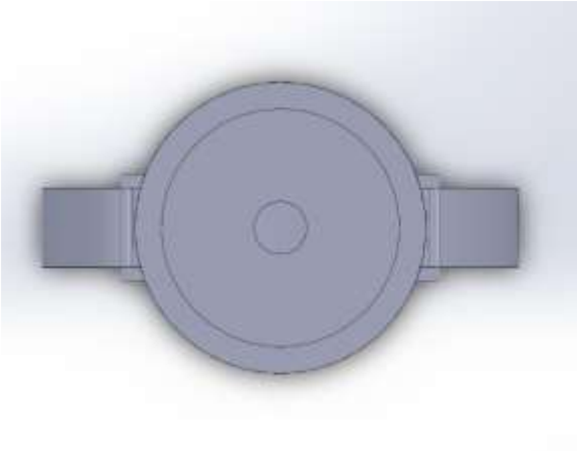
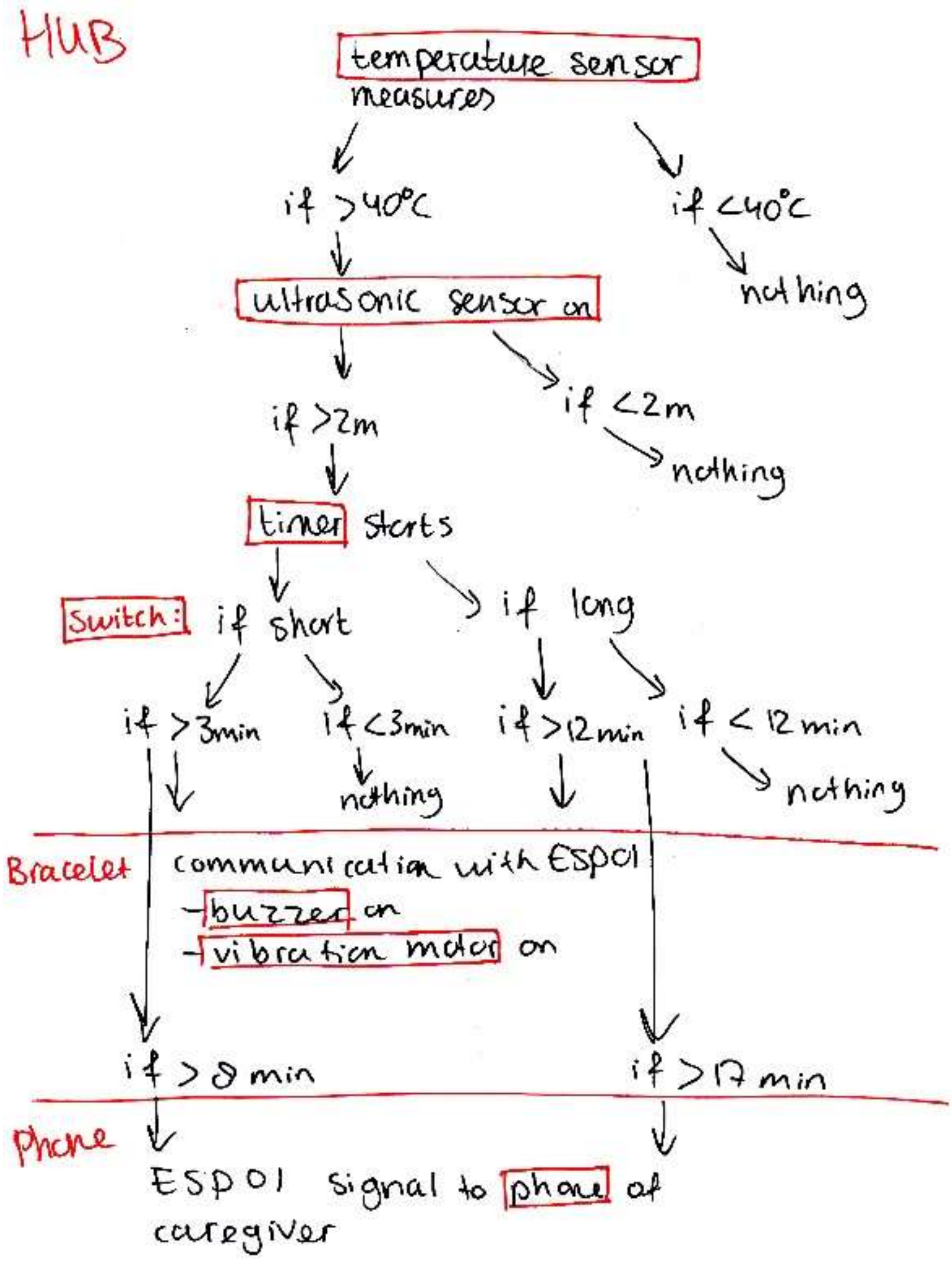


