KeeCo

- Assistive Technology -

cooking with cognitive impairments

TEAM 3

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Abstract

Dette projekt omhandler udarbejdelsen af et system af smart-objects, KeeCo, som samarbejder om at hjælpe en person med kognitive udfordringer igennem at lave en madret.

Kognitive udfordringer betyder at nogle dagligdags aktiviteter kan blive umulige at gennemføre. Grunden til dette kan være nedsat evne til at: huske, koncentrere sig, lære nyt og strukturere. Likeledes indbære det at personen har nedsat kritisk sans, tidsfornemmelse, rækkefølge fornemmelse, visuelt syn (visuel agnosi, hemianopsi og andre synsfeltsudfald), opmærksomhed til højre/venstre (neglect), initiativ og forhøjet træthed.

I dette projekt er det valgt at indsnævre dette til: nedsat evne til at huske, nedsat rækkefølge fornemmelse, nedsat tidsfornemmelse, nedsat logisk sans og mental træthed.

Det indledende tema for dette projekt var at udarbejde en "Socially assistive robot (SAR)" som skulle implementeres på et rehabiliteringscenter for unge med hjerneskader i frontallappen. Igennem den indledende research blev det afklaret at der var et større behov for at implementere et hjælperedskab i overgangen mellem at være på et rehabiliteringscenter og at komme hjem.

Herefter valgte teamet først at sætte fokus på personlig pleje og efterfølgende madlavning, da testpersoner ikke kunne findes til personlig pleje. Gennem yderligere indsnævring valgte teamet at give to eksempler på hvordan systemet hjælper gennem madlavning. En opskrift på pandekager og stegt flæsk med persillesovs var valgt.

Dette er mundet ud i et koncept bestående af 11 køkkenredskaber som kommunikere med en app og dermed guider og støtter en person med kognitive udfordringer igennem at lave en madret.

Preface

Reading Guide

The project consists of two main parts.
The "PROCESS REPORT", which documents the design process until the identification of the final proposal, encompassing continuous reflections and conclusions that led to the final concept, presented in the "PRODUCT REPORT"

APPENDIX, WORKSHEETS and TECHNICAL DRAWINGS are found on the enclosed USB, containing research, interviews, tests, technical drawings, etc.

References in the text follow the Harvard method.

Illustrations and pictures are numbered and described as: "Ill. number, name of illustration".

Table of contents

Pre-Phase

This chapter gives an overview of the point of departure from which this thesis project is developed.

0.1. Initial theme: "A robot for patients with Frontal Lobe Damage"

The initial theme chosen for this Master Thesis project is proposed by Karl Damkjær Hansen, Postdoc at AAU, Department of Electronic Systems:

> "A Socially Assistive Robot (SAR) for patients with frontal lobe brain injury living in a rehabilitation center"

Karl is working with the idea of developing a Socially Assistive Robot that can be inserted in different environments, such as rehabilitation centers and hotels. One of the cases is to create a robot to be placed in a rehabilitation center for people with frontal lobe injury. This case is identified as a good opportunity to explore. Prior to the starting point of this project, the team has received material from Karl regarding the concept [**Appendix 15**]. Likewise, a meeting was arranged in order to discuss opportunities, expectations from the collaboration and the respective anticipated outcome. The initial theme has afterwards been revised multiple times.

Karl's proposal

From the meeting and the exchanged material, the initial theme can be described as follow [**Worksheet no. 01**]:

• USER

The SAR robot is meant for patients with frontal lobe brain injury living in rehabilitation centers.
Due to the fact that gestures comprehension is located in the back of the brain, these abilities are preserved by the patients. Therefore, it is important to keep into consideration the impact of the robot's gestures.

• COLLABORATION

A collaboration has been arranged with a Rehabilitation center located in Tønder. This center hosts patients with frontal lobe injuries that are between 18 and 28 years old. Some of them are wheelchair users and all of them have no longer a long term memory, they rely just on the short term memory. They are no longer able to understand systems.

• ROBOT'S PURPOSE

Helping patients with their daily tasks and routines, reminding them of events, e.g. it could be a planner tool that the patients can use, since they are no longer able to understand systems, hence structure their day.

> Aside from very general and superficial information, Karl has no insight regarding the user's specific issues and needs.
> Likewise, he has no information regarding the context in specific, e.g. how does the center work, in order to sustain the choice of inserting a robot.

• THE ROBOT

The number of robots to insert in the rehabilitation-center has not been defined yet. The ideal solution, according to Karl, is to have one robot for each patient.
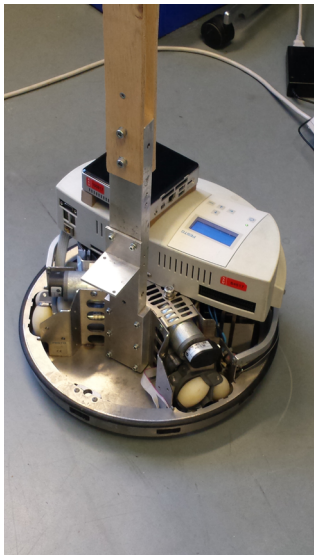Current technical components wished to be implemented in the robot are as follows (Ill. 01):
- Stewart platforms positioned at different heights, in order to give the robot the possibility to imitate a torso-movement.
- Large base, compared to the upper part, to ensure stability. The base will contain the main parts of the engine.
- The type of battery chosen according to the number of hours of autonomy that are expected. The robot will go in sleep mode to save energy when not in use.
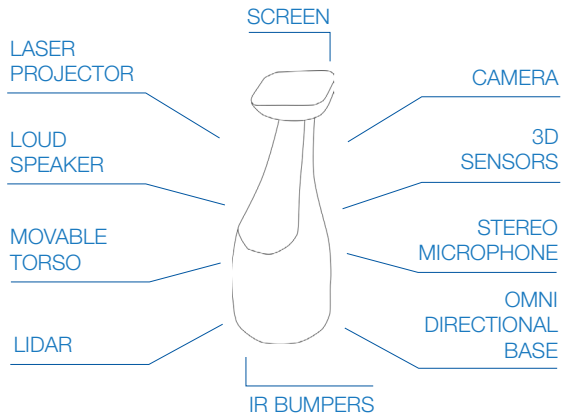
Ill. 01. Robot's basic technical components (from Karl's material)

Ill. 02. Karl with prototype   Ill. 03. Robot base

• TECHNICAL ASPECTS

Ensuring safety is one of the crucial aspects. Karl's robot (Ill. 02) is currently using a depth camera and a laser to scan the surroundings. The sensors in the robot's base (Ill. 03) are able to detect if the robot clashes with something. Furthermore, a laser could be used as a tool to catch attention and point towards objects.

• PHYSICAL APPEARANCE

In relation to the physical appearance, a series of questions arise. How can this robot be fitted into the environment it is designed for? Will the appearance of the robot make people expect it to have certain functions? If the robot does not meet the expectations, will people get disappointed? E.g. if a robot has arms, people will expect it to be able to use them to grasp things or perform other tasks that involve arms.

According to Karl, the purpose is to have as little features as possible, while ensuring to satisfy all the patients' needs. The aim is not to create a human-like robot, because the robot is intended to be used and perceived as a tool.
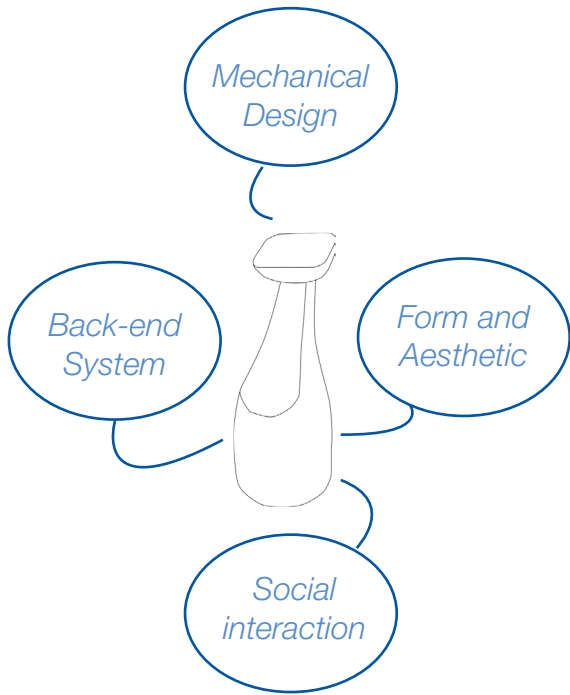
Ill. 04. Robot's research areas (from Karl's material)

> It is a different approach in dealing with a design process; the only available knowledge is regarding the technology.
> There is a complete lack of knowledge and insight regarding the user (issues and needs) for which the solution should be designed, as well as the context in which the solution should be inserted.
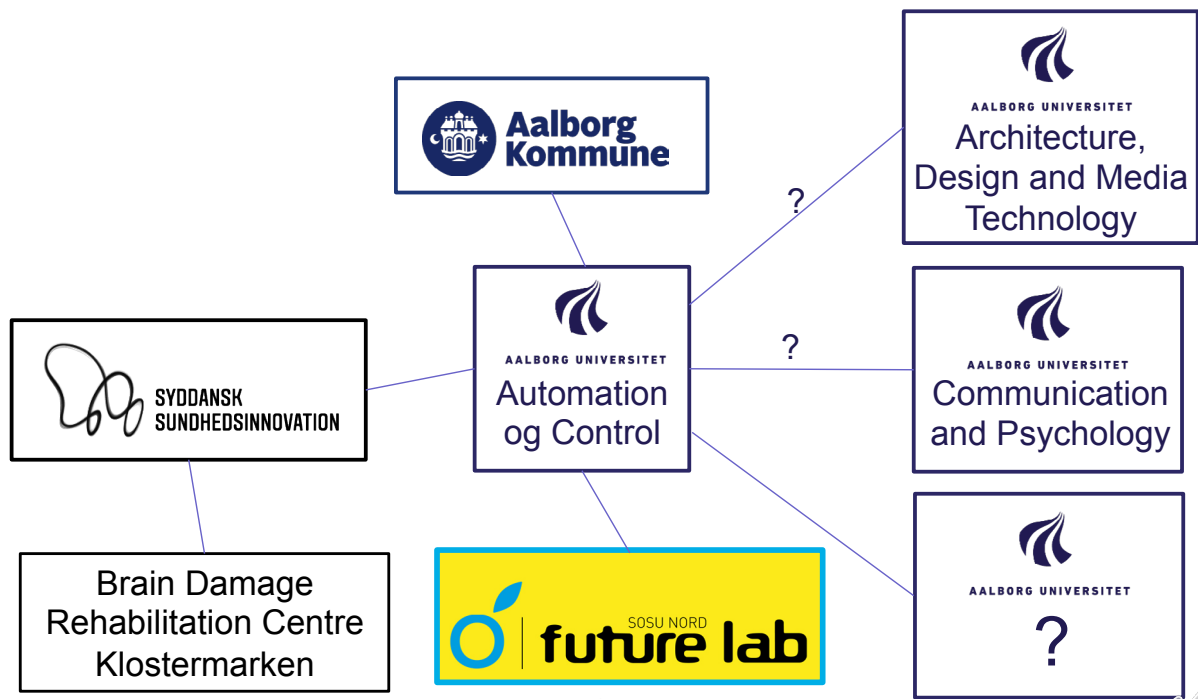
Ill. 05. Imagined collaboration network (from Karl's material)

The superficial insight regarding the user is based on general considerations indirectly reported. The center in Tønder has never been visited by Karl.

> The necessity of introducing a robot in this context for the specific users needs to be validated.

Research methods such as field study, interviews, observations and other tools will be used, in order to get a more satisfying insight regarding the context and the user. This will be used to define the needs and issues of the user that have to be met.

Conclusion

From the gathered material, an overall initial plan has been outlined, to organize the research effort and break down the main unknown topics of interest regarding the project:

• **Understand the injury** - Frontal Lobe Brain injury: What are the consequences? How is the person affected in practice?

• **Understand the context** - for which the robot is introduced: rehabilitation centers in which patients are either treated for a limited period, or have permanent residence.

• **Understand the technology**: Socially Assistive robots - their challenges, technical and aesthetic aspects, state of the art, etc.

Tech-push Design

This chapter investigates the main topics related to the initial theme, using field research, interviews, and online research, in order to gain insights on:

- What are Socially Assistive Robots (SAR)? Related issues and factors to take into consideration.

- What is Frontal Lobe Brain Injury? What are the consequences on individuals? How does the healthcare system assist them? Who are the stakeholders involved in the system? How is the system working?

- An initial proposal according to the collected data.

1.1. Socially Assistive Robots

Socially Assistive Robots (SAR) are robots which aim to provide assistance to people through social interaction (without physical contact). This type of robots can be considered as the result of an intersection between Assistive Robots (AR) and Socially Interactive Robots (SIR) (Ill. 01) [**Worksheets no. 02, 05, 07**].

Ill. 01. Socially Assistive Robots
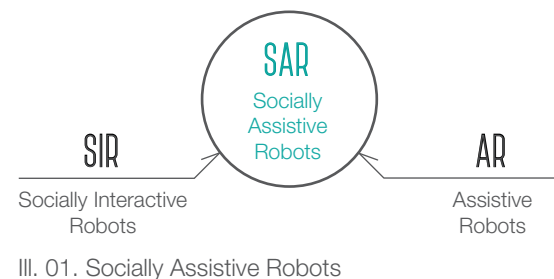
• **AR** aims to develop robots able to give aid or support to human users, such as rehabilitation robots, wheelchair robots and other mobility aides. These robots are intended for use in a specific range of environments, e.g. schools, hospitals, and homes.

• **SIR** aims to entertain humans through social interaction, by addressing to the human perception of robotics, particularly the difference in social sophistication between humans and social robots.

SAR

The goal of SAR is to provide assistance to human users as it is done by AR, but through social interaction as SIR, in order to create close and effective interaction with a human user, for the purpose of achieving measurable progress in convalescence, rehabilitation, learning, etc.

The implementation of SAR can be relevant when covering tasks where social interaction rather than physical contact is useful, e.g. recovery post stroke. For this reason, the interaction components that need to be developed within the SAR can be described by the following properties:
• Embodiment and personality.
• Emotion and dialog.
• Human-oriented perception.
• User modeling.
• Socially situated learning.
• Intentionality.

Factors to consider

Target Group - address various users, ranging in age, impairment and need. For instance individuals with physical or cognitive impairments (e.g. wheelchairs, robot manipulators) or in convalescent care, elderly, etc.

Task - the robots are driven by the needs of the user, such as physical therapy, domains where is needed repetitive exercise (e.g. post stroke patients) to meet rehabilitative goals.

Daily Life Assistance - robots can assist in daily cognitive and physical activities, e.g. help elderly with schedule planning and maintenance.

Emotional Expression - use robots to encourage emotional expression.

Sophistication Of Interaction - the most common interactive modalities currently employed in SAR are: Speech (conversation); Gestures (body language) e.g. ability to point and recognize the object of pointing; Direct Input: in some cases it is most appropriate e.g. when deciding among several locations on a map or when searching for a schedule.

Role - designing robots with special addressed roles such as: caregivers alongside doctors, nurses and physical therapists, therapy aids, social mediators, companions.

> Correctly defining the role of the robot in these situations is important for crafting its appearance and interaction modalities. The role may be defined by the task the robot is assisting with and the target group it is working with, together with the impression it gives through its appearance and behavior.

Challenges

There are several types of challenges that can be encountered during the development of such type of robot. The main ones are in regard to:

User Task Performance
• Engage the user effectively - establish and maintain a collaborative connection with the user.
• Achieve the goals of the specific activity / recovery, training, etc.
• Be responsive to the needs and requirements of both user and caretakers.

Level of Autonomy
Ideally, a SAR system requires no expert operator or extensive training for use. It should be self explanatory and capable of being started, stopped and configured by people already providing care, with a minimum burden placed upon them.
It should also conform with the changing routines and demands of the user and caretakers.

Embodiment versus Non-embodiment
Embodiment plays a key role in engagement. How that role translates into measurable outcomes in robot-assisted therapy, convalescence, and learning is yet to be explored, being one of the major areas of pursuit.
The robot's physical embodiment plays a key role in its assistive effectiveness. Inasmuch embodiment denotes not only physical reality but also participative status.

The authors of "Socially Assistive Robotics" state the following:

> *"Social behavior plays a fundamental role in assisting all people, including people with special needs. The robot's physical embodiment, its physical presence and appearance, and its shared context with the user, are fundamental for creating a time-extended engaging relationship with the user. An adaptive, reliable and user-friendly hands-off robot that can provide an engaging and motivating customized therapy protocol to participants in school, clinic, and ultimately, home environments, can establish a very complex and complete human-robot relationship."*

(Tapus,A.,Mataric, M.J., Scassellati, B., 2007)

Relevant Projects

Getting an understanding of the current SARs on the market and on the projects under development gives a better understanding of the present level of technology and on the possible direction that this project could take.

Bandit & Nico

Bandit (Ill. 02) is a hands-off therapist robot designed at University of Southern California / Interaction Lab. It has been designed to engage elderly users in physical exercises, while focusing on maintaining engagement through personalized social interaction.
A camera is located on the waist of the upper-torso humanoid robot, and is used to capture the movements of the user's arms during the exercise interaction, allowing the robot to provide appropriate performance feedback to the user. The robot's speech and lip movements are synchronized.
Nico (Ill. 05) has been designed for social interaction with one-year-old children.

Ill. 02. Bandit
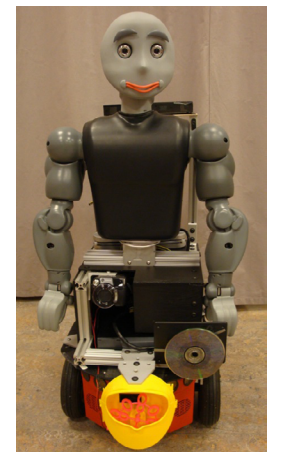
Ill. 03. Nico

Buddy

Buddy (Ill. 04) is a robot created by the French tech start-up Blue Frog Robotics, with the objective of providing a companion robot.
It is an open-source device, meaning that people can make their own programming, e.g. it can be programmed to be your personal assistant, remind you of scheduled appointments, patrol your home when you are away and alert you if something is out of the ordinary, as well as provide entertainment.
The robot has no arms, therefore it can be considered like a voice-activated smartphone. This limits the functions to verbal assistance and entertainment (Hurst, S., 2015).

Jibo

Jibo (Ill. 05) is a SAR for the home. It can see, hear, speak and relate to people, be used as a personal assistant, a messenger, to take pictures, to tell stories and to keep company. When people mention its name, it will pay attention to that person, similar to voice control on a smartphone.
It has a small built-in camera that registers movement. It is therefore able to patrol when people are not home. It can also use the camera to recognize people, take pictures and make video calls. Compared to the other robots mentioned, Jibo is much smaller and is not able to move around on its own.

Ill. 04. Buddy   Ill. 05. Jibo

Pepper & Nao

NAO (Ill. 06) and Pepper (Ill. 07) have been created by Aldebarans.
NAO is a small robot that is only 58 cm tall, while Pepper is 120 cm tall. Both robots are able to have different applications installed, to fulfill the user's specific needs.
Pepper is designed to live with people, to detect specific emotions and react to them. For instance, it will try to tell a joke if it detects sadness.
Pepper moves around using wheels while NAO has legs. Their ability is of constant adaptation and self-improvement, 'learning' from humans and acclimate to their behavior.
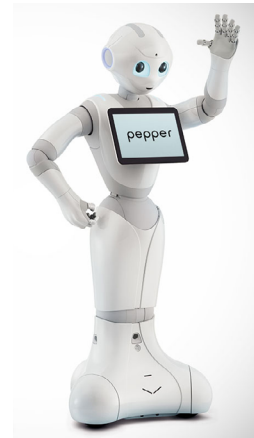
Ill. 06. NAO   Ill. 07. Pepper

Conclusion

Among the evaluated SARs, a possible visual reference is Jibo. According to the direction outlined so far, it is the only one that does not aim to remind in any way of a human like presence and it is clearly identifiable as a tool.

SAR represents a rather new field. The amount of projects and products available on the market is fairly restricted.

1.2. What is Frontal Lobe Injury?

The Frontal Lobe

The Frontal Lobe is positioned at the front of the cerebral cortex and constitutes one of the four brain's lobes. It is divided into three main areas: prefrontal cortex, premotor area, motor area (Ill. 08).
It is responsible mainly for:
• Motor functions and higher order functions.
• Planning, reasoning, judgment, impulse control.
• Memory.

Personality expressions and planning of complex cognitive behaviors are managed by the prefrontal cortex, while the execution of voluntary muscle movement is controlled by the premotor and the motor area (Bailey, 2014).

The Frontal Lobe is the most common area for brain injuries to occur (Healthline Editorial Team, 2015). The main causes are car accidents, falls, firearms, etc (Frontal Lobe Brain Injury, 2015).
Furthermore, it must be taken into consideration that, even though two patients are hit in the same area of the head, the consequences of the injuries variate from case to case. This makes it impossible to categorize the consequences experienced by different patients.
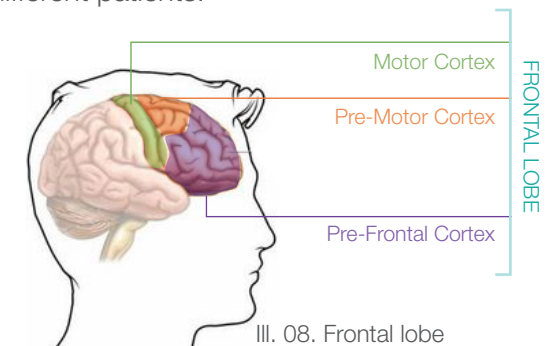
Ill. 08. Frontal lobe

Consequences of Frontal Lobe Injury

The effects of the injury vary, with the most frequently experienced being:
• Disturbance of motor functions, that can lead to loss of fine movements and arms, hands and fingers' strength.
• Display of little spontaneous facial expression.
• Difficulty in speaking.
• Impact on divergent thinking, flexibility, problem solving ability.
• Continuing interference with attention and memory, even after treatment.

• Diminishing (left frontal lesions: fewer, spontaneous facial movements and decreased speech ability) or excessive (right frontal lesions) "behavioral spontaneity".
• Difficulty in interpreting the feedback from the environment (repeating a response, risk taking, non-consent of rules, impaired associated learning, etc.).
• Impact in orienting ability of the body in space.
• Dramatic changes in the social behavior - especially when both of the sides are injured (Centre for Neuro Skills, 2016).

The individuals that experiences this type of injury, in the majority of cases, are not able to regain the same functions they possessed before the injury occurred.

Specialists in the health care sector are offering treatments and rehabilitation programs that help these patients regaining as many functions as possible. Neuropsychologists, psychiatrists, physical therapists, social workers and other figures play an important role in assessing the severity of the injury, in order to formulate a personal rehabilitation plan. Likewise, they are assisting the patient and relatives in the process of coping with their new life (Frontal Lobe Brain Injury, 2015) [**Worksheet no. 03**].

People suffering from the consequences of Frontal Lobe Injury mainly experience cognitive issues, which is evaluated to be the area of interest for defining the user during the design process.

It is desired to obtain a more personal understanding of the given target group, but since the collaboration with the center proposed by Karl (Tønder) is not an optimal solution due to the big distance, another collaboration with Senhjerneskade Center Nord in Frederikshavn has been achieved.

1.3. First visit to a rehabilitation center

Senhjerneskade Center Nord in Frederikshavn (Phase IV)

Ill. 09. Common area at Frederikshavn Center

Ill. 10. Private apartment at Frederikshavn Center

In order to understand the context and the user, a visit to Senhjerneskade Center Nord has been performed together with Karl Damkjær. At this visit, the environment intended for the robot has been investigated and The Double Telepresence Robot (Ill. 11a, b) has been presented to the residents, in order to observe the reaction to such technology and to get insight knowledge about the center, the residents and the staff [**Worksheets no. 08, 09, 10**].

The facility

The Center in Frederikshavn is a residential facility established in 2012 which offers 24 hours staff coverage and integrated day care for people that suffer from the consequences of brain injuries. The people living at the center are referred to as residents. They are not considered patients since the facility is their permanent home. The center comprises of 24 apartments, out of which around 20 are currently in use.

The Residents

The group of adults that are entitled the right to live in the center are adult citizens with acquired brain injury ranging from moderate to severe cognitive and functional decline. They have all completed the health care treatment and need further assistance in their daily life which can not be provided through other accommodation offers.

Collected data

In total, there are more than 80 employees working at the center. On an everyday basis, there are about 15 employees, without counting the administrative staff.

The core competencies of the different employees working at the center are:
• **Occupational therapists** - assess the residents' skills, functional level, need for compensating aids, accessibility in the home and its surroundings. Likewise, they help with training and daily activities.
• **Physical therapists -** instruct the residents in scheduled training such as balance, coordination, endurance and body functions. Likewise, they also assess the residents standing and sitting positions, walking, muscle strength, range of motion, etc.
• **Nurses -** assess the residents' need for care and personal assistance.
• **Pedagogues -** are working with initiatives that contribute to life quality, learning and personal development. This could be the development of social skills and relationships.
• **Social and healthcare assistants (SSA)** - are focusing on undertaking basic nursing tasks for each resident, as well as care assignments and tasks (SCN Living Lab, 2014).

The residents are very different one from another, they have different issues and degrees of independence. Some are physically functional, but suffer from severe cognitive impairments (e.g. memory, speech, etc.), while others are partially or fully paralyzed but have no or limited cognitive impairments.

Drastic diversity in issues and needs are found among the residents. This make it difficult to create a general robot to assist them all.

Testing the Double Telepresence Robot

The residents' reaction varied greatly from person to person, depending on their ability of speaking and level of interest in technology. Only one resident showed great interest and engaged himself in finding as much as possible about the robot and the idea behind it's implementation.

The following considerations to be implemented in the future concept have been discussed and observed while testing the Double Telepresence Robot:
• It should not interfere with the personal space of the person.
• It should not follow the person if the person doesn't desire such action.
• The appearance should be inviting, pleasant.
• When communicating with a person, the "face" should be directed to the person.
• Consider having body language.
• It should be autonomous.
• Different methods of communicating, by having more screens, etc.
• It should be able to understand the body language of each individual (e.g. some of the residents will only show, by moving their foot, that they feel uncomfortable.

Creating communication with the target user is crucial for understanding the needs. In this case, interfering with the usual routine of the residence can break a delicate equilibrium, provoking issues to their psyche. Therefore, the gathered material was mainly referred from the staff of the center [**Worksheet no. 11**].

Ill. 11a. Double robot
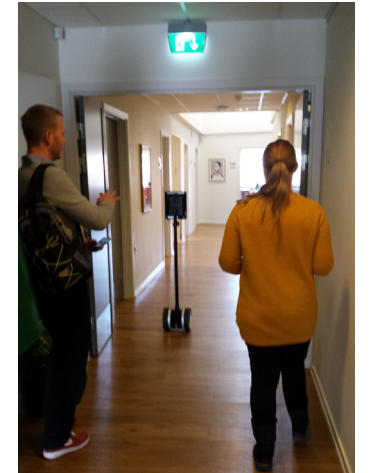
Ill. 11b. Test with Double robot

A robot is perceived as superfluous by the staff, mainly because is needed to be very sensible in interpreting the physical and emotional assistance that can best suit the resident's need in every specific situation, since these people do not respond to stimuli as an average person.

With the current information, a better understanding of the target group has been reached. Since most of the residents at the center suffer from traumatic brain injuries, it is decided to take a step back and explore brain damage at a greater level [**Appendix 16**].

1.4. What is Traumatic Brain Injury?

Traumatic Brain Injury (TBI) is an acute injury affecting the brain, which can cause very different consequences, depending on the severity of the damage to the brain. The main causes of TBI are car accidents and falls.

The consequences of TBI can affect all aspects of the life. The healing process is very different from individual to individual, since there are not two brain injuries that are alike and the healing process can differ greatly.

The symptoms may appear immediately after the injury (primary brain injury) or after days or weeks from the accident (secondary brain damage). There is the possibility for the person to not even realize that a brain injury has occurred (Traumatic Brain Injury.com 1, 2004).

TBis can be classified according to the gravity of the injury into mild, moderate or severe injuries.

Mild TBI (concussion or minor TBI)
• Loss of consciousness and / or confusion lasts less than 30 minutes.
• Physical, sensory, cognitive or mental symptoms, which might appear immediately after the accident or in few days or even weeks.

Moderate to severe TBI
The difference between the two is defined by the time span of loss of consciousness (Glasgow Coma Scale, 2014).

The moderate TBI presents:
• Loss of consciousness from 20 minutes to six hours.
• Glasgow Coma Scale of 9 to12.

The severe TBI presents:
• Loss of consciousness longer than 6 hours.
• Glasgow Coma Scale from 3 to 8 (Traumatic brain injury.com 3, 2004) [**Worksheet no. 14**].

Consequences
The consequences of TBI variate in the way they affect the individual's life (Ill. 12a).
As previously stated, in the majority of cases, individuals are not able to regain the same functions they possessed before the injury occurred.
Therefore, in some cases, the person will be able to return to his life in the community (with the help of some support). In other cases, the person will need to become a permanent resident in centers specialized for his care.

Ill. 12a. TBI consequences
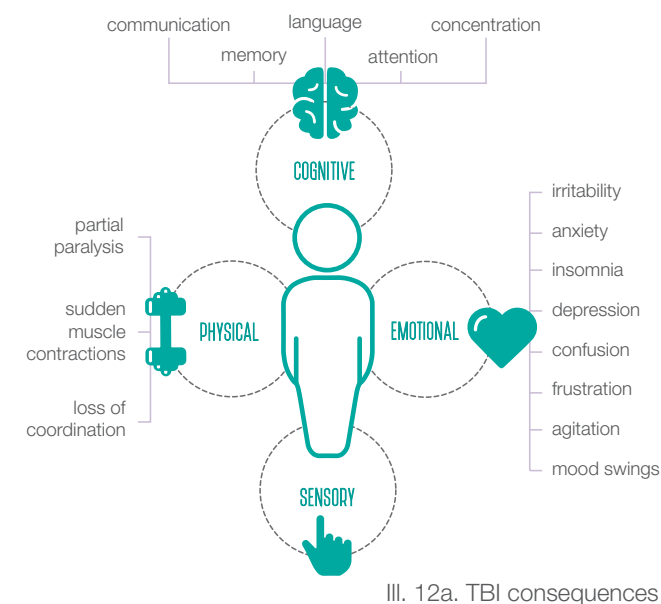
This investigation opened new directions to explore, in relation with more users and their specific issues and needs. Therefore, field research and interviews need to be performed within the healthcare system.

1.5. Understanding the system

The objective of the research is to gain knowledge regarding:
• How does the system work in relation to the process that the patient undergoes after TBI occurrence until the moment in which he is reintroduced in the municipality?
• Which are the stakeholders involved in the process and what is the role they play?
• How are the rehabilitation centers designed to assist the people?

The following data has been acquired by contacting Aalborg Sygehus [**Worksheet no. 06**], Senhjerneskade Centers in Northern Jutland, looking at documents provided by the Danish healthcare system (Sundhedsstyrelsen) and listening to a radio-program on P1 [**Worksheet no. 20**].

After the hospitalization subsequent to the Traumatic Brain Injury (TBI), the patient is evaluated and, according to the gravity of the injury, the patient can either:
• Be sent to a neuro-rehabilitation center (Aalborg Sygehus sends their patients to Brønderslev or Hammel).
• Return home, monitored with periodic MRIs.

