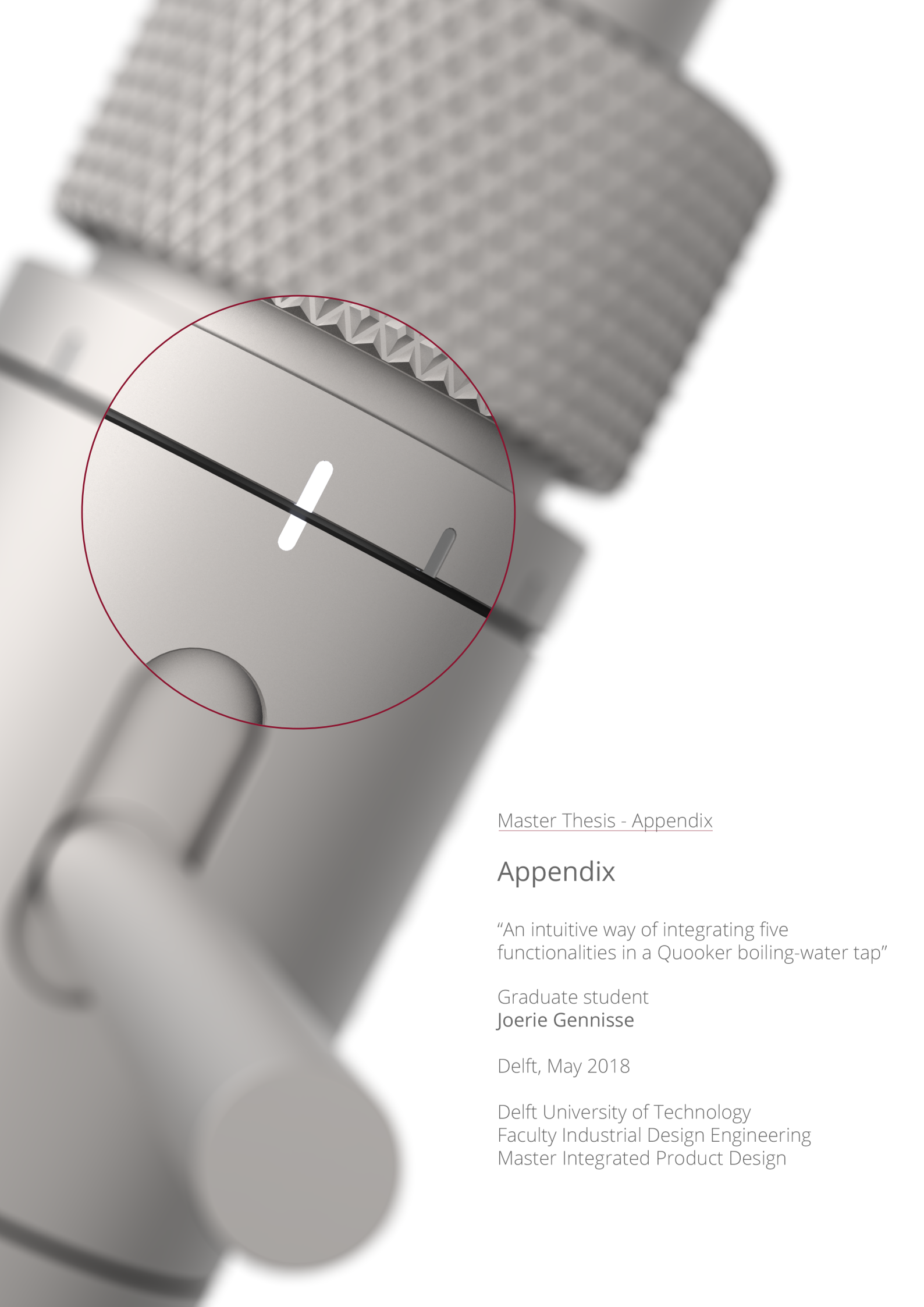

Master Thesis - Appendix

Appendix

"An intuitive way of integrating five functionalities in a Quooker boiling-water tap"

Graduate student
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Delft, May 2018

Delft University of Technology
Faculty Industrial Design Engineering
Master Integrated Product Design

Disclaimer
This master thesis is written in context of the master Integrated Product Design at the faculty of Industrial Design Engineering at the Delft University of Technology in The Netherlands.

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Appendix Content

Appendix A - Company

In this section, an overview of the specific business value of Quooker will be described. The business values include: vision, mission, core values, targets & long term target. Furthermore, A more elaborated conclusion has been described.

Onze Visie

"Wij zijn ervan overtuigd dat het gemak van direct beschikbaar kokend water uit de kraan onmisbaar wordt in iedere keuken. Quooker heeft de ambitie als marktleider de wereld te veroveren met verrassende innovaties op het gebied van kokend water ."

Onze Missie

"Wij willen wereldwijd, consumenten verrassen met het dagelijks gemak van direct beschikbaar kokend water van de hoogste kwaliteit.

Met veilige en betrouwbare, innovatieve en energiezuinige producten van wereldklasse, zelf ontwikkeld en geproduceerd, met aandacht voor onze mensen en het milieu.

En we doen dit als familiebedrijf onder eigen merknaam op onze eigen, originele en vastberaden manier."

Onze Kernwaarden

Origineel: bij Quooker is een ieder welkom om ideeën in te brengen, eigen bevindingen te delen, van elkaar te leren. En we verkennen nieuwe, niet betreden paden: hoe te maken, te verbeteren, te verkopen en te servicen, hoe de rest van wereld te veroveren. Hierbij kiezen we eerder onze eigen, praktische richting dan dat we iets doen omdat iedereen het doet.

Onafhankelijk: we zoeken naar oplossingen die ons onafhankelijk houden van toeleveranciers; als het moet zijn we in staat onze producten helemaal in eigen beheer te fabriceren.

Onze Kernwaarden

Vastberaden: een groot geloof dat dingen die we willen realiseren gaan lukken; door hard werken, dankzij discipline, door uitproberen en te leren, en nooit opgeven.

Verantwoordelijk: in ons familiebedrijf voelen we ons verantwoordelijk voor ons bedrijf, ons product, voor elkaar en voor onze omgeving en gedragen ons hiernaar. Daarom helpen we elkaar, en vragen om hulp als we die nodig hebben. Wij bieden toekomstperspectief in carrière en opleiding.

Onze Doelstellingen

We willen als onderneming:

- Eigen baas (eigenaar) blijven
- Marktleider blijven
- Substantiële groei vasthouden
- Wereldwijd actief zijn
- Een organisatie van wereldklasse zijn
- Quooker waarden en stijl behouden

Onze Doelstellingen

We willen voor onze klanten en afnemers

- Mensen blij maken, 100% tevredenheid
- Het hoge kwaliteitsniveau van product en dienstverlening behouden

We willen voor onze medewerkers

- Teamgeest, trots en de 'Rotterdamse' spirit behouden
- Toekomst perspectief bieden in carrière en opleiding

Lange termijn Visie

Quooker is in 2020 de grootste fabrikant van kokend-water-kranen ter wereld met:

- In voor ons belangrijke landen een eigen organisatie
- Een door een hoofdkantoor aangestuurde wereldwijde distributie
- Toonaangevende innovaties op het gebied van kokend-water kranen en producten rond de spoelbak.
- Marketing als succesvol element in onze bedrijfsvoering
- Beheersing van de volledige keten van idee tot en met verkoop, installatie en service
- Omzet van 500.000 Quookers per jaar met gezonde Ebita (20%)
- Sterke lange termijn en relatie-gerichtheid
- Effectieve samenwerkingen met de handel in het bedienen van de keukenmarkt
- Contact met onze gebruikers
- Gepassioneerde en betrokken medewerkers
- Onveranderde aandacht voor mens en milieu

Elaborated conclusion

Quooker has gained a lot of expertise in the field of boiling water taps since it was officially founded in 1987. It all started with a simple idea of henri Peteri to provide instant boiling water. However, the development of the Boiling water tap has experiences highs and lows (see historical timeline). Only after the moment Niels and Walter joined the company, Quooker was able slowly grow to a financial stable company. After 2010, Quooker BV extended to other European countries and experienced a rapid growth.

Currently, Quooker BV counts around 250 employees in which most of the parts are assembled in-house. This makes the entire process very effective and efficient since communication lines are relatively short and departments are able to easily communicate with each other.

With its innovative mind-set Quooker is now grown as a market leader in the Netherlands. Additionally, they are selling their product in seven different countries of which most of them are based in Europe.

One of the aspects that Quookers differentiates itself from is the high quality product which is related to multiple patents that are hold by the product. Moreover, Quooker also provides high quality service to their end-user which is another unique selling point.

Appendix B - Working principle & Characteristics

In this part the product principle has been analysed. A brief explanation is given of the different elements that are integrated in the Quooker product. Furthermore, main features and product specification are also explained. Information is gathered from Quookers website ("Quooker taps | The boiling-water tap for your kitchen", 2017), In addition, an interview with an employee of Quooker BV has been established. Insights are clustered and used as input for the SWOT analysis and product requirements.

Competitive advantage

It has been found that this is a strength of Quooker since competitors do not always deliver an exact amount of 100C water (e.g. Dornbracht and Hotto have an output temperature of respectively 93 and 97 degrees Celsius).

Installation

For installing the Quooker, technical skills are required. Fortunately, Quooker BV offers a good service to their customers. Next to the installation manuals that can be downloaded on the website, Quooker BV provides assistance for the total installation of the system. However, there is a big difference between the installation of the Pro tank of the Combi tanks. Combi tanks are more difficult to install and could take up to one hour (interview Ronald Harkema – Account manager). In general, an average person would need help from their kitchen dealer or plumber. Especially, for the installation of the tank since it need to be connected to the utility network.

Safety

Six aspects are mentioned on the website of Quooker that focus on safety:

- Childproof double-push-and turn button.
- Insulation ensures the spout is not too hot to touch.
- Height-adjustable tap to prevent splashing.
- Fine spray that prevents burns.
- 360 degree tuneable spout.
- A red light ring which is activated when boiling-water is dispensed or when the reservoir is heating up.

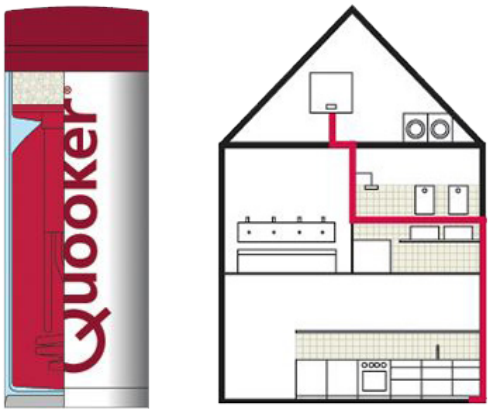
Sustainability

The reservoir includes several working principles that are patented. Moreover, the most relevant one is the patented high-vacuum insulation. With this technology, less energy is needed to keep the water at constant temperature of 110°C. When reflecting this to the costs, it can be concluded that the system ensures that the Quooker standby usage is only 5 eurocents per day. Additionally, Quooker claims to be 60% more efficient than other boiling water taps. It also has been found that the system holds around thirty patents and is therefore protected against plagiarism from elsewhere in the world. Most of the patents are related to integrated technologies and not to aesthetical aspects of the Quooker (conversation with Paul Peteri – R&D engineer).

When reflecting the Quooker, the main advantages on sustainability are achieved by the following aspects:

- The exact amount of water is boiled. (e.g. in most cases not all the water in an electric kettle is used and is therefore a waste)
- The water is boiled directly underneath the sink. This means that people don't have to wait for hot water to be piped through the house from the main boiler.
- The high-vacuum insulation causes the Quooker to be a sustainable product.

The level of efficiency is related to the selected tank that is integrated. After analysing the website of Quooker and



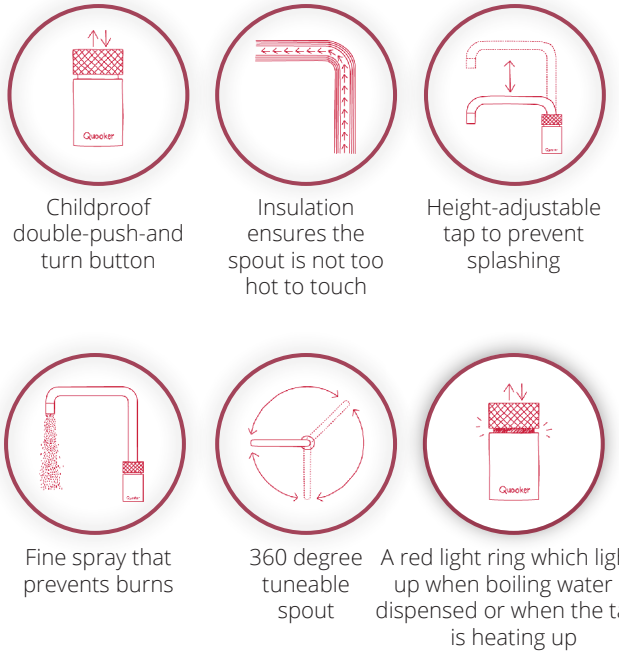
Left: the high-vacuum insulation. right: a conventional way of heating up water

an interview with Ronald Harkema, it has been concluded that the Combi version is most sustainable by means of efficiency. With a regular household, people can save up to 171 euros and 7049 litre of water a year.