Figure 52: 3D model bracelet top view

Figure 53: 3D model bracelet side view

C. Code

Code structure



Hub

```
void setup() {
  Serial.begin(115200);                        // for debugging
  //wifi

  WiFi.begin(ssid, pass);                      // connects to the WiFi router
  while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
    delay(500);
  }

  Serial.println("Connected to wifi");
  Serial.print("Status: "); Serial.println(WiFi.status());             // parameters from the network
  Serial.print("IP: ");     Serial.println(WiFi.localIP());
  Serial.print("Subnet: "); Serial.println(WiFi.subnetMask());
  Serial.print("Gateway: "); Serial.println(WiFi.gatewayIP());
  Serial.print("SSID: "); Serial.println(WiFi.SSID());
  Serial.print("Signal: "); Serial.println(WiFi.RSSI());
  Serial.print("Networks: "); Serial.println(WiFi.scanNetworks());
  //rest
  Serial.println("Tempreature sensor is on");
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  dht.setup(tempPin, DHTesp::DHT11);                                   // Connect DHT humidity sensor to D4
  //Bracelet
  pinMode(vibOutPin, OUTPUT);
  pinMode(buzzer, OUTPUT);
}
```

```
//Engeineering design
//Group 76
//Code sensor

#include "DHTesp.h"                     // uses library DHT Sensor library for ESPx by beegee_tokyo
const int trigPin = D6;                 // pin the ultrasonic transmitter is connected to
const int echoPin = D7;                 // pin the ultrasonic receiver is connected to
const int tempPin = D4;                 // pin the DHT11 humidity sensor is connected to
const int analogPin = A0;               // pin that the potmeter is attached to
byte ledPin = 2;
const float thresholdTemperature = 23.0;   // the minimum temperature to detect cooking is started        //In Real Product: 40 degrees.
const int thresholdSwitch = 50;         // the minimum voltage of the potmeter defining switch is on long
const int thresholdDistance = 100;      // the maximum distance to define presence                      //In Real Product: 200cm.
int seconds;
unsigned long time_now = 0;
long duration;
int distance;
DHTesp dht;

//Bracelet
const int vibOutPin = D2;
const int buzzer = D6;

//WiFi
#include <SPI.h>
#include <ESP8266WiFi.h>
#include <IFTTTWebhook.h>
#define IFTTT_API_KEY "fvzhYQw_Vt2DQrVPdA-W62wqJxq1UUQkU1R5__hFLmw"
#define IFTTT_EVENT_NAME "Notificatie"
char ssid[] = "FRITZ!Box 7581 HW";          // SSID of your home WiFi
char pass[] = "29507345541553071418";       // password of your home WiFi

IPAddress server(192, 168, 10, 170);        // the fix IP address of the server
WiFiClient client; // Web Client
```

```
void loop() {
  int analogValue = analogRead(analogPin);
  Serial.print("Potentiometer value:");
  Serial.println(analogValue);
  //Serial.println("cooking started");
  delay(dht.getMinimumSamplingPeriod());
  float temperature = dht.getTemperature();