The possible scenarios of the steps through which a patient undergoes after the occurrence of TBI are represented in illustration 12b.
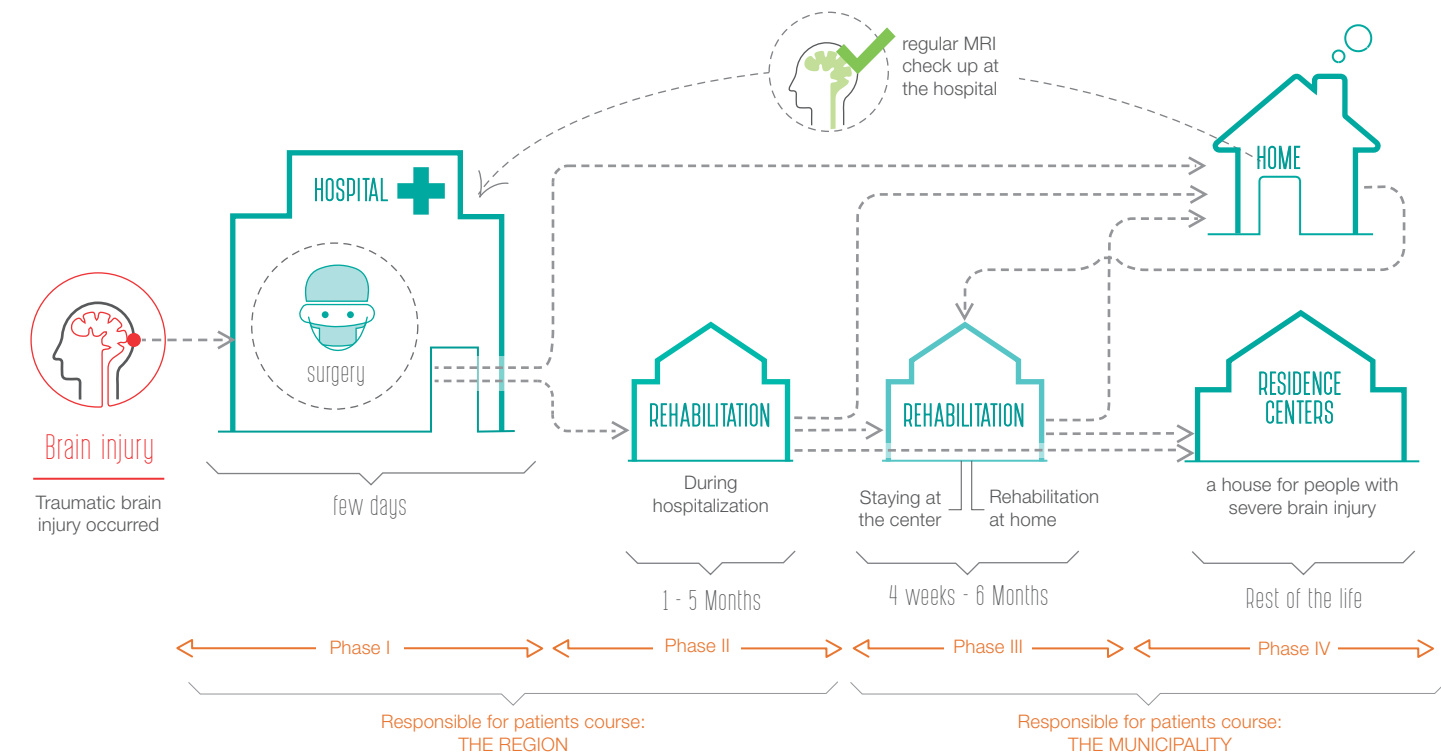
Ill. 12b. Care system for TBI patients

Current stage (Program Description)

REHABILITATION Phase IV

Cognitive Issues

USER ⋯ CONCEPT

USER

SAR

Lives permanently in a Rehabilitation center for people suffering from the consequences of TBI (Phase IV). Needs assistance in everyday life activities.

Ill. 13. Current stage

Intended as a tool to help and assist the user with planning and reminding about his daily routine (e.g. dressing, washing clothes).

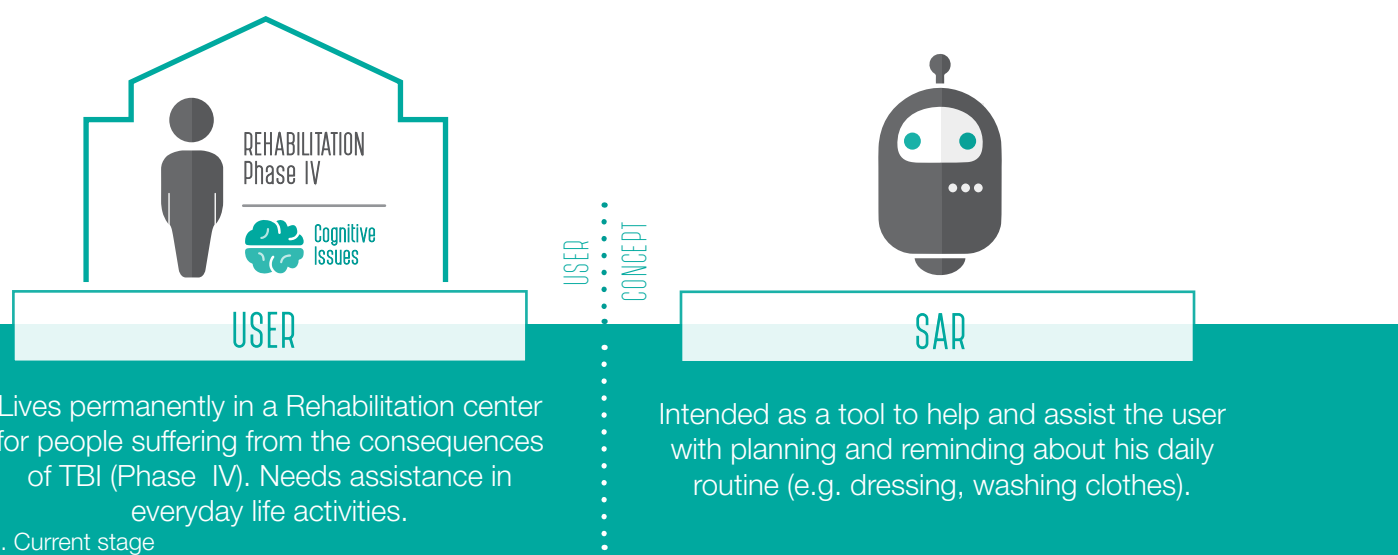Person suffering from the consequences of TBI living in a rehabilitation center [**Worksheet no. 10**].
• Either walking or active wheelchair user.
• Has problems with short term memory.
• Has problems with performing daily tasks, e.g. dressing up, making a coffee, etc.
The user is relatively active in relation to the support and care received.
The user needs moderate support for managing and structuring everyday life and activities.

Mobility / physical functional difficulties:
Vary from walking to being active wheelchair users.
The user needs from little to moderate verbal guidance in personal hygiene. Can be either self-reliant or in need of a little physical guidance.

Mental functional difficulties:
The user's memory varies form good to difficulties in short term memory. Has preserved most of the language skills and needs moderate guidance.

Communication and cooperation:
The user needs clear specific communication, otherwise he can have a slightly choppy or aggressive reaction. Likewise, if exposed to too much stimuli, he will react in such way.

Secondary User
Staff at the center - the concept can function as a collaborative tool to be exploited by the professional staff within the center in the management and organization of tasks.

Concept
The robot is intended to be recognized as a tool. For this reason, its physical appearance does not aim to imitate or simulate a human-like presence. The desired direction is to create an entity which physically "invites" users to interaction.

Project Scope
The robot is intended as a helping tool to assist and support the user in everyday life. Furthermore, it is intended to be a useful tool for the professional staff operating in the center.

The main tasks it should be able to perform are:
• Assist and help Traumatic Brain injured people in their daily life. This could include managing schedule, reminding daily tasks, sorting laundry, entertain, etc.
• Manage and organize daily tasks of the staff at the centers.

Since the conditions of the residents greatly variate from one another (mobility, verbal communication and cognition), the robot should be able to:
• Give clear and simple directions for tasks completion.
• Recognize non-verbal communication: sense body language and its meaning, recognize emotions and respond appropriately.
[**Worksheet no. 17**]

1.6. Identifying the gap

Brønderslev (Phase III)

Ill. 14. Brønderslev Rehabilitation Center

The reported data has been collected by interviewing Nicky Møller [**Worksheet no. 12**], a physiotherapist with 10 years experience at Brønderslev Rehabilitation Center (Ill. 14). He works with both patients who had suffered from stroke and from traumatic injuries. An occupational therapist has also been contacted, Anja Børkild Nielsen [**Worksheet no. 18**], whom has been working at the Center for 11 years.

Structure

This rehabilitation center treats different types of patients. Therefore the environment in the facility is not especially tailored for helping people suffering from TBI.
Patients arrive directly from the hospital and, in some cases, they will go to another center afterwards, e.g. Hjerneskade center, if they do not get better.

There are currently 10 out of the 37 hospitalized patients which suffer from brain injury. They are clustered in the same area in order to be provided with the specific care they need, with more focus on cognitive problems.

The statement: *"it is not possible to categorize the patients according to common issues"* is concluded again. Every person experiences very different issues at different degrees of intensity.

Assistance

The professionals assisting the patients are: physiotherapists, occupational therapists, nurses, doctors, neuropsychologists (Ill. 15). The professionals at the center make a weekly schedule for the patient to follow. The schedule is made in co-operation with the patient.

There are goal meetings set with the patient, where three or four major goals are established, together with a series of minor goals. The schedule varies in intensity, depending on the status of the patient. Every three weeks there is a status meeting to evaluate the patient's improvements.

"Here it is like a hotel, we do everything for them and we help them whenever they need. They are never left alone."
Nicky Møller

When the patient goes back to the community, he will still get professional help. Usually two - three times a week, around one hour each time, depending on how severe the injury is. Depending on the case, they do the training either in a center or at home.
With all this, the training after the patient is sent home is not enough because at the center the training is done almost every day, for around 20 hours a week.

"Having a strategy of reintroduction to everyday tasks would be the best thing. Because it is problematic to transit from a day to another, from a situation where you are served and helped in every situation to one in which you have to do everything by yourself. This is currently a big issue, especially for patients with cognitive problems".
Nicky Møller
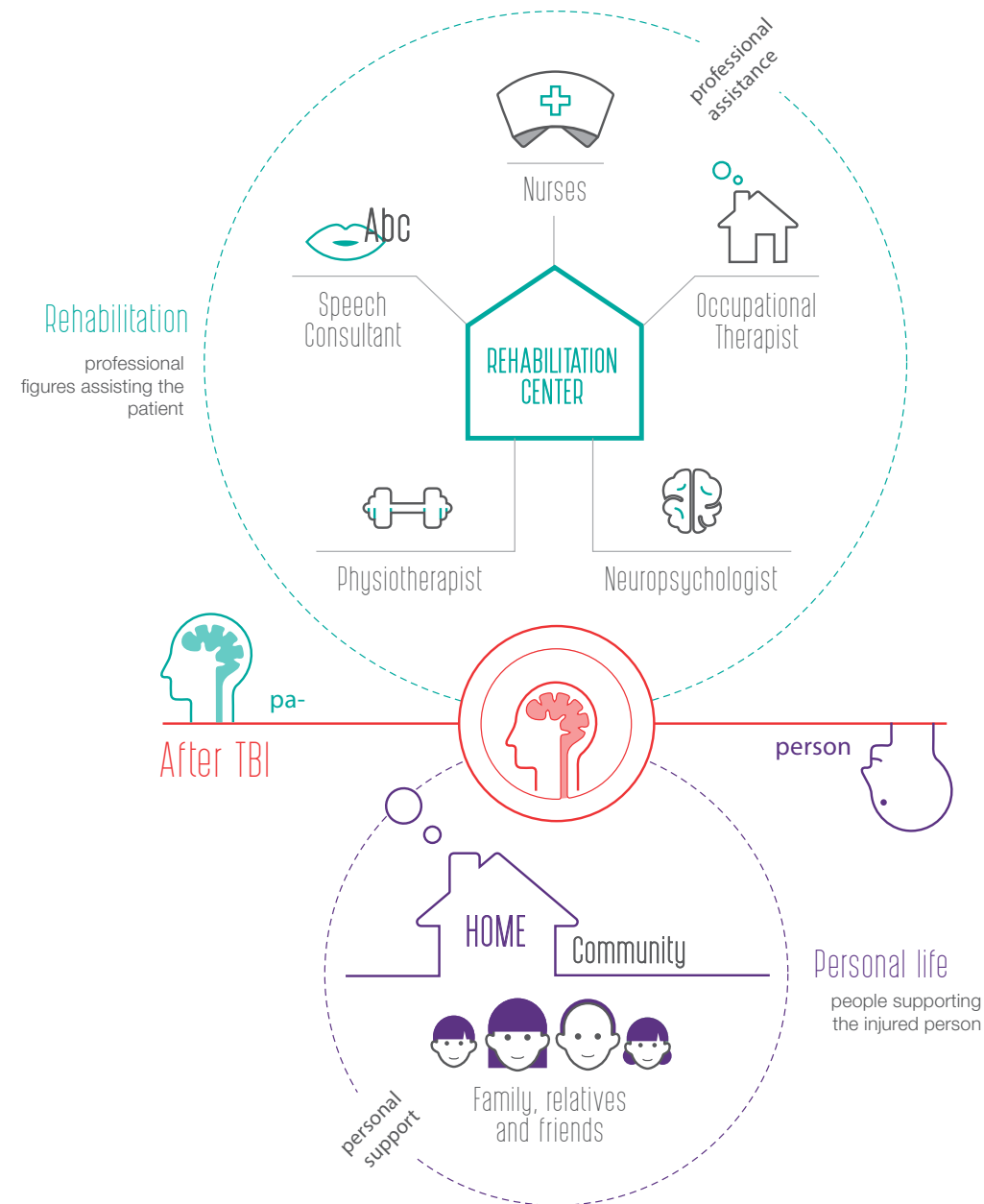
Ill. 15. Stakeholders surrounding the patient

> The main concern regarding the training of the patient is that in the center they do specialized training to achieve goals, while out in the community they do generalized training.

Patients

Patients suffering from TBI stay in the center from a minimum of one month to a maximum of four / five months, depending on the severity of the injury.

Patients stay at the center during the week and if their condition is evaluated as good enough to be spending some time at home, then they can go home to spend the weekend. Prior to this, there is an inspection of the house from the center to ensure that the house is suitable and prepared to welcome the person suffering the injury. If the patient is not evaluated as ready to spend time home, then he will not go home during the weekend.

Often, in the beginning of reintroducing the person in the environment of the house, he is sent home just for few hours and the time spent is progressively increased along time.

> *"It would be good to train them in their own homes but this is not possible for a question of resources"*.
> Nicky Møller

The hospital, in collaboration with the center, the municipality and the relatives, decide when the patient is ready to return to the community.
The time spent home by the patients is crucial for reporting to the professionals in the center what are the difficulties that they encounter in their everyday life.

Occupational therapy

The occupational therapist is the professional figure that helps the patient regain the ability to perform tasks that are part of the everyday life, for example personal hygiene, cooking (Ill. 17), dressing, house cleaning, shopping. They can also practice recreational activities which are of their interest (Ill. 18), such as painting, knitting, sewing, gardening, etc.

> The patient desires to become independent as soon as possible in the basic activities of everyday life, such as toilet visits, personal hygiene, cooking, cleaning, etc.

Ill. 16. Assistance gap

Ill. 17. Training kitchen

Ill. 18. Room for recreational activities

Conclusion - the gap

From the gathered material, a gap between the level of assistance provided in the center and the one offered when the patient is reintroduced in the community has been identified (Ill. 16). The cut of resources for the rehabilitation system made this gap be even more prominent. It represents a great concern from the professionals point of view, as they consider that the person is not receiving the appropriate support.

> Identifying and choosing a specific issue or set of issues that characterize the user is crucial for the further development of the project.
> Everyday activities pose the most critical areas for the patients to master, and for this reason they are identified as potential direction for the project.

1.7. Ideation

An ideation round based on the acquired knowledge has been performed, in order to put on paper the initial ideas that emerged [**Appendix 12**].
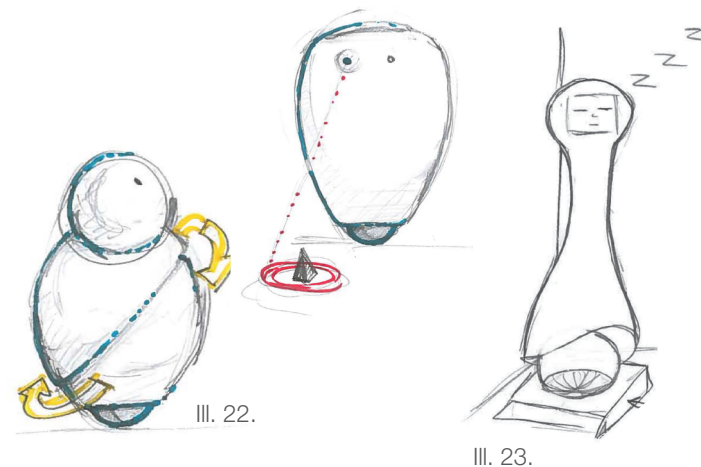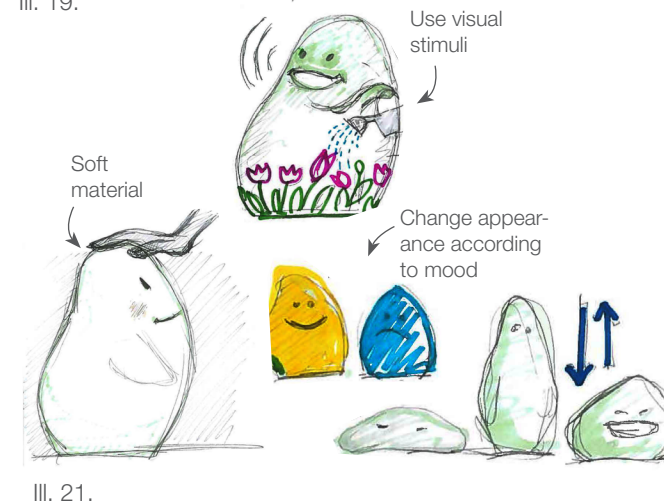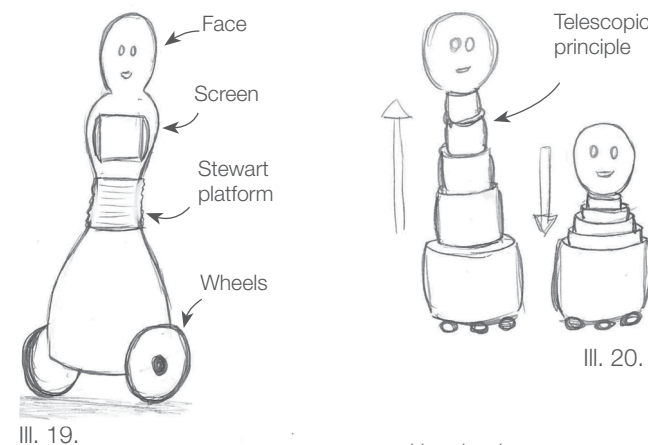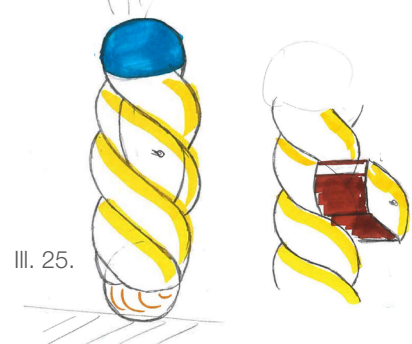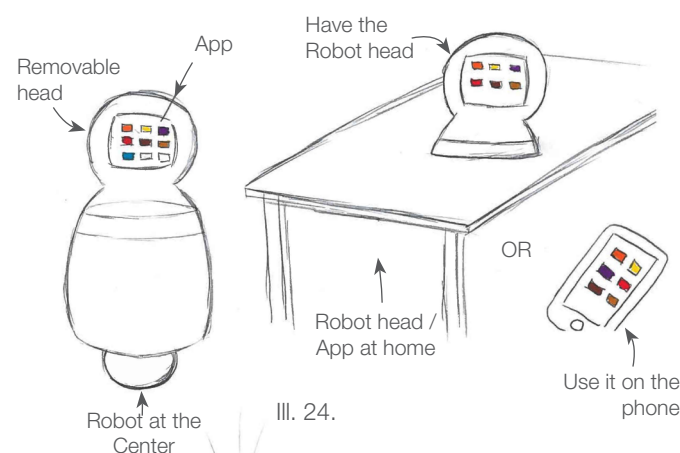
Considerations for ideation

Skills:
• Able to gain attention.
• Able to point at objects (Ill. 22).
• Communicate mainly through visual stimuli (reflect on use of sounds and voice) because they are the one most easily understandable.
• Able to interact with users both on wheelchair and standing (Ill. 20).
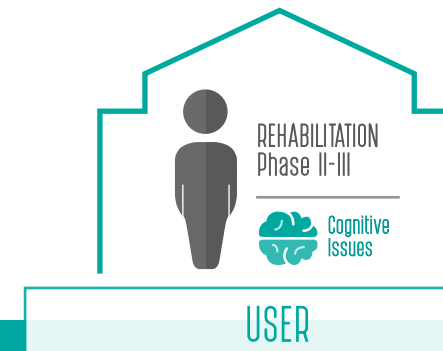
Physical appearance:
• Merge to the context.
• Use colors to reflect mood, e.g. if a task has been done well or not (Ill. 21).
• Have a soft outer cover (e.g. silicone like) so people would not get hurt if hitting it, and is more pleasant at touch than a hard surface (Ill. 21).
• Display the information e.g. on screen, with a projector, etc. to show tasks (Ill. 19, 21, 23, 24, 25).
• Not appear intimidating (Ill. 19, 21, 22).
• Use visual stimuli.
• Have an app for each need.
[**Worksheet no. 13, 15**]

Face
Screen
Stewart platform
Wheels

Ill. 19.

Telescopic principle

Ill. 20.

Use visual stimuli
Soft material
Change appearance according to mood

Ill. 21.

Ill. 22.

Ill. 23.

Removable head
App
Have the Robot head
Robot head / App at home
OR
Use it on the phone
Robot at the Center

Ill. 24.

Ill. 25.

The result from the ideation rounds was presented at the first Status Seminar [**Appendix 01**].

Current stage (Status Seminar 1)

REHABILITATION Phase II-III
Cognitive Issues

APP 1   APP 2   APP 4   APP 5

USER / CONCEPT

USER

In transition from rehabilitation center to reintroduction in the community.
Cognitive impairments - needs support to perform tasks of daily routine.

Ill. 26. Current stage

SAR - smartphone analogy

A tool for helping patients in the transition to the home environment.
App can be installed according to specific issues.

Person with the age from 15 to 24 years old, that is concluding his stay at the rehabilitation center and will soon be reintroduced to the community.

Impairment
• Not physically impaired.
• Able to communicate verbally.
• Cognitive issues:
- Confusion regarding what he has done (e.g. put on deodorant multiple times because he has forgotten he did it already) or needs to do.
- Insecurity or lack of understanding regarding how to perform a task, which steps to perform and their sequence.
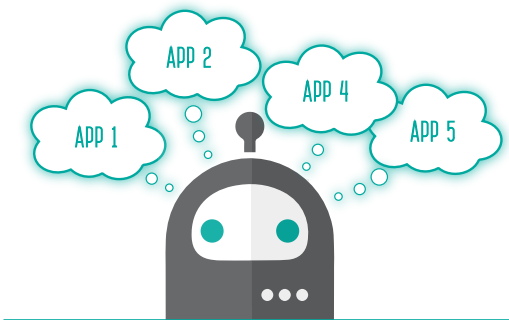• Roughly able to use technological devices - smartphone / tablets.

Issues
• Does not know when is the appropriate time in which to perform a task (e.g. want to shower in the middle of the day even though the action has been performed in the morning);
• Does not remember sequence and order of steps that need to be performed in order to complete a task (e.g. put socks before shoes).

Wishes
Regain independence in the basic everyday activities as fast as possible: toilet visits, get dressed, personal hygiene (showering, brushing teeth, etc.).

Needs
Specific communication / description of steps when performing a task.

The robot is meant to help the user by providing information and directions on how to perform tasks of different types that are part of the daily routine, e.g. showering, scheduling, etc.
Different apps can be installed on the robot's platform. Each app is designed for assisting in a specific task.

The robot is thought to be introduced at the rehabilitation center by the occupational therapist and will follow the patient at home in order to mitigate the gap in the level of assistance from the center to the one back in the community.
Thereby, the person will be able to get familiar with the product from the center, by it being part of the rehabilitation training. And when returning to the community, the user will not feel completely 'abandoned'.

Ill. 27. Follow the patient home
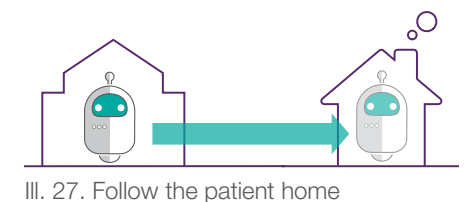
The need for the product may greatly variate: some will need the product for a limited amount of time if improving, others might need it the rest of their life.

Practical applications

At the center
- Direction guidance.
- Help the caretakers monitoring patients.

At home
- Sorting laundry.
- Prepare grocery shopping list.
- Monitoring.

Home & center
- Record important moments.
- Video call the family.
- Medication reminder.
- Rehabilitation helper.
- Reminder of daily schedule.
- Daily activities guide.

User case

REHABILITATION EXERCISES
ASSIST DURING EXERCISES EXECUTION

show how to perform exercises, motivate and remind person

DAILY SCHEDULE
HELP ORGANIZE AND REMIND DAILY SCHEDULE

remind appointments, activities etc.

ACTIVITIES GUIDANCE
1 > 2 > 3
GUIDE PERSON IN PERFORMING TASKS

explain steps to reach a result (e.g. take shower, make coffee)

Ill. 28. Practical application and user cases

Conclusion

From the collected data, the choice of placing a robot technology in the context of people suffering of Traumatic Brain Injuries results as forced.

Rather than a 'Technology-Push', the team has decided to take a step back and look at Assistive Technology, as a broader field.

By following the designer approach, the team decided to focus on gaining a better insight of the user and then propose a solution derived from the identified issues and needs.

Problem Based Design

This chapter contains a set of ideations regarding assistive technology, together with further investigation of the user, which is rephrased according to the collected data.
Furthermore, the development of the concept is based on a specific task in order to provide a valuable solution.

2.1. Assistive technology

The term 'Assistive Technology' technically refers to any item used by a person with a disability to increase independence and to make the tasks of daily living easier. When considering people with Traumatic Brain Injuries, it tackles cognitive, emotional, sensory and motor impairments. It can be used for traveling, participating in recreational and social activities, learning, working and communicating with others.

Assistive technology can be found in a variety of applications, from a very basic case, as simple and low-tech as a spiral notebook, arriving to the most extreme case of a very sophisticated computer-powered vocal assistant to aid with communication [**Worksheet no. 19**].

MOBI:DO

MOBI:DO [**Worksheet no. 35**] is one of the existing apps created to aid individuals with cognitive difficulties when performing different tasks. It is used for daily structuring, homework, recipes, laundry, task list and other tasks by people suffering from ADHD, autism, acquired brain injury, mild dementia and learning disabilities.

The guidance in the app offers the possibility of creating a task and breaking it down in minor steps and specific details, depending on the individual's needs and difficulties. In fact, MOBI:DO is addressed to caretakers / staff whom can create their own guidance for their patients.

Observations
• No overview on the process - what has been done? How many steps are missing to complete the task?
• It is not possible to go back to the previous step in the task.
• Requires multiple touch interaction in a single step within the task.
• Still picture accompanied by text not always explanatory in a satisfactory manner.
• Every task works with a QR-code that needs to be scanned, therefore they must be available in the house.
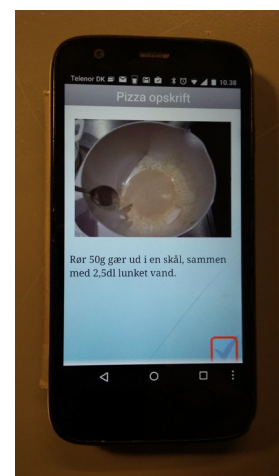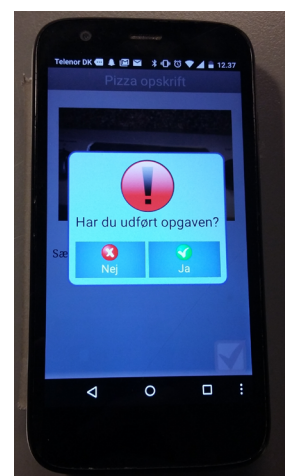

Ill. 01. MOBI:DO
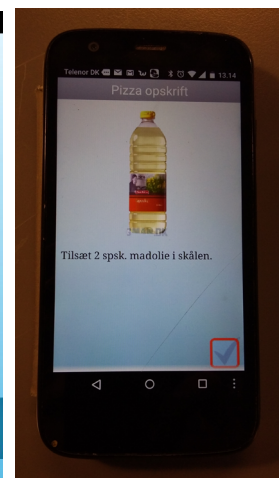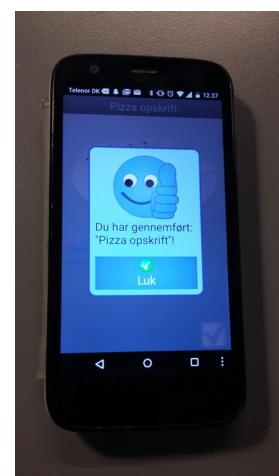

Ill. 02. Step Pizza recipe 1

Ill. 03. Check step

Ill. 04. Step Pizza recipe 2

Ill. 05. alarm box

Ill. 06. Task completed

2.2. Choosing a focus

By focusing on the user outlined so far, in order to provide a valuable solution, the area in which the product should help needs to be narrowed down.

Therefore, the previously identified relevant tasks - namely the one trained by the occupational therapist in the rehabilitation center - have been evaluated according to several criteria, in order to identify the most suitable ones to cover (Ill. 11b). These criteria span from testability to relevance, according to different stakeholders [**Worksheet no. 24**].

According to the findings obtained from the graph, the decision has been to cover two activities within the personal hygiene domain: showering and tooth brushing.

Ideation on Showering & Tooth brushing
Starting from the described user, a round of ideation regarding a product that could guide the user in performing the two tasks has been performed [**Worksheet no. 29 and 30**].