Conclusion

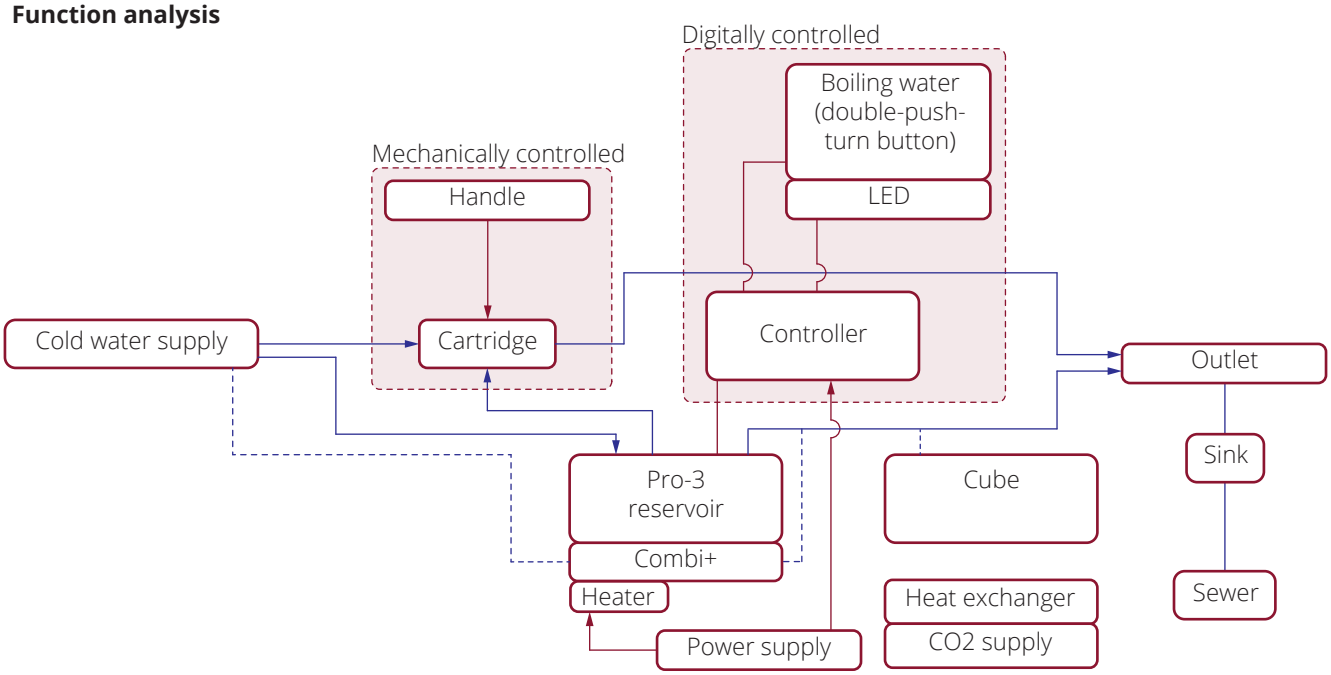
Analysing the product working principle of Quooker concludes that Quooker is high quality product providing 100°C boiling-water. This can be seen as a competitive advantage. However, Quooker is a technical product and requires technical skills for the installation. Fortunately, Quooker offers a good service to all its end-users which is another aspect of high quality.
Additionally, the high-vacuum insulation, which is one of the thirty patents, causes the Quooker to be a sustainable product. Especially when comparing the Quooker with conventional appliances. With this in mind, the Quooker can save the end-user a serious amount of euros and water a year.

Furthermore, the Quooker is integrated with multiple safety features to avoid accidents during the interaction. Most of these interactions are related to cooking and instant preparations of food and drinks.



Six elements of Quooker to improve the safety

Function analysis



An elaborated version of the function analysis

The product or feature that will be designed in the next phases is aimed to fit in the product portfolio of Quooker. Therefore, the product range of taps and systems that are currently sold by Quooker are analysed.
As a first part, the product development of Quooker has been analysed in order to get a better feeling of the development of the product that is sold today. Additionally, current taps, systems and accessories are studied. As a last part, the design of Quooker has been reflected on its core values to find the main characteristics behind the design.

History
As being explained earlier, Henri Peteri, came up with the idea when he was working on the development of instant soup. Henri was very convinced about his own idea of creating a tap delivering instant boiling water. He thought that the development of such a product would not be that difficult, but the contrary happened. Despite his immense drive, he did not managed it to get any further than the prototype phase. The appliance was hard to sell and broke down regularly (1970 – 1973).
Real developments were made after the moment both sons of Henri joined the project. The Quooker Basic was launched in 1992 which was the first in a series of taps designed by Niels Peteri. The classic model followed in 1997.
In 2000 a revolutionairy high vacuu insulation model was invented which was called the Quooker VAQ reservoir. This made the design very energy efficient and compact.

Flex
The Flex is a boiling water tap and mixing tap in one. Currently, this is the newest and most innovative version of taps being sold by Quooker (launched in 2016). The Flex provides a pull out hose for more reach and extra functionality. Additionally, the tap provides warm, cold and boiling water which was already integrated in the previous version, the Fusion tap. The Flex does not provide boiling water when the hose is pulled out (for safety reasons). Aan overview is given of the products that are currently sold by Quooker BV. (Note: this design just won the Dutch Design Week Award (Lorden, 2017))

Fusion Square & Round
The fusion tap is provided in two different shapes; a square and round design. Additionally, this is a single tap that provides cold, warm and boiling water. The boiling water can be activated with the child proof double-push-and-turn handle. A red LED light will light up when the boiling water is activated.

Nordic Square & Round Twintaps
Like the Fusion tap, the Nordic tap can also be ordered in two different shapes. However, this older version distinguishes itself by two separated taps. One tap provides warm and cold water. The second tap provides the instant boiling water. Additionally, the boiling water tap is height adjustable.

Nordic Square & Round single tap
The Nordic version is also provided as one single tap. However, this version only provides boiling water and is launched to combine the tap with an existing tap that is already integrated in the kitchen.

Classic
Different taps like the “classic” version are still sold. However, most of the old versions are not produced anymore and only sold in for instance the United Kingdom and Ireland. The final batch of classic taps will be sold in these countries. Note that the main differences between the older versions (the Basic, Classic, Design and the Modern) and the new versions are related to operation aspects. Older versions are operated mechanically and almost never fail. Newer versions are equipped with electronics (e.g. red LED and mechanic safety mechanism).

Reservoirs
When choosing a Quooker, a reservoir is always part of the system. This is something customers sometimes overlook since they only compare water taps with the Quooker tap. In fact, when choosing a Quooker, they always buy the whole system.
Three different reservoirs are available for the Quooker system. The Pro reservoir only provide boiling water whereas the Combi versions provide boiling water as well as hot water. The pro reservoir contains 3 litre whereas the combi reservoirs both have an capacity of 7 litres. Each of the reservoirs features the patented high vacuum technology which makes the product very sustainable (compared to competitors). A Combi reservoir can only be installed when a cold water supply connected is provided. When the end-user has both connections, warm and cold, a Combi plus reservoir should be installed.

Accessories
The Quooker system can be extended with accessories. Within this category customers can choose to extend their system with a Nordic soap dispenser, water filter and a scale controller. The last two items are mainly used abroad since the water quality is not perfect like Dutch people are used to.

Finishes
Currently, Quooker tapes can generally be finished in four different materials; polished chrome, steel, stainless steel and black. However, the availability of different finished of the taps are related to the demand in different countries. Therefore, not all finished are offered in every country. As an example, in Denmark a material finish has been launched which is called “bruneret messing”. This is a material that changes in colour over time (like copper turns into a green appearance over time) (“Quooker taps | Collection”, 2017).
When analysing the different versions, it can be

concluded that the first version are not designed with the principle of 'form follows function'. Here, all components are integrated in one single cylinder (the design was more important). This principle was also confirmed by one of the R&D engineers who explained the additional assembly difficulties of these versions. Moreover, the new flex tap is designed with more freedom which makes the product more efficient to assemble and repair (service aspects).

Quooker knows a rich history when looking at the product developments of the boiling-water-tap. With an immense family drive, ups and downs and the creation of several prototypes, Quooker made it to become a healthy company. From this analysis, it can be concluded that Quooker has a lot of knowledge in the field of boiling-water-taps which can be seen as a strength of the company.

Con

Historical timeline of Quooker products

Flex tap
A boiling-water tap and mixing tap in one with an addition pull out hose.

Fusion round tap
A boiling-water tap and mixing tap in one.

Nordic Round Twintaps
Two separated taps providing cold & warm water and boiled-water.

Nordic Round single tap
A single tap that only provides boiling-water.

The current product portfolio of Quooker BV

Kranen	Finishes	Reservoirs		
		PRO3 kokend water	COMBI kokend en warm water	COMBI+ kokend en onbeperkt warm water
 Flex	chroom	€ 1195,–	€ 1495,–	€ 1495,–
	roestvrij staal	€ 1345,–	€ 1645,–	€ 1645,–
 Fusion Square	chroom	€ 1195,–	€ 1495,–	€ 1495,–
	steel	€ 1290,–	€ 1590,–	€ 1590,–
	roestvrij staal	€ 1490,–	€ 1790,–	€ 1790,–
	zwart	€ 1640,–	€ 1940,–	€ 1940,–
 Fusion Round	chroom	€ 1195,–	€ 1495,–	€ 1495,–
	steel	€ 1290,–	€ 1590,–	€ 1590,–
	roestvrij staal	€ 1490,–	€ 1790,–	€ 1790,–
	zwart	€ 1640,–	€ 1940,–	€ 1940,–
 Nordic Square Twintaps	chroom	€ 1250,–	€ 1550,–	€ 1550,–
	steel	€ 1395,–	€ 1695,–	€ 1695,–
 Nordic Round Twintaps	chroom	€ 1250,–	€ 1550,–	€ 1550,–
	steel	€ 1395,–	€ 1695,–	€ 1695,–
 Nordic Square single tap	chroom	€ 995,–	€ 1295,–	€ 1295,–
	steel	€ 1090,–	€ 1390,–	€ 1390,–
	roestvrij staal	€ 1245,–	€ 1545,–	€ 1545,–
 Nordic Round single tap	chroom	€ 995,–	€ 1295,–	€ 1295,–
	steel	€ 1090,–	€ 1390,–	€ 1390,–
	roestvrij staal	€ 1245,–	€ 1545,–	€ 1545,–

Accessoires

Nordic zeeppomp	chroom	€ 200,–
	steel	€ 250,–
	roestvrij staal	€ 295,–
	zwart	€ 345,–
Ophangbeugel PRO3		€ 80,–
Ophangbeugel COMBI/COMBI+		€ 80,–

Customer Group	Totaal	Belgium	Germany	Scandinavia	Schweiz	The Netherlands	UK
	72.189	1.369	3.880	9.497	898	38.190	18.355

en de verhoudingen per land voor de reservoirs:

Customer Country	Product Grouping	PRO EQ	COMBI EQ	PRO	COMBI
The Netherlands		33%	62%	3%	1%
UK		71%	8%	21%	0%
Scandinavia		90%	6%	3%	0%
Germany		72%	25%	2%	0%
Belgium		26%	69%	2%	2%
Schweiz		81%	16%	3%	0%

en de verhoudingen per land voor de kranen:

Customer Country	Tap Type	Flex	Fusion	Nordic	Single taps
Totalen		32%	51%	9%	8%
The Netherlands		39%	49%	8%	3%
UK		7%	61%	10%	21%
Scandinavia		35%	49%	12%	3%
Germany		49%	42%	7%	2%
Belgium		47%	39%	11%	4%
Schweiz		57%	28%	13%	3%

Energiebesparing

€ 171,29

Waterbesparing

7049 liter

Hoeveel personen kent jouw huishouden?

4 personen

Wat is de afstand van de CV naar de kraan?

12 meter

Wat zorgt bij jou voor warm water?

Combiketel (CR)

Op welk soort fornuis wordt er gekookt?

Gas

Hoe kook je water?

Elektrische waterkoker

See

- Minimalistic, feminine (however, knurl surface looks masculine), high quality, slim, functional

Hear

Bruised high frequency sound, the double-push-turn button (when close by only)

Smell

Natural smell in general. The smell of soap after several times of cleaning (when very close by).

Feel

Strong grip, heavy force (related to high quality), vapour when moving above the tap, slightly painful drips when holding the cup too far from the spout, cold metal.

Taste

Very hot

Appendix C - Vision generating session

Most of the part of this section are carried out in Dutch since the session is also held in Dutch which makes the result easier to conclude and write down.

Goal of the session
Duidelijk naar voren laten komen wat de specifieke kernwaarden zijn van het product Quooker. Dit niet alleen gebruiken om zelf een helder beeld te krijgen van de kernwaarden van Quooker, maar om ook medewerkers om één lijn met elkaar te krijgen.

Method
Five employees participated in this session and are stated below:
- Ivo Legel (Manager techniek, Research & Development)
- Roemer Linkers (R&D engineer, Research & Development)
- Martijn Punt (Marketing director, Marketing & Communications)
- Walter Peteri (Director, Management)
- Erwin Harreman (Employee R&R, Return & Recovery)

After a small introduction of the graduation project and the goal of the session, participants were supposed to choose two ambiguous illustrations that were spread over the table. For this step, participants needed to select the illustrations related to the following questions:
1) What are your thoughts on the product Quooker from your own perspective as employee?
2) How do you think customers experience the product Quooker?

Additionally, participants explained why they choose the selected illustration. Meanwhile, the facilitator wrote down the most important product values on post-it's and helped the participants to really explain the latent feelings behind their thoughts by asking specific question. Note that the session was facilitated by the graduation student.

All post-it's were separated from each other based on the earlier mentioned questions (employees and customers perspective). Eventually, post-it's were ranked based on importance by having an open discussion with each other.

Duur van de sessie:
1uur

The session
Stap 1 (11:45): inloop
Stap 2 (11:50): uitleg over de sessie en het doel.
Stap 3 (11:55): iedere deelnemer kiest van de stapel twee ambigue foto's. Deze zijn gekoppeld aan de onderstaande twee vragen:
1) "Hoe zie jij het product Quooker als medewerker".
2) "Hoe denk jij dat het product Quooker overkomt bij de gebruiker?"

Stap 4 (12:00): Vervolgens verteld iedere deelnemer aan de groep wat zijn gedachte achter de twee gekozen amigue foto's zijn.

Ondertussen schrijf ik de kernwoorden op post-it's en maak een verschil tussen 1) perceptie medewerkers en 2) perceptie gebruikers. Deze worden verdeeld over twee verschillende vellen papier.