  Serial.print("Temperature:");
  Serial.println(temperature, 1);
  if (temperature > thresholdTemperature) {
    // Clears the trigPin
    digitalWrite(trigPin, LOW);
    delayMicroseconds(2);
    // Sets the trigPin on HIGH state for 10 micro seconds
    digitalWrite(trigPin, HIGH);
    delayMicroseconds(10);
    digitalWrite(trigPin, LOW);
    // Reads the echoPin, returns the sound wave travel time in microseconds
    int duration = pulseIn(echoPin, HIGH);
    // Calculating the distance
    int distance = duration * 0.034 / 2;
    // Prints the distance on the Serial Monitor
    Serial.println("Distance is on");
    Serial.print("Distance: ");
    Serial.println(distance);
    if (150 > thresholdDistance) {
      Serial.println("person away");
      if (analogValue = 1024) {
        Serial.print("Time in seconds: ");
        seconds = (millis() - time_now) / 1000;
        Serial.println(seconds);
        if ((seconds >= 20) && (seconds <= 26)) {
          Serial.println("Bracelet ALARM ALARM ALARM ALARM");
          //connect to bracelet
          client.connect(server, 80);   // Connection to the server
          client.println("on");
          Serial.println("Signal sent to bracelet");
          client.flush();
        }
        if ((seconds >= 480) && (seconds <= 484)) {
          Serial.println("Caregiver ALARM ALARM ALARM ALARM");
          IFTTTWebhook hook(IFTTT_API_KEY, IFTTT_EVENT_NAME);
          hook.trigger();
        }
      } else {
        Serial.print("12min timer: ");
        seconds = (millis() - time_now) / 1000;
        Serial.println(seconds);
        if (seconds > 720) {
          Serial.println("Bracelet ALARM ALARM ALARM ALARM");
          //connect to bracelet
          client.connect(server, 80);                              // Connection to the server
          client.println("on");
          client.flush();
          //Vibration motor
          digitalWrite(vibOutPin, HIGH);
          delay(1000);
          digitalWrite(vibOutPin, LOW);
          delay(1000);
          //Buzzer
          digitalWrite(buzzer, LOW);
          tone(buzzer, 1000); //1kHz
          delay(1000); //1sec
          noTone(buzzer);
          delay(1000);
        }
        if (seconds > 1020) {
          Serial.println("Caregiver ALARM ALARM ALARM ALARM");
          IFTTTWebhook hook(IFTTT_API_KEY, IFTTT_EVENT_NAME);
          hook.trigger();
        }
      }
    } else {
      Serial.println("person near");
      time_now = millis();                                        // reset timer
      //connect to bracelet
      client.connect(server, 80);                                 // Connection to the server
      client.println("off");
      client.flush();
    }
  } else {
    Serial.println("temperature low");
  }
  delay(2000);                                                    // needed for reliable temperature sensor readout
}
```