Considerations taken into account during ideation
The product could be used for both tasks (it could be movable or not). Its configuration should be performed before use, so to suit specific needs of the user. The product should be able to:
• Guide through the task's steps.
• Give confirmation that the steps have been performed correctly.
• Monitor that the steps are performed correctly, and if not, give input for correction.
• Multi-modal interaction to fit to different users' needs (e.g. a combination of visual and verbal instructions).
• Lower as much as possible the degree of complexity when performing a task.
• Remind when is needed to perform a task.
• Do not jeopardize patient's privacy.
• Not stigmatizing.
• Able to draw attention to itself (establish an authority so that the person will actually follow the instructions and not ignore them.
• Movable or fixed in one place.
• Compatible with other devices owned by the user.
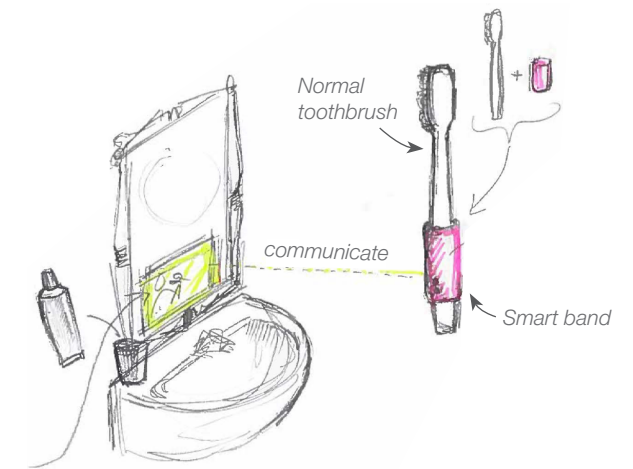
Ill. 07. System of Objects for tooth brushing
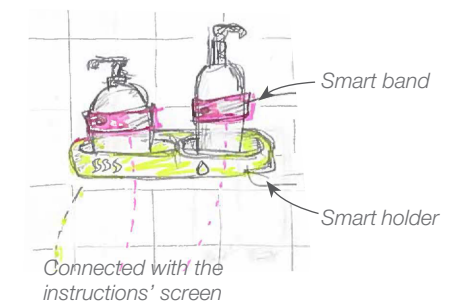
Ill. 08. System of Objects for showering

Ill. 09. Smart dispenser A

Ill. 10. Smart dispenser B

Ill. 11a. Smart holder

CRITERIA vs TASK matrix (Ill. 11b. Choosing the task)

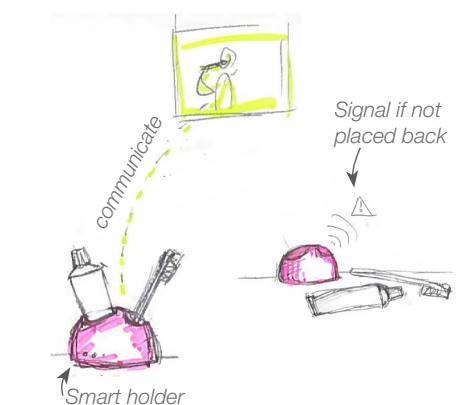| CRITERIA	SHOWERING	BRUSHING TEETH	TOILET VISIT	DRESSING	COOKING	CLEANING
Task's Reiteration	2 - 6 times/week	2 - 3 times/day	6 - 8 times/day	2 times/day	3 - 6 times/day	1 time/week
Expand to other tasks	Cover bathroom activities	Cover bathroom activities	Cover bathroom activities	Can be performed in different places (ironing)	Big task (contain several sub-tasks: different recipes etc.)	// //
Relevance — User	high	high	high	medium	medium	medium
Relevance — Kommune	high	high	high	medium	medium	low
Testability	difficult	medium	difficult	medium	easy	easy
Promote — User	easy	easy	easy	easy	easy	easy
Promote — Center	easy	easy	easy	easy	medium	difficult
Promote — Kommune	easy	easy	easy	easy	medium	difficult
Gain knowledge	medium	easy	difficult	easy	easy	easy
Amount of Users	high	high	high	high	medium	medium

Legend: easy / medium / difficult — low / medium / high

Ill. 11b. Choosing the task

The created sketches have been discussed, in order to underline related issues and opportunities.

System of objects: make normal objects become smart

Both sketches (Ill. 07, 08) further develop the idea of system of objects communicating with one another in order to best ensure that the task is performed correctly. Instead of designing 'smart objects', make smart the normal objects already in use by the user. This could allow flexibility to apply the same concept in performing other tasks.

System of objects: guidance plus smart object

Having the screen unit communicating with an object involved during the task performance, where the linked objects are appositely designed as smart:
- Showering task (Ill. 09, 10): universal soap dispenser connected with screen unit.
- Brushing teeth task (Ill. 11a): 'smart holder' for toothbrush and toothpaste that communicate with a screen unit, for making sure the person is actually following the instructions.

Smart mirror - brushing teeth

A screen-mirror to help toothbrushing (Ill. 12) (could also be applied to dressing).

Instructions' screen - showering / brushing teeth

To be placed in strategic spots for the visibility of the instructions (Ill. 13, 14, 15).

Other options than a normal screen have been explored, such as a hiding screen (Ill. 17) or a product that has all the necessary parts in one object (Ill. 16).

> Three directions have been identified out of the previous findings:
>
> • System of objects
> • Add-on device
> • Smart object

Camera supervising the user
Shows what to do
Speaker
Ill. 12. Smart mirror
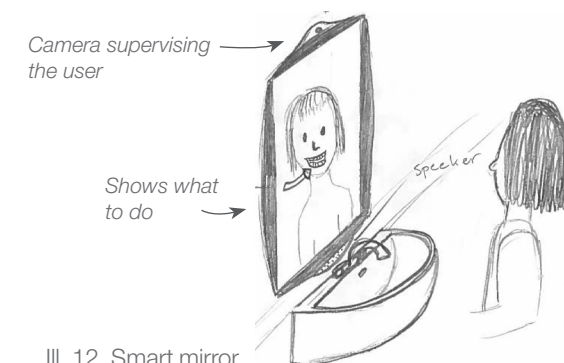
Small screen shows what to do
Screen
Ill. 13. Instructions' screen - showering
Ill. 14. Instructions' screen - brushing teeth

Screen
Ill. 15. Instructions' screen - showering
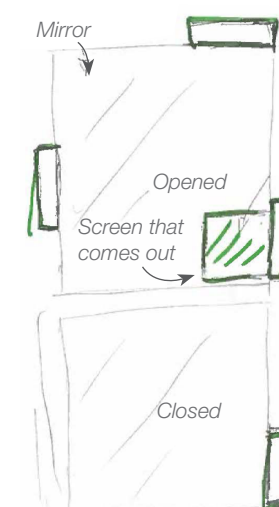
Mirror
Opened
Screen that comes out
Closed
Ill. 16. All in one
Ill. 17. All in one

2.3. Three directions on brushing teeth task

Ill. 18. System of objects

Ill. 19. Add-on device

Ill. 20. Smart object

NOTE: The brushing teeth is just an exemplification of a task to which the basic principle could be applied, e.g. showering, cleaning, cooking. [Worksheet no. 29]

A. System of objects

Set of objects able to communicate to each other in order to guide the user through the steps of the task (Ill. 18).
Considerations: a drawback could be that the objects would need to be appositely designed. This would raise the costs and would enable to perform only that specific task.

B. Add-on device

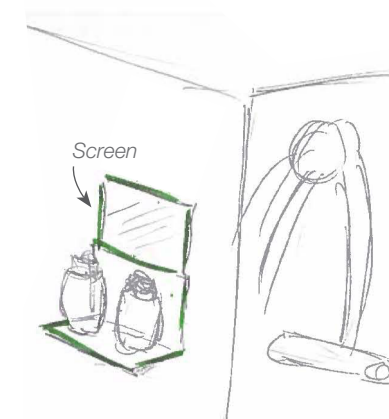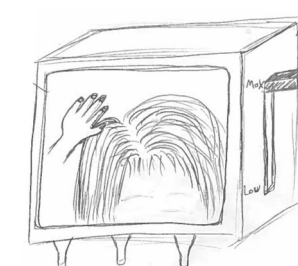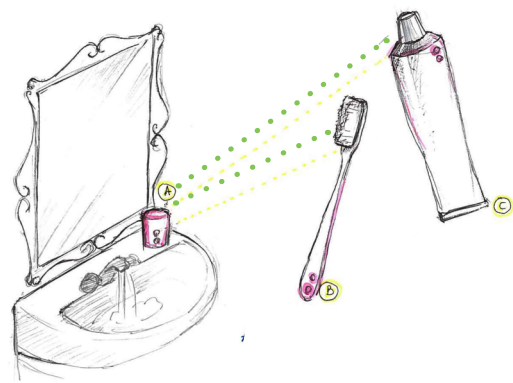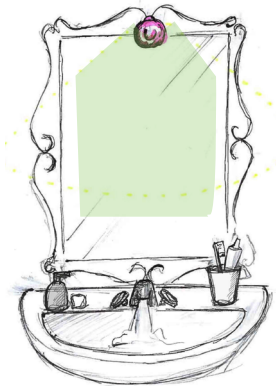Develop a device that can be located in a strategical position in order to give instructions to perform the task, e.g. above the sink for brushing teeth (Ill. 19).
Considerations: a benefit could be that the same object could be moved around to assist in different types of tasks. A drawback would be that the visibility of the image projected is diminished when the room is lighted. Also, the projection surface has to be plane.

C. Smart object

An intelligent object that is able to assist and guide during the task performance would be designed for a specific task. In this case, a product that looks like a mirror when not in use and turns into a surface to provide information (visually and with sounds) when is needed to perform the task (Ill. 20).

Considerations: the development of such object would increase the costs, since it would be able to cover only specific tasks which are performed in the mirror area.
E.g. smart mirror above the sink to guide through teeth brushing. Factors such as personal taste and style of the house would need to be taken into consideration.

Sum-up

All the concepts aim to make the objects of everyday life become smart, in order to guide the user in performing the task in a correct way.
The need of a visual guidance has been identified as essential. For its transmission, it has been decided to rely on the tablet, since it is a well known technology widely used in the market and easily accessible.
The concept of a system of objects that connect to the guidance in order to ensure the correct performance of a specific task is chosen for further development (Ill. 21).

Ill. 21. Guidance & smart objects

Feedback on the three directions

The three identified directions have been presented to a rehabilitation center Phase III (Ill. 22, 23, 24, 25) in order to get feedback from the context in which the product should be inserted.
The visit also gave to opportunity to get an understanding on how the patients are managed in the center [**Worksheet no. 21**].

Nykøbing Mors - The facility

Currently, there are eight people staying at the center (capacity of 14 places), whom are referred to as clients. They are from 22 to 60 years old.
Same network of professionals found in Brønderslev are following each patient: occupational therapists, physiotherapists, nurses, speech consultants, etc.

Ill. 22. Nykøbing Mors

Gained information

A joint interview with both an occupational therapist and a physiotherapist has been carried out.
The gathered material showed that the center implemented the same strategy used in Brønderslev. Patients are confirmed to have very different issues and to be very motivated in improving their situation.
Dressing and personal hygiene are outlined as the areas in which both the patients and the municipality are most interested in becoming independent, due to the costs implicated [**Worksheet no. 28**].

Evaluation on the presented concepts

• Regarding stigmatizing objects: people are often not even aware, or they are very motivated in getting better, so they will not care about having an object that shows that they have a problem - they do not care how it looks like.

• Authority: Might be an issue that the person will not listen to the directions given by the device, if a person has a previous different routine in performing a task.

• Introduce the product in the center: could be relevant, so that the person could be introduced to it by the staff. They could train in using the tool everyday, but back to the community, the introduction of the tool can be trained just two or three times a week.

• The Community is the one that pays for aid tools. They also approve the request of buying the tool. The tools that they know of are found e.g. by personal research, occupational therapist meetings and conferences, a database that contains all the tools.

> No patients with issues related to brushing teeth. They know how to perform the task, but some loose track of time (could brush them for 30 minutes if nobody stops them). If applied to showering, the caretakers would not have to stand beside them to assist the patient, due to the expenses required.
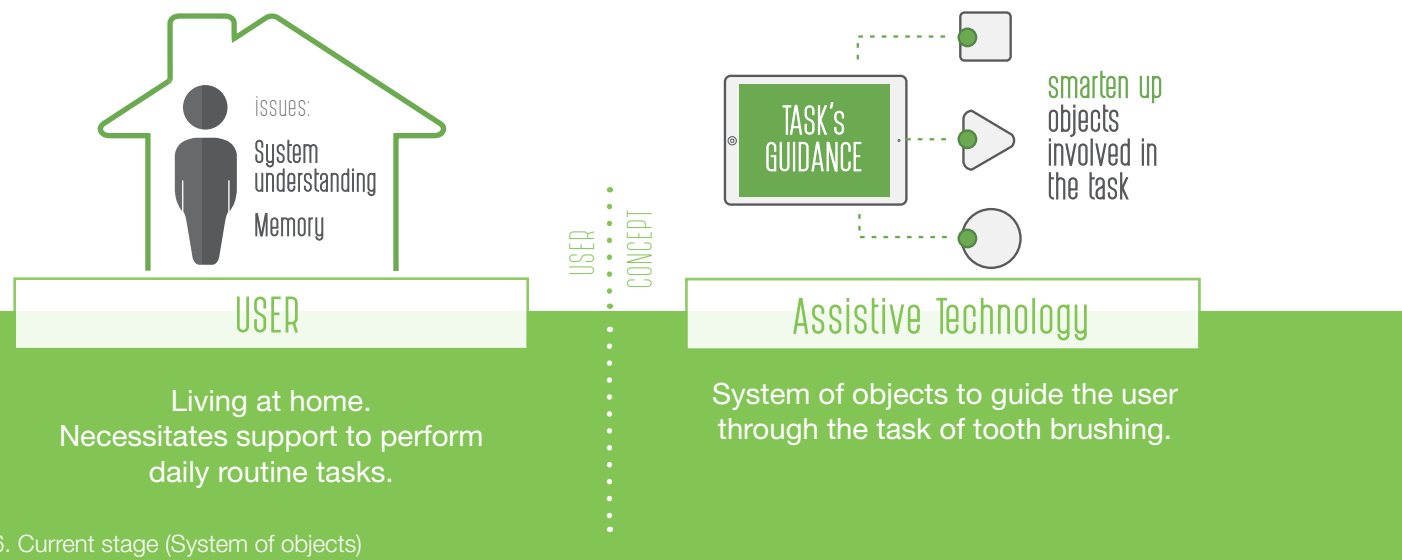

Ill. 23. Client's room

Ill. 24. Training bathroom

Ill. 25. Training kitchen

Current stage (System of objects)

USER

issues:
System understanding
Memory

USER CONCEPT

TASK's GUIDANCE

smarten up objects involved in the task

Assistive Technology

Living at home.
Necessitates support to perform daily routine tasks.

System of objects to guide the user through the task of tooth brushing.

Ill. 26. Current stage (System of objects)

The user has no physical impairments and is able to communicate verbally. Able to roughly use a smartphone or a tablet.

Cognitive issues
• Memory: confusion regarding what he has done (e.g. put on deodorant multiple times because he has forgotten he did it already) and needs to do.
• System understanding: insecurity or lack of understanding regarding how to perform a task.

Issues applied to everyday life
• Needs assistance and guidance to perform everyday basic activities (showering, teeth brushing, get dressed, etc.) and in structuring his day.
• Needs to be reminded when is the appropriate time to perform a task. Does not remember the sequence and order of steps that need to be performed in order to complete a task (e.g. forget to put on toothpaste before putting the toothbrush in the mouth, put socks before shoes, etc.)

Wishes
• Regain independence in basic everyday activities.
• Have specific communication / description of steps when performing a task.

Emotional perspective
Would like to improve, feels frustration if not able to perform a task [**Worksheet no. 36**].
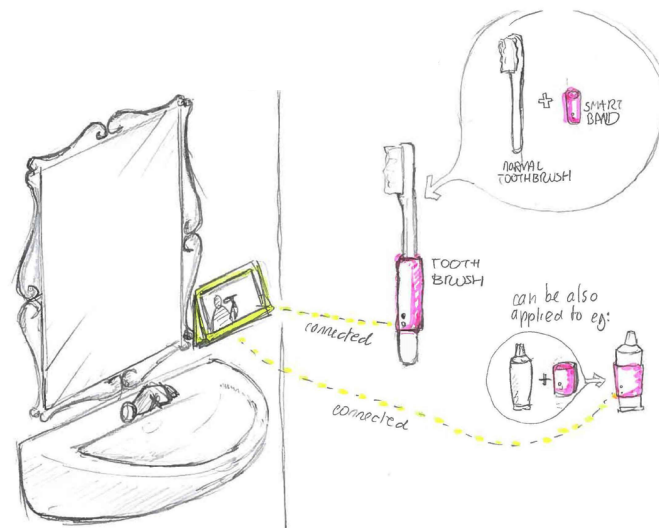
Ill. 27. System of objects

The product consists of:
• **Guidance** - displayed on tablet. It provides instructions to the user regarding the steps to perform in order to successfully complete the task.
• **Smart labels** - applied to the objects involved in the performance of the task. In the case of tooth brushing, the tags are applied to the toothbrush and the toothpaste. These labels aim to gather data from the objects involved in order to send feedback to the guidance, to ensure that the directions are followed correctly.

Conclusion

The way of communicating information through the guidance needs to be further explored according to the user's impairments and to the specific task. An initial proposal is to use mainly visual communication such as picture and short video clips, supported by verbal directions, in order to maximize understandability - use of redundancy. A series of tests have been performed with Mik Jensen, affect-ed by a minor TBI, to understand what is the level of details that a guidance in performing a simple task has to have. [**Worksheet no. 23**].

Furthermore, the state of the art regarding the technology implemented in objects communicating to each other needs to be investigated, together with existing projects similar to the identified concept.

24. Life with TBI

The research performed so far provided mainly a systematic understanding of the context surrounding the identified user, rather than the user itself. Therefore, the team has listened to a interview with a person suffering from TBI on Hjernekassen P1 [**Worksheet no. 20**]. After achieving a better understanding of the life with TBI, the team contacted Kim Velf, the president of Hovedtropperne Organization (Ill. 22), which is a sub-group under the brain injury department in the north of Jutland (Hjerneskade Foreningen Aalborg / Vendsyssel) [**Worksheets no. 25, 31, 37**], and Jeanette Gadegaard [**Worksheet no. 22**], a woman affected by TBI who is trying to sensitize society regarding the issues brought from this injury.

he broke his back in the accident.
Since he was young at the moment when he got the injury, he started at the university shortly after recovering. He finished an education within communication and started working. During the education, he took breaks when needed, but after starting working he did not tell his employer about the injury, which eventually led to loosing the job. He experienced the same situation several times, when it was difficult to keep up with everyday activities of a normal life. This led to him admitting that he will have to face the situation and adapt to the new life he has.
He is now hired in a part time job and has finally accepted his condition after 13 years.

Radio interview from Hjernekassen

From this interview, the word mental tiredness and the feelings related to having a brain injury were introduced for the first time. The man interviewed got a brain injury from a skiing accident when he was only 21. Since the accident, he struggles with mental tiredness approximately three times every day. The feeling is described as if a black cloud is covering the mind, which starts with blurred vision, troubles talking and pain in the head. It is different from when being tired in the evening and feels like not being alive for a moment. His current way to deal with it is to take a power nap of approximately ten minutes where he has to lay on the floor because

The mental tiredness is a great barrier to live a normal life and it takes a very long time to accept the consequences of the injury.

First visit to the club Aalborg / Vendsyssel

At the meeting, a conversation with different people in relation to their previous and current problems was initiated (Ill. 28).
The first lady spoken to (Else) told that she got a stroke. She was hospitalized for two - three weeks after which she was send home. From the injury, she lost the understanding of numbers:

"I have always worked with numbers, salaries and calculations and suddenly all the numbers would not make sense."

Else

Because of this, she created her own system for understanding the numbers.
Another lady spoken to (Mette) also had a stroke. She told funny but also embarrassing stories from the early days after injury.

"In relation to personal care, one of the first things I remember was that I got a deodorant from a nurse and I did not understand what it was. I did simply not understand what to use it for. Therefore the first thing I did was to put it into my mouth.
[...]
In the first long time after the stroke, when I took a shower, I would step out from the shower onto my towel. Then I would try to take it up from the floor and not understand why I could not get the towel up from the floor. That was of course because I was standing on it. This, I kept doing for a very long time and every time I did it, I did not understand why I could not get it up from the floor. It took me so long time to understand that I could not take it up while I was standing on it. Today I am aware of it."

Mette

Both of the women experience the mental tiredness many times a day and describe it as follows:

"It is being inside a big bubble that you can not get out from. You are not a part of anything and you are just observing what is happening around you."

Else

"Likewise you do not care what is going on outside your bubble"

Mette

Ill. 28. Club meeting

Main issues
From the conversations with the people at the club, the following issues have been identified as consequences of brain injuries:
• Chronic mental tiredness.
• Short term memory issues.
• Not able to do multitasking.
• When very tired, suddenly can not remember or get confused on how to perform a task.
• Needed to learn some things all over again and needed repetition to perform some tasks again.
• Have problems with reading and had to attend a reading course.
• Have problems finding the right words.
• Needed several years before accepting the new condition.

JEANETTE GADEGAARD

Ill. 29. Jeanette Gadegaard

Main issues
• Memory issues and Dyscalculia (not able to understand numbers).
• Can not perform daily activities such as: cooking, empty the dishwasher, vacuum clean and clean. The system of performing such activities is too complex. She lacks the capacity of having an overview of the task and of managing several processes at the same time.
• Only able to perform one part of a task at the time and often forgets what to do next, gets confused and is not able to perform the rest of the task.
• Confusion e.g. when trying to clean, she will get confused about what product to use.
• Able to perform all tasks regrading personal care by herself, but she sometimes looses track of time. E.g. while brushing teeth or put on deodorant multiple times after showering because she can not remember if she did it already.
• Gets tired easily - enhances confusion.

Needs
• Needs help to remember when to do different tasks / activities.
• Needs help to perform daily activities - has home assistance only once per week, for 45 minutes.

She sets an alarm on her smart-phone to remind when she needs to perform specific tasks, such as brushing teeth, take a shower, take her medicine and five minutes before she has to go somewhere. She finds the alarm very stressful.

Wishes
• To be able to perform daily tasks again, such as cooking (is her passion) and cleaning.

Conclusion

Gaining knowledge directly from the people dealing with the consequences of TBI in their everyday life was fundamental in order to better define the user and the practical issues encountered.
The collected material also allowed to outline the emotional sphere surrounding the person. The main findings are showed in the empathy map in the following page (Ill. 30).

No crucial issues related to brushing teeth task. But identified issues mainly with cleaning and cooking.

From contacting both centers and people that have been reintroduced to the community, there has been no confirmation regarding the validity of working with the task of brushing teeth. The showering task has been evaluated as not feasible to pursue as well, mainly because of testing.

Think & Feel

"I want to get better fast and go back to my normal life"

"Why me? I am sad about not being able to do basic tasks anymore"

Frustrated about his continuous tiredness
Feel he is not fitting into the former life
Desires to be independent in basic everyday life tasks (cooking, cleaning, grocery shopping etc.)

Hear

"How can you not understand?!"

"Do you need help?"

"You did that already"

Sometime people treat me as if I am stupid

See

"Sometime people treat me as if I am stupid"

People that I love do not know how to cope with the situation.

Ill. 30. Empathy map

Say & Do

"I do not want help from a stranger, I can do it on my own"

"I want to regain my independence and personal space."

Needs breaks or naps during the day
Take a lot of medication

Pain

"People do not understand the difficulties I am tackling."

"I was really good at this before and now I do not even know how to do it"

"I am a burden"

Gain

"I finally accepted the limits that are now part of my life"

Being able to feel independent ans as normal as possible.

Between the tasks of cleaning and cooking, the latter one has been identified as the most valuable solution to further develop, due to having a person that is experiencing the issue and is willing to cooperate (Ill. 31).

tooth brushing → cooking
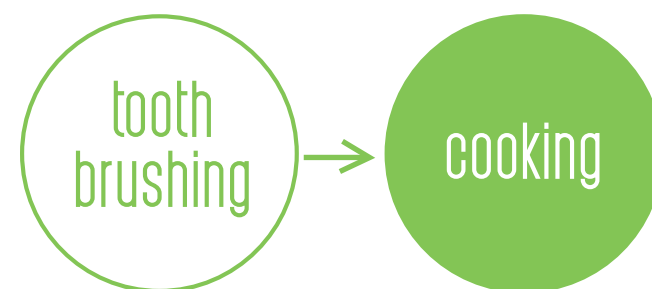
Ill. 31. Task's shift

2.5. Extracting data from the environment

A research regarding systems of objects communicating with each other has been performed, in order to understand the type of technology implemented and gain an understanding regarding the state of the art on projects making normal objects become 'smart', being connected by technology.
This activity aimed also to provide inspiration for the further concept development and possible issues encountered when developing such products [**Worksheet no. 33**].

Internet of Things (IoT) - is the term used to indicate a network of physical objects embedded with electronics, software, sensors and network connectivity that enables these objects to collect and exchange data.
IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems.
Experts estimate that the IoT will consist of almost 50 billion objects by 2020 (Cisco, 2011).

Beacons - technology which allows mobile apps to listen for signals from beacons in the physical world and react accordingly, understand their position on a micro-local scale and deliver hyper-contextual content to users based on location (Ill. 32, 34).
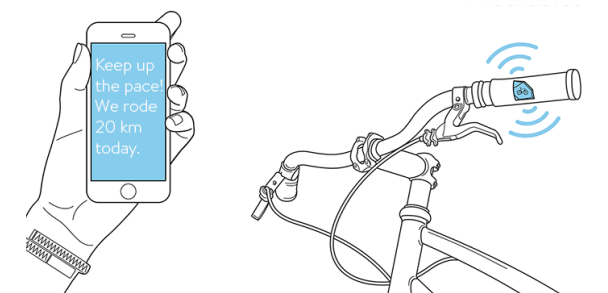
Nearables (or nearable technology) - term used to describe the idea of smart objects: everyday items with wireless computing devices and sensors attached to them. Thanks to this, they are able to provide mobile devices in range with information about their location, state and immediate surroundings (Ill. 33).

Both Beacons and Stickers are small wireless sensors that can be attached to any location or object, turning them into "nearables".
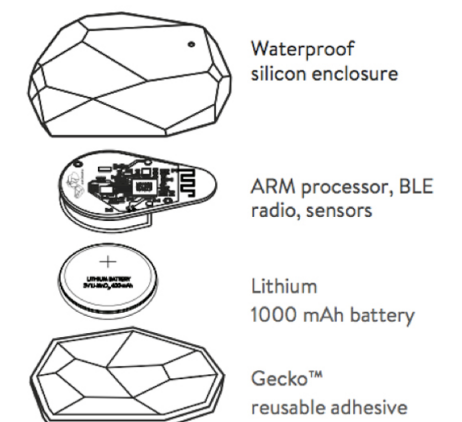
• **Obtained data**: micro-location, ownership, approximate location, temperature and motion.
• **Technology used:** BLE (Bluetooth Low Energy), a power consumption Bluetooth with low energy requirements. It can last up to 3 years on a single coin cell battery. It is ideal for simple applications requiring small periodic transfers of data.

Ill. 32. Estimote Beacons and Stickers

Keep up the pace! We rode 20 km today.

Ill. 33. Send data

Waterproof silicon enclosure

ARM processor, BLE radio, sensors

Lithium 1000 mAh battery

Gecko™ reusable adhesive

Ill. 34. Beacons components

Pixie Point - bluetooth beacons

The product is an always-on locating tag that works with Bluetooth LE. The tags are flanked by a smartphone app. The beacons can create a digital map of all the tagged items (Ill. 35).
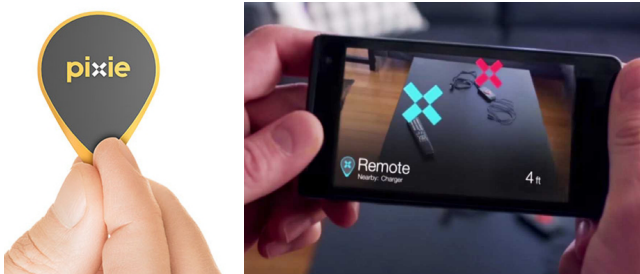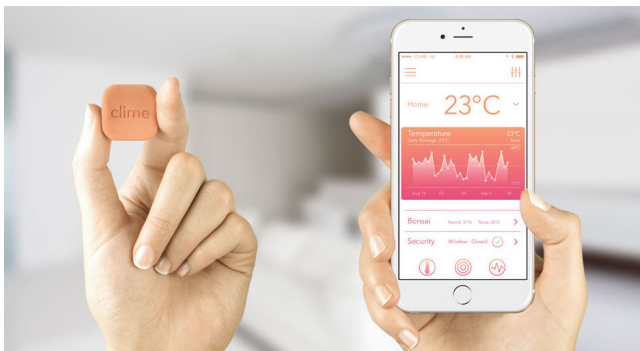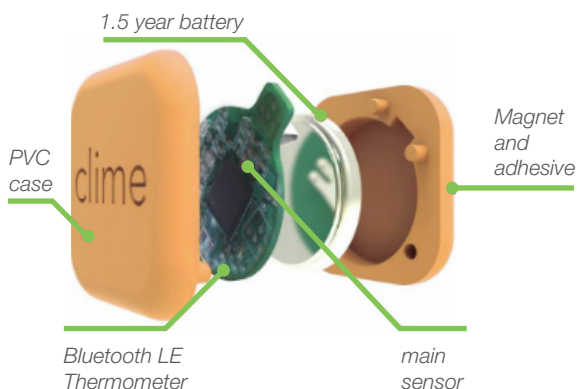

Ill. 35. Pixie beacons

Clime

These sensors aim to make the home smart, by collecting environmental data through the beacons placed around the house (Ill. 36, 37).
The beacons collect data regarding temperature, light, humidity and movement.

Ill. 36. Clime plus phone

1.5 year battery

PVC case

Magnet and adhesive

Bluetooth LE Thermometer

main sensor

Ill. 37. Clime

Conclusion

The main findings from the research:

• Possibility of obtaining 'smart tags' of reasonably small dimensions.
• Use of BLE to transmit information [**Worksheet no. 32**].
• Necessity of battery - most used are coin size lithium battery, that can last up to 3 years.
• The sensors can usually detect information regarding orientation in space, location, motion in X, Y, Z axis, temperature, battery level, etc.

Reflection

What is necessary to be monitored to ensure that the person is following the directions given to perform the task? Investigation of the task and the pattern is needed.

Framing

This chapter describes the final user to which the product refers, together with an overview of the chosen concept, which will be further developed in the next chapters.

3.1. The User

Ill. 01. Cognitive impairment

- The user's everyday life is affected from the consequences of a TBI. He is physically completely functional, but suffers from cognitive impairment.

- Does not live alone (spouse or family members which can support and help him when in need).

- Desires to be independent and to live a life as similar as possible to the one he was living before the TBI. Therefore, he is willing to accept tools that would enable him to do so.

The target user is not defined by taking into consideration either age or gender, but rather by targeting the issues he is experiencing in everyday life. For this reason, the user could be identified in illnesses different from TBI, that have similar consequences (e.g. alzheimer, dementia, or with little experience in cooking).

User's cognitive impairment

It is important to be clear on the actual limitation and abilities of the user, in order to design a valuable solution, able to respond to the user's needs and issues:

• Mental tiredness
The mental tiredness the user experiences could be compared to the tiredness people experience when they have been sightseeing all day. After gathering so much information, the brain is completely depleted of energy which might even lead to having a headache. This feeling is experienced on a daily basis by the user.

• Memory issues
The memory issues the user experiences are forgetting from time to time how to perform a specific task. Another aspect of this is that the user keeps loosing the track of a task. This could be compared to when looking for something and suddenly forgetting what you were looking for and trying to remember by thinking back to what you where doing. The user experiences the same feeling in repetitive numbers when doing something.

Ill. 02. Preponderant emotions

• Logical thinking
The difficulties the user experiences are regarding the logic of knowing what to do when the information given is incomplete.
E.g. if a recipe says: weigh 500 grams flour. In this case it does not state what to put the flour into while scaling and it does not remind the user of reseting the scale when putting a bowl on top of it.

• System understanding
The user experiences difficulties closely related to the logical thinking, more precisely understanding the order in which a task should be performed. E.g. when performing a task for the first time, the order of the steps is unknown.