Stap 5 (12:30): Samenvattende ronde doe ik zelf
stap 6 (12:35): de deelnemers krijgen ieder vier stickers. Nu mogen de deelnemers de post-its gaan rankschikken. 2 stickers per vel op een post-it.
(Hier komen dan waarschijnlijk een stuk of 8 kernwoorden uit per vel waarbij wellicht een duidelijk verschil zal onstaan tussen de perceptie van de medewerkers van Quooker en de perceptie van gebruikers. Dit zijn punten waar aan gewerkt zou kunnen worden. Dit onderdeel zal vervolgens samengevat worden waarna de sessie ten einde komt)

Stap 7 (12:40): afronden en bedanken

Stap 8 (12:45): einde sessie

Results:
Kernwaarden medewerkers
Ivo (rood)
- Luxe
- Losse elementen
- Systeem van producten
- "being part of the Quooker team/ family"
- een familie aan producten
- Kwaliteit
- Techniek
- Identiteit

Erwin (geel)
- Gebruiksvriendelijk
- Hergebruik
- Milieu vriendelijk
- Duurzaam

Roemer (geel groot)
- Focus
- Uniek
- Zelf doen
- Functionaliteit
- Schoonheid

Walter (blauw)
- Werkt goed
- Eigen visie
- veratnwoord
- origineel
- innovatie

- kwaliteit

Martijn (groen)
- Niet trend volgend
- Doordacht
- Wijsheid
- Mooi
- Belsuitvaardig
- Eigen richting

Kernwaarden klanten
Ivo (rood)
- Veilig
- Onmisbaar
- Toegevoegde waarde
- Handigheid
- Gevaar

Erwin (geel)
- Goede investering
- Nodig?
- Duur
- Geld
- Gewenning

Roemer (geel groot)
- Schoonheid
- Duurzaamheid
- Conversation starter
- Een feest om uit te pakken
- Een echte experience

Walter (blauw)
- Veel comfort
- Simpel product
- Onmisbaar

Martijn (groen)
- Service
- Succes van het bedrijf
- Eigenheid
- Bij Quooker willen horen
- Er is hard voor gwerkt

Selectie medewerkers
- Kwaliteit (5 stippen) - Directeur & R&D manager
- Innovatie (3 stippen) - Directeur
- Technisch (2 stippen) - R&D manager
- Origineel (2 stippen) - Directeur
- Duurzaam (1 stip) - R&R employee
- Eigen richting/focus (1 stip) – Marketing manager
- Identiteit – R&D manager

Achteraf toegevoegd:
- Functionaliteit
- Schoonheid

Selectie gebruikers
- Onmisbaar (5 stippen) - Director
- Een echte experience (2 stippen) – R&D employee
- Bij Quooker willen horen (2 stippen) – Marketing manager
- Service (2 stippen) – Marketing manager
- een goede investering (1 stip) – R&R employee
- Eigenheid (1 stip) – Marketing manager
- Veilig (1 stip) – R&D manager

Achteraf toegevoegd:
- Schoonheid
- Duurzaamheid

Core values Employees
1) Quality (5 stippen)
2) Innovation (3 stippen)
3) Technical (2 stippen)
4) Original(2 stippen)
5) Sustainable (1 stip)
6) Own focus (1 stip)
7) Identity (1 stip)

Achteraf toegevoegd:
- Functionaliteit
- Schoonheid

Core values Customers
1) Indispensable (5 stippen)
2) A real experience (2 stippen)
3) Be part of the Quooker family (2 stippen)
4) Good service (2 stippen)
5) A good investment (1 stip)
6) Particularity (1 stip)
7) Safety (1 stip)

Achteraf toegevoegd:
- Schoonheid
- Duurzaamheid

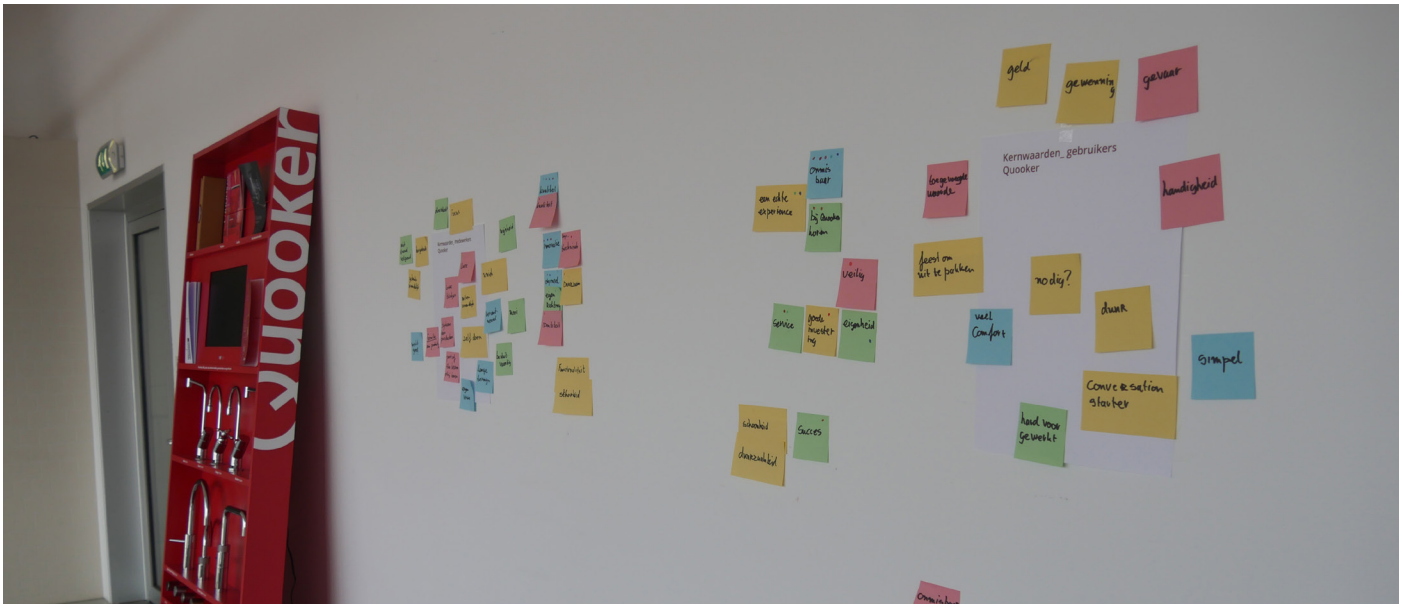
Figure 1: *Some of the ambiguous pictures that have been used during the session (in total 40 pictures were used)*

Reflection
In general, the session went really smooth without any hassle to get everything done within time. The ambiance felt good and everyone acted open-minded from the beginning. However, in the beginning everyone was a bit more silent since they did not know what to expect. Additionally, the director started a quite specific discussion with me which was about what I was doing for graduation and what de added value of the session would be which was form my point of view totally of topic. Fortunately, I managed to slowly bend the conversation toward the topic of the session.
While explaining the different thoughts to each other it was noticeable that everyone had a different perspective on the brand which was probably related to their own activities at their own department.
During the sessions only few changes were made. Eventually, two rounds of explanation were proposed so that all illustrations were explained one by one (not two illustrations per person in one round which resulted in a more extensive explanation with more outcomes).
The colour of the Post-it's was related to a specific participant in order to afterwards see what outcomes came from which person.
One think that I have like to do was a more extensive discussion on the final values that were created. Due to time restrictions, I was not able to ask more deeply on the these values (e.g. what does quality exactly means to you all?)
Afterwards, all employees were very surprised by the method used in this session. They were all not familiar with this approach and found it very excited to join. Moreover, I got some compliments not only on the way a performed the session, but also the fact that I managed it to let Walter (the director) join this session. It has been said that Walter is in most cases not willing to join such a session. Especially when someone lower in the company (like me as an intern) performs the session. Therefore, I was really excited after reflecting this session.

Explaining the planning and goal of the session

Participants choose two ambiguous images

Participants selecting the most important core values



Post-it's on the wall showing the result

Appendix D - Internal stakeholders analysis

Explanation Internal stakeholders map

A simplified overview of the product lifecycle has been created in order to understand the relationship between different departments see figure on the adjacent page.

① The R&D department can be seen as the first step of product development and/or innovation.
② After verifying the design, components are send for manufacturing to for instance China.
③ Additionally, components are shipped to Ridderkerk and checked whether the components are in line with the technical specs. This will be carries out by testing samples (not all components are being checked).
④ In Ridderkerk, all components from different manufacturers come together. Different versions of Quooker taps as well as reservoirs are assembled. All taps are assembled from scratch and are packed before they are sent to the customer.
⑤⑥ Meanwhile, the sales team is promoting the product and tries to sell batches to kitchen dealers.
⑦ In general, a plumber of the kitchen dealer carries out the installation when the customer has bought a new Quooker.
⑧ The Quooker has a guarantee of two years. When the product has a malfunction during its usage, the customer is able to call Quooker in order to solve the problem.
⑨ First of all, the customer could call the service team. The service team can help the customer by sending new parts. In addition, when the problem is too difficult to personally solve the problem, the service team can come by.
⑩ The last part in the overview shows the Repair and Recovery department. This department receives broken parts or entire products that do not work properly anymore or failed the quality check before it was send to the customer. Additionally, this department communicates very often with other department due to their knowledge of common problems. As an example, they give feedback to the R&D department in order to improve the product.

Interviews

In this part, main insight per interview have been elaborated. An elaborated documentation of this can be found in the last part of this appendix.

The first interview with I. Legel, R&D manager, was held in order to get a better understanding of his opinion on the Quooker product. Legel explained several aspects of the Quooker from a technical perspective. When asking about safety aspects of the Quooker, Legel explained the different functionalities that were integrated such as the double-push-turn feature in order to make the product safer for the end-user. Moreover, he stated that it is important to keep in mind the way safety aspects are communicating. ***"Try to warn people in a subtle way"***, Legel said. Furthermore, he explained that the product should be kept simple when integrating more features. According to Legel, more and more products nowadays have a lot of features integrated that create a certain pressure towards the user, meaning that the product rules or dictates you instead of the other way around. This could be seen as an overkill of features. Therefore, Legel explained; ***"You should feel empowered when controlling the Quooker."***
When asking about a potential target group to focus on, Legel advised to focus on the younger age group; ***"Focus on the younger age group of people who are interested in new features and/or technologies which can be created by smart materials"***.

In the second interview two managers of the production department have been interviewed. First of all, C. de Marché explained about the main activities at his department. In the response to the question: "What should be improved in order to make your function more pleasant?", Marché stated that the current product is quite difficult to assemble. ***"My function as team leader will be more pleasant when the product will be made simpler"***, Marché said. To the same question G. Feshaye argued that it is strange that employees need to do a lot of quality checks of sub-components received from manufactures. Normally, manufactures should check their own components before sending it to Quooker. ***"I want to have high quality products that not have to be checked by Quooker anymore."***, Feshaye said.
Marché also stated that he feels more pressure due to the fast growing company, as he explained: ***"I feel more pressure during my work since targets are up scaled lately."*** G. Feshaye, also mentioned a negative point. He sometimes recognizes behaviours of employees in the production department who are not very engaged with the work and do not show the "family mentality", meaning that they work for themselves instead of as a team together. ***"I don't like the mentality from some people who immediately stop working when the horn sounds at 5 o'clock"***, Feshaye said.

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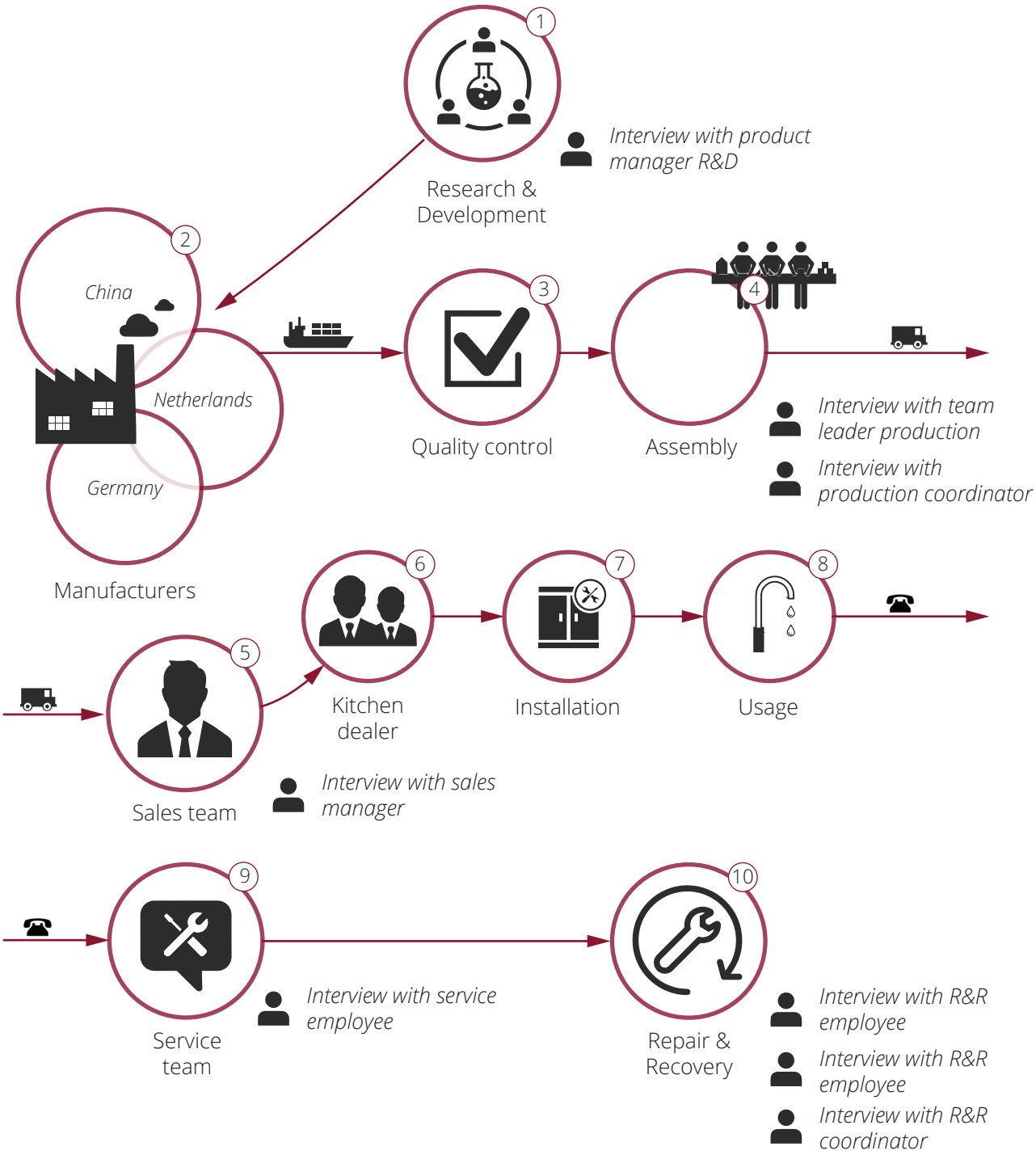
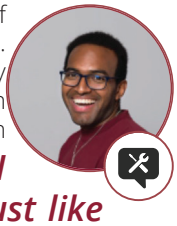
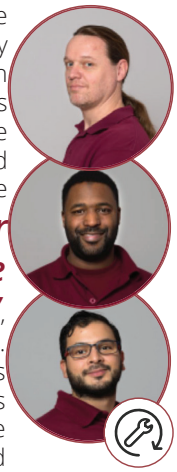


In the third interview, R. Harkema, part of the sales team, about his opinion on the product Quookers. First of all, he explained that scale is currently a very big problem for Quooker. Especially in areas with bad water quality. In these areas the heat elements can break down after two years already. ***"Scale might be seen as one of the biggest enemies of Quooker"***, Harkema said. Another negative aspect Harkeme explained was about the installation of the Quooker. Since Quooker is a technical product, it can be difficult to install the product for the plumber and especially the end-user. ***"Installing the Quooker is quite a hassle"***, Harkema said.