Bracelet

```
//Engineering Design
//Group 76
//Code Bracelet

//Connects to the home WiFi network.
#include <ESP8266WiFi.h>
String codeVersion = "Version 1.0  Oct 2020 by Amy";
char ssid[] = "FRITZ!Box 7581 KW";                    // SSID of your home WiFi
char pass[] = "29507345541553071418";                 // password of your home WiFi
const int vibOutPin = 0;                              // GPIO_0 pin3;
const int buzzer = 2;                                 // GPIO_2 pin5;
WiFiServer server(80);
IPAddress ip(192, 168, 10, 170);                      // IP address of the server
IPAddress gateway(192, 168, 10, 1);                   // gateway of your network
IPAddress subnet(255, 255, 255, 0);                   // subnet mask of your network

.
void setup() {
  Serial.begin(115200);                               // only for debug
  delay(10000);                                       // extra time to let you start the monitor
  Serial.println();
  Serial.println();
  Serial.println(codeVersion);

  pinMode(LED_BUILTIN, OUTPUT);                       // Initialize the LED_BUILTIN pin as an output
  Serial.println("Set monitor");

  // Connect to WiFi network
  Serial.println();
  WiFi.disconnect();
  WiFi.mode(WIFI_STA);
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.config(ip, gateway, subnet);                   // forces to use the fix IP
  WiFi.begin(ssid, pass);                             // connects to the WiFi router
  server.begin();                                     // starts the server
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println(".");
  Serial.println("Connected to wifi");
  Serial.print("IP: ");     Serial.println(WiFi.localIP());
  pinMode(vibOutPin, OUTPUT);
  digitalWrite(vibOutPin, HIGH);
  pinMode(buzzer, OUTPUT);
  digitalWrite(buzzer, HIGH);
}

void loop () {
  WiFiClient client = server.available();
  if (client) {
    if (client.connected()) {
      String bracelet = client.readStringUntil('\r');
      Serial.print("From kitchen hub: "); Serial.println(bracelet);
      while (bracelet == "on") {
        Serial.println("bracelet is aan");
        //Vibration motor
        digitalWrite(vibOutPin, LOW);
        delay(1000);
        digitalWrite(vibOutPin, HIGH);
        delay(1000);
        //Buzzer
        digitalWrite(buzzer, LOW);
        delay(1000); //1sec
        digitalWrite(buzzer, HIGH);
        delay(1000);
      }
      client.flush();
    }
    client.stop();                                      // tarminates the connection with the client
    delay(2000);                                        // client will trigger the communication after two seconds
  }
}
```

D. Links to ordered parts:

Table 12: Links to the parts of the kitchen module

Part	Link
Temperature Sensor	https://www.tinytronics.nl/shop/nl/sensoren/temperatuur-lucht-vochtigheid/dht11-thermometer-temperatuur-en-vochtigheids-sensor
Ultrasonic Sensor	https://www.tinytronics.nl/shop/nl/sensoren/afstand/ultrasonische-sensor-hc-sr04
Arduino with Wifi	https://www.tinytronics.nl/shop/nl/platforms/wemos-lolin/main-boards/wemos-d1-mini-v2-esp8266-12f-ch340
Wires	https://www.tinytronics.nl/shop/nl/kabels/prototype-draden/breadboard-draden-140-stuks-verschillende-maten-in-doosje
Breadboard	https://www.tinytronics.nl/shop/nl/prototyping/breadboards/breadboard-170-points-zwart
Project box	https://opencircuit.nl/Product/Project-box-zwart-160-x-95-x-55-mm
Voltage Regulator	https://www.tinytronics.nl/shop/nl/spanning-converters/step-down/ams1117-3.3v-spanningsregelaar-module-losse-headers
Powerbank	Bought in store, link not available

Table 13: Links to the parts of the bracelet

Part	Link
Vibrating motor	https://www.tinytronics.nl/shop/index.php?route=product/product&product_id=758
Wifi Shiel with IFTT	https://www.antratek.nl/wifi-module-esp8266-esp01
Battery	https://www.tinytronics.nl/shop/nl/batterij-en-accu/knoopcel/gp-cr2032-3v-lithium-batterij
USB to ESP01 Adapter	https://www.tinytronics.nl/shop/nl/communicatie/serieel/ch340-3.3v-ttl-usb-serial-port-adapter-voor-esp-01
Buzzer	https://www.kiwi-electronics.nl/piezo-buzzer
Battery Holder	https://www.tinytronics.nl/shop/nl/batterij-en-accu/batterijhouders/cr2032-lir2032-batterij-houder-voor-printplaat
Transistors	https://www.tinytronics.nl/shop/nl/componenten/transistor-fet/pnp-transistor-2n3906