Emotions
Because of the mentioned issues, individuals reported to often experience strong negative emotions. The main ones have been identified (Ill. 02):

• Frustration
They feel frustrated about not being able anymore to do what they used to be able to.

• Loneliness
They feel lonely because it is so hard to make people understand what they are going through. It is a hidden disability and therefore the surrounding individuals will not always know what to do.

• Loss
They feel the loss of an ability, as the loss of a friend. E.g. activities that they were good at, they are not able to perform anymore.

This emotions also derive from the fact that cognitive impairments can be defined as a *'hidden illness'*. In fact, since the person looks normal, people would expect him to be as functional as a healthy person.

[**Worksheets no. 20, 21, 22, 25, 27, 31, 34 and 37**]

Issues applied to cooking

Miss the overview of the task

Get stuck in the middle of the task

Difficulties in understanding numbers/amounts

Lack of sense of timing

Ill. 03. Issues applied to cooking

Cure

• Simplify the cooking process as much as possible
• Reduce mistakes' occurrence
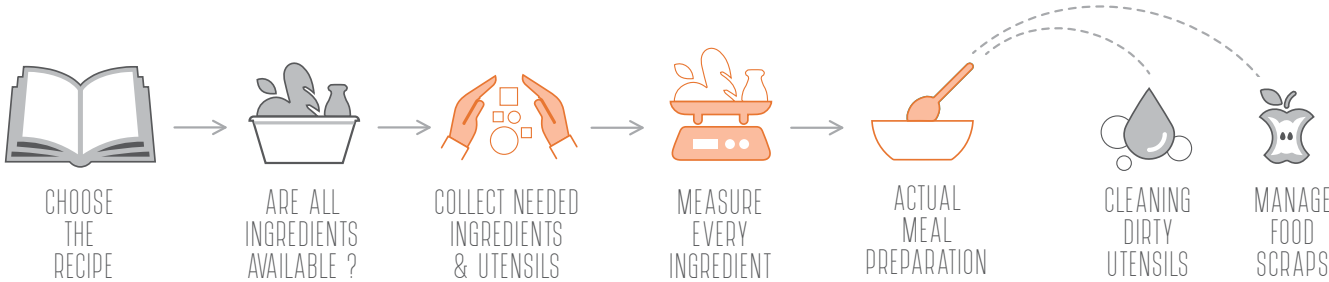• Manage the process

Value to the user

• Regain independence in preparing a meal
• Take partially away responsibility
• Regain confidence

Focus in cooking task

When considering the task of preparing a meal, there are several steps and activities in order to obtain the finished dish (Ill. 04).

Considering the issues of the user, relevant areas of interest within the cooking task have been identified, representing the area of focus explored during ideation:

• Collect all ingredients and utensils needed
• Measure ingredients in right amount
• Actual meal preparation

CHOOSE THE RECIPE → ARE ALL INGREDIENTS AVAILABLE ? → COLLECT NEEDED INGREDIENTS & UTENSILS → MEASURE EVERY INGREDIENT → ACTUAL MEAL PREPARATION → CLEANING DIRTY UTENSILS → MANAGE FOOD SCRAPS

Ill. 04. General steps in preparing a meal

3.2. Relationship with the system

In order to understand and describe the desired relationship between the user and the system of objects, a research has been carried out with main focus on this relationship. Therefore, a movie entitled "Chappie" has been watched, the chapter "Redefining the relationship of man and machine" in the book "The future business" has been analyzed, an interview about the helping-tool Melvin has been made and a brainstorm regarding the relationship has been carried out **[Worksheet no. 16]**.

Information obtained through research
In the movie "Chappie", the parent - child relationship is defined between a robot and a human, where the human takes the mother´s role for the robot. The level of trust between the two protagonists is increasing along the movie.
A similar relationship is wanted between the system of objects and the user, but with a switch of roles, where the system of objects becomes the "parent".

Taking into consideration the knowledge acquired so far regarding the user, a brainstorming session has been performed (Ill. 05) to identify how should the product be perceived by the user. A metaphor has been formulated to describe the relationship of the product with the user.
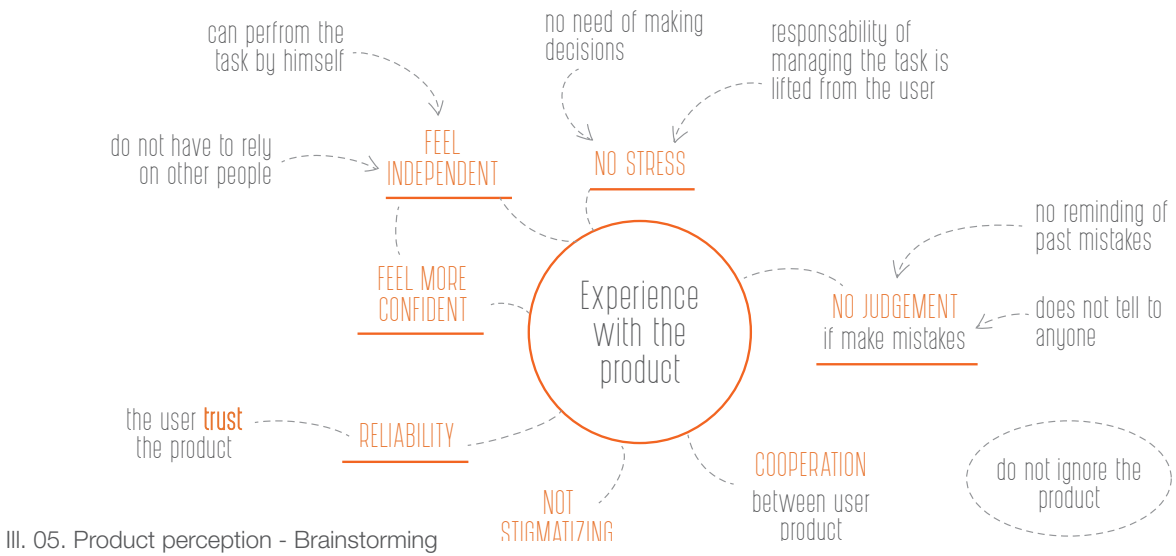
Ill. 05. Product perception - Brainstorming

Identified metaphor

Perceived as the friend that you trust and take advices from. That does not underline your mistakes and does not judge you.

Systematic and personal relationship with the product

The user and system of objects have to be at the same level and need to collaborate in order to perform the task. It should always be the user that has the control. For the same reason, the system of objects should not take over any physical parts of the task, e.g. dispensing the right amounts of ingredients.

> *"Technology is no longer about if or how, but about why? The question is no longer whether something is possible with technology, but more about if it should be possible. What will be the limit? How much do we as human want the future intelligent robots to take over?"*
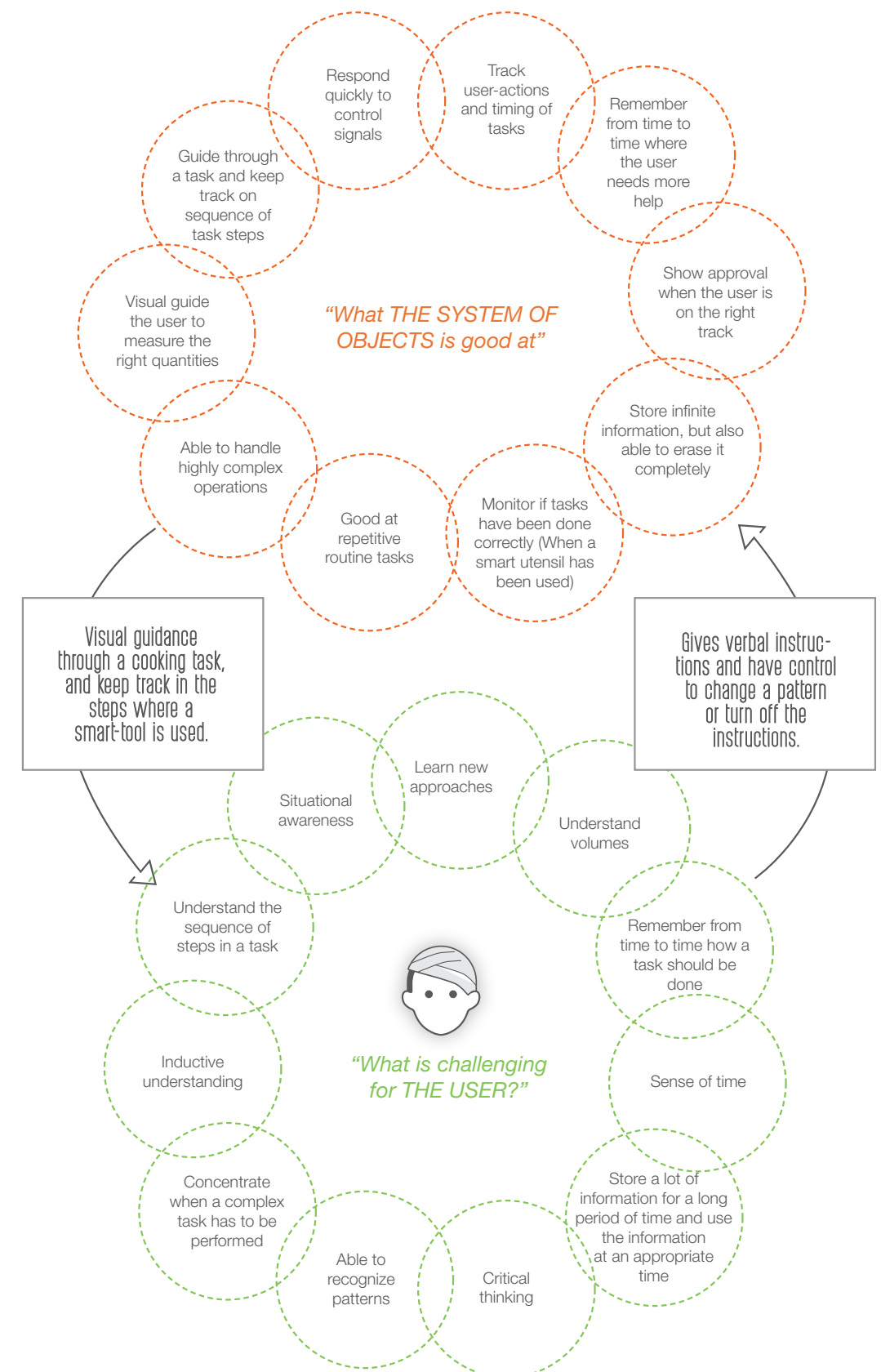> (Leonhard, G., 2015)
>
> - Futurist Gerd Leonhard

This kind of relationship is also similar to the one between the user and the helping tool, Melvin. In order for Melvin to do the task it is meant for, the user has to collaborate with it. If the user is not standing correctly, allowing Melvin to pull down the pants, it will simply not succeed. The user has to trust that Melvin is not hurting him / her and has to allow the tool to help in a task that crosses personal boundaries. Melvin will neither underline nor judge the user, but it will simply help in a task he / she cannot do alone anymore [**Worksheet no. 26**].

> In relation to the system of objects, how much and in which parts of the process does the user want for the system to take over the task? (Ill. 06)

In the scenario of the present project, the user can not cook anymore because the understanding of the system and structure in cooking has been lost. Not being able to cook anymore, which the user feel he should be able to do, is a very frustrating feeling. It is a personal challenge that is both embracing and condescendingly. Therefore, it is a task that the user will not allow anybody to help with.

The primary reason for the user to utilize the system of objects is simply because he / she can not cook without it. Secondly, the system of objects needs to add human value, by making the experience of cooking not just a duty, but a feeling of success, by overcoming a challenge. It should not be underlining in any way the difficulties arising along the process, while the small mistakes will become a secret between user and the system of objects.

"What THE SYSTEM OF OBJECTS is good at"

- Respond quickly to control signals
- Track user-actions and timing of tasks
- Remember from time to time where the user needs more help
- Guide through a task and keep track on sequence of task steps
- Show approval when the user is on the right track
- Visual guide the user to measure the right quantities
- Store infinite information, but also able to erase it completely
- Able to handle highly complex operations
- Good at repetitive routine tasks
- Monitor if tasks have been done correctly (When a smart utensil has been used)

Visual guidance through a cooking task, and keep track in the steps where a smart-tool is used.

Gives verbal instructions and have control to change a pattern or turn off the instructions.

"What is challenging for THE USER?"

- Learn new approaches
- Situational awareness
- Understand volumes
- Understand the sequence of steps in a task
- Remember from time to time how a task should be done
- Sense of time
- Inductive understanding
- Store a lot of information for a long period of time and use the information at an appropriate time
- Concentrate when a complex task has to be performed
- Able to recognize patterns
- Critical thinking

Ill. 06. Man - system of objects relation

3.3. Recipe analysis for error occurrence

Two recipes with different degree of complexity have been analyzed according to the user's issues [**Appendix 13**], in order to identify the critical areas. The *'Stegt flæsk med persillesovs'* (Ill. 07) recipe is chosen for testing, due to the fact that it contains three separate dishes in itself.

NOTE: The emerged issues can be applied to any recipe in general.
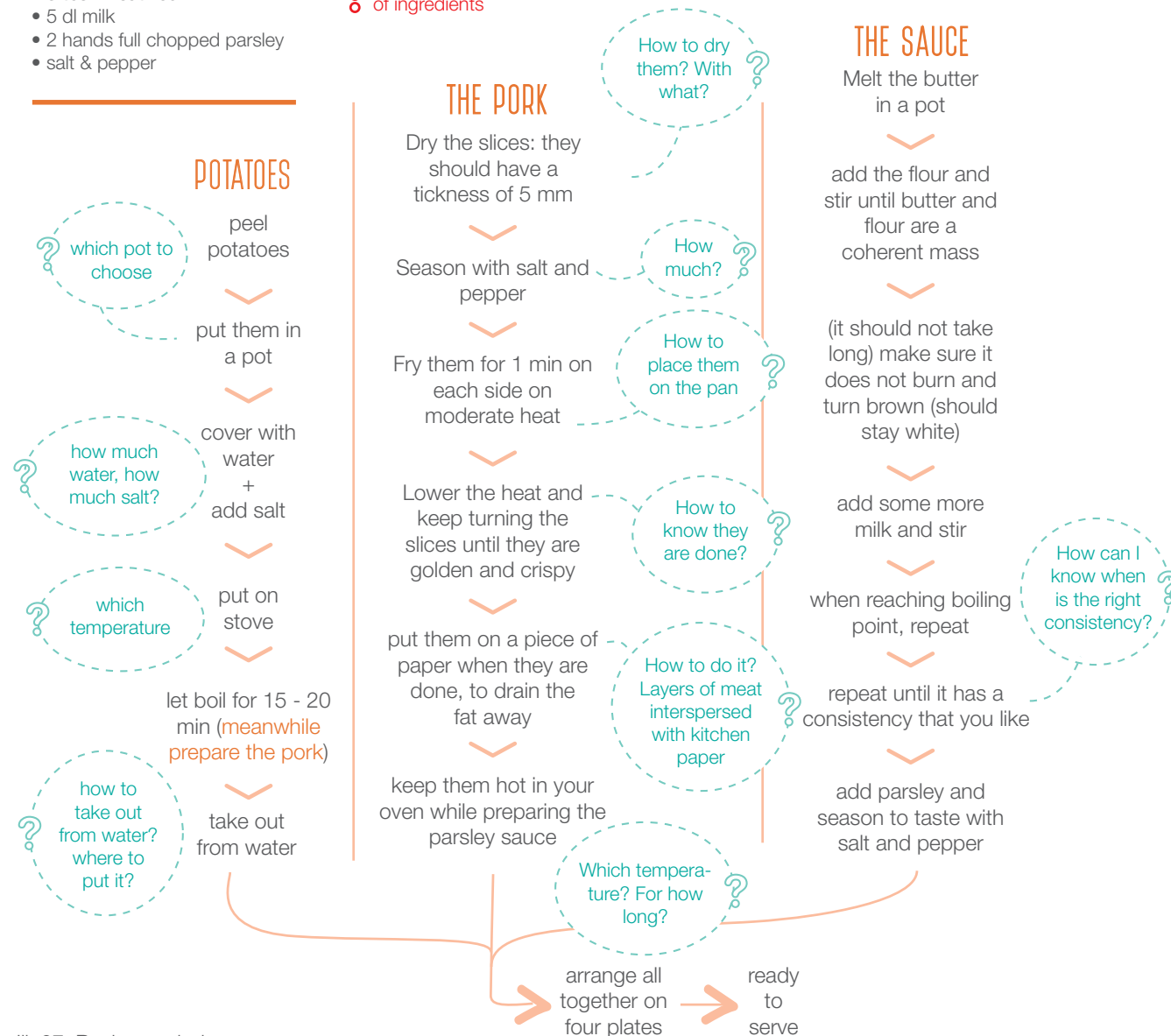
General observations:
• Do all ingredients & utensils needed have to be prepared in advance? Or is it more confusing?
• How to perform small tasks?

INGREDIENTS - 4 people

If you want to cook for less/more people, you need to modify amounts

• 600 g pork belly in slices
• 1 kg potatoes
• 30 g butter
• 3 tbs wheat flour
• 5 dl milk
• 2 hands full chopped parsley
• salt & pepper

measure right amount of ingredients

POTATOES

which pot to choose

peel potatoes

put them in a pot

how much water, how much salt?

cover with water + add salt

which temperature

put on stove

let boil for 15 - 20 min (meanwhile prepare the pork)

how to take out from water? where to put it?

take out from water

THE PORK

Dry the slices: they should have a tickness of 5 mm

How to dry them? With what?

Season with salt and pepper

How much?

Fry them for 1 min on each side on moderate heat

How to place them on the pan

Lower the heat and keep turning the slices until they are golden and crispy

How to know they are done?

put them on a piece of paper when they are done, to drain the fat away

How to do it? Layers of meat interspersed with kitchen paper

keep them hot in your oven while preparing the parsley sauce

Which temperature? For how long?

THE SAUCE

Melt the butter in a pot

add the flour and stir until butter and flour are a coherent mass

(it should not take long) make sure it does not burn and turn brown (should stay white)

add some more milk and stir

when reaching boiling point, repeat

How can I know when is the right consistency?

repeat until it has a consistency that you like

add parsley and season to taste with salt and pepper

arrange all together on four plates → ready to serve

Ill. 07. Recipe analysis

---

34. Ideation on cooking task

An ideation related to the tree different aspects of cooking was initiated:
• Collect the needed ingredients and utensils.
• Measure every ingredient.
• Prepare the meal.

From this ideation, four sub-concepts were brought to a second visit to the brain injury club Aalborg / Vendsyssel, in order to get them validated. All of the sub-concepts are a variation of an app showing videos or images to explain the steps of a cooking task.
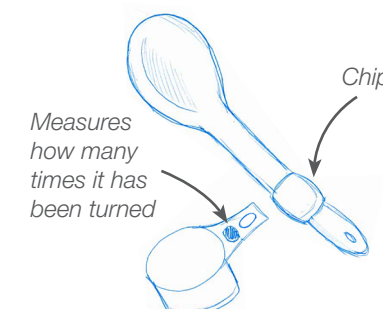
Sub-concept I
In this sub-concept, whenever a tool or ingredient is needed, the app will send a signal to a sensor placed on the drawer or cabinet that contain it. The sensor will light up or make a sound in order to make the user know where to get it from (Ill. 08).
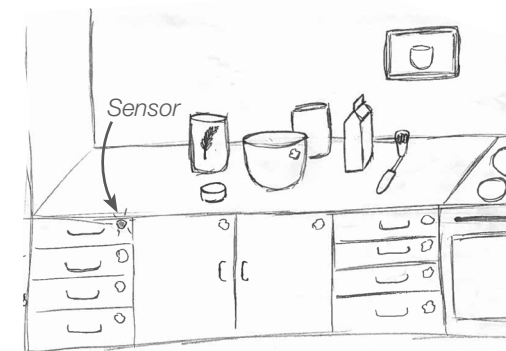
Sensor

Ill. 08. Sensor on the drawers

Sub-concept II
In this sub-concept, whenever a tool is needed, the app sends a signal to a sensor placed on the tool. The sensor will light up or make a sound to make the user know where the tool is (Ill. 09).

Chip

Measures how many times it has been turned

Ill. 09. Sensor on the utensils

Sub-concept III
The user will receive a start-kit with some sensor-stickers that can be placed wherever needed. Whenever a tool with a sensor-sticker is needed, the app will send a signal to the sticker-sensor and locate the tool.

Sub-concept IV
The user will receive a kit / box with smart-utensils with build-in sensors. The utensils could include many types of sensors that also track movement and make sure that the tool is used in the right way.

Validation of current sub-concepts
A second visit at the Aalborg / Venvsyssel took place, in order to get feedback regarding the concepts generated. A conversation was initiated with Magrethe, who suffers from a stress-related brain injury. Her difficulties are related to bad short-term memory and lack of system understanding.
She is able to understand systems like cooking tasks, but it takes her a very long time to locate all tools needed for the cooking task and therefore she uses a lot of energy and ends up with a headache. Every time she tries to cook, she ends up with a bad experience. She gets very tired throughout the day and is usually exhausted around 15:00.

"I think the most important part is to get an overview of the task in order to not be afraid of doing it. From my experiences, I know that some people (depending on the brain injury) will be afraid of the responsibility of having e.g. both the oven and stove turned on at the same time. It is not very pleasant to deal with something that you can not overcome.
[...]
I think that once in a while everyone deserves the joy of getting something home cooked, something that you made yourself.
[...]
From the concepts I would benefit a lot from concept I and II. Also in relation to finding everything in my house. I know how to cook and might not be the right person to ask about the other sub-concepts."

Magrethe

In order to help through the entire task of cooking, further ideation rounds took place, for combining the separate concepts into a system of objects

In these ideation rounds, a further narrowing down of the cooking-task was needed. Therefore, the assistance offered by the system of objects is considered to start from the point where the user has all the ingredients and tools or knows where to find them until the end of the cooking. The produced ideas have afterwards been categorized on different themes, with the intention of comparing them

and finding the most suitable combination [**Worksheet no. 43**]. The method also offers the possibility of coming back to the ideas and choosing another solution, in case the chosen one proves to be not suitable.

The identified categories are:
1. Measure ingredients.
2. Choose the right utensil.
3. Ensure right consistency.
4. Ensure right temperature.
5. Other ideas.

1. Measure ingredients

Being a very important part from the cooking process, measuring the ingredients presents a vital focus for the project.
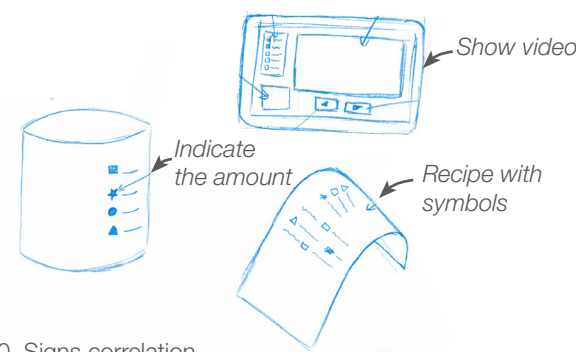
Ill. 10. Signs correlation

Signs correlation - The recipe uses signs instead of numbers, so the user has to put the ingredient until the sign that is shown in the recipe, e.g. until the level of the star.
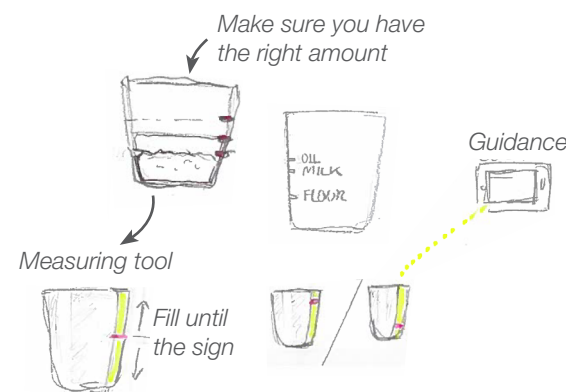
Ill. 11. No number measuring

No number measuring - the measuring bowl has a light sign connected with the tablet. The light sign will indicate the level to reach without need to understand numbers.

2. Choose the right tool

The user has to use certain utensils while cooking. The following ideas involve some of the methods of ensuring that the right utensil is used.
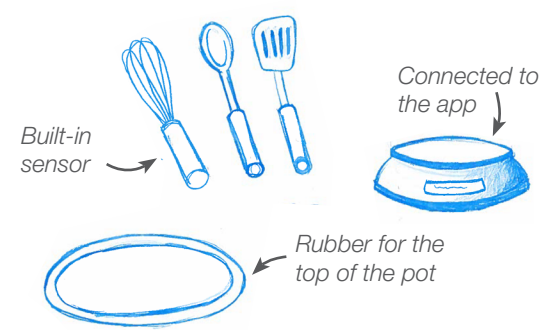
Ill. 12. System with different devices

System with different devices - The devices are connected to the app. The scale is connected as well and knows the quantity of the ingredients needed. The utensils have built-in sensors. A rubber band is placed on the top of the pots, which senses the temperature and if the liquid inside is boiling over.


Ill. 13. Configuration possibility

Configuration possibility - When buying the package, the app has to be configured according to the utensils available, either with the ones you already have in the kitchen or with the ones received in the package. The configuration is made with a family member or a caretaker.
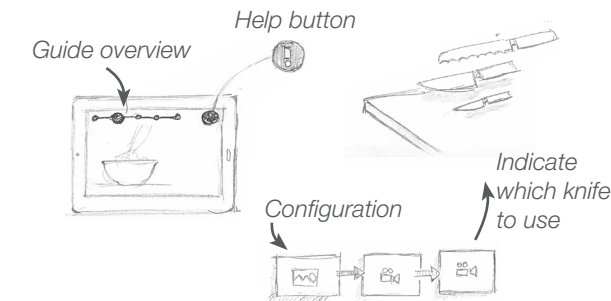
3. Have the right temperature

Knowing at all times the temperature of the food that is being cooked is an important part of making a dish.
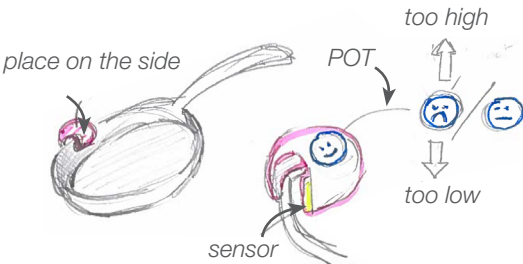
Ill. 14. Temperature gadget

Temperature gadget - The gadget is placed on the lip of the pot. It senses the temperature of the food and when it needs to be higher or lower, an emoticon appears, according to the command needed.

4. Other ideas

Ill. 15. Guidance specifications

Guidance specifications - The guidance has a bar where the overview of the cooking task is visible. A help button on the side is also needed. The guidance is done by photos or videos, depending on the scene. The utensils used in the guidance are configured according to what utensils does the user have in the house.

Conclusion

All the ideas generated are listed in Ill. 16, according to the category they fit in. Considering the advantages and disadvantaged of each of them, the most feasible ones are chosen, highlighted with orange.

Measure Ingredients	Choose right utensils	Ensure right consistency	Have the right temperature	Other ideas
Signs correlatiom	Toolbox	Thermometer	temperature sensors	Ensure to add all ingredients
sensor camera	Configuration possibility		smart rubber band	Collect all ingredients
sensing amounts	communicative tools		Flexible wire	Guidance specifications
understanding amounts	smart utensils 1		Temperature gadget	
verbal and visual measurment guidance	Smart utensils 2			
no numbers measusres	System with different devices			

Ill. 16. Table with ideas and the chosen combination

3.5. Initial Proposal

An Assistive Technology composed by a system of smart objects communicating with a guidance that help the user in the task of cooking.

The imagined concept is composed by the following components (Ill. 17):

GUIDANCE
• Tablet size - Made for standard eight inch, nine inch, ten inch (functioning on iOS, Android).
• Video & text guidance - short video clips showing every step of the recipe.
• Voice recognition - no need to touch the screen when cooking.

Issues: define the words to be recognized by the programming, since not everybody will say "next" to go to the next step. Will the program be able to recognize all possible ways?

SMART UTENSILS
• BLE - Bluetooth Low Energy (BLE) could be used to connect the tools with the guidance. This technology is currently the one most used in IoT and beacons technology [**Worksheet no. 33**].
• Accelerometer - To monitor when the tool is in use.
• Battery - most likely a coin cell battery, due to the small dimensions.
• Wireless charging receiver.

SCALE
• BLE - to receive information from the guidance.
• Load cell - is the one that actually enables to measure the weight.

MEASURING BOWL
• Light - To give visual signal of the level.

FOOD THERMOMETER
• BLE vs. WIRE - Need to decide if wireless or not.
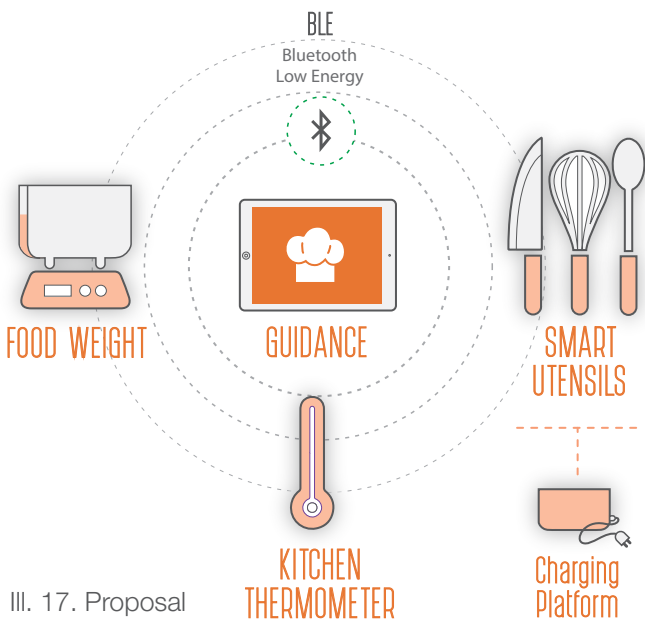
III. 17. Proposal

Level of assistance

The different tools are supposed to provide different degrees of assistance / monitoring during different phases of the task's performance.
The application is the 'brain' of the product. It sends and receives information from the other components of the system: the scale and the measuring bowl, the utensils and the thermometer, so to monitor the user during the actions and to provide assistance during the task performance (Ill. 18).
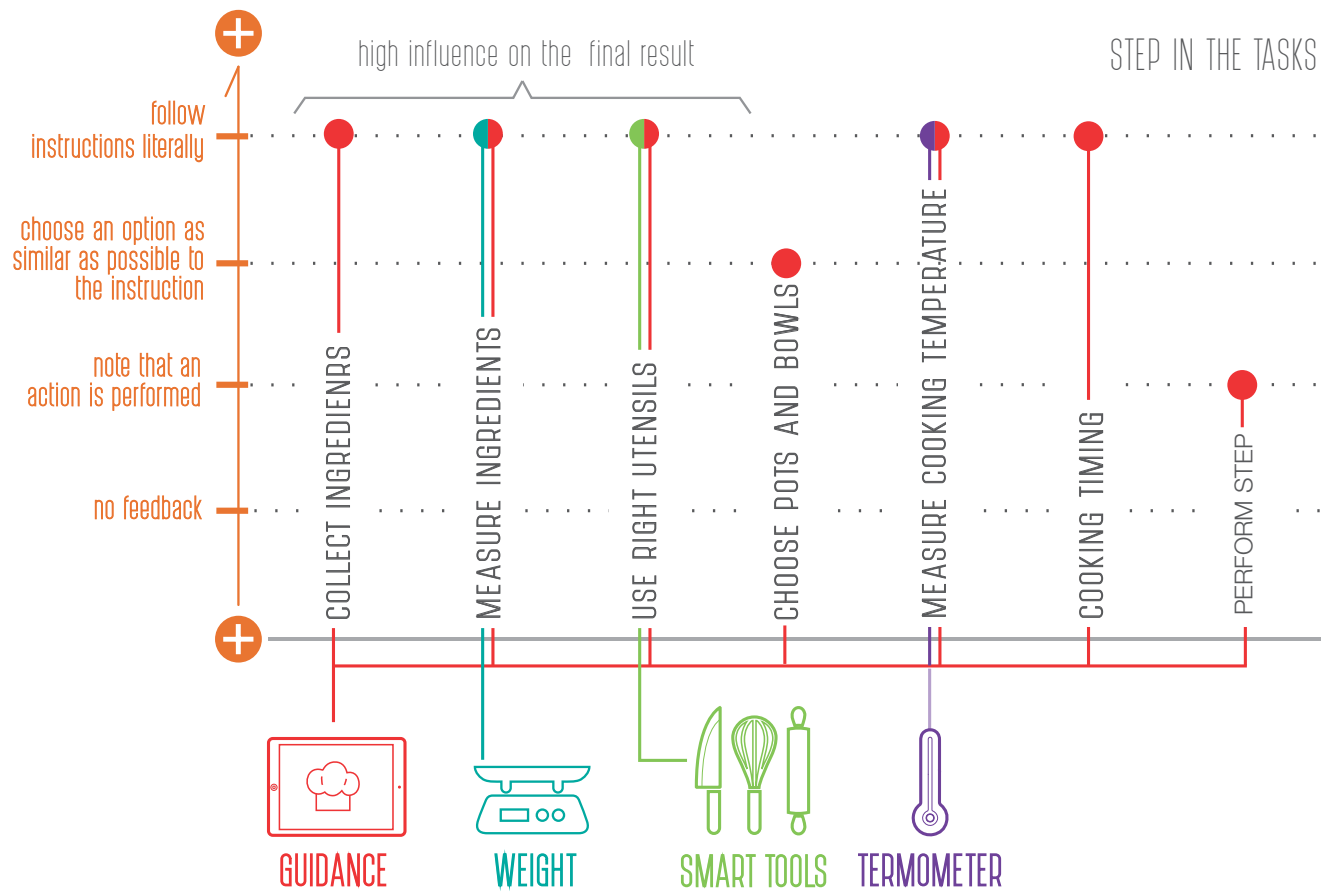
III. 18. Level of assistance

3.6. General requirements

THE GUIDANCE

• Show all the steps of the recipe in the most understandable manner.
• Show current stage in the process.
• Ensure correct use of amounts of ingredients and utensils.
• Alert the user when the wrong amounts of ingredients or wrong utensils are used.
• Allow personalized configuration for each user.
• Transmit and receive information from the other objects of the system.
• Possibility of using voice commands for simple tasks such as moving on to the next step.
• Compatible with Android and iOS.