When asking about his vision on the future product of Quooker. Harkema said: ***"I would like to have a better view in applications that show user aspects of the end-user"***. He explained that this can have benefits in two ways when integrating such an application. First of all, Quooker will gain more information on how the product is being used by the end-user, which can be used to avoid problems and make additional product improvements. Secondly, feedback can be given to the end-user on how much water and/or electricity is used. Harmema said: ***"People think the Quooker consumes a lot of water and electricity."*** However, Quookers is actually more sustainable compared to competitors he explained.



In the fourth interview an employee of the service team has been interviewed. In general, J. Reinoso described very positive aspects of both his own opinion on the product Quooker and his own activities at the service department. ***"I really love my job"*** and ***"I just like to repair stuff and help customers solving it"*** are two good examples of this. In addition, Reinoso thought that the service of Quooker is very well organised. ***"Our service is perfect"***, Reinoso said.



The last interview was held with three employees of Return & Recovery department. After explaining the main activities at department, some aspects of improvement were described. The way the Quooker have to be cleaned should be better communicated to the end-user. ***"Why does Quooker not better communicate how to clean the Quooker?"***, as they all questioned themselves. Currently, most of the components break down due the fact that end-users use very strong detergents to clean the Quooker. Furthermore, they explained that they would like to have better access to scan the product. Currently, that takes quite some time before finding the internal error as they explained: ***"I would like to easily scan the product digitally to find the exact error more efficiently."***. Also they found it hard to disable the product without damaging it since the product is a very compact designed. ***"It is difficult to disassemble the product without damaging the product."***, as they all said and agreed on.

Interview Return and recovery (R&R) team – Bruno (technical employee), Erwin (employee return and recovery) and Petrus (coordinator R&R department) – 3-10-2017

Insights

- the department of R&R is the place where products or part are send back for repair and recovery. Four different streams are connected to this department. The first 2 are coming from the UK and Denmark). The second one is a stream of products and parts from the production department in Ridderkerk and the last one is coming from the service department. The R&R department does not exists that long. Before, all products were just thrown away which was huge waste. Last year Quooker earned half a million with this new system.
- Something that is related to this system is the SWAP project. With this project, Quooker wants to sell refurbished tanks to the customer for a lower price.
- The R&R department can easily give feedback on product failures/improvement to the R&D department.
- there is nothing big that could be improved from the Quooker. Only small some small parts could be improves such as the chrome handle in several versions. Scratched can appear on the surface when pushing it up and down for multiple times which is an example for a minor detail that could be improved.
- I don't like the Flex! It is way too big and does not look appealing in a smaller kitchen (like I have).
- an improvement could be made on the communication of how to clean the product. A lot of customer user very strong soap types (e.g. Cillit bang). Additionally, the outside of the tap is protected but at smaller wholes soap can come in and damage internal components often. Quookers should make this clearer to their customer.
- Improvements can be made when focussing on the service department. Think about how to install the product, how to disassemble the product. Kitchen dealers often install the Quooker. Most of these plumbers working for the kitchen dealer do not know how to install the Quooker in a correct way. Maybe Quooker could give some courses to these people to solve this problem?
- Think about an improvement in which product lines can be limited. In this way you could try to make one line which lowers the production costs etc.
- It would be very good if I can easily scan/ read out the product. In this way, I can find the problem that occurred more efficiently. The product should be made more "smart".

Thing that are want to scan quickly:
1) when is the product installed at the customer
2) what kind of error
3) consumption
4) amount of times the button is used.

- I want to have a water tester in my department. Currently, I always need to walk to the R&D department to do such test.
- I found it difficult to disassemble a product without damaging it.
- The Quooker button is 6 to 9 times used a day on average.
- Sometimes new intentions from R&D are not discussed with other department such as the R&R department. R&R can think along with R&D people in order to avoid early product errors.
- Customers do not know that cold and boiled water coming from the tap is separated from each other. Therefore, cold water can immediately be dispensed after having dispensed an amount of boiling water.
- The hose of the Flex tap does not work properly. A magnet sensor is integrated for safety reasons. However, the hose expanse when boiled water is coming through which also moves the magnet. This could result in errors.
- The service team is very accommodating with replacing new Quooker product. This costs the company lots of money, but also shows the goodwill towards customers.

Strength

- Quooker is focussed on e recycling system in order to throw away less parts. The SWAP project is a good example for this.
- The R&R department can easily give feedback on product failures/improvement to the R&D department.

Weakness

- sustainable projects started only a year ago. Current sustainable projects are not fully operating yet.
- Currently, finding the specific error takes a lot of time and is not very effective caused by Quookers system which is not "smart".
- the product is difficult to disassemble without damaging it.
- Sometimes new intentions from R&D are not discussed with other department such as the R&R department.
- Errors in the hose of the Flex tap are often experienced by malfunctioning of the magnet sensor.

Opportunities

- Quooker could anticipate on aspects to let the customer know how to clean the product in a proper way.
- Quooker could emphasize more on sustainable projects in order to higher its revenue from this division.
- Quooker could make the product more "hufterproof". In this way, customers can continue to clean the Quooker with strong soaps.
- Quooker could give courses to kitchen dealer in order to avoid incorrect installations done by their plumbers.

- make Quookers product "smart" in order to find specific errors more easily.
- More communication between departments (before the product is put in production) could avoid product errors.

Threat
- people clean their Quooker with strong soaps which damage the internal parts.

With more electronics involved multiple things can happen:
- overkill of featurs
- cyper attacks
- the past has shown that electron procuts of Quooker lst horter compared to mechanical controlled taps.

Requirements
- the product or feature need to be easily assembled and disassembled by the service team.
- make a product or feature that fits the production facilities of the production department.

Meeting Ivo Legel – Manager R&D

Asked questions (dutch):

Target group
Wat is de voornaamste reden dat mensen een Quooker kopen denk je?
Wat houd deze mensen tegen om een Quooker te kopen?
Zie jij interessant behoefte die momenteel nog niet vervuld worden door de Quooker?
Wat zijn voornamelijk klachten van customers die al een Quooker hebben?
Zie jij bepaalde trends in de markt die belangrijk zijn om op in te spelen (in de keuken én binnen kokend water kranen)
Wat zou een interessant doelgroep zijn om voor deze opdracht op te richten? (of is het wellicht de doelgroep binnen Quooker, zoals het service team?)

Product
Wat zijn vanuit jou oogpunt momenteel de USP's van Quooker?
Waar moet Quooker zich momenteel nog op verbeteren denk je? (ook gekeken naar concurrentie)
Waar zie jij Quooker over een paar jaar staan? Ook qua product specifications?
Waar is Quooker naar op zoek wat betreft de productontwikkeling?

Zie jij interessante richtingen voor het gebruik van smart materials en een toepassing op het product Quooker?

Insights:
- an interesting focus could be the younger group of people within the current target group (current target group is aged between the 30 and 60)
- These people like to have fashionable products and are in for products with new features or technologies. They also want to distinguish themselves and want to be part of a 'unique group' (the early adapters).
- Quooker wants to prevent the user from burning their hand. Several functionalities have been integrated in order to secure the user enough safety. Quooker has a clear vision of how providing this. Important is that no warning signs should be placed on the product. Quooker wants to bring this message in a subtle way in which the user is not constantly faces with warning signs. Competitors work on a dispense function in which a pre-programmed amount of water is set. In this way, the user can walk away while a glass or a bucket is being filled (this can be seen as more safe). Another important thing is that the product should be treated as a child and not the other way around in which a product is dictating you.
- also think about cost reduction that can be realized with smart materials. As an example, one of the components, a reduce valve consists of 6 components. When choosing a material that can met the same results out of one part, cost reduction could be the outcome.
- Currently, the water jet that comes out of the spout does not have a constant quality. This is due to the different water pressure in different areas of the country.
- Always think of different hallmarks when developing a product for Quooker. Different hallmarks are applicable for different countries. (Germany: W270 & KTW) (UK: WRAS) (NL: KIWA)
- trends mentioned in the area of boiling water taps are:
    - the use of displays and touch
    - the awareness of sustainability. People are becoming more critical on consumption aspects and whether the product is good for the environment.
    - think of using the heat that is thrown away in the sink.

Strength
- Quooker has integrated safety features in a subtle way (without creating an overkill of functionalities)

Weakness
- The current water jet is does not have a constant water pressure.

Opportunities
- Focus on younger groups that want to differentiate

themselves (like early adapters). They look for new features or technologies and want to show this to their friends.
- think about ways to pre-program the amount of water a customer wants to have.
- Smart materials could be used to reduce production costs by reducing the amount of parts integrated in one product.
- make a solution in order to keep the water pressure that comes from the tap constant in every region.

Requirements
- the product or feature should be in line with the a hallmark which is applied in the country concerned.

"You should feel empowered when controlling the Quooker"

"Focus on the younger group of people who are interested in new features and/or technologies which can be created by smart materials"

Visit area30 & art of kitchen fair
On September 20, two different fairs have been visited in Germany. Both fairs have been visited in order to get inspiration and insights of customer's opinions, competitors and other trends in this market segment. Unfortunately, both fairs weren't that big. Therefore, relevant insights of this day weren't that broad. However, some people that have been interviewed revealed some relevant information. This information is elaborated below.
As a preparation of both fairs, different questions were prepared. However, it appeared that most conversations lead to improvised conversation with different outcomes.

Main questions asked in interviews/conversations:

Customers
1. Did you ever heard about boiling water taps? And do you know the product Quooker?
2. Would you consider buying a boiling water tap? (what prevents you of buying one?)
3. What are the main considerations of buying a Quooker?
4. For what activities would you use a boiling water tap?
5. What could be improved on boiling water taps do you think?
6. How does the future boiling water tap looks like?
7. Did you know that boiling water taps can be more sustainable than conventional kitchen appliances? What do you think of the water/electricity consumptions?
8. Do you think boiling water taps are safe to use.
9. –
10. What do you think of the brand Quooker?
11. Does the Quooker perform properly reflecting the product on safety and sustainability?
12. What do you think of the price of the different products?
13. What are the USP's of Quooker?

Companies
1. Could you explain the working principle of your product
2. Does it provide boiling water?
3. How is the product properly secured (safety aspects)
4. How sustainable is the product?
5. How does the future boiling water tap looks like?
6. What are market trends?
7. Where is the customer currently looking for in the product, and in the future?

Insights:
Ingo marré (sales manager Quooker – area30)
Most customers have doubts about the following aspects (aspects of German customers):
- Sustainability (how much does the Quooker consumes relating to water and electricity consumption?)
- Scale: in Germany there is a lot of chalk scale which is bad for the functioning of the whole Quooker system. Customers want to know whether the scale is being filtered in order to avoid this deterioration. In some areas in Germany, the reservoir needs to be cleaned every week, which is a lot of a hassle. This might be seen as the biggest enemy of Quooker.
- Safety: Customers do not know how the Quooker is secured and if this will eventually work properly.

There is also a big difference between the different reservoirs relating to the installation time. Quooker provides three different reservoirs (pro, combi & combi+). Ingo explained that the pro reservoir can be installed within ten minutes whereas the combi versions take at least an hour for installation. This has to do with the different warm and cold water connections and the replacement of multiple tubes etc.

Ronald Harkema (Account manager Quooker - Art of kitchen)
An interview with account manager Ronald Harkema has been conducted in order to get insight on trends and future product ideas.

When asking Ronald about his perspective on the next

generation Quookers he came with the following topics:
- in the future it would be way more efficient when errors in the system will be detected before the customer will face the problem which is currently the situation. In the current scenario, a customer calls the service of Quooker when an error has been detected. Thereafter, people of the service team will drive to the customer to solve the problem. In other scenarios, updates of the system also need to be carried out by the service team. It can be concluded that for every error or update the service team need to go directly to the customer which is definitely not an efficient way of dealing with these subjects.
- It would be good for Quooker to have more insights into how the customer uses the system. In this way, errors (and the reason of the error) can be found more easily. Additionally, Quooker could get more insights on the consumption of the customer as well which eventually can be used as feedback as well. In this way, customers get more insight on their own consumption.
- In general, the majority of customers do not know that the Quooker system is more sustainable than conventional systems (e.g. boiling water kettle). Making the Quooker more intelligent (e.g. Internet of things) could show the customer that Quooker is indeed more sustainable. Currently, the website of Quooker only shows a calculation tools that shows general numbers of sustainable aspects of the system. This only makes sense before the purchase of the Quooker. After purchasing, customers do not look to this tool anymore and have now idea how sustainable there actually are.
- people without a Quooker have doubts about:
    - the Quooker is way to expensive. (most of the people compare the Quooker with other taps, but the main difference is that people buy a whole system when choosing Quooker. Not just a tap..)
    - "we do not drink tea"
    - it consumes a lot of energy. ("that reservoir underneath the sink is constantly warming of the water"!)
    - the Quooker is not safe

- In general, people use a watertap twenty times per day.