SCALE

• Communicate with the Guidance.
• Display amounts visually and numerically.
• Notify when the desired amount has been reached / exceeded.
• Other containers can be placed on it.
• Easy to clean.

MEASURING BOWL

• Communicate with the scale.
• Visually indicate amount of liquids: flour, sugar.
• Liquids can be easily poured from it.
• Can be held with one hand.
• Able to see the ingredient from outside.
• Easy to clean.
• Fit onto the scale.
• Maximum capacity of one liter.

THE UTENSILS

• Sense when being moved and transmit information to the Guidance.
• Should not fall into the pot while cooking.
• Protect the components inside the handle from external damaging factors, e.g. heat, liquids.
• Easy to clean.

UTENSILS' charger

• Easy to connect to power supply and to relocate.
• Minimum fit to charge the Starter Kit.
• Easy to clean.

Observations

A round of ideation for each of the components of the system must be performed, in order to identify the visual language of the overall system. All the elements must be recognized as part of the same system.
The following factors need to be verified:

• **Guidance** - Create a User Interface that is understandable by the user and verify its effectiveness by testing it along the process.

• **Utensils** - Verify the choice of the chosen utensils through further research and testing.
Identify what is the necessary degree of monitoring: to track the action or is it sufficient to know that the tool is being moved.

• **Scale & measuring bowl** - Verify the functionality and degree of comprehensiveness.

• **Thermometer** - Investigate possible methods of having a wireless, heat resistant solution.

Measure small quantities
It is necessary to be investigated how to measure small quantities , e.g. salt, oil, etc.

Conclusion

A list of clear requirements that the solution must be able to satisfy needs to be formulated, in order to dive into details on what each component of the system of objects must be able to do in order to identify the most suitable solution.

Refining the concept

This chapter contains the development and refinement of the final proposal, according to the performed testing and research.

4.1. The utensils

Market research

In order to understand and define which are the utensils needed in the starting package, a market investigation regarding existing starting kits has been performed [**Worksheet no. 41**]. The number of utensils included variates from basic set to the expanded cooking utensil starter-kit (Ill. 01).

Smart devices such as HAPIfork can be found among the existing utensils. The fork senses the pattern of eating and reacts by lighting and gentle vibration when eating too fast. The data can be uploaded via USB or Bluetooth on HAPI.com platform, where the eating process can be tracked over time (Ill. 02).

Ill. 01. Existing starting kits
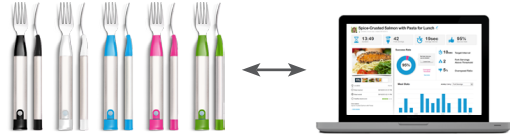
Ill. 02. Existing starting kits

Due to the complexity of developing a thermometer [**Worksheet no. 38**] and that the cooking tasks can be performed also without its use, it has been decided to keep the focus on the other components in the System of Objects, and consider its development as a future opportunity.

Starting package utensils

Since the System of Objects assists the user exclusively during the cooking process, the chosen utensils are those that are being usually most exploited during the preparation of a dish. An initial solution for measuring small amounts is to simply use a visual reference in the guidance.

Ill. 03. Spoon

Ill. 04. Whisk

Ill. 05. Turner

Ill. 06. Cook's Knife

Ill. 07. Peeler

Ill. 08. Vegetable Knife

The utensils included in the starting package are: Spoon (Ill. 03), Whisk (Ill. 04), Turner (Ill. 05), Cook's Knife (Ill. 06), Peeler (Ill. 07), Vegetable Knife (Ill. 08). The focus in the utensils' development is set on the handle, which contains the technology to communicate with the guidance.

The ideation process comprises sketches, 3D renderings, prints and foam models, that set the basis for decision-making and testing.

The shape of the handle takes into consideration the ergonomics (Ill. 09, 12), which is further on tested.

The idea of using a protuberance or a recess in the handle shape has been considered, in order to prevent the utensil from falling inside the bowls or pots when used (Ill. 10, 11).
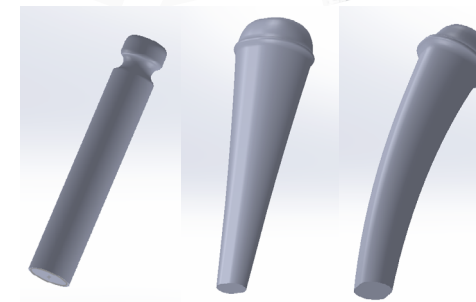
Since the idea has been evaluated as influencing negatively the ergonomic and aesthetics of the handle, the use of a non-slippery material has been considered as sufficient for preventing the utensils from slipping.
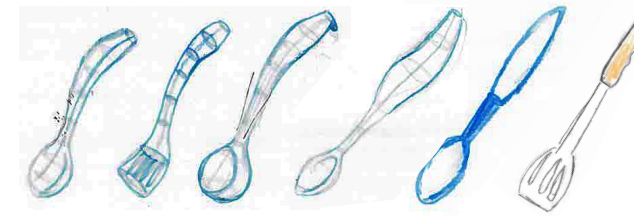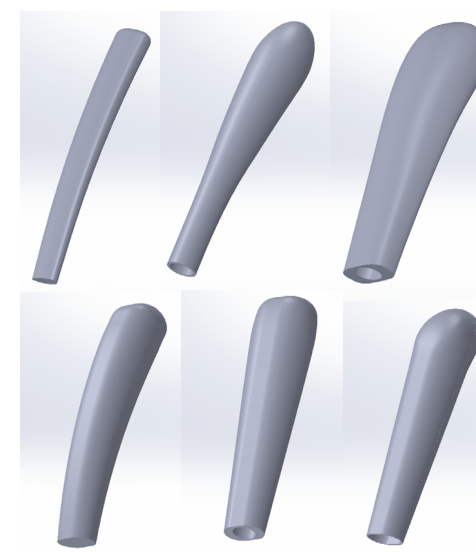

Ill. 09. Ergonomic shape of handle
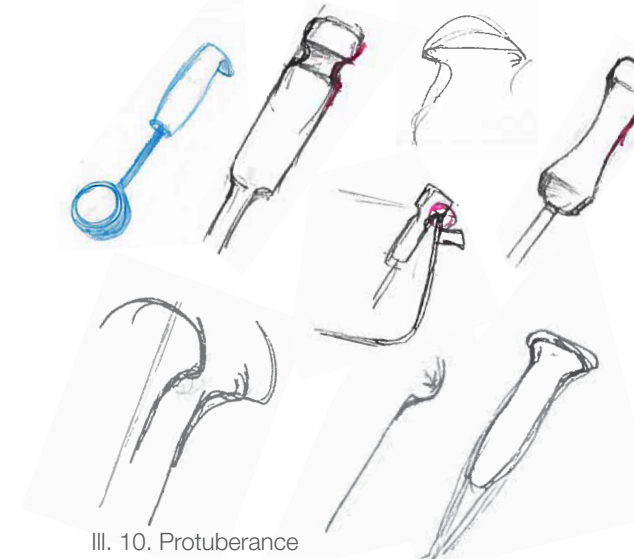
Ill. 10. Protuberance

Ill. 11. Protuberance 3D

Ill. 12. Handle shapes 3D

Ill. 13. Models of curved handles

Ill. 14. Models of straight handles

4.2. The charging platform

Taking into consideration the limited amount of time for product development, the charging platform has not been considered as main focus within the overall concept. Nonetheless, possible directions have been explored, for setting the ground knowledge for the further development.

Market research

The technology of inductive charging, also called wireless charging, has increasingly become more used in everyday applications (Ill. 15).
The product that needs charging, called receiver, has to be placed on the charging platform, the transmitter. Depending on the design of the components, the receiver can be placed either freely or on a specific spot on the transmitter, in order for the charging to take place at maximum efficiency [**Worksheet no. 42**].

Ill. 15. Wireless charged applications

Ideation

The areas where the platform could be placed within the kitchen environment are explored (Ill. 16), together with the possible methods of placing the utensils in the charging unit (Ill. 17).
The utensils need to be stored in the charging unit after each use, in order to ensure that they will be ready for subsequent use.

Reflection

• Proximity to a plug.
• Having an individual casing for each utensil would help observing if any of them are missing from the charging platform, but would most likely use much more space.
• Having the charging platform placed in the user's visual range would increase the possibility for the user to observe if all utensils are placed in the docking station. In this case especially, considerations regarding how to integrate the set in the kitchen environment are needed.

• The possibility of expanding the charging platform for containing more utensils than the Starting Package needs to be considered.
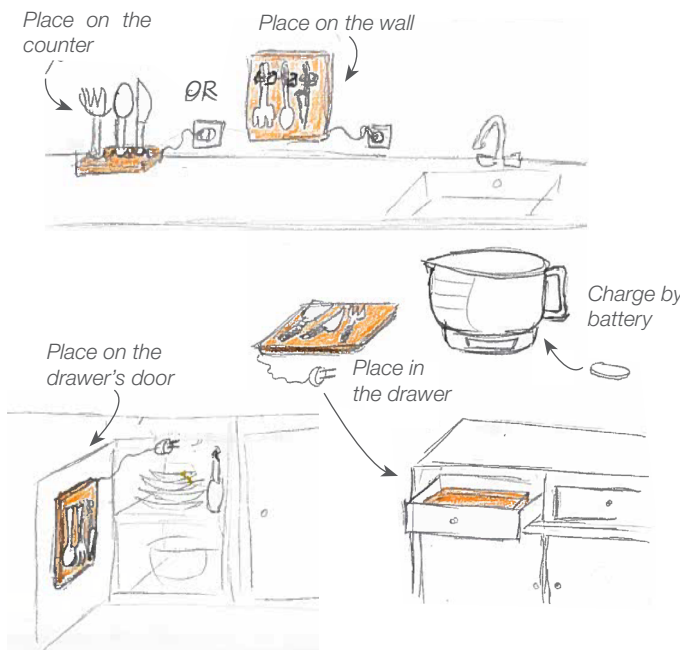
Ill. 16 Places to position the charging unit
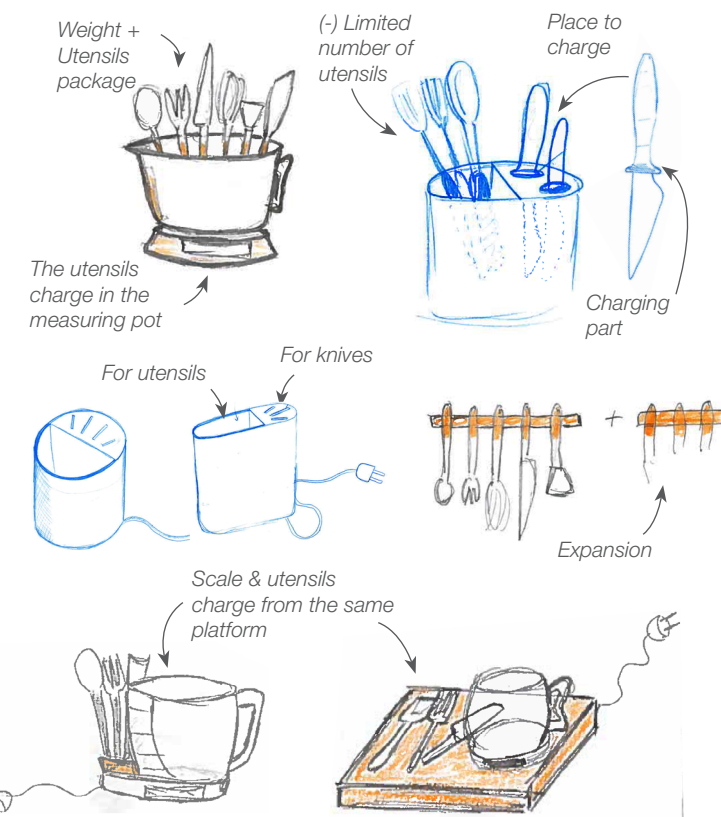
Ill. 17. Methods for placing the utensils to charge

4.3. The kitchen scale

Market research

In order to understanding the possible features to be implemented in the scale and in the measuring bowl, desk research regarding existing products has been made [**Worksheet no. 40**]. The products on the market vary greatly in shape and functionality, covering a wide range of taste and preferences.

Ill. 18. Scales on the market

Drop is one of the products on the market that offers a step-by-step guide throughout the steps of a recipe (Ill. 19). The concept comprises of a scale connected with an app, that allows the user to find, make and share the dish in a pleasant, interactive way.
For nutrition-aware cooking, SmartConnect kitchen scale comes in help, by offering a detailed nutrition analysis for creating a food journal. The scale is connected wireless with an app, for transmitting the weight measurements (Ill. 20).
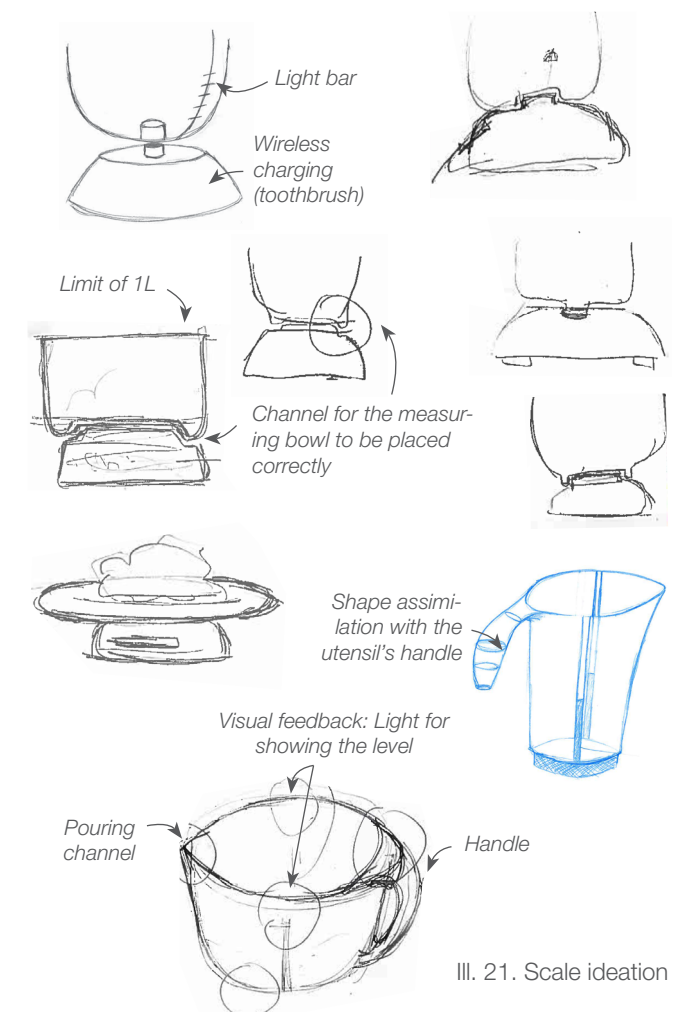

Ill. 19. Drop

Ill. 20. SmartConnect

> The functionality of the scale and its understanding by the users and other individuals needs to be tested.

Ideation: scale & measuring bowl

The design and functionality of the scale and the measuring bowl are explored (Ill. 21).
The scale can be powered by a set of replaceable batteries. For powering the electronics needed in the measuring bowl, inductive charging between the scale and the measuring bowl has been considered as the optimal solution for providing a long-lasting product. The jointing between the scale and the measuring bowl has been explored, with the focus on placing the measuring bowl correctly at all times. For visually indicating the amounts measured, the scale could have a light bar that increases as the ingredient is poured. The measuring bowl could have a light bar as well, that would indicate the level until the ingredient (flower, milk, sugar, etc.) has to be poured. Creating a visual relation between the components of the package could be done by having shape assimilations between the handle of the measuring bowl and the utensil.


Ill. 21. Scale ideation

4.4. The guidance

Market research

Exploring the existing cooking apps specifically designed for individuals with little to no experience in culinary activities, represents a valuable starting point for designing the Guidance platform [**Worksheet no. 39**].

Features such as pictures- and video-based explanatory steps (Ill. 22, 23, 24), voice activated recipe navigation (Ill. 22, 23, 24) or precise timing of several meals prepared at the same time (Ill. 24, 25, 26) are embedded.
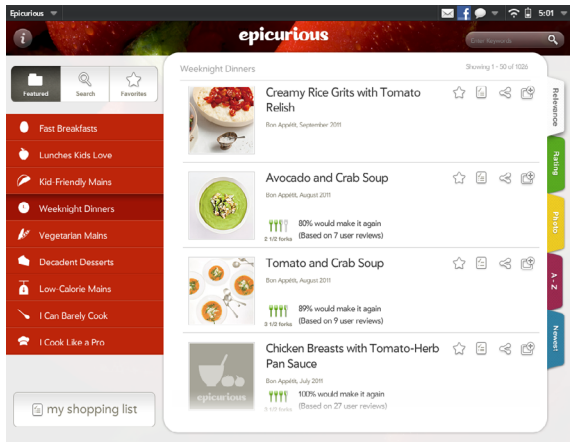
Information such as steps of the recipe, ingredients needed, tips and tricks or detailed explanation of specific steps are presented through different methods, such as text, icons, etc.
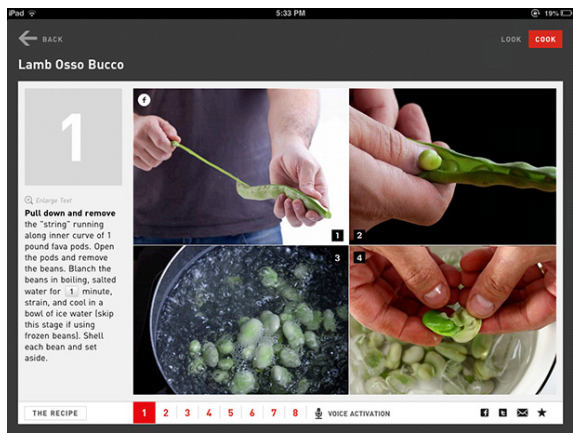
Ill. 22. Look and Cook
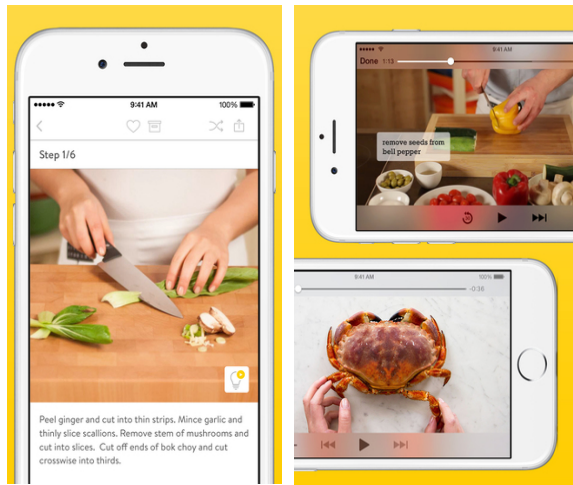
Ill. 23. Kitchen stories

Ill. 24. Epicurious

Ill. 25. Escoffier Cook's Companion

Ill. 26. Cooking Timer app

A proposal of the content to be placed in the User Interface is shown in Ill. 27.

SPLASH (just icon + pic)
entering the app

1ST time configuration

SETTINGS
- use sound (voice over video)/ mute
- set up preferences

- syncronize tools
- set up preferences

HOME SCREEN
- CATEGORIES OF RECIPES (e.g. appetizers, main course, desserts etc.)
- main buttons (acces to settings and filters

IN RECIPE BOX e.g. appetizers
scroll up and down to see recipes in the category

possibility of 'fast search': e.g. alphabetical A-Z or with ingredients

FAST OVERVIEW ON RECIPE
to know main info about recipe without opening it e.g.
- ingredients
- timing

according to the recipe you use, it will notify you when is time to start for having the dish ready at a certain time

RECIPE

COLLECT INGREDIENTS
- check list

VIDEO STEP

VOICE RECOGNITION
what are the vocal commands? (e.g. next, previous, or make questions to which the answer is yes or no, so that the app will bring you to the next step

Is the person going to remember what to say? (most likely NO)

DEFINE ACTIONS POSIBLE DURING THE VIDEO
e.g. play, pause, repeat

OVERVIEW ON RECIPE
- know at which point you are in the process
- navigate the recipe: both previous and next steps

- can make weekly plan of meals
-by choosing the recipes, can make a grocery shopping list

Ill. 27. Overview of User Interface

User interface development

Home menu

- Allow access to settings and filters.
- Have a search button.
- Allow access to recipes' categories.

Recipe categories - After a brief analysis, it has been decided to divide them into Appetizers, Main course, Side dish, Breakfast, Desserts and Favorites. Illustration 28 contains some of the graphic options, where the chosen one is outlined in green.

Ill. 28. Recipes categories

The third option has been evaluated as optimal because it provides a more effective visual understanding using both picture, icon and text.

Illustration 29 shows the 'Home menu' in two different stages of development, with the second one identified as final choice.

Recipes visualization

Each recipe should be visualized with an identifying picture and give access to (Ill. 30):

- Main information - to have a general understanding of the recipe.
- Booking - make possible to formulate a weekly schedule, so that the app will tell you when you need to start cooking in order to have the dish ready at a certain hour.
- Start cooking - button to start the guidance.
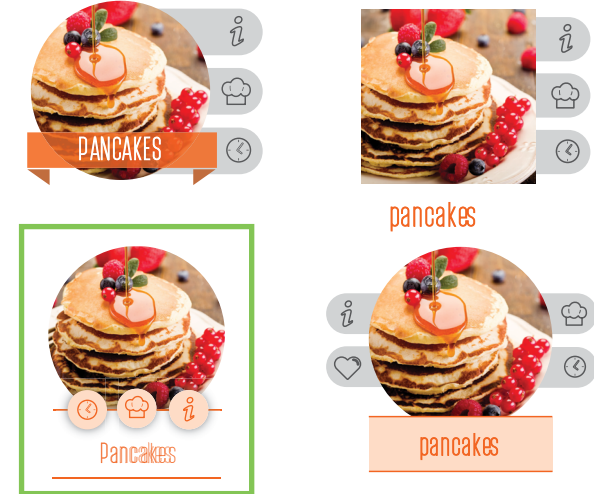
Ill 30. Recipes visualization

Ill. 29. Home menu
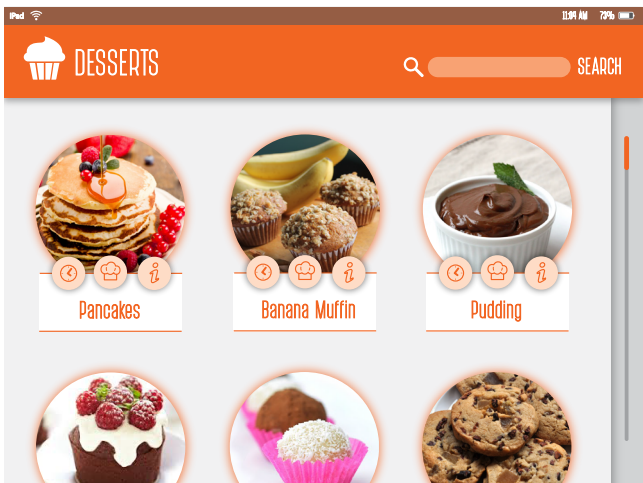
Ill. 31. Recipes categories
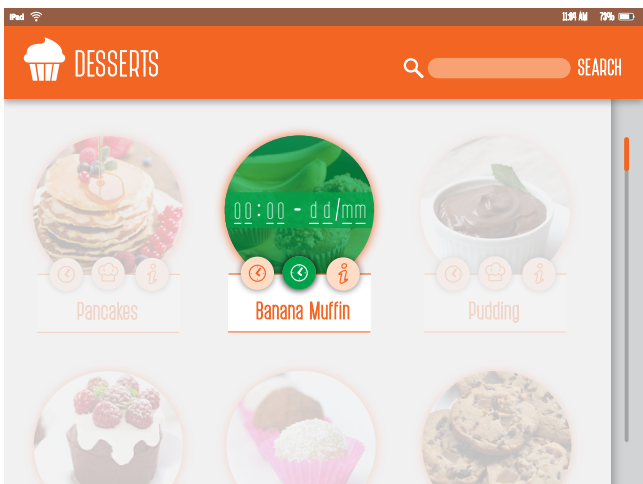
Ill. 32. Selecting

Ill. 33. Displaying a video
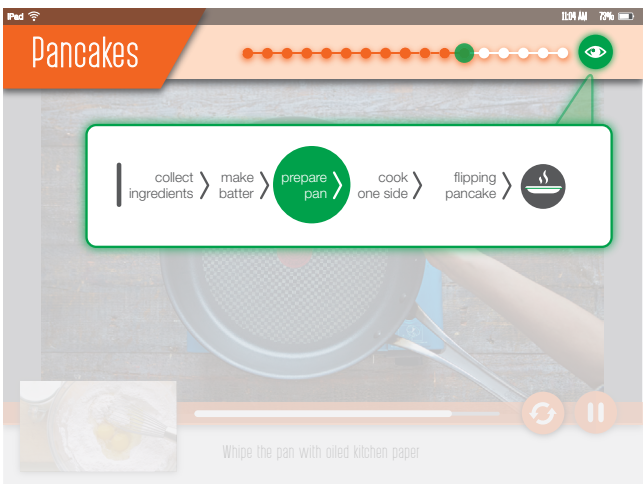
Ill. 34. Details of the steps

Two steps of the evolution for the recipes overview is shown in Illustration 31. When selecting items, they turn green colored (Ill. 32).

A proposal for the display of the image or video is made (Ill. 33). The screen could have the image of the previous step on the left bottom side of the screen. The evolution of the process can be seen in the top bubbled bar. By pressing on the eye icon on the right top side, the user can observe the previous and next steps in a more detailed level (Ill. 34).

> The functionality and understandability of the proposed interface needs to be tested with the user.

4.5. Test with unexperienced cook

Testing the overall understanding of the System of Objects and the interaction with the guidance represents an essential step in the development of the concept. Stefan Tanderup, an unexperienced cook of age 21, is the first person to test the concept.
Refer to **Appendix 7** for observing the Guidance process and to **Worksheet no. 44** for a detailed description of the test.

Set-up
The recipe is presented from a computer, with the steps going back and forth being controlled by the facilitator by the keyboard arrows according to the voice signal. The test takes place in an unfamiliar kitchen for Andreas.

Result
The task for Stefan to prepare the "Fried pork with Parsley sauce" recipe is well performed, with minor difficulties along the process. Andreas was content with the result, although the consistency of the sauce was not perfect.

Considerations for further refinement
Boiling potatoes
• The amount of potatoes that have to be peeled should be measured beforehand.
• The timing of the process of boiling potatoes has to be adjusted, according to the boiling speed of every specific situation.
• The action of cutting the potatoes should be done in a safer way, such as cutting on a cutting board, and not directly in the hand.
• Before starting the next task, the working area should be cleared.

Frying the pork
• The amounts of seasoning ingredients has to be more clearly described.
• The Guidance could inform how many pieces should be placed in the pan at once.
• The Guidance could indicate that a kitchen extractor should be activated.
• A time indicator regarding how much the slices of pork have to be left on one side could be useful. Likewise, a reference point on how fried should they be.
• An indication of adjusting the pan's temperature in such way that is not too high.

Preparing the parsley sauce
• The size of the cut parsley has to be better indicated.
• The amount of flower that has to be used needs to be indicated in a more precise way.
• The amount of milk that has to be gradually added needs to be better explained.

Overall considerations
The users might not trust completely the Guidance from the first use, since he is not used with such a detailed explanation throughout the process.

Conclusion
The process described in the guidance needs several changes for improving the user's experience.
The progression during the guidance should be controlled just by the user, and not by the utensils also.
The package of utensils needs to be revised, with the consideration of including the measuring cups.

Revise utensils
The utensils presented in Illustration 35 have been included in the Starting Kit, as a conclusion from the first test. The handles of the measuring cups have been colored for a comprehensive referral along the guidance.
• Red cup: one table spoon / 15 ml
• Blue cup: one tea spoon / 5 ml
• White cup: ½ tea spoon / 2,5 ml
• Yellow cup: ¼ tea spoon / 1.2 ml

Ill. 35. Measuring cups

The recipe of "Fried pork with Parsley sauce" is recorded again with the updated version of the Starting Kit [**Appendix 8.2**].
A three minutes timer is added for the stage when the slices of pork have to be fried, after which they have to be turned on the other side.

4.6. Test with final user

A test was performed with Jeanette Gadegaard [**Worksheet no. 48**], which presents the issues defining the user. She has not been able to cook since the occurrence of TBI.
Jeanette has presented high interest in the project and in the challenge of testing her abilities of cooking, by fully relying on the System of Objects.
The test implied both investigation of the functionality of the concept and of Jeanette's ability of preparing the recipe on her own.