Improvements on the product:
- functionality of the Quooker could be improved
- the safety or the perception on safety could be improved
- the products should be kept simple. (do not put too much functionalities in this products otherwise this will be an overkill of actions that could be carries out by the customer.)
- all improvements should be focussed on keeping the concerns from customers away.
- IoT could also help to get insights on when reservoirs need to be cleaned or replaced.
- The system could be set on holiday modes. After three days you have the breakeven point when this could be more sustainable.

Weakness
- for every error (also small ones) the service team needs to come by which results in high costs.
- Quooker does not have specific details on how their customer uses the Quooker system (e.g. amount of water used, electricity, etc.)
- People without a Quookers think the Quooker consumes a lot of water and energy which results in high costs after purchase.
- People without a Quooker think the system is not safe enough.
- Quooker only has a 3-1 combination launched whereas competitors already extended their portfolio with 4-1 and 5-1 combination taps.

Opportunity
- Sustainable aspects could be better communicated to the customer. Quooker could also anticipate on real life feedback related to the consumption (this can be related to IoT related developments).
- Safety features can be made clearer to the customer (especially for people who do not own a Quooker).
- Detect errors in the product before the customer will face them.
- let customers solve errors in the products themselves.
- get a better overview of how customers are using the Quooker system (make Quooker smart).

Threat
- The water quality in the Netherland is very good. However, In other countries the quality is lower and can cause a lot of scale which can damage the internal components.
- Competitors already launched taps with more than 3-1 combinations and are further developing multifunctional products.

Wishes
- The product should be kept simple related to the interaction. Do not make an overkill of functions (customer should feel empowered when controlling the Quooker instead of the other way around).

Kunststoffenbeurs Veldhoven 27-9-2017

The kunstoffenbeurs fair has been visited on 27th of September. Several lectures have been attended. Additionally, several conversations have been executed on order to get more information about certain topics. Most relevant insight have been stated below.

Lecture by Arnoud Passenier, Senior Programmamanager Circulaire Economie, Ministerie van Infrastructuur & Milieu
- Currently, recycled plastics do not meet the requirements of the commercial market (to low quality). Therefore, the demand for recycled plastics is very low.
- China stops importing recycled plastics from January 2018. China wants to deliver higher quality products which cannot be achieved with recycled plastics.

- for designers; think about the lifespan of the material, not only the product itself.
- Government is focussing on regulations in order to reduce the amount of CO2 emissions.

Lecture Promolding
- Moulds can be made very cheap by 3d printing them (with a connex printer)
- this causes low cost investment in the beginning of a design process.
- however, the amount of produced product is relatively low (between the 10 and 200 parts)
- product are preferably hand sized.

Lecture "make polymers dance in the light"
- PHD student Anne Helene Gelebart
- she focussed on materials that can change shape when light is absorbed in the material also called photo-responsive LC polymer films.
- smart materials can be used in many applications. They for instance can be seen as actuators.
- Sometimes it is difficult to see the application of the material because it related to high cost developments or the benefits of the materials itself are to low (e.g. force of bending)
- Contact: Anne Helene Gelebart, Msc - a.h. Gelebart@tue.nl

Insights:
- think about a sustainable development of the feature of product taking into account all its components and the lifespan of the integrated materials.
- for the prototyping phase, 3d printed moulds could be used with low costs.

Opportunity
- Keep plastics separated when recycling the parts of the Quooker. In this way, the quality of the plastic does not degrade.
- New technologies enables moulds to be made from plastic which can reduce production costs (for both prototyping and end products).
- Almost all kinds of problems can be solved with smart materials. However, some smart materials are difficult to commercialize due to high costs production or low benefit outcomes.

Wishes
- Keep CO2 emissions and energy usage as low as possible to stay in line with sustainable aspects being part of the vision of the Dutch government.

Meeting Carlo de Marchi (Team leader production) & Gad Feshaye (coordinator production)

Insights (Carlo):
- Most important USP's are 1) quality, 2) the design and 3) A product which is well designed (almost all components are developed in-house
- A benefit is that all departments are staying close to each other and give feedback which makes the process very effective.
- Carlo guarantees the quality of products and manages the production flow through the production department. Additional activities are: optimal supply of components, safety, clothing and shoes for employees etc.
- a lot of parts in the Quooker can be improved on assembly aspects. For example, the lid of the tanks is assembled with 8 screws on top. This requires precision and results in more time which is unnecessary. In addition, some of these parts need to be assembled by hand. I would like to improve different assembly steps.
- The red lid on top of the tank is very difficult to assemble.
- My function as team leader should be more pleasant when the product will be made simpler.
- Some part in the assembly line are not managed effectively. For example, the construction manual is separated and sorted for every country. This goes wrong very often.
- Carlo feels more and more pressure since targets of the production are scaled up. Currently, 550 tanks need to be assembled per day. On average, they complete around 530 tanks. Moreover, it has become normalized to overwork. It often happens that employees need to start at 7 in the morning and stop at 9 in the evening. Sometimes they even work on Saturday. This is related to the growing demand. For example, last week the production had a record of assembling 2800 tanks in one week. However, the Quooker was sold 3200 times in the same week. Slowly, the buffer of Quookers is running out.
More employees can be equipped with more employees to produce more products. However, the amount of employees that can work has reached a peak. This means that the production technologies should be up scaled soon.
- Carlo also explained that by the rapidly growing company the mentality also changes negatively. People stop working at 5 a clock and do not for instance want to continue five or ten minutes to reach the target.
- Quooker needs to check all incoming components which should actually be done by the manufacture himself.
- in addition, a lot of components do not meet the technical specs and need to be send back. Controlling the components takes a lot of time. When a failure occurs will slow down the assembly line.

Gad
- Quooker guarantees 100C degree boiling water.
- Quooker is sustainable. ROI is within a few years (unknown how much exactly)
- Gad want to produce more numbers of taps.
- Components do not meet the technical specs.
- "I want to have High Quality products that not have to be checked anymore".

- Think of developments where people do not have to touch the tap to activate the tap. -- Also think of a new kitchen tap that comes out of the wall instead of the sink.

Strengths
- Almost all components are developed in-house. Therefore, Quooker is a unique design (e.g. benefit is that most parts have a one way fit which cannot be assembled incorrectly).
- Departments are positioned close to each other which makes the process time very effective.

Weakness
- Some of the Quooker parts are difficult to assemble or need to assembled by hand which results in a high production time.
- The production cannot produce the amount of Quookers that are being sold.
- Quooker controls their incoming components which should be carries out by the manufacturer. This is an unnecessary action. Additionally, a lot of components do not meet the technical specs.

Opportunities
- Develop a product or feature which can easily be assembled.

Threat
- With more and more Quookers sold, the buffer is running out which can result in a delivery delay to customers.
- The amount of employees that can work has reached a peak. This means that the production technologies should be up scaled soon which are related to which investments.
- Mentality of employees will be influenced negatively when Quookers grows further rapidly.

Requirement
- The product or feature should be made easy to assemble.

Meeting with Jonathan reinoso (technical employee of Service department)

- Quooker is a unique product. All parts are invented inhouse. Most of the parts are outsources for manufacturing in China and Germany.
- Jonathan helps employees solving their problems with the product.
- There are three options for the customer

1) Part can be send to the customer (cheapest option).
2) Help from from the service team that comes by.
3) Customer can come to the service centre in Ridderkerk himself.

Improvements:
- this is a difficult question, the product is already very good. Our service is perfect as well.
- One issue might be the fast growth of the company. Along with this, products are being improved rapidly. Jonathan rather sees a product that is 100% developed before continues to a next version. Additionally, new improvements require new information for the service team which is not always good communicated. This makes the work more difficult.
- Quookers is going to introduce the new 5-1 combination tap. Jonathan is afraid that this will requires a lot of space underneath the sink. This might be a drawback for the customer.
- I really love my job and there is actually nothing in the product that should be improved in order to make my work more pleasant. I just like to repair stuff and help the customer solving it. One thing could be that the product of Quooker should last longer, but in this case there is less to repair which I don't like.

Weakness
- the fast growing company results in multiple improvements in the product which is difficult for the service team to keep up to date.

Threat
- People with less space in their kitchen are not able to place the 5-1 combination tap which requires multiple tanks that need to be installed underneath the sink.

Appendix E - Introduction days

Insights
- every Monday morning the COO give a small speech about last week and the upcoming week.
- The in-house production makes a process time very effective and efficient.
- Breaks for the production department are strictly organized (a horn can be heard for every break)
- It was my task, after an explanation, to assembly the three different versions of Quookers taps.
- Quookers Fusion is the tap which is currently most sold. An amount of 200 fusion taps are being made very day.
- due to production errors target can't be met.
- the "lean approach" of integrated in the production line. This means that all components are build up in a most efficient way. Additionally, Boxes with components are being refilled before they are empty and they can be found within reach. The fusion tap is assembled related to the single line approach. This means that one person build's up the whole tap step by step.
- All production employees wear Quooker clothing.
- The Quooker flex is introduced on the market after the fusion tap. The flex tap is an improved version of the fusion and consist of less components. This results in an easier and faster assembly.
- Although most of her products are being sold in the Netherlands, most of the taps that are sent back to Quooker are coming from the UK. This has to do with bad water quality in the UK (amount of scale). In addition, plumbers in the UK are not connected to Quooker and operate on their own. This results often in incorrect installations of the system.
- The service of Quooker is very good.

Strength
- R&D team is improving their taps by making them consist of less components (e.g. The Flex tap is an improvement from the Fusion).
- Quooker creates an environment where everybody feels they are part of the team.
- The integrated the lean approach which makes the production process more efficient.

Weaknesses
- Production target are not met since there are still a lot of errors on the production line.

Threat
- Quooker is not able to deliver the right amount of Quooker taps. This might result in delivery deployments to the customer.

Opportunities
- Create a new system in which taps are easier to install for plumbers in the UK. This could also be solves by a better communication towards dealer in the UK.

Appendix F - Customers & End-users 1

Several studies on Quookers customers and end-users already have been carried out over the years. The results of these studies show valuable information and are used in this chapter to analyse the customer and the end-user more thoroughly. Note that the studies used in this chapter are carried out in the Netherlands and were carried out by Quooker. Personal research into customers and end-users has not been carried out thoroughly in order to deal efficiently with the time (small interviews have been conducted with several end-users during a day with the service team, introduction days). It is planned to carry out thorough user research after the selection of a more specific design direction.

Other characteristics of the end-user

Other characteristics revealed the majority of people that are moving, get a new kitchen or remodel their kitchen are a potential target group. In addition, it has been found that people in this group are looking for new equipment in their kitchen (Groeikansen Voor Het Merk Quooker® In Nederland, 2016). The main aspects of the potential target group are shown on the adjacent page.

People without a Quooker

People not owning a Quooker have another perception on the product. One of the reason of not purchasing a Quooker is related to the price. They think they do not need the product necessarily since it is not a primary need. Additionally, they often think that the energy and water consumption of the Quooker is high which could result in high costs afterwards (Pathways Quooker, 2016) (Crijns, 2016). Again, note that the shown information is related to end-users based in the Netherlands.

Another report, in which a call-survey was conducted, revealed that people not owning a Quooker still have doubts for purchasing a Quooker. These findings show that 30% of the participants still think of 'danger' when reflecting on the boiling water tap (Crijns, 2016). Research on the brand Quooker, established by TNS NIPO, also provides the same insight. When reflecting the Quooker, only 33% of the participants think they can safely use the Quooker. Moreover, 26% think that the Quooker is well secured. Another insights from this research showed that only 23% think the Quooker can save energy (Trackingsonderzoek Quooker, 2015).

Purchasing process

Recent customer research shows that 71% of the customers are related to kitchen dealers. Accordingly, Quookers are being sold by webshops (13%), directly via the Quooker website (8%) and others (8%)(Crijns, 2016). When the Quooker is bought at a kitchen dealer, a plumber will install the Quooker, whereas other sale channels require the end-user in general to install the Quooker him- or herself (29% of the Quooker are installed by the end-user). This might result in more difficulties and incorrect installations. However, it also appeared that plumbers sometimes installed the Quooker incorrectly. An overview is shown of the purchasing process of end-users with percentages included. The figure differentiates three different touch-points, starting with the first moment when the end-user comes in touch with the Quooker product; "getting to know". Secondly, it shows the touch-point where end-users want to get more information on product specifications; orientation". Lastly, it shows the moment where the Quooker is being bought; the "actual purchase". Note that the given percentages are related to end-users based in the Netherlands.

Current target group

Quooker is aiming on a specific target group although they sell their product to a broader range. Below, several characteristics are stated that are related to their current target group (Starprofiles Quooker, 2016).

- Age: 30 - 60
- Cohabiting/married
- Higher social class
- Plans to move, purchase a new kitchen or remodel their kitchen

Taking into account these characteristics results in a market size of around 550 thousand people living in the Netherlands that can be reached today.

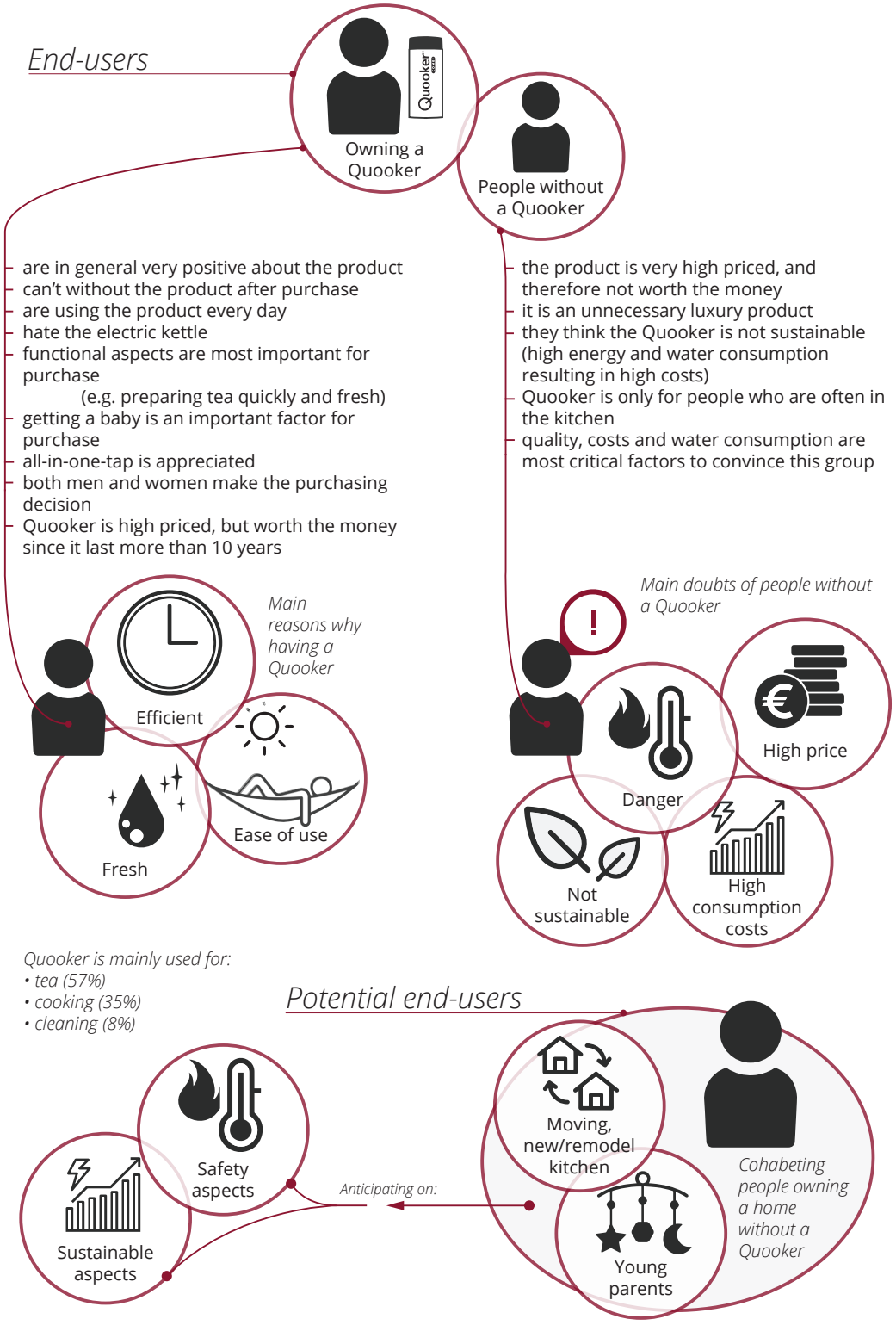
Potential target groups

Several conclusions can be drawn that could lead to a potential end-user to focus on. First of all, it has been found that the majority of people that are moving, get a new kitchen or remodel their kitchen are a potential target group. In addition, it has been found that people in this group are looking for new equipment in their kitchen (Groeikansen Voor Het Merk Quooker® In Nederland, 2016).

The (5-1 combination tap)

As being described before, Quooker is aiming to introduce a 5-1 combination tap on the market in 2018. This means that next to the cold, warm and boiled water, sparkling and cooled water will be provided as well. This is a positive extension to provide the end-user with more functionality out of one tap. However, there are also downsides forecasted which are related to the interaction and feedback of the user.

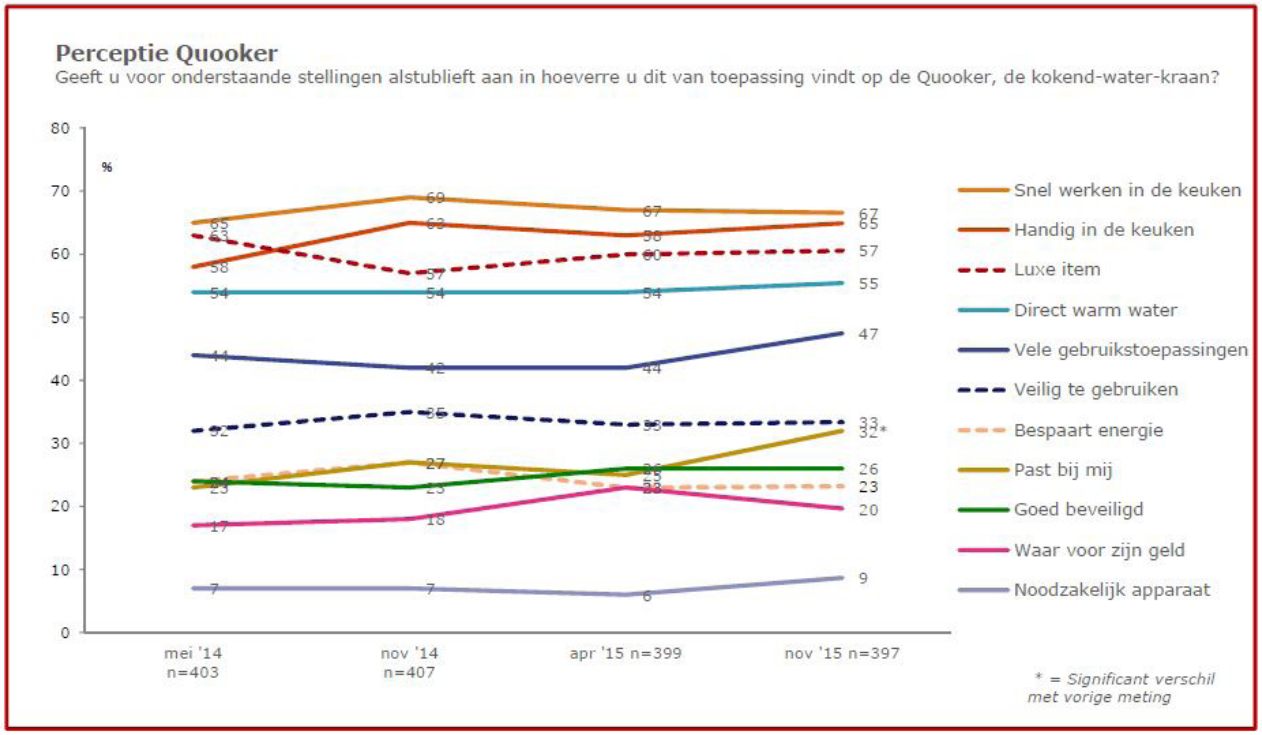
Currently, the boiled water is separated by the push-push-turn button from the warm and cold handle. This makes a clear distinction between the 'save' zone (the

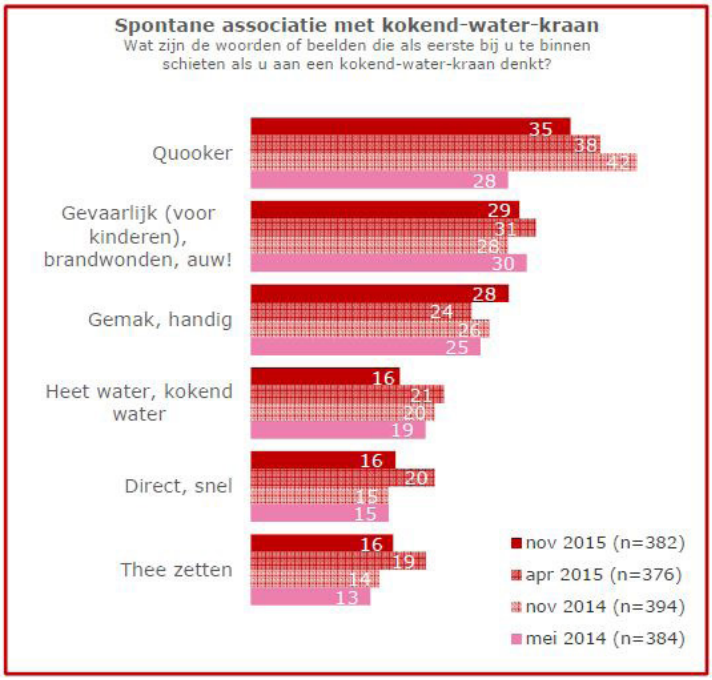


handle with cold and warm water) and the dangerous zone (the boiled water). However, people have still doubt when interacting with the current tap which was found earlier. Moreover, the 5-1 combination tap (in marketing terms called the "Cube") will result in more functionalities and therefore more interactions that need to be controlled by the end-user.

A first user-test with the Cube (established by Quooker) revealed that end-users have quite some difficulties understanding the different functionalities of the Cube. Moreover, people did not understand how to activate the different varieties of water after it was explained once.

Information shown on the following pages have been used to gather the information of chapter Customer & End-user.





Men associeert de kokend-water-kraan nu iets meer met gemak, handig.

Drie op de tien mensen denkt nog altijd als eerste aan gevaar.

* = *Significant verschil met vorige meting*

Verbouwing van de keuken blijft de voornaamste reden voor aanschaf van een kokend-water-kraan

Mogelijke aanleiding

Wat zou voor u een aanleiding/moment zijn voor de aanschaf van een kokend-water-kraan?

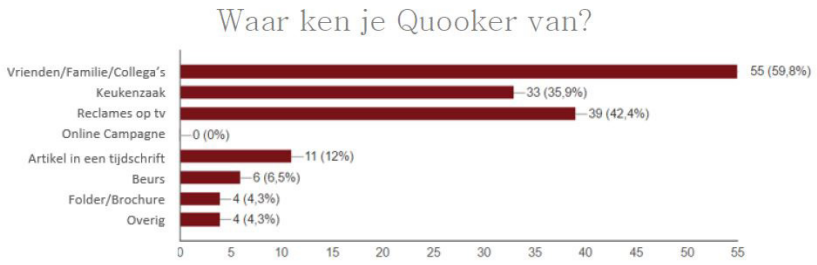
Type	12-meting mei '14	13-meting nov '14	14-meting apr '15	15-meting nov '15
Verbouwing van de keuken	51%*	64%*	61%	57%
Aanschaffen nieuwe inbouwapparatuur	13%	20%	15%	22%
Aanschaffen nieuwe warmwatervoorziening	13%	14%	17%	16%
Verhuizing naar bestaande woning, waarbij keuken is aangepast/nieuwe keuken is geplaatst	26%	29%	23%	26%
Verhuizing naar nieuwbouwwoning	18%	25%	17%	19%
Als ik er genoeg geld voor heb	0%	3%	3%	-
Basis:	n=194	n=234	n=197	n=228

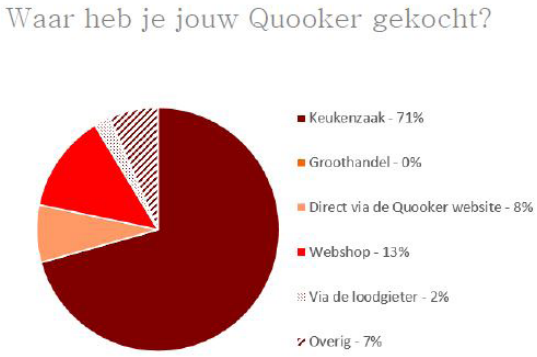
Tracker Quooker nov 2015 - 15-meting

1) perceptie op veiligheid van de Quooker (onderdeel "veilig te gebruiken", staat op 33 = niet heel hoog)) □ goed beveilgid staat nog lager, op 26.

2) perceptie op duurzaamheid van gebruik van de Quooker, 23 (staat nog lager en staat onder het kopje "bespraart energie")

- Drie op de tien mensen denkt nog altijd als eerste aan gevaar.
- Verbouwing van de keuken blijft de voornaamste redden voor aanschaf van een kokend-water-kraan.
- Internet en keukenwinkels zijn de belangrijkste informatiebronnen.





De nieuwe toepassingen van de Quooker Flex




In de actuele commercial van Quooker worden verschillende toepassingen van de Quooker Flex getoond. Enkele momenten die worden getoond in de commercial, zijn ook voorgelegd aan respondenten.

NB. Het onderzoek is uitgevoerd voordat de ATL campagne is gelanceerd.

Pasta en thee

Het vullen van een kan thee of pan pasta met heet water, zijn de situaties die door consumenten nu al het sterkst sterk aan Quooker worden toegeschreven.

Schoon aanrecht

Het aanrecht schoonmaken en een opgeruimd aanrecht worden wel al aan Quooker gelinkt, al is de link nog niet sterk. (het schoonmaken van de wasbak is niet voorgelegd aan respondenten).

Koud en warm water toepassingen

Het drinken van koud water of het vullen van een emmer met warm water vindt men nog niet bij Quooker passen. Het vullen van een vaas is niet voorgelegd aan respondenten.

Samenvatting resultaten - relevante koop- en behoeftesituaties Quooker

Quooker is voor consumenten mentaal het sterkst gelinkt aan **koken** en bereiding van eten en drinken waarbij **direct kokend water** nodig is.

Bij het **vernieuwen van keukenapparatuur** zit Quooker al goed in het hoofd van consumenten. Het verbouwen van de keuken of het kopen (en inrichten) van een nieuwe keuken zijn relatief eenvoudig nog sterker te koppelen aan Quooker.

Een **schoon aanrecht** – één van de toepassingen van de Flex, wordt positief gelinkt aan Quooker, maar nog wel zwak. Dit geldt ook voor situaties waarbij heet water nodig is om voor de **baby** te zorgen evenals bij situaties waarin men **zuinige keukenapparatuur wil** of waterverspilling wil voorkomen.

Een **huis kopen** is (nog) geen relevant aankoopmoment voor de Quooker en ook moeilijk te claimen. Het lijkt te vroeg in het oriëntatie / beslisproces te zijn.

Dit zelfde geldt voor de **koud en warm** (niet kokend) water toepassingen van de Quooker.