Set-up
The components of the Starting Kit and a tablet of 10,6 inches have been prepared for the test, in order to create the setting as close to the real scenario as possible. The Guidance has been presented on the tablet (Ill. 36) and maneuvered from a computer, through Team Viewer. The recipe steps are controlled by pressing the keyboard arrows at every voice signal.

Result
Jeanette managed to prepare the recipe until the end, with no issues.
Along the guidance, the explanation had to be completed by the facilitator, since some of the steps were not clear enough. Managing the preparation of the recipe represented a positive achievement for Jeanette, that was nervous regarding the challenge. The parts of the recipe were correctly performed, besides the fact that the fried pork was not very crispy, which was quite important for her.

Considerations for further refinement
Boiling potatoes
• The necessary ingredients and objects should be shown each at a time, with a proper explanation of which kind of pots and pans are needed.
• The step of peeling and cleaning the potatoes should be revised, the involvement of the sink may need to be replaced (Ill. 37).
• The knife and the peeler should be able to detect the movements that have been done with them and adjust the flow of slides according to the actions that the user is doing.
• The guidance could have a series of options for the type of stoves existing, and allow for the user to configure it at the beginning.
• A thermometer placed in the water to boil for the potatoes would be useful for solving the problem of keeping track of the part of boiling potatoes.
• A better explanation of how to define that the potatoes are ready has to be included (Ill. 38).

Frying the pork
• The guidance could allow for the user to measure how much meat is in total, and adjust the recipe according to the amount available.
• Different types of containers for seasoning ingredients have to be taken into consideration, because
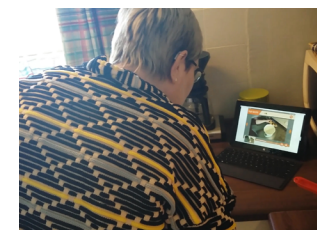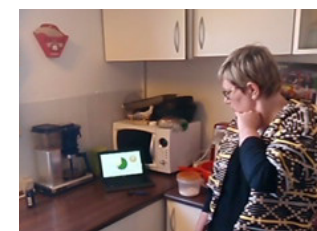

Ill. 36. Guidance on the tablet

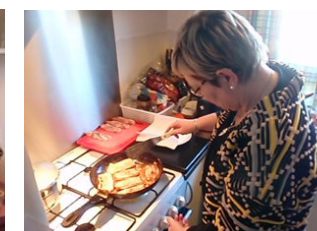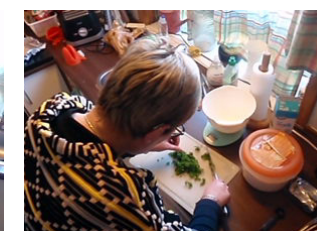Ill. 37. Peeling and cutting the potatoes

Ill. 38. Checking the potatoes

Ill. 39. Seasoning with pepper

Ill. 40. Timer for the pork

Ill. 41. Checking the pork

Ill. 42. Cutting the parsley

Ill. 43. Measuring the milk

it is difficult for the user to fill in a spoon of pepper, directly from the grinder (Ill. 39).
• The amount of butter needs to be better indicated.
• The timer proved to be non efficient, since the tested person had to use too much time just paying attention for when the time has reached the three minutes (Ill. 40).

Preparing the parsley sauce
Cleaning the parsley represents a challenge and needs a more thorough explanation. Likewise, the method of cutting it could be more detailed, regarding how small should it be (Ill. 40).

The scale
Along the steps of the guidance, the use of the scale was needed. The system of the light bar proved to be functional and easy to comprehend for Jeanette (Ill. 43). Addition of confirmation sound when reaching the desired amount and alerting sound when going over the limit were considered as a good idea.

The use of the measuring bowl was considered as unnecessary, since the Starting Kit already includes the scale, that is commonly used for measuring.
Using both the measuring bowl and the scale at the same time would require too much distributive attention, which patients with TBI do not possess. Moreover, the components that have to be measured differ in volume from brand to brand (e.g. flower), which would make the measuring bowl be unreliable.

The Utensils' handle
The handle for the utensils should ensure a secure grip, considering that the user might have a withered hand. The curved, organic shape presented highest interest for Jeanette (Ill. 44).

The Interface
The size of text depends on the preferences of the user. The chosen dimension was of 22 pt (Ill. 45).

Conclusion
• The overall steps of the guidance might need to be shown at the beginning of the recipe, so the user has an idea of the overall tasks.
• The use of sound recognition for moving back and forth in the process does not function, because the user does not remember what is the word that has to be pronounced, or does not even remember that a word has to be pronounced.
• The configuration of the guidance should allow the possibility of choosing between verbal, written or combined communication of the instructions.
• The ingredients that have to be used for each part of the recipe could be measured before starting the cooking process.
• When measuring an ingredient, the amount that has to be weighted could be indicated beforehand, so the user has an idea of how much is needed.
• Further tests have to be performed regarding choosing the appropriate shape of the handle. Likewise, the functionality of the scale needs to be verified more thoroughly.

The suggestions offered throughout the test should be implemented and presented in an exemplary dive when presenting the concept.

Ill. 44. Testing the handles

Ill. 45. Size of text

4.7. Test of the utensils handle

In order to define the shape of the handles for each utensil included in the Starting Package, a series of tests have been made [**Worksheet no. 46**].

The testing persons have been asked to choose among seven handle versions (Ill. 46) which would be most suitable for six of the utensils from the starting package: the spoon, the whisk, the turner, the cook's knife, the vegetable knife and the peeler. The measuring spoons have not been included in the tests due to the short time span in which they are being used along the recipe. The choices are presented below.

Ill. 46. Handles for testing

The Spoon
Front view *Side view*
Curved shape as no. 7.
Less bulky at the top.
Bigger diameter at the bottom.

The Whisk
Front view *Side view*
Straight shape as no. 1.
Rounded structure as no. 7, with the organic end as no. 6.

The Turner
Front view *Side view*
Curved shape as no. 4.
Organic ending as no. 5.

The Cook's Knife
Front view *Side view*
Straight shape as no. 1.
Have an organic indication of where the blade begins.

The Peeler
Front view *Side view*
Straight shape as no. 1, but with smaller dimensions.
Less bulky at the top.
Bigger diameter at the bottom.

The Vegetable Knife
Front view *Side view*
Straight shape as no. 1, but with smaller dimensions.
Have an organic indication of where the blade begins.

4.8. Test of the scale

The functionality of the light bar for communicating amounts needs to be verified.
Ten individuals have been subject to the test, where a normal kitchen scale, sugar, a bowl for placing the ingredient, a manually-maneuvered light bar and 12 versions for the screen's dimensions have been used (Ill. 47). The tests comprised of four parts [**Worksheet no. 47**]:
• Test the light bar system (Ill. 48);
• Test the light bar system with sound when reaching the amount;
• Test the light bar together with numbers (Ill. 49);
• Choose preferred size of screen (Ill. 50).

Results

The tests proved that the light bar system is comprehensible, with all the testing persons delivering a correct performance. Nonetheless, several comments have been mentioned along the process:
• During the test with the light bar, it is difficult to understand amounts (to comprehend how much has to be taken out, in case too much of the ingredient has been put on the scale).
• When adding too much of the ingredient, an arrow could point to the left, indicating that the limit has been exceeded and a certain amount of the ingredient has to be removed.
• The sound could both indicate when reaching the desired amount and when exceeding it.
• Having both numbers and the light bar is not effective and may lead to confusion.
• The light bar is preferred to be as long and thin as possible. The chosen dimensions are: 80 mm width and 10 mm height.

Conclusion

• The light bar system for the scale proved to be functional.
• The light bar and the numbers should not be shown simultaneously.
• The precision of the tests was influenced by the method of maneuvering the functional model. For this reason, a thorough set of tests would be necessary to be performed, in order to verify the idea at a more rigorous level.
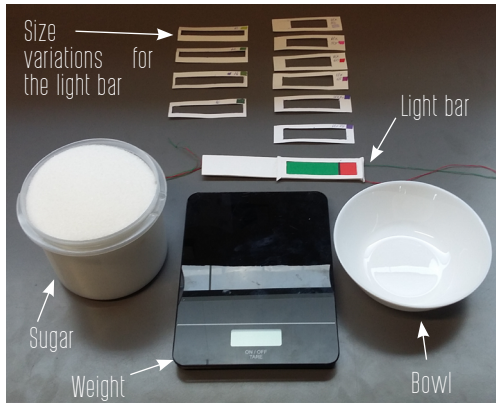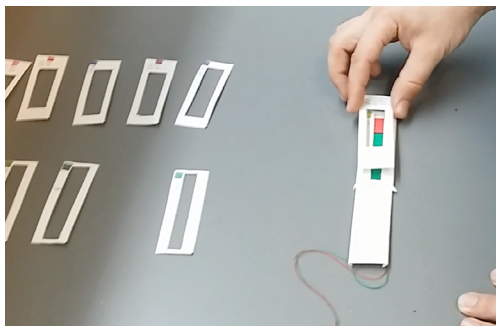

Ill. 47. Equipment used along the test
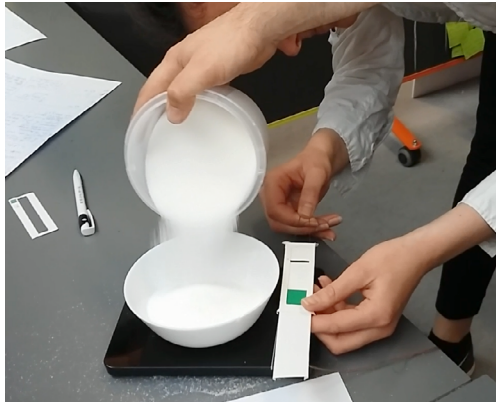
Ill. 48. Test light bar system
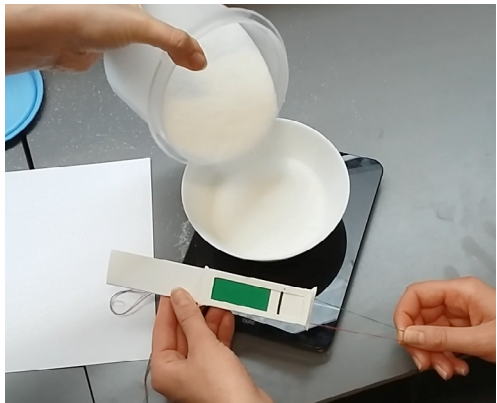
Ill. 49. Test light bar system and numbers

Ill. 50. Choose preferred size of screen
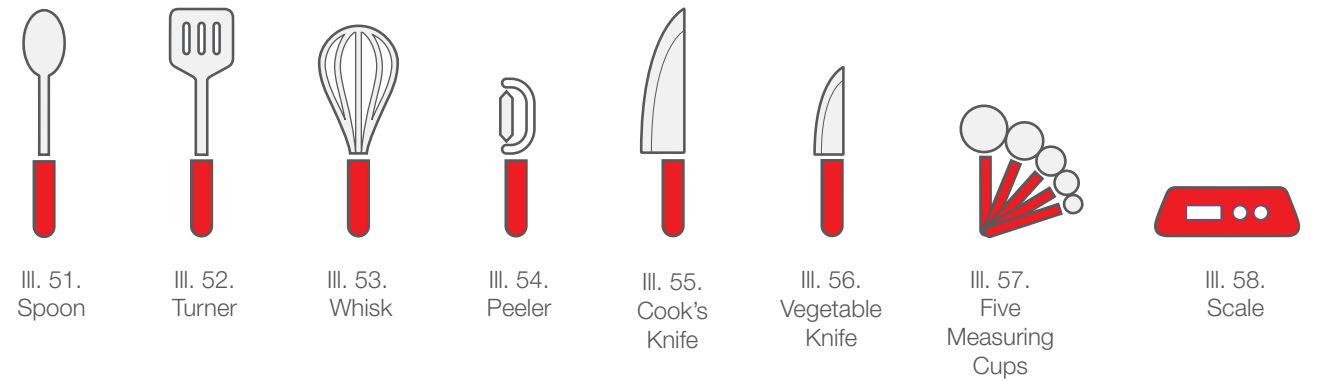
4.9. Sum-up

The tests have led to a series of changes regarding the System of Objects.
• Measuring cups are needed for performing the cooking task.
• The measuring bowl of the scale is eliminated from the System of Objects package.
• The guidance requires improvements.

The utensils contained in the Starting Kit are: Spoon (Ill. 51), Turner (Ill. 52), Whisk (Ill. 53), Peeler (Ill. 54), Cook's Knife (ill. 55), Vegetable Knife (Ill. 56), Five Measuring Cups (Ill. 57), Scale (Ill. 58).
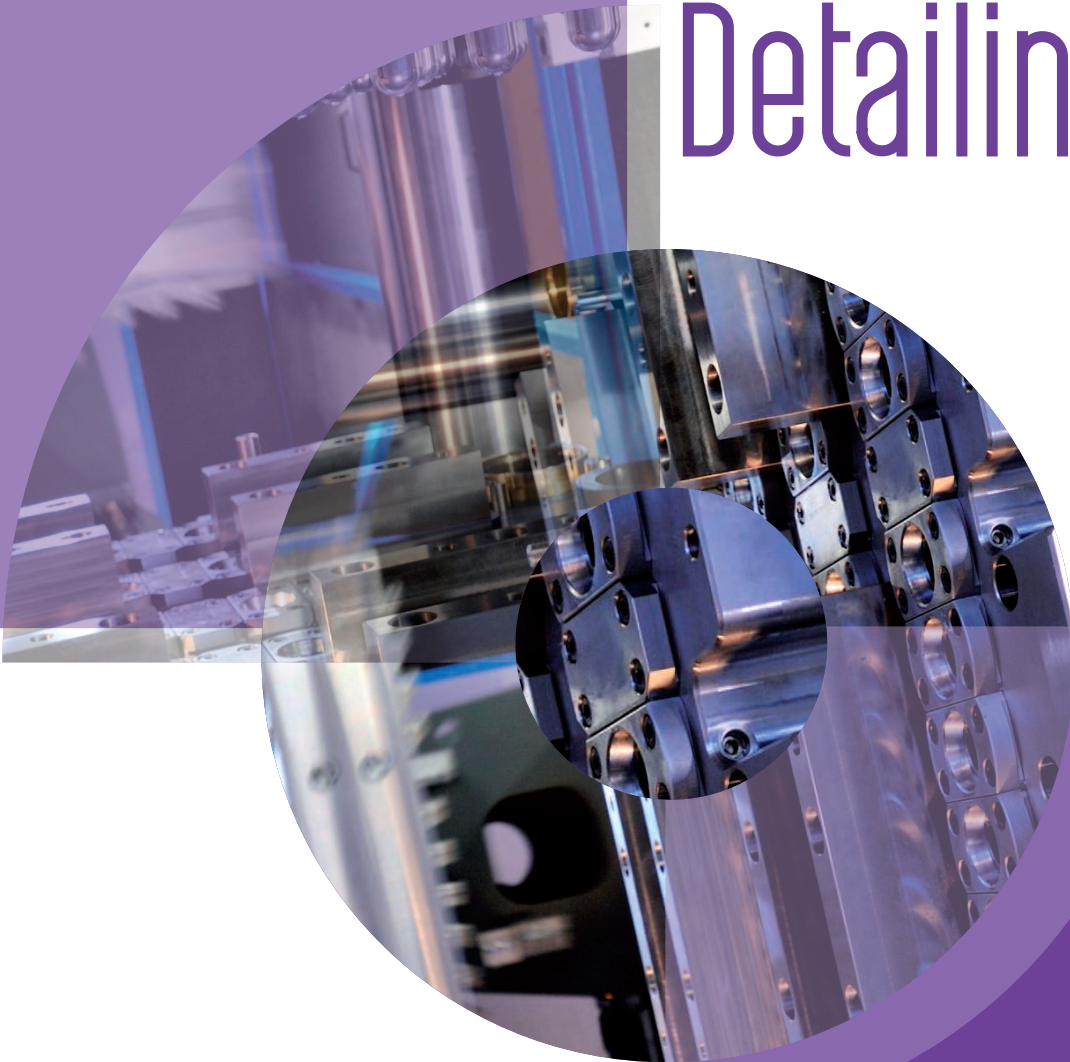They have been chosen according to two factors:

1. The most frequently used utensils in most of the cooking tasks.
2. Utensils that make the cooking process easier (the Measuring Cups), by making it easier to understand what quantities to put in the recipe, e.g. how much salt, pepper, etc.

Ill. 51. Spoon | Ill. 52. Turner | Ill. 53. Whisk | Ill. 54. Peeler | Ill. 55. Cook's Knife | Ill. 56. Vegetable Knife | Ill. 57. Five Measuring Cups | Ill. 58. Scale

Detailing

This chapter encompasses the final detailing of the product, together with technical components, materials utilized and production methods, together with the business perspective.

5.1. Refinement

Scale

For defining the shape of the scale, a series of sketches (Ill. 01) and 3D models have been explored [**Worksheet no. 49**], with combinations between the glass or steel top part and the organic or edgy extremities of the bottom part (Ill. 02).
Different combinations between the colors used in the guidance have been explored (Ill. 03).
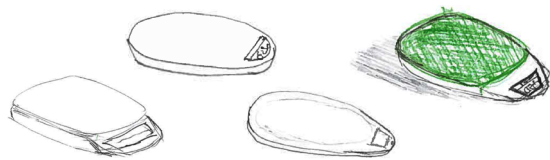
Ill. 01. Sketches of the scale
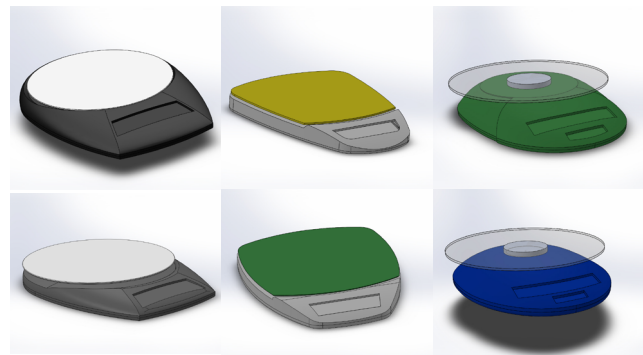
Ill. 02. Shape of the scale

Ill. 03. Colors of the scale

The position of the buttons and their functionality plays an important role in the interaction that the user has with the scale (Ill. 04).
Having two buttons, one for ON / OFF and one for TARE, is considered to be the optimal solution to ensure redundancy and simplicity.
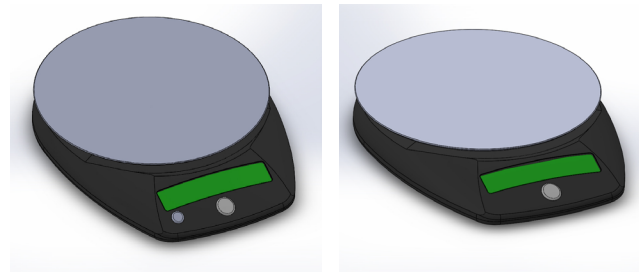
Ill. 04. Button versions for the scale

Conclusion

• The shape of the scale should ensure an intuitive interaction and purpose.
• The shape of the scale should ensure that the inner components are not easily exposed to liquids, in case of pouring from above.
• The screen's position and dimensions should ensure maximum visibility both of the light bar and of the numbers.
• The top part should be easily removable for washing, by unscrewing, allowing for an easy grip.
• The scale should have two buttons, one for ON / OFF and one for TARE function.
• The measuring unit of the scale can be changed from grams to pounds in the Settings of the Guidance.
• The identity of the product should be recognized along the components of the package.
• The scale should indicate by sound when the desired limit has been reached and when the desired limit has been exceeded.
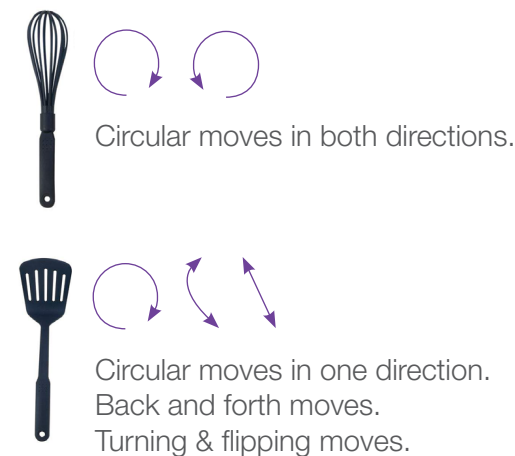
The following aspects are set as
further investigation:

• The understanding of the
buttons' functionality.
• The placement and aesthetics
of the limit line.
• The types of sounds used when
reaching and exceeding the limit.

Utensils

Since the utensils communicate with the guidance, it is essential to explore the benefits brought by inserting technology in the handle. An exemplary dive is required for understanding what is the pattern when the utensils are used. The whisk and the turner are chosen for investigation, considering that those two tools are used for the longest time while preparing the "Fried pork with parsley sauce" recipe.

A series of tests have been made with ten individuals, where they have been asked to show how are they using the tools [**Worksheet no. 46**].

Circular moves in both directions.

Circular moves in one direction.
Back and forth moves.
Turning & flipping moves.

Ill. 05. Pattern for whisk and turner

The pattern for the two utensils is inserted in the programming of the guidance. When the utensil needs to be used, the sensors within the handle can detect if the correct movement is done. In this way, the process can be tracked and corrected if needed.

The shape of the utensils is concluded from the tests performed. The focus is set on the whisk and the turner, while for the remaining utensils from the Starting Kit (the spoon, the cook's knife, the vegetable knife, the peeler and the four measuring cups) a general proposal that needs to be further developed is given.
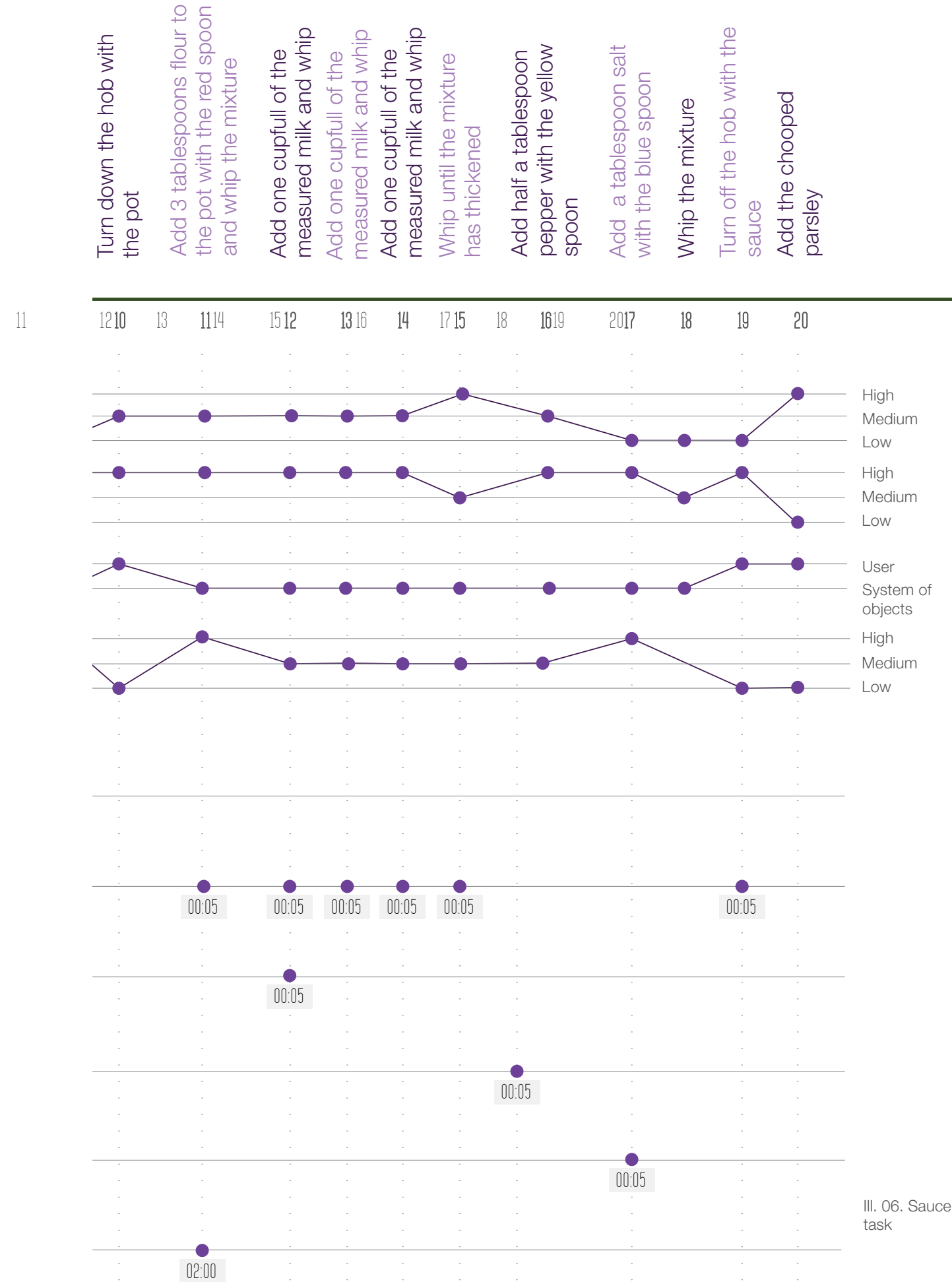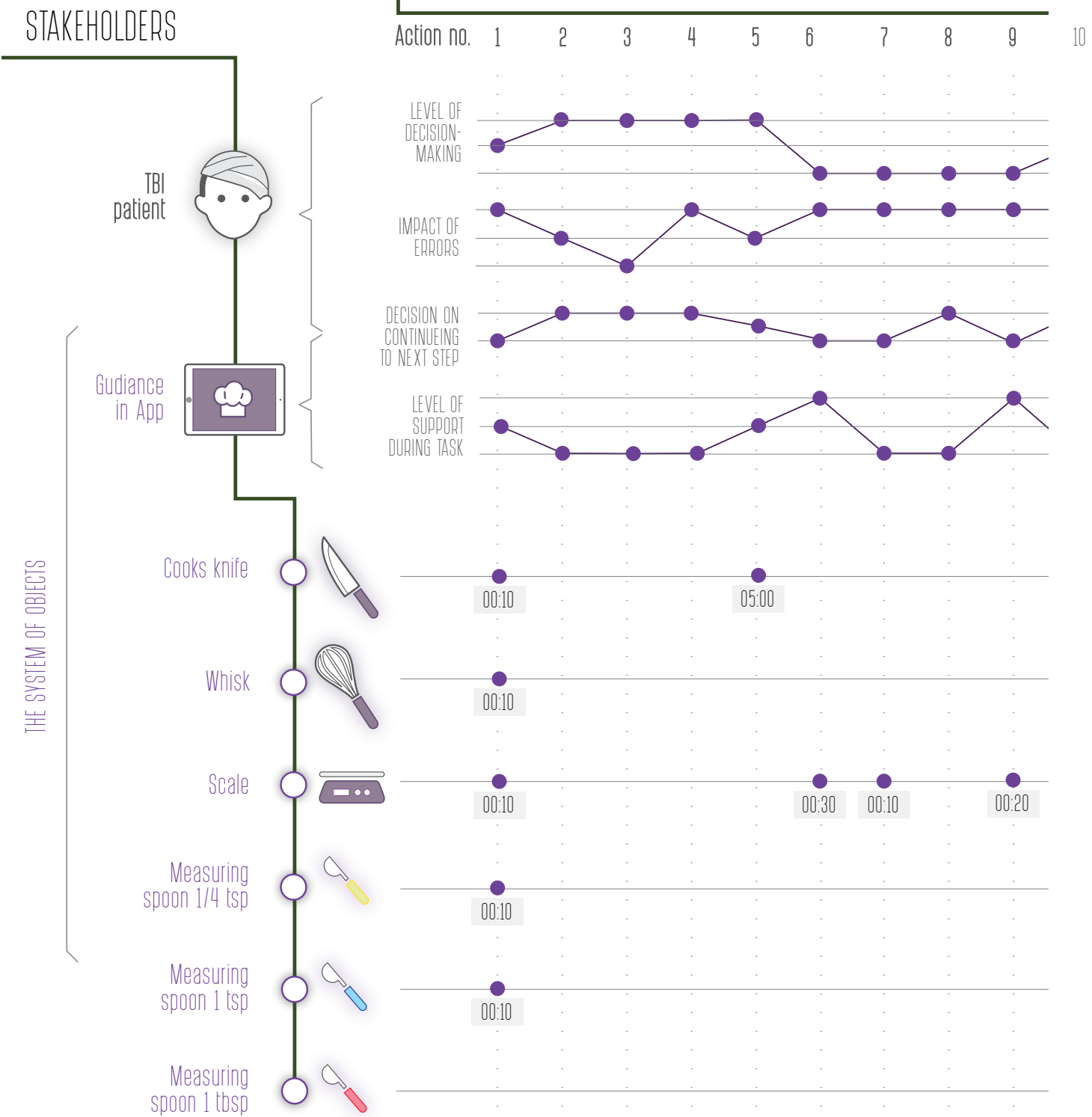
The ergonomics of the handles
need to be further investigated,
to ensure that the user has
a pleasant experience.

System

For having a detailed understanding of the system's functionality, respectively how does the overview during cooking takes place, a zoom-in on the sauce task of the "Stegt Flesk med Persillesovs" recipe is represented (Ill. 06).

The level of decision making and impact of possible errors along the task are plotted, together with the level of assistance from the guidance and the time span when the scale and the used utensils are used.
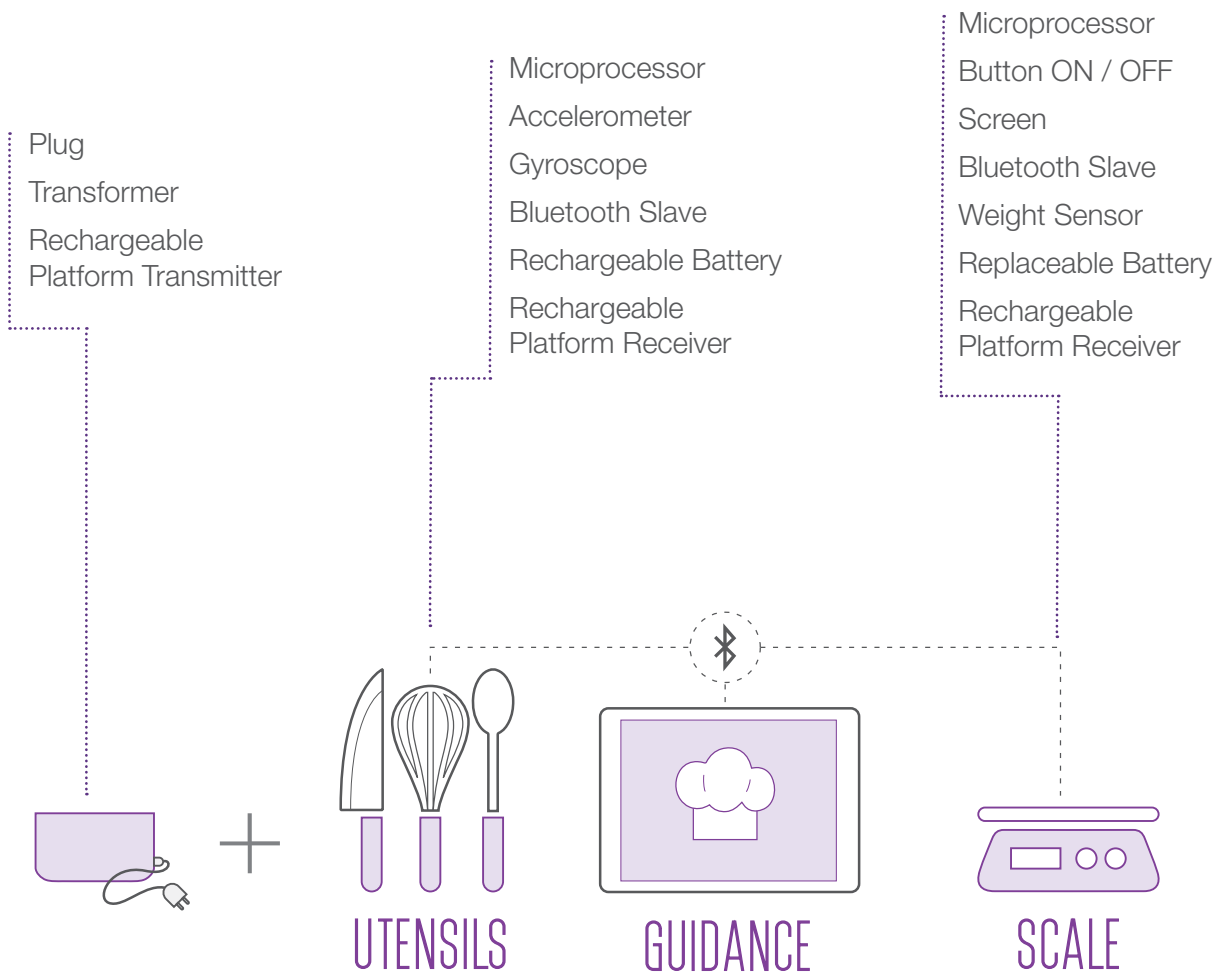
Sauce-task

Ill. 06. Sauce task

TASKS TO PERFORM

Action no.	Task
1	Collect ingredients and utensils
2	Move pot to stove
3	Pick a handful of parsley
4	Wash parsley
5	Finely chop the parsley
6	Cut and measure 30 g of butter
7	Put butter into pot
8	Turn on the hob with the pot
9	Measure 500 g of milk
12 10	Turn down the hob with the pot
13 11 14	Add 3 tablespoons flour to the pot with the red spoon and whip the mixture
15 12	Add one cupfull of the measured milk and whip
13 16	Add one cupfull of the measured milk and whip
14	Add one cupfull of the measured milk and whip
17 15	Whip until the mixture has thickened
18	Add half a tablespoon pepper with the yellow spoon
16 19	Add a tablespoon salt with the blue spoon
2017	Whip the mixture
18	Turn off the hob with the sauce
19	Add the chooped parsley

STAKEHOLDERS

TBI patient

Gudiance in App

THE SYSTEM OF OBJECTS

- Cooks knife
- Whisk
- Scale
- Measuring spoon 1/4 tsp
- Measuring spoon 1 tsp
- Measuring spoon 1 tbsp

LEVEL OF DECISION-MAKING — High / Medium / Low

IMPACT OF ERRORS — High / Medium / Low

DECISION ON CONTINUEING TO NEXT STEP — User / System of objects

LEVEL OF SUPPORT DURING TASK — High / Medium / Low

5.2. Technology

The System of Objects is based on the communication through bluetooth between the scale and the smart utensils with the guidance.

The duty cycle of the products during one day of usage gives an overview on the performance of the components [**Worksheet no. 45**]. The products are expected to be able to function for a timespan of maximum four hours continuously.

When choosing the electrical components (Ill. 07) for the System of Objects, factors such as lowest dimensions, price and current consumption played a decisive role.

Plug
Transformer
Rechargeable Platform Transmitter

Microprocessor
Accelerometer
Gyroscope
Bluetooth Slave
Rechargeable Battery
Rechargeable Platform Receiver

Microprocessor
Button ON / OFF
Screen
Bluetooth Slave
Weight Sensor
Replaceable Battery
Rechargeable Platform Receiver

UTENSILS   GUIDANCE   SCALE
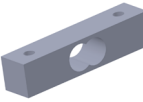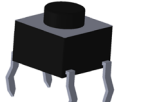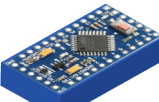
Ill. 07. Electrical components

Scale

The components that are comprised within the scale (Ill. 08) play an essential role in the lifetime of the battery, the accuracy of the feedback and the quality of the user's experience.
For powering the components within the scale, a set of four AAA batteries is required. The lifetime given by the batteries, assuming that the scale is used for 10 minutes for every recipe, is of 84 recipes. Considering that the user prepares a recipe every second day, the scale's batteries will supply energy for approximatively half a year, after which the batteries need to be replaced [**Worksheet no. 51**] [**Appendix 10**].
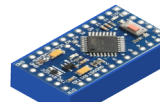
Bluetooth Low Energy	Speaker	Load Cell	Button	Microprocessor	Screen	Replaceable Battery
5 x 5 x 1 mm 13 mA 1.9 ... 3.6 V 16.40 DKK	10 x 10 x 2,9 mm 2,5 mA 8 V 15 DKK	55,25 x 12,70 x 12.70 mm 5 V 45,56 DKK	6 x 6 x 8,50 mm 50 mA 2,30 DKK	33 x 18 x 6 mm 150 mA 5 ... 12 V 10,79 DKK	6,5 x 92 x 23,3 mm 70 mA 2,4 V ~ 5,5 V 129.43 DKK	10,5 x 10,5 x 44,5 mm 1000 mAh 1,5 V 29,00 DKK/4

Ill. 08. Electrical components of the scale

Utensils

The electrical components within the utensils are placed in the handle. They influence the handle's shape and dimensions, and for this reason, the smallest components have been chosen (Ill. 09).
For powering the components, a set of two rechargeable batteries are required. The components are able to function for a total of eight hours, until the batteries need to be recharged.
When on stand-by, the batteries provide the necessary power for a total of 21 days, after which they have to be recharged [**Worksheet no. 50**].

| Bluetooth Low Energy	Accelerometer	Gyroscope	Rechargeable Platform Receiver	Microprocessor	Rechargeable Battery
5 x 5 x 1 mm -40 to 85 °C 13 mA 1.9 ... 3.6 V 16.40 DKK	2 x 2 x 0,95 mm -40 to 85 °C 130 µA 1.62 ... 3.6 V	3 x 3 x 1 mm -40 to 85 °C 5mA 2.2 ... 3.6 V	10 x 10 x 2 mm -20 to 105 °C 19.61 DKK	33 x 18 x 6 mm 150 mA 5 ... 12 V 10.79 DKK	20 x 20 x 1 mm -20 to 60 °C 280 mAh 3 V 31.24 DKK

Ill. 09. Electrical components of the scale

5.3. Production

Heat protection

The utensils are both exposed to high heat from the stove and when being washed in hot water. Therefore, the materials and parts surrounding the electronics have to be chosen with this in mind.

Furthermore, the materials chosen should not be heat conductive.
Therefore, the construction of the parts surrounding the inner shell with electronics is made with a layer of air, for isolating. Likewise, all parts of the utensils are made from either plastics or silicone, which are not heat conductive (Ill. 10).

Air layer   Plastic
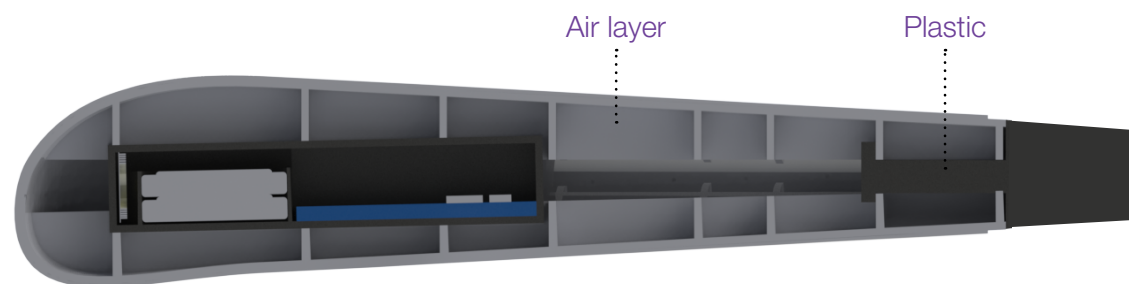
Ill. 10. Handle's construction

Ingress protection

Since the handles of the utensils contain electronics and are exposed to both solid and liquid comestibles, as well as water for cleaning, they need a certain level of protection.
Therefore, they are given an IP-code which classifies the degree of protection from intrusion of solid objects such as: body parts, dust, accidental contact and water in electrical enclosures. By giving the utensils this standard, the user will have much more knowledge about what do the utensils withstand.

The IP-coding chosen for the utensils is IP66. The first number means the utensils are dust tight, hence no dust will get inside the handle to the electronic parts. The second number means the utensils are resistant to powerful water jets (water projected in powerful jets of a 12,5 mm nozzle), hence no water will get into the electronic parts of the handle.

The scale is given the IP-code IP32. The first number stands for protection against objects that are the size of 2,5 mm and smaller. The second number stands for protection of dripping water when tilted up to 15° (DSm&T, 2016).

Conclusion

With the above mentioned considerations in mind, the utensils and scale have certain limits. The utensils should not be washed in a dishwasher both because of the high heat and too much water. They should be able to withstand resting on a hot side of the pot for a longer period. If they fall into a hot pot, they should also withstand being in the pot for a short period of time, after which the heat will eventually reach the electronic parts.

Selection of materials

ABS parts
ABS has been chosen for the scale-body, buttons, measuring-plate supporters and battery lit because it is a versatile material which is also used for other types of plastic scales. It is a low cost material which is easy to process and color match. It has an excellent stiffness and is scratch resistant.

Silicone parts
Silicone has been chosen for the feet of the scale, to achieve a less slippery base. Likewise, the head of the turner utensil is coated with silicone, due to its high temperature resistance. The handles of the utensils are coated with silicone as well, for diminishing the possibility of the utensil to slip in the pot. The validity of the statement has to be verified in the further work, through tests.

Polystyrene parts
Polystyrene (PS) has been chosen for the screen-protector because it has a crystal-like clarity that allows the user to see the screen behind it. It is easy to mold and has excellent stiffness and strength.

Polyamide parts
Polyamide (PA) has been chosen for the inner parts of the utensil handles, the inner part of turner-head and the whisk- and spoon head. It is has a high temperatures resistance (around 200°C), a high tensile strength and low friction. PA is already used for other types of kitchen-utensils on the market.

Stainless steel parts with a brushed surface
Stainless steel has been chosen for the measuring plate. It is easy to process, is extremely tough and has a wide range of surface finishes.
A brushed surface finish has been chosen for the measuring plate to achieve a matte surface, which is non-reflecting.

Steel parts
Steel has been chosen for the load cell holder because it is an easy material to process, has a low cost and can be punched into the shape needed [**Lefteri, C. 2014**].

Production methods

Scale body - ABS
The ABS body for the shell is injection molded. In this production method, plastic granulate are being fed into a heated cylinder with a transportation screw. The screw transports the melted plastic into runners and further into the mold, where the component is formed.

The same production method is also used for the following components with the listed materials:
• Feet - Silicone;
• Screen protector - PS;
• Buttons - ABS;
• Measuring-plate supporters - ABS;
• Battery lit - ABS;
• Inner holder for electric components - PA;
• The Whisk-head - PA.

Measuring plate - Stainless steel
The round shape of the plate is obtained by a method called sharing. In this process, the metal sheets are placed on a rotating part of the machine. While this part is spinning, a cutter is gradually cutting the circle. Afterwards, the edges are being milled.
The surface finish is made by hot-rolling, followed by cold rolling. The metal sheet is heated prior to rolling. After rolling, it is given a heat treatment to ensure a uniform micro-structure and that it will meet mechanical property requirements.
After these steps, the surface has a dark non-uniform appearance called "scale". This surface has to be removed in order to achieve the expected level of corrosion resistance.

Load-cell holder - Steel
This part is being punched from a metal sheet and afterwards formed by punching.

Turner Handle and head - PA and Silicone
The handle parts are being 2K-molded. This production method is similar to injection molding, just with two types of plastic. When the PA-part is molded, the mold rotates, after which the Silicone-coating is molded on the outer side of the part.
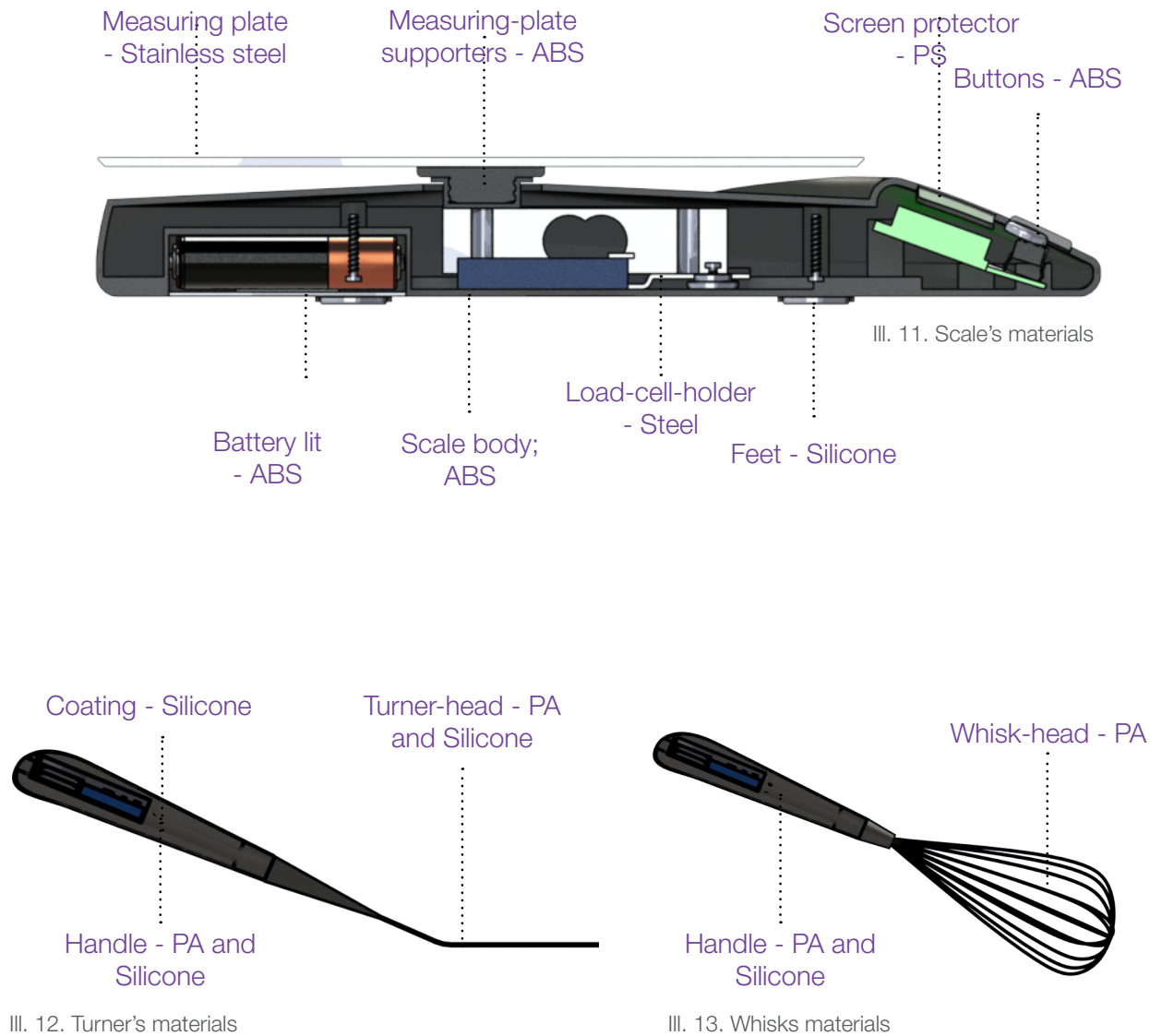
Assembling

Scale body
The scale body is assembled with four screws that are placed behind the feet. The feet and screen are glued to the scale-body. The measuring plate is screwed onto the measuring-plate-supporter, which allows the user to unscrew it and wash it separately (Ill. 11).

Utensils
All parts are glued together, not allowing the user to take it apart. The electrical components within the handle are placed on a basic housing, that is used for all utensils. The basic shell is covered by the outer shells, specific for each utensil (Ill. 12, 13).

Measuring plate - Stainless steel
Measuring-plate supporters - ABS
Screen protector - PS
Buttons - ABS
Battery lit - ABS
Scale body; ABS
Load-cell-holder - Steel
Feet - Silicone

Ill. 11. Scale's materials

Coating - Silicone
Turner-head - PA and Silicone
Handle - PA and Silicone

Ill. 12. Turner's materials

Whisk-head - PA
Handle - PA and Silicone

Ill. 13. Whisks materials

5.4. Business

The business strategy (Ill. 14) chosen for this product is of starting up a new company called KeeCo I/S, which is comprised of two employees [**Osterwalder & Pigneur, 2010**].

An important key activity is the field work needed in order to get an understanding of the target-group. This activity includes multiple rounds of testing in order to understand all possible methods of doing a cooking task. In order to make this happen, an important key-partner is the brain injury organization. Likewise a cameraman, a film editor, a cook and a programmer represent important key partners in relation to creating the KeeCo application.

The company develops the product and outsources the production, programming and assembling. After the sales are starting, the company keeps developing KeeCo, while offering customer support. At the beginning, the costumer will buy a starter kit consisting of the KeeCo app, the smart scale, 10 utensils and 30 recipes chosen by the costumer. The utensils included in the starter kit are basic utensils and will function with all the recipes included. Both recipes and utensils can be bought at a fixed price. After the user has purchased the starting kit, the catalog of recipes can be extended, by buying new recipes, and subsequently the utensils required for the recipe to be prepared.

The value proposition for this product is to make the users independent and give them the joy of creating a home cooked meal, that they made "without help".
In relation to the Customer relations, there are two perspectives: buying and installing the application, which is done by the user. If needed, telephone service is also available.

The product is ordered and bought through websale or stores that sell helping tools. Description of the product, information about functionality, price, purchasing opportunities and users' feedback can be found on KeeCo's webpage. The customers for KeeCo are people with cognitive difficulties that prevent them form cooking on their own.


Ill. 14. Business Model Canvas
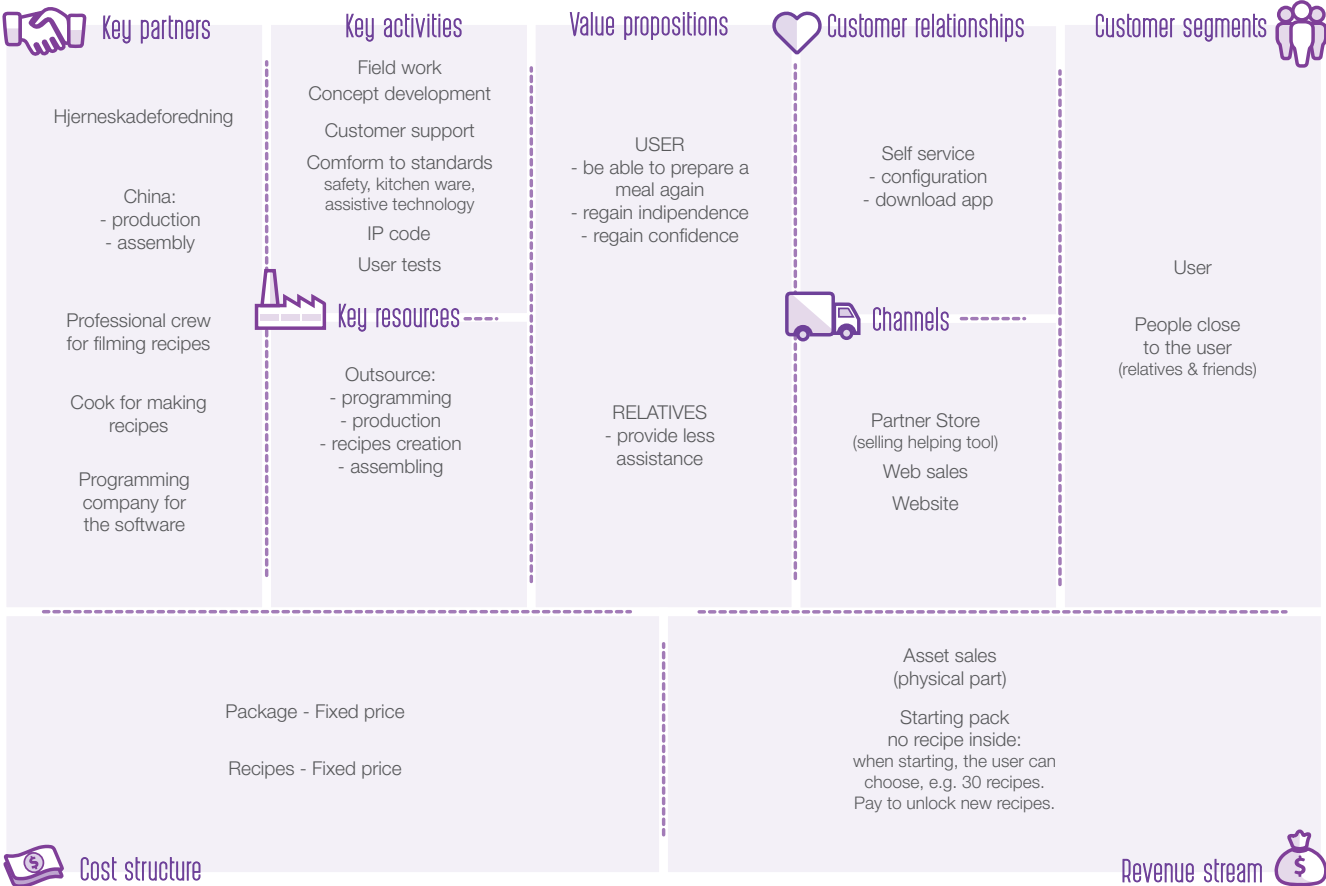
Break-even

This break-even analysis is based on the number of potential costumers in Scandinavia that suffer from either a Brain injury, Dementia or ADHD. The reason for expanding to both dementia and ADHD is because people suffering from these disorders might have similar difficulties in relation to cooking.

From these disorders, an estimate of people suffering from cognitive impairments has been found to be around 140.000 [**Worksheet no. 04**], out of which it is estimated that 5% will buy the first year, 8% the second year and 15% the third year. After the third year, the rate of profit will be 41,4% [**Appendix 11**].

In order to develop a satisfactory system, 2 years of development are needed. Within these 2 years, different cooking patterns have to be investigated, in order to understand both the different methods of performing the task but also the erroneous ones. These patters will further be used to create algorithms to let the system know what the user is doing. The algorithms have to be tested with different users in order to understand if they work. In relation to the videos used in the application, different camera-angles and degrees of detail will be investigated, created and tested.

Ill. 15. Break-even analysis
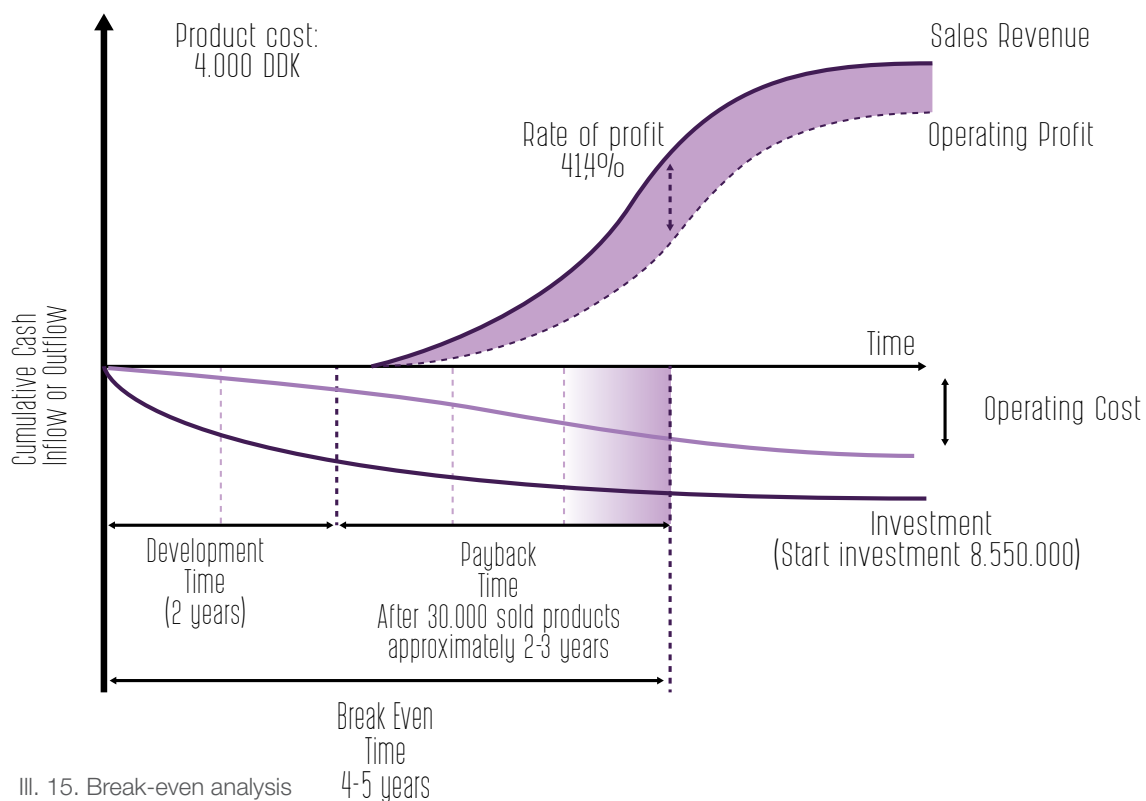
Price estimate

The price is estimated with basis on an expected sale of approximately 40.000 starter kits during 3 years. It is a two-men company that are renting work-tables and managing all sales online or through a distributor. The cost-price per starter kit has been estimated to 1257,31 DKK [**Appendix 11.1**]. Likewise, an estimated investment has been made for KeeCo. The investment includes salary for two employees for two years, outsourcing of programming, application transitions, approvals, travels, prototyping, materials, tools and other expenses. The total investment adds up to 8.550.000 DKK [**Appendix 11.2**], which leads to a final estimated sales price of ~ 4000 DDK [**Appendix 11.3**]. When desiring to extend the package, new recipes can be purchased for 30 DKK.

Closing

Is now following the final reflection and conclusion, together with the reference list and illustrations.

Conclusion

Starting with the proposed theme: 'A Socially Assistive robot for patients suffering from Frontal Lobe Brain Injury' as a departure point, the collected and processed information led the team to designing a solution that helps individuals suffering from the consequences of Traumatic Brain Injury in regaining independence in performing a cooking task.

The outcome of the project is KeeCo, an Assistive Technology composed by a system of smart objects communicating with a guidance, which assist the user through cooking tasks.

Further development

For further development, KeeCo needs to be tested by more different users in order to confirm that it fulfills multiple needs.
Each possible pattern of using the utensils in a cooking recipe has to be explored. These patterns will be used to create an algorithm for the system in which to base its algorithms. In this way, it will ,to a certain extend, be able to customize its guidance according to the user and not the other way around.
Other utensils and kitchen tools have to be examined and included in the solution. In this way, KeeCo will know more about what the user is doing at a certain point.
Other areas of cooking can be included in the KeeCo line, as for example the actions that take place before and after cooking (e.g. buying / collecting items needed and cleaning up afterwards).
Likewise, other areas of the household will become a part of KeeCo in the long run.
Lastly and maybe most importantly, the relationship between the user and KeeCo has to be further developed. In this area, considerations such as the role and functionality of KeeCo have to be developed in depth.

Reflection

Project management

The use of worksheets to collect and organize the data acquired along the process proved to be an effective way to keep track of the acquired knowledge, especially when research topics and activities were covered separately.
Nonetheless, the team often lacked in critically evaluating the collected information and in aligning (converging) them in order to further proceed.

Continuous re-framing

Starting the project with focusing on the technology, instead of the traditional approach of defining a problem statement and, according to the identified needs and issues, identify the most valuable solution, proved to be misleading for the team.
In fact, as more knowledge was acquired along the process, the team re-framed several times the user and consequently the identified solution.

Project team and work flow

The composition of the team proved to be well balanced since each team member possesses different strengths and focuses in different aspects of the process. This allowed to gain a more comprehensive approach on the project.
Must also be noted that, by being three members, it was possible to manage a considerable amount of work, as well as effectively divide the tasks in order to make the most out the time available.

Due to the delicate subject of Traumatic Brain Injury, difficulties have been encountered when trying to establish a direct relation with the users. The situation is especially amplified when cooperating with Rehabilitation Centers, in which the privacy and protection of the user did not enable the team to get direct feedback from these individuals.

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Illustrations

Chpt. 0

Ill. 01. Appendix 15
Ill. 02. - 03. Own pictures
Ill. 04. - 05. Appendix 15

Chpt. 1

Ill. 01. Own illustration
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Ill. 51. - 57. Own illustrations

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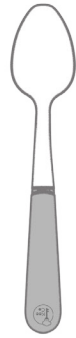**Ill. 05. - 15.** Own illustration

ARKITEKTUR & DESIGN

KeeCo

AALBORG UNIVERSITY
DENMARK

KeeCo

- Assistive Technology -

cooking with cognitive impairments

MSC04 - 03 INDUSTRIAL DESIGN
Aalborg University, may 2016

TEAM 3
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Abstract

Dette projekt omhandler udarbejdelsen af et system af smart-objects, KeeCo, som samarbejder om at hjælpe en person med kognetive udfordringer igennem at lave en madret.

Kognetive udfordringer betyder at nogle dagligedags aktiviter kan blive umulige at gennemføre. Grunden til dette kan være nedsat evne til at: huske, koncentrere sig, lære nyt og strukturere. Ligeledes indbære det at personen har nedsat: kritisk sans, tidsfornemmelse, rækkefølgefornemmelse, visuelt syn (visuel agnosi, hemianopsi og andre synsfeltsudfald), opmærksomhed til højre/venstre (neglect), initiativ og forhøjet træthed.

I dette projekt er det valgt at indsnævre dette til: nedsat evne til at huske, nedsat rækkefølgefornemmelse, nedsat tidsfornemmelse, nedsat logisk sans og mental træthed.

Det indlende tema for dette projekt er at udarbejde en "Socally assistive robot (SAR)" som skulle implementeres på et rehabiliseringscenter for unge med hjerneskader i frontallappen. Igennem den indledende research blev det afklaret at der var et større behov for at implementere et hjælperedskab i overgangen imellem at være på et rehabiliseringscenter og at komme hjem.

Herefter valgte teamet at sætte fokus på madlavning. Igenenm ydereligere indsnævring valgte teamet at give to eksempler på hvordan systemet hjælper igennem madlavning. En opskrift på pandekager og stægt flæsk med persillesovs var valgt.

Dette er mundet ud i et koncept bestående af 11 køkkenredskaber som kommunikere med en app og derved guider og støtter en person med kognetive udfordringer igennem at lave en madret.

Table of content

Introduction

In Denmark, 120.000 people are living with a brain injury. From these people, a large group suffer from cognitive issues, which make daily routines difficult or impossible to perform. With this in mind, a system of smart-objects called KeeCo has been developed.

KeeCo is the first system of smart objects that is specifically developed from the difficulties caused by a brain injury in mind.

KeeCo can help a person with cognitive difficulties through a cooking task. It consists of an app, a smart scale and 10 smart utensils. The assistance granted by KeeCo covers the steps from the moment the ingredients need to be collected, to the finished dish.