Installation by a Quooker engineer

If you prefer your Quooker can be installed by one of our trained engineers. This service includes the drilling of any solid surface(excluding glass, Dekton and worktops over 50 mm in thickness) and the connection only to existing water and electrical services. Once we have received your order and payment we will contact you to arange a date and time for installation.

◎ Do it yourself installation ◎ Installation by a Quooker engineer.

◎ Yes, I have read and accepted the Quooker conditions

Next step ›

Uitsplitsing salience naar doelgroepen

Sommige koop- en behoeftesituaties passen specifiek bij een bepaalde consumentengroep. Quooker zou als merk idealiter opvallen (salient zijn) wanneer men zich in een relevante behoeftesituatie bevindt.

**Let op: Inzichten zijn indicatief, vanwege de lage steekproefomvang van de subgroepen (n = +/- 60).*

Quooker vaker relevant onder Quooker bezitters

Consumenten met een Quooker heet-water-kraan hebben meer en sterkere positieve linkjes naar het merk. Opvallend zijn de sterkere associaties met verhuissituaties ('een nieuw huis kopen', 'zoeken naar een nieuw huis'). Wellicht zijn dit de logische koopmomenten van een tweede Quooker.*

Quooker vaker relevant voor ouders van een baby. Wanneer men een baby in huis heeft, koppelt men Quooker ook sterker aan de behoeften rondom babyverzorging.*

Consumenten in de lagere sociale klasse koppelen Quooker sterker aan de behoefte aan zuinige keukenapparatuur.*

Quooker niet vaker relevant voor recente huizenkopers. 'hypotheek afsluiten', 'je keuken verbouwen' en 'een woonwinkel bezoeken', koppelen consumenten die onlangs (< 2 jaar) hun woning kochten minder vaak aan Quooker.*

Voor vrouwen zijn de momenten rondom baby verzorging, koken en kokend-water bereiding van eten en drinken relevanter dan voor mannen. Mannen scoren niet anders dan vrouwen op de momenten rondom luxe.

Gemak en handigheid

De category entry points zijn impliciet (onbewust) uitgevraagd. Daarna hebben de respondenten die een Quooker heet-water-kraan hebben, ook een beredeneerd antwoord gegeven op de open vraag waarom ze deze hebben aangeschaft.

Vaakst genoemde rationele redenen zijn: 'gemak' en 'handigheid' in gebruik. Daarnaast zien we veel van de voorgelegde category entry points terug in de antwoorden.

Nieuwe entry points

In de antwoorden zitten ook een aantal potentiele category entry points, potentiele nieuwe behoeftesituaties voor Quooker. De entry points die worden genoemd, zijn:

- "als ik niet lang kan staan";
- "als ik snel warm water wil (niet heet)" en
- "als ik echt verse thee wil".

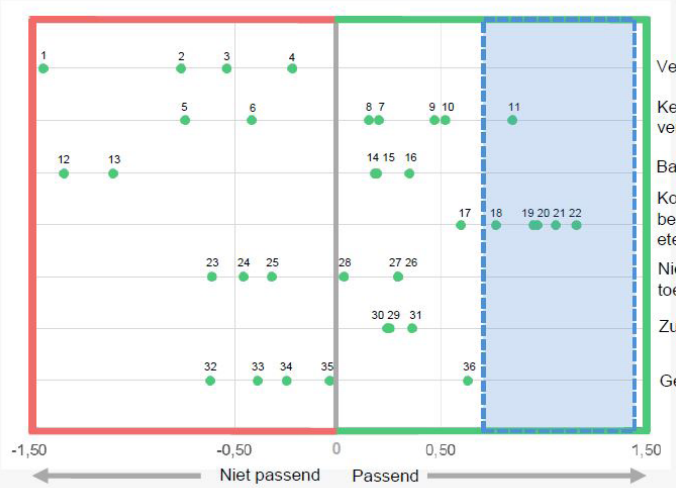
Niet hoeven wachten totdat water kookt, is belangrijk voor mensen die slecht (lang) kunnen staan.

Thee is niet alleen snel klaar, maar, ook vers. Het hete water brengt een gevoel van goede kwaliteit met zich mee.

Snelheid essentieel voor Quooker. Niet alleen snelheid van kokend water, maar ook de snelheid waarmee je warm water tot je beschikking hebt.

Quooker staat voor koken en kokend-water bereiding

In het gearceerde deel van de grafiek zitten de momenten waarop Quooker voor consumenten het relevantst is. Met andere woorden: dat zijn de momenten waarop Quooker sterk in de hoofden van consumenten zit. Dit zijn voornamelijk momenten waarop men bezig is met koken of met het bereiden van eten en drinken waarbij direct kokend water nodig is. Daarnaast is Quooker relevant in situaties waarbij men nieuwe apparatuur in de keuken wil aanschaffen.



1. Hypotheek afsluiten
2. Zoeken naar een nieuw huis
3. Nieuw huis kopen
4. Je huis verbouwen
5. Woonwinkel bezoeken
6. De kraan lekt
7. De boiler is kapot
8. Keukenwinkel bezoeken
9. Je keuken verbouwen
10. Nieuwe keuken kopen
11. Nieuwe apparatuur in je keuken
12. Baby spullen kopen
13. Baby verzorgen
14. Kruikjes maken voor een baby
15. Flesvoeding maken voor een baby
16. Babyflesjes of speentjes steriliseren
17. Koffie maken
18. vlugge maaltijd bereiden
19. Aardappelen en groenten koken
20. Eten bereiden
21. Pasta koken
22. Thee maken
23. Koud water drinken
24. Handen en gezichten van kinderen wassen
25. Dweilen
26. Het aanrecht schoonmaken
27. Een opgeruimd aanrecht
28. Een druk huishouden
29. Letten op het energieverbruik
30. Bewust omgaan met energie
31. Zuinige keukenapparatuur zoeken
32. Op zoek gaan naar gadgets
33. Anderen je huis laten zien
34. Snel kunnen schakelen
35. Genieten van thuis zijn
36. Aantrekkelijke keuken hebben

Appendix G - Customers & End-users 2

User test - 5-1 combination 'Cube"

Installatie CMS kernpunten
Op 4/9 punten in advocaten kantoor CMS in Amsterdam zijn chillers geplaatst.
Na het plaatsen van de chiller zijn aan 4 groepjes van 3-5 man per keer instructies gegeven.
Daarnaast zijn de overige 5/9 enkel Quooker systemen nagelopen.
Iedereen was super enthousiast maar deze evaluatie gaat natuurlijk vooral over de verbeter punten. Voor nu of in de toekomst.
Bediening
1) Gebruikers snapte de bediening niet na 1 maal uitleg.
Het lijkt mij waard te onderzoeken of de bediening intuïtiever kan (Roemer was er ooit al mee begonnen).
Intuïtiever = minder nadenken = minder risico dat er per ongeluk kokend i.p.v. bruisend wordt afgenomen (al aantal maal gezien).
2) Gebruikers moesten denken hoe bruisend water af te nemen.
Tijdens het denken stopte het knipperen, de gebruiker raakte in de war.
Kan de LED langer doorknipperen?

3) Gebruikers maakte regelmatig fouten tussen de verschillende stromen.
Vervolgens ze zitten dan vast in de time-out die ze niet begrijpen. Onterecht proberen ze door.
Weegt het voordeel van de time-out wel op tegen het complexer maken?
4) Gebruikers snapte het opwarmlampje niet.
Ze raakte in de war en dachten dat de kookfunctie voorgeselecteerd was.
Prestaties
1) Spetteren, volgens het kantoor zijn er al 'slachtoffers gevallen met brandwonden'.
Spetteren is een veel gehoord argument. Zie ook de 5 sterren specialist (zie onder aan deze email).
2) Bruisend water was erg geliefd. Men was zeer tevreden over de intensiteit.

3) De chiller tot 2x ontluchten was echt een must om voldoende CO2 in het water te krijgen.
Duidelijke installatie instructies zijn vereist.
Lijkt mij iets om t.z.t. met marketing over te denken hoe en of dit te communiceren.

4) Als de pomp aanstaat lijkt de flow van koud water laag.

Appendix H - Competitors analysis

Grohe

Insights:
- already launched a boiling & sparkling water tap
- Interaction is difficult to understand (own experience and observation from other users-area30 fair). Therefore, safety slot looks doubtful (working principle of boiling water is done by touch)
- uses one water jet that comes out of the spout. Therefore, users could burn their hands more easily compared to the "spraying" jet in the tap of Quooker.
- Customers can either choose a Grohe Red or Blue which means that the combination of boiling water and sparkling water is not realised yet. If customers want both types of water, then they need to order two separated taps.
- 5 years of guarantee on the product
- are developing a product to enable the user to have an overview on the water consumption (will be released for around 500 euros)
- the boiling water tap (3-1 version) cost around 1450 euros.

Pros & cons
+ have accessories to provide the customer with feedback on consumption
+ are more oriented towards the IoT
+ the boiler is silent
+ have already launched a tap that provides cooled and sparkling water
- touch interaction is difficult to use
- the boiling and cooled water cannot be combined in one tap
- boiling water goes to the same outlet as the standard hot and cold water.

Source:
1. GROHE Sense Guard waterbesturing | GROHE. Grohenl. 2017. Available at: https://www.grohe.nl/nl_nl/smarthome/grohe-sense-guard/. Accessed September 26, 2017.
2. GROHE watersystemen - gekoeld, bruisend en/of kokend heet water | GROHE. Grohenl. 2017. Available at: https://www.grohe.nl/nl_nl/keuken/watersystemen.html. Accessed September 26, 2017.

Itho Daalderop

Insights
- Integrated with a touch operation and a 3-1 solution
- led indication of boiling water
- the tap is also integrated with a 'slim' feedback function. This shows the user when to replace the filter.
- Only a few variations of taps and finishes.
- other systems of Daaldrop are very focussed on slim technologies. The core business of this company is based on home based system such a cv boiler and solar water heaters etc. With the integrated slim technologies the customer is able to regulate the systems by an application. Additionally, customers have a view on the amount of consumption and costs.

Pros & cons
+ is integrated with a 'slim' feedback function for replacement of the filter.
- only a few types of boiling water taps

Source:
3. Itho Daalderop. Ithodaalderopnl. 2017. Available at: http://www.ithodaalderop.nl/. Accessed September 26, 2017.

Floww

Insights:
- the boiling water tap (3-1 version) cost around 750 euros.
- multiple taps are available with different combinations of liquids. They for instance also sell the 4-1 combination. The salesmanager of FLoww explained that the 5-1 combination is already introduced. In addition, the tap can also be combines with for instance a beer or wine barrel. However, on the website these combinations cannot be found.
- warm and cold water are separated by two different handles. In addition, two versions of interactions are provided; a 'twist' control and a touch control which involves led feedback.

Pros & cons
+ Seems to have the technologies to launch a 5-1 combination in the near future
- Warm and cold is separated from each other with two different handles. (Could be difficult for left handers)
- Quality does not seem to be good

Source:
5. floww. 2017. Available at: https://www.floww-water.nl/. Accessed September 30, 2017.

Franke

Insights
- have launched a 4-1 tap (warm/cold, boiled and cooled)
- does have two different handles for warm/ boiling and cold/ cooled water.
- design expresses more functionality and simplicity, stands for reliability.
- the boiling water tap (3-1 version) cost around 800 euros.

Pros & cons
+ are trying to take the lead with the 4-1 combination tap
+- is priced in the medium market segment
- Difficult to operate the boiling water handle when left handed

Source:
4. Instant boiling water taps. Frankecom. 2017. Available at: https://www.franke.com/gb/en/ks/products/instant-boiling-water-taps.html. Accessed September 30, 2017.

Dornbracht

Insights
- Provides a 3-1 boiling water tap
- Boils water to 93C Celsius
- Core business in high quality kitchens
- have developed an innovative system including several features (e.g. set the amount of water coming out of the tap, set the temperature, set the water jet pressure, etc.). This system is most applicable in professional kitchens or showers where the amount of water and a specific temperature are more important. With the system, Dornbracht can easily couple their system to an IoT system which could be the next step for them.
- the system is very expensive (around 5000 euros)

Pros & cons
+ developed an innovative system
+have a 3-1 boiling water tap
- market price is very expensive
- more applicable for professional kitchens or in the shower

Source:
7. eUnit Kitchen / Kitchen / Fitting / Dornbracht. Dornbracht. 2017. Available at: https://www.dornbracht.com/en-gb/products/kitchen/eunit-kitchen/. Accessed September 30, 2017.

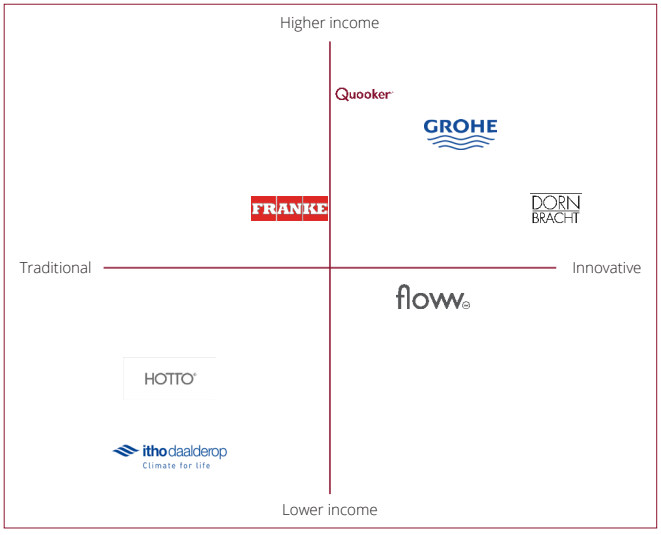
Hotto

Insights
- sells the 3-1 combination for 660 euros
- the quality of the product is related to the relative cheap price. Some forums with customer feedback have been analysed and show some unhappy customers of Hotto:

Pros & cons
+ cheap model
+ good service
- not a high quality product

Source:
6. HOTTO, de betaalbare kokend water kraan. Hottocom. 2017. Available at: http://www.hotto.com/#overhotto. Accessed September 30, 2017.