Through the cooking task, the app will guide the user by showing videos or images of each step. Furthermore, it will, through blue-tooth, know when and how the smart-utensils and smart-scale are used in order to reduce and correct error occurrence.

USER

The user's everyday life is affected by the consequences of a Traumatic Brain Injury. He is completely functional physically, but suffers from cognitive impairments.

LACK OF SYSTEM UNDERSTANDING

MEMORY ISSUES

LACK OF LOGICAL THINKING

MENTAL TIREDNESS

Issues applied to cooking

DIFFICULTIES IN UNDERSTANDING NUMBERS AND AMOUNTS

GET STUCK IN THE MIDDLE OF THE TASK

MISS THE OVERVIEW OF THE TASK

LACK SENSE OF TIMING

loneliness

loss

frustration

Cure

Simplify the cooking process as much as possible

Reduce mistakes' occurrence

Manage the process

Value Proposition

Regain independence in preparing a meal

Take partially away responsibility

Regain confidence

Relationship with the product

Perceived as the friend that you trust and take advices from. That does not underline your mistakes and does not judge you.

KeeCo *the key to cooking*

KeeCo consists of a system of objects communicating to each other, in order to enable the user to perform a cooking task.

GUIDANCE

Application installed on a tablet that guides the user through the steps of a cooking task.

SCALE

Communicates with the guidance to provide feedback and support.

UTENSILS

Communicate with the guidance to provide feedback on their usage.

Recharging platform

Provides electricity for the utensils.

Storyboard

1 Turn on app and choose the desired recipe: Pancakes
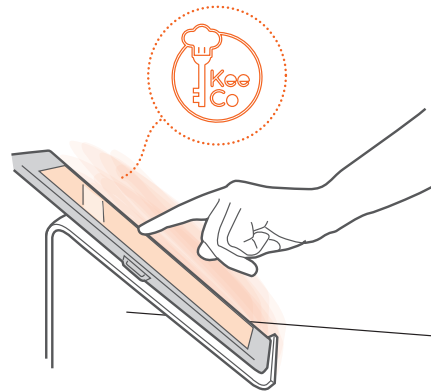
2 The guidance gives a check list of the ingredients to collect
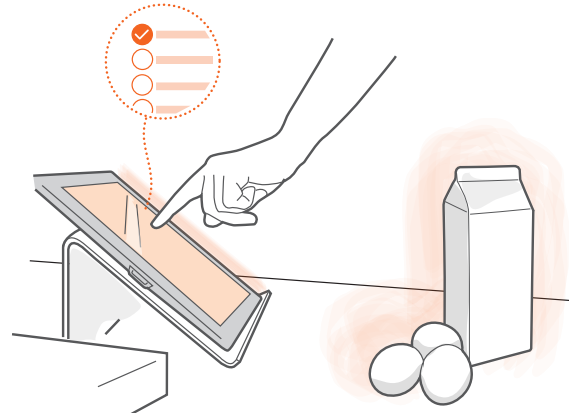
3 The guidance gives a check list of the utensils to collect
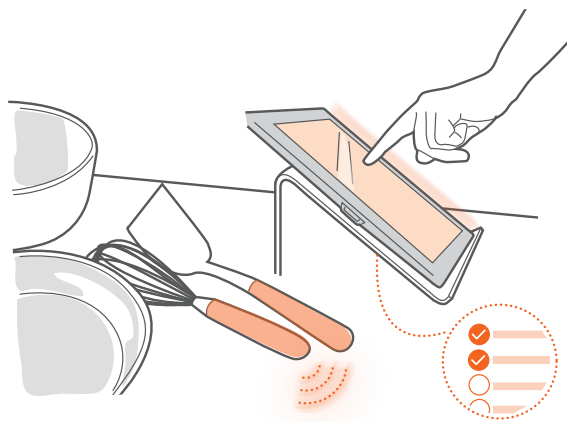
4 The ingredients are weighed according to the guidance's instructions
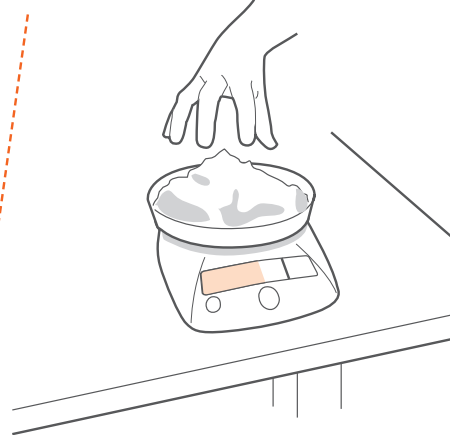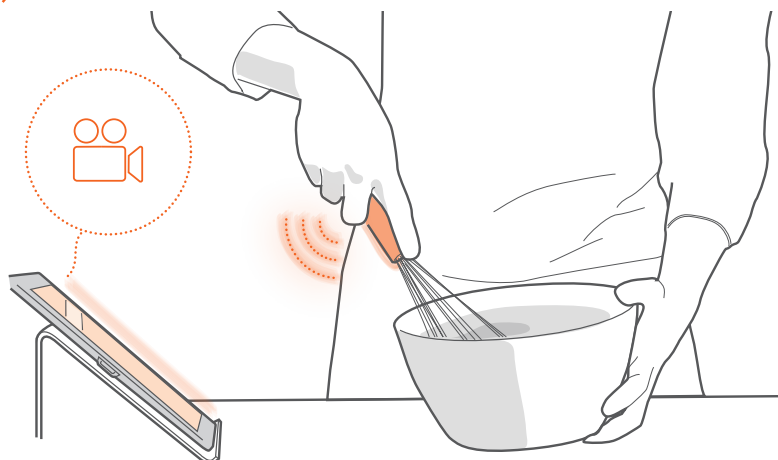
5 The user follows the indications of the video clip explaining the step. Its actions can be monitored thanks to the utensil communicating with the guidance

6 The app notifies the user regading cooking timing
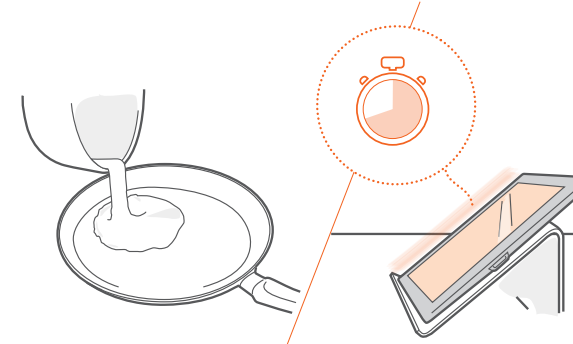
7 The use of the utensil is detected by the guidance
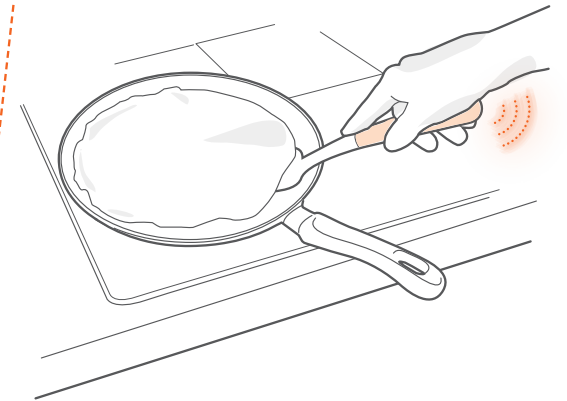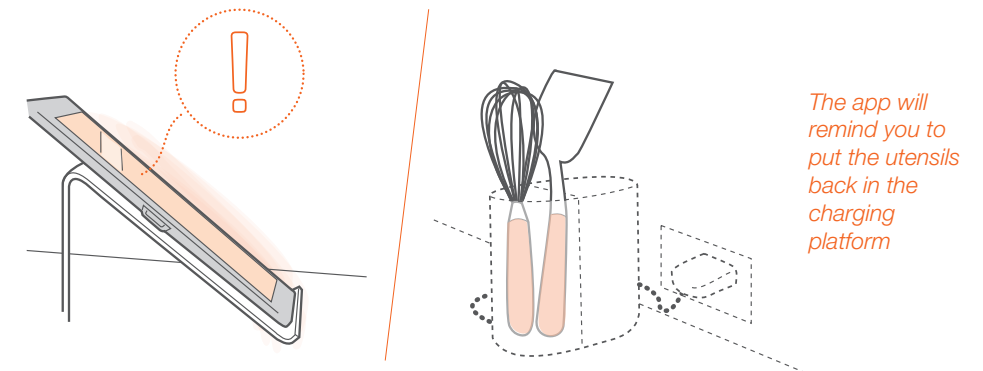
8 The app will remind you to put the utensils back in the charging platform
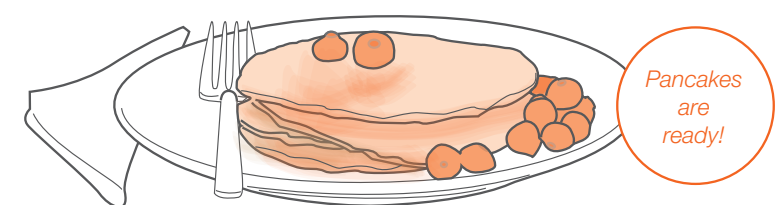
9 Pancakes are ready!

SCALE

The scale is exchanging information with the guidance. It is designed to help people with difficulties in understanding numbers.

Removable plate

Grab-space ensures easy mount / demount.

No sharp edges

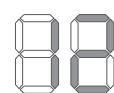Product identity embedded in the design.

Display

Large surface for visualizing measuring

TARE

ON / OFF

The scale can be used also when not connected to the guidance. Numbers will be displayed.

138 g

The scale's light bar increases while pouring. A full bar corresponds to the amount told by the app.

The right amount is reached and a check sound is made.

The scale emits sound when the amount is exceeded. The scaled amout may deviate +/- 5%

Measuring plate
Stainless steel

Screen protector
PS

On/Off button
ABS

Supporter screw
ABS

Tare button
ABS

Upper scale body
ABS

4 x M1.6 Screws
Stainless steel

Supporter nut
ABS

Load cell

Load cell holder
Steel

Microprocessor
BLE mounted

Speaker

Screen

Lower scale body
ABS

4 Batteries
AAA

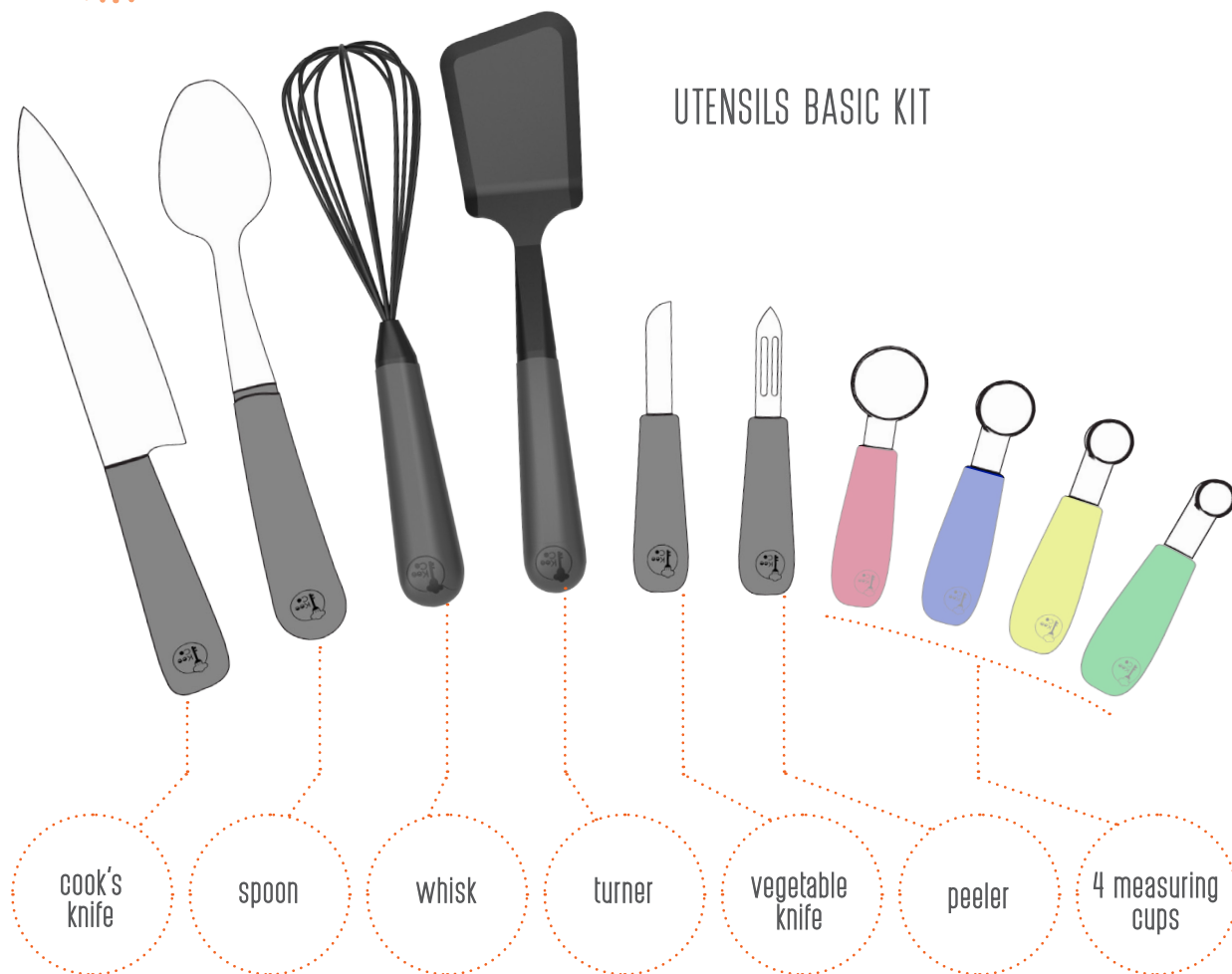Battery lid
ABS

4 x M1.6 Screws
Stainless steel

4 x Feet
Silicone

UTENSILS

They communicate with the guidance, providing continuous feedback on the user's actions. When purchased, KeeCo contains a set of basic utensils.

UTENSILS BASIC KIT

- cook's knife
- spoon
- whisk
- turner
- vegetable knife
- peeler
- 4 measuring cups

When not in use, the utensils need to be placed in the rechargeable platform to ensure that they are ready to use at all times.
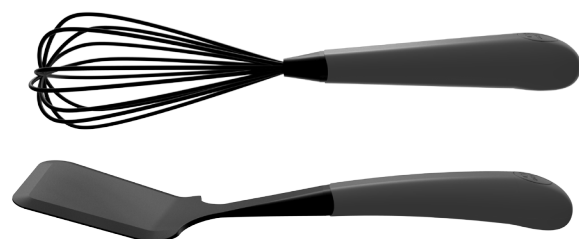
Whisk and turner are detailed in relation to the movements that they can track.

no scratched surfaces

ergonomic and slip free grip

brand awareness

Outer shell cover
PA & silicone

Inner shell cover
PA

Rechargeable platform receiver

Rechargeable battery

Microprocessor
Mounted: BLE, gyroscope, accelerometer

Inner shell base
PA

Whisk head
PA

Outer shell base
PA & silicone

Handle shell

The electrical components of the handle are assembled in a heat-resistant shell that fits to all types of handles within the package.
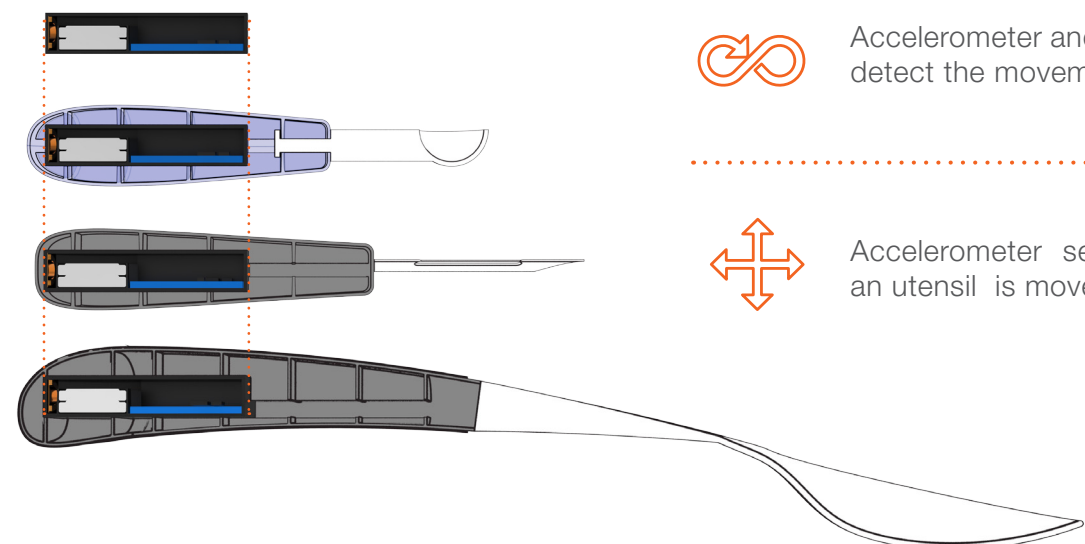
Sensing movement

The accelerometer and gyroscope placed on the microprocessor detect and track the utensil's movement.
The information is transmitted to the guidance via BLE - Bluetooth Low Energy, which reacts accordingly.

Accelerometer and gyroscope detect the movement pattern.

Accelerometer senses when an utensil is moved.

GUIDANCE

KeeCo guidance assists the user through the recipe, with explanatory videos and images. The communication with the utensils and the scale offer continuous feedback regarding the performance of the user. This enables the sequence of steps within the recipe to adjust according to the user's actions. For advancing or going backwards along the recipe, voice signals or tap feature can be used.

Sections of the interface marked with √ have been tested and refined according to the user's feedback, while the remaining ones require further development.

5 √

The user has access to different categories of recipes.

6 √
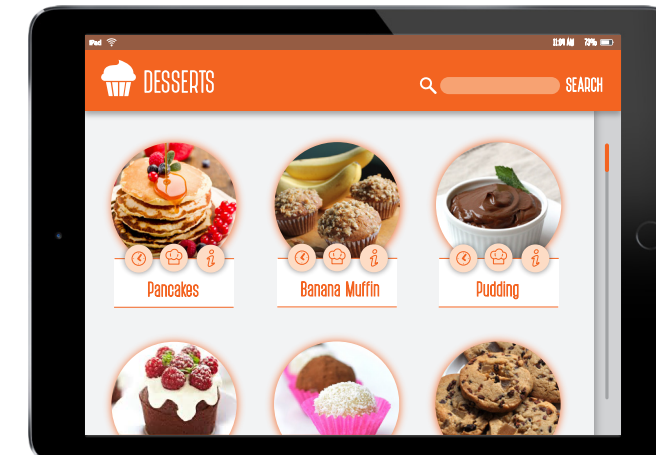
When selecting a category, the available recipes are listed.

1 √

KeeCo is accessed by opening the app.

2 √

The key to cooking is now ready to be used.

7

The day and hour of when the recipe should be made can be set.

8
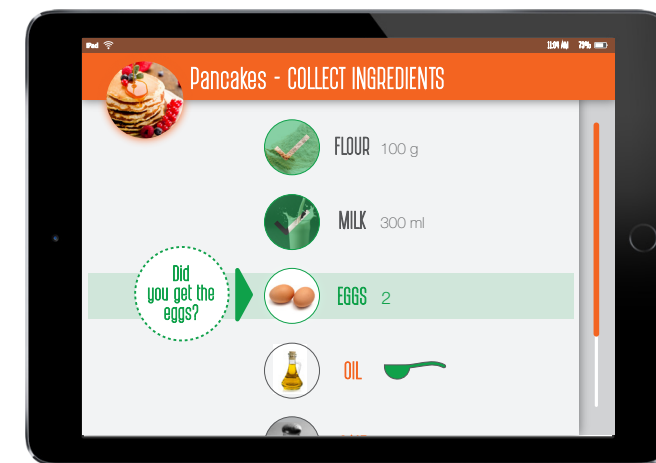
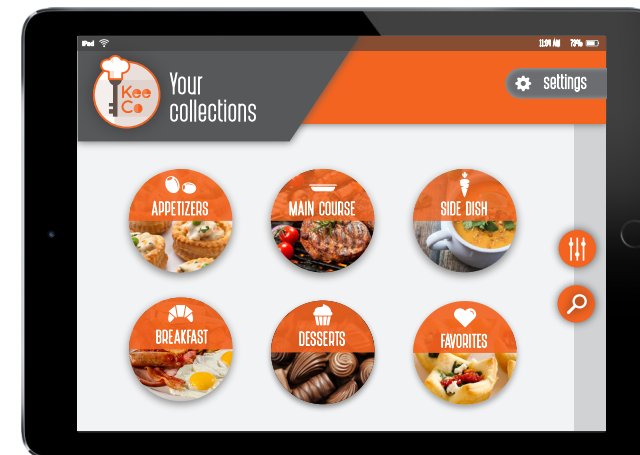KeeCo gives precise indication on the amount of each ingredient needed.

3 √

The activation code received at purchasing needs to be inserted.

4 √

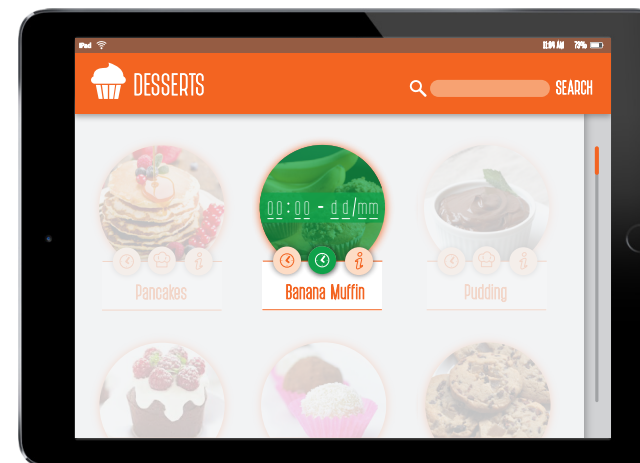When installing the app, utensils must be synchronized.

9 √

Before starting the recipe, the user is provided with the process overview.
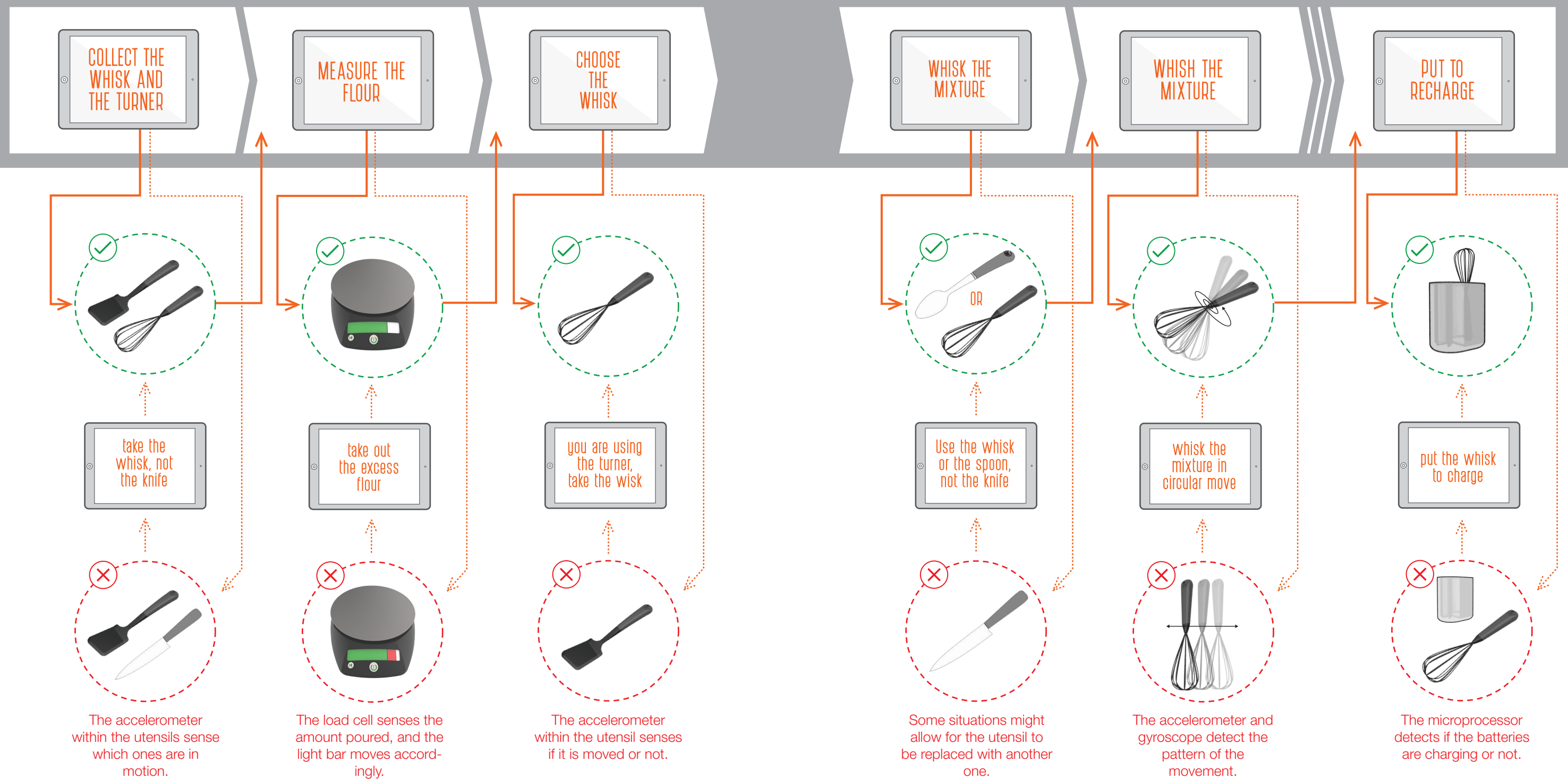
10

Videos and pictures assist the user along the recipe.

System

The illustration shows how the system responds to the user's interaction in order to ensure that the right action is performed and to reduce error occurrence.
This is done for each component of the system in relation to the embedded electronics.

| COLLECT THE WHISK AND THE TURNER | MEASURE THE FLOUR | CHOOSE THE WHISK | WHISK THE MIXTURE | WHISH THE MIXTURE | PUT TO RECHARGE |

take the whisk, not the knife

take out the excess flour

you are using the turner, take the wisk

Use the whisk or the spoon, not the knife

whisk the mixture in circular move

put the whisk to charge

The accelerometer within the utensils sense which ones are in motion.

The load cell senses the amount poured, and the light bar moves accordingly.

The accelerometer within the utensil senses if it is moved or not.

Some situations might allow for the utensil to be replaced with another one.

The accelerometer and gyroscope detect the pattern of the movement.

The microprocessor detects if the batteries are charging or not.
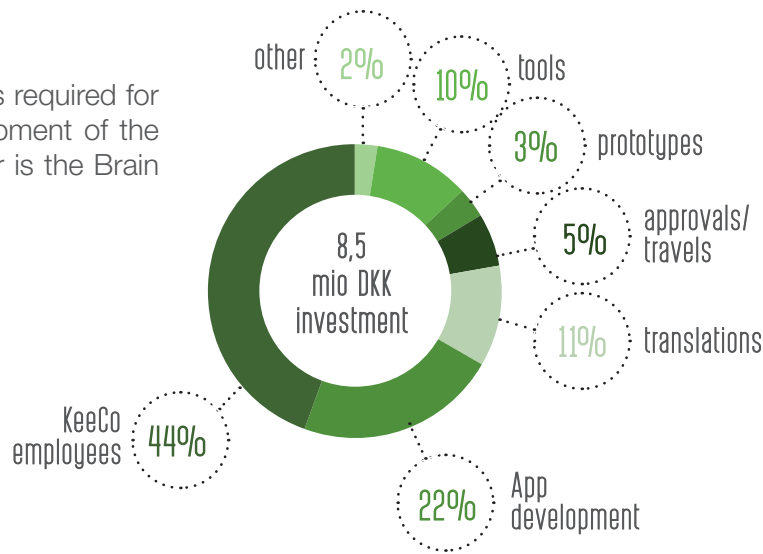
Business

Users

KeeCo is initially designed for the Scandinavian market. For a profitable departure point of the business, other causes that lead to cognitive difficulties in cooking besides brain injury are considered, such as dementia and ADHD. With this in mind, approximately 149.800 potential customers are identified.

149.800 customers

ADHD - 11%
Brain Injury - 25%
Dementia - 62%
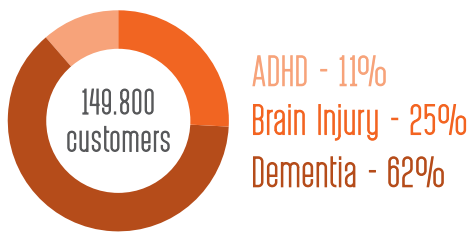
Investment

An investment of 8,5 million DKK is required for KeeCo I/S to continue the development of the concept, where a possible investor is the Brain Damage Society.

8,5 mio DKK investment

other 2%
tools 10%
prototypes 3%
approvals/travels 5%
translations 11%
App development 22%
KeeCo employees 44%

Awareness

KeeCo is introduced on the market by attending healthcare fairs, sending promotion materials to home care occupational therapists and getting in contact with the municipality representatives regarding Brain Damage Society.
The customers can find relevant information and other purchasers' reviews regarding the product on KeeCo webpage.

Pricing

The package available for purchasing consists of the guidance, the scale, a set of ten utensils and 30 recipes that are chosen by the customer, according to preferences. It is expected for the starting price to be of approximately 4.000 DKK.

4000 DKK

GUIDANCE APP

Basic set of utensils

Scale

Set of recipes

Break-even

With the starting investment, it is predicted for the break-even to take place four to five years from start of development. The product will be on the market for three years when break-even is reached.

Expansion

The customer has the option of purchasing more recipes, at the cost of 30 DKK each. For recipes that require the use of other utensils than the ones included in the starting package, the customer may purchase these utensils separately.
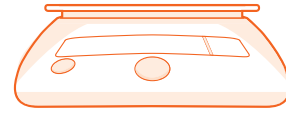
Further work

Guidance
The guidance needs to be understandable by a wide range of users. For this reason, possible differences and difficulties in understanding the interface need to be investigated and implemented.

Dementia & ADHD
Since it is desired to develop the concept for people suffering from dementia or ADHD as well, an analysis of their specific needs in relation to cooking is required.

EUROPE expansion
For further expansion to the rest of the European countries, a proper investigation of culinary variations from country to country is required. Furthermore, the healthcare related aspects specific to each country might impact KeeCo's envisioned business.

Testing
The functionality of the concept is proven best by testing with the final user. For this reason, more people with cognitive impairments and therefore difficulties with cooking, need to be approached in order to perform improvement.

Electronics
For ensuring the proper functionality of the system, the wireless communication needs to be tested. Factors such as heat and water jet resistance play an important factor in the approval of launching KeeCo, and for this, most effective and reliable components need to be chosen.

User needs' alignment
The relationship created between the user and the concept plays a vital role in successfully bringing the task of preparing a meal until the end. Since KeeCo is desired to be perceived as a trustworthy friend, such relationship needs to be further defined and implemented in the concept.

Conclusion

KeeCo offers the support needed
throughout the process of a cooking task.
Users simply needs to follow
the presented steps in order to
successfully prepare the
dish by themselves.

ARKITEKTUR & DESIGN

KeeCo

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