	Sparkling water	Cooled water	IoT oriented	Price
Grohe	Yes	Yes	No	++
Franke	No	Yes	No	+
Floww	Yes	Yes	No	+-
Hotto	No	No	No	-
Itho Daaldrop	No	No	Yes	--



Note: Higher & lower income aspects are related to the market price of the 3-1 combination taps provided by the brand.

Some reviews of customers:

Grohe

"It doesn't deliver hot water at 99.9C as it says on the box - using a thermal tester, it averages around 91C and the hottest we have had it is at 92.8C. Still OK for a decent cup of tea, but it's not "near boiling" as is advertised"

"Most surprisingly, the boiler itself is silent! Previous hot water taps I have used would be very noisy when heating water, but this is so quiet, I had to question whether it was actually plugged in! It's well insulated too - I turned the unit off for a day or so whilst we were moving house, and when I came to plug is back in about a day and a half later it was still very warm"

"Generally this product does what it says however there is one significant drawback. Because the Boiling Water flow goes through the same outlet as the standard hot & cold water - the flow valve (which is designed to ensure that Boiling Water comes out of the tap at a restricted low pressure) also restricts the flow of the standard hot & cold water flows. This leads to frustratingly slow fill times for the sink. This is a feature which becomes ever more frustrating as time goes on to the point where I am now considering ditching this tap for a standard hot & cold flow tap such as the Franke Eiger"

Franke

"After several attempts to make this unit work - replaced filters, checked main water pressure, disconnected the feed and supply pipes at all possible locations, removed the unit completely and checked the flexible pipes - I have come to the conclusion it is now junk status.
What a massive and expensive error ! Worse thing is to replace the whole hot tap unit requires new taps, pipes and boiler unit. I already spent several hundred pounds trying to make this one work. Will never buy another Franke product and i suggest anyone reading this takes this advice".

"A really great quality tap, need to leave space behind the left hand side to allow your hands to go around fully when operating the hot tap".

"I bought one of these and had it installed a year ago. I turned it off while on holiday and on return it has ceased to work. Franke wont look at it for repair and I have now heard of other friends who have had the same problem. The unit is clearly unreliable despite having spent nearly £1,000 in all. Franke wont even look at it to establish whether its a manufacturing fault or not as they are hiding behind the one year warranty from purchase not from fitting".

Itho Daaldrop

"Ik heb nog nooit een bedrijf gezien met zo'n een schandalige service en brutale servicedesk als Itho Daalderop! Ze leveren producten waar ze geen service voor verlenen en schuiven alles af naar een derde partij lees Feenstra. In ons geval gaat het om een combiketel waar simpelweg de monteurs van Feenstra al bij beginnen te hoofdschudden als ze hem zien en zelf aangeven geen of weinig verstand te hebben van deze ketel. Na contact met Itho Daalderop krijg je een standaard mail terug dat je weer met Feenstra contact op moet nemen en de cirkel is weer rond en het probleem niet opgelost! Schandalig!!!!!!!"

"slechte kwaliteit. vaak net na garantie gaat Daalderop apparatuur defekt. slecht voor milieu. slecht voor mijn portemonnee. beter een Cooker boiler genomen. had ik nu nog warm water ".

Appendix I - Market trends

Below, an overview is made of the most important trends that have been found during the analysis. On the next page, a table has been shown in which all insights have been clustered.

Demography

Within this segment, it has been found that the Dutch population is slowly changing towards ***an aging society***. From this point of view, it might be interesting for Quooker to anticipate on this society segment and anticipate on the user behaviour of elderly people who might have more difficult interacting with the product. Additionally, it also have been found that the number of ***single households increases***. Currently, almost 40% of private households exist of one person ("Kennisbank Openbaar Bestuur", 2017) ("Bevolking - Cijfers - Maatschappij", 2017). Lastly, cities are growing worldwide. 1.3 million people move to cities every week which will result in an increase to ***58% of people living in cities in 2025***. In conclusion, these trends show a strong change in the society composition nd the way people will live in the future. Quooker could focus on these aspects in order to more conform their product with the needs of people within this society segment ("Demografie: groeiend, vergrijzend en samenscholend", 2017).

Ecological

Within this segment, multiple trends have corresponding insights showing an overall ***environmental awareness***. Companies are more and more investing in environmental related subjects to fight against climate change and show they are sustainable oriented. ("Klimaatverandering en grondstoffenschaarste", 2017) Moreover, consumers are becoming more conscious about their consumption. People seek out ways to make positive decisions about what they buy and look for a solution to the negative impact ("The rise of the conscious consumer", 2017). Quooker is on its way to become more sustainable. First of all, they are more sustainable compared to competitors. Therefore, this could be seen as a strength since these developments are in line with the above mentioned trends. Additionally, Quooker is also integrating a new business model in which they reuse reservoirs (the SWAP-project). This became clear during the interviews with employees. Furthermore, Quooker could further anticipate on sustainable developments.
Furthermore, the production of ***renewable electricity from wind, biomass, solar and hydroelectric power will increase***. This might be related to a slow change in which people will more and more use electricity instead of other non-renewable energy sources. This might be seen as a benefit since the Quooker uses electricity to heat the water ("Energie - Cijfers - Economie", 2017).

Political

The most relevant insight that have been found within this segment is based on regulation from the Dutch government. The Dutch government is aiming to ***reduce the CO2 emission*** for companies (Passenier, 2017). In 2016 the Dutch government has accepted the climate agreement of Paris. In 2023, 16% of all the energy need to come from sustainable energy recourses ("Klimaatakkoord betekent 'revolutie' in Nederland", 2017). Quooker could think of improvements in their product development that is in line with this regulation.

Economics

After the crisis in 2008, the amount of houses that have been sold is equal to the amount before the crisis (2006) or even surpassed. Moreover, ***nearly 54 thousand newly built homes are registered which is equal to a growth of 11%*** in 2016 compared to 2015 ("Bouwen en wonen - Cijfers - Economie", 2017). Both scenarios will result in more people that will move, remodel or get a new kitchen. As earlier described at chapter "Customer & End-users", this segment is a potential target group. This is a beneficial trend which will help Quooker to further grow.
Another economic trend is related to web shops. More and more people in the Netherland are ***buying products online***. The last 10 years, the amount of web shops has increased with 4,4% which will continue to grow ("Energie - Cijfers - Economie", 2017). Quooker might emphesiss more on selling their products online in order to anticipate in this trend.
Lastly, ***new economy systems, focused on sustainability, appear.*** These systems are slowly more focussed on consumer goods that have a new sustainable destination (recycling process) ("Dit zijn de duurzame trends voor 2017 (en later)", 2017). This might give Quooker more possibilities to develop sustainable processes.

Social

Within the social segment, it has been found that ***people are becoming more familiar with ICT related tasks***. The trend reveals that more people are getting basic ICT skills with a computer and internet. Also, ***Internet becomes more accessible to everyone***. In addition, smartphones and laptops are becoming the most important appliances to access internet. 80% own a smartphone and 75 % own a laptop, Along with this, more digital services will be available ("Trends - Maatschappij", 2017). This shows possibilities that Quooker could improve their product on IoT related subjects since this will result in people that have less difficulties interacting with a product.
Furthermore, it has been found that people nowadays

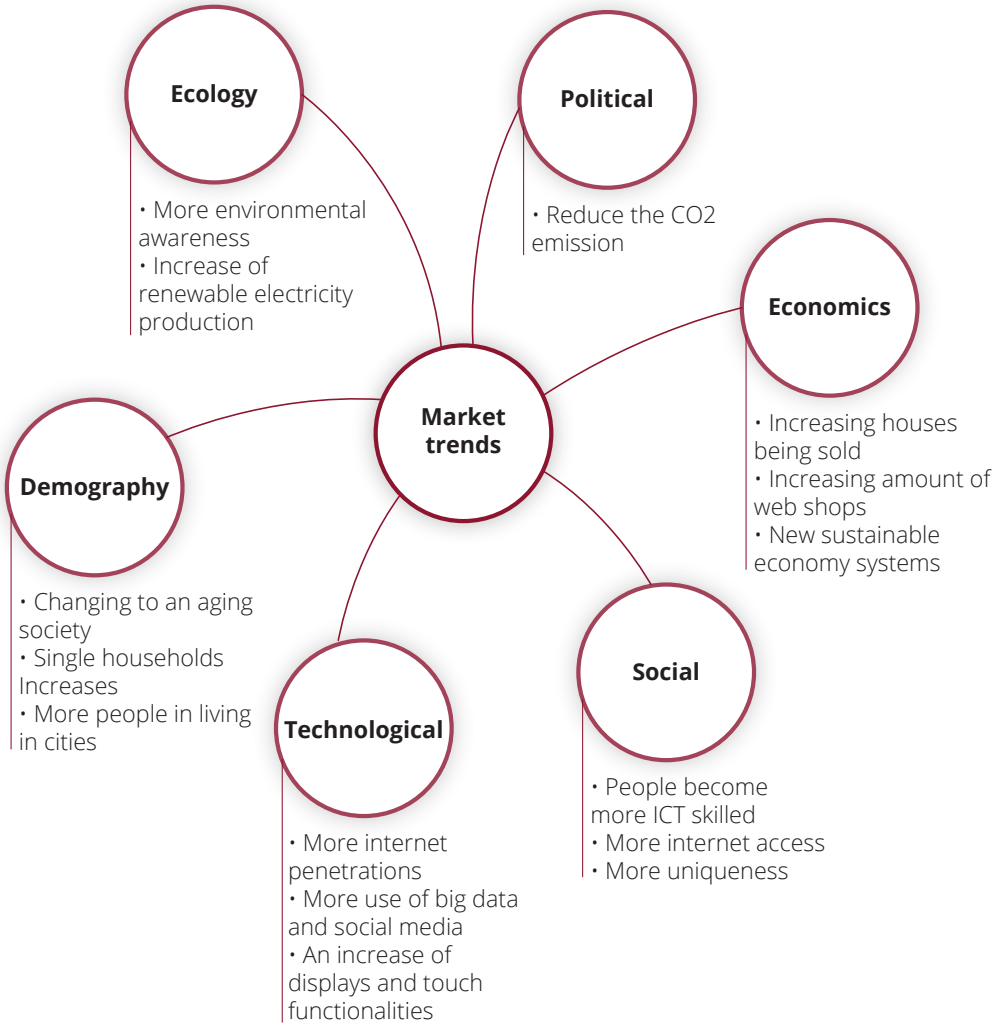
want to be part of a certain social group by having unique product. With this, ***they prefer customized products.*** This could be interesting for Quooker to find out how to make customized product. However, the extension of the product portfolio might also result in higher production costs and distribution difficulties (Overzicht trends en ontwikkelingen, 2017).

Technological

Most of the trends that have been found in this segment could be relevant for Quooker. As explained before, people are becoming more ICT skilled. Along with this, it has been found that there is an ***increase of internet penetrations***, especially in the age group of 45 years and older. Also, people are becoming more and more connected with each other by technological developments. ***Opportunities with big data are also increasing and social media will influence the behaviour of people more and more.*** ("Kennisbank Openbaar Bestuur", 2017) ("Demografie: groeiend, vergrijzend en samenscholend", 2017). For Quooker, this could be an interesting opportunity to look into possibilities of making the product smarter. This could result in a product that is connected to other devices such as the smart phone to make the interaction with the product richer.

On a product level, trends show the ***developments of displays and touch functionalities***. It has been found that these technologies slowly make their entry in the water tap segment. Furthermore, competitors also seek for unique appearance of the tap by looking for new material (finishes). A good example is the lately introduced black tap of Quooker (Legel, 2017).

In conclusion, the trend analysis has resulted in a lot of different insights that eventually will be used as input for the SWOT analysis. Furthermore, better understanding is gained on the market developments and trends that might be relevant for further developments of this

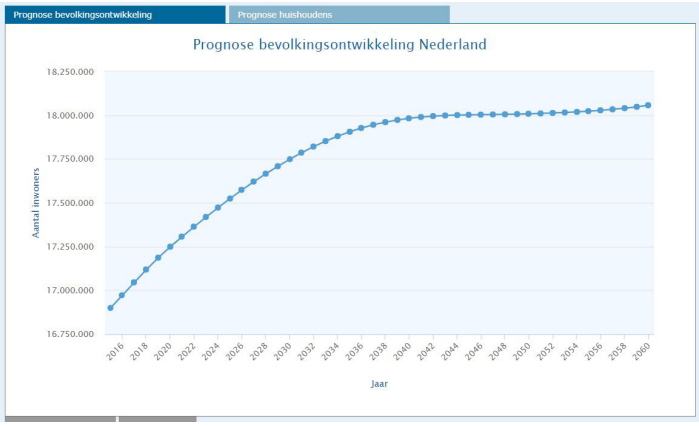


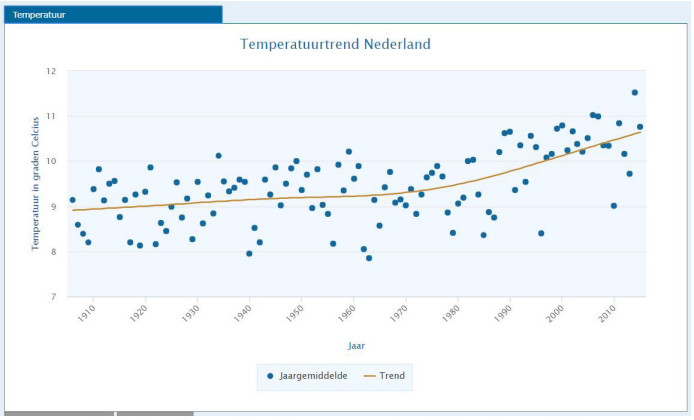
Demographics		
Potentiality	Subject	
	Population growth	• The Dutch population will continue to grow steadily[1].The same can be seen on world level. In 2025 it is expected that the world population will be 8 billion. Mean growth will be caused by the growth in Africa and Asia. Moreover, the growth will be maintained but the speed will decrease caused by the increasing prosperity worldwide[2].
+	*Aging society*	• The Dutch population will slowly change to an aging society. This aging process will mostly occur at the country side. With this, the contrast between the countryside and urban regions will become bigger[1].
+	*Single households*	• An increase in the number of single households. Currently, almost 40% of private households exist of one person[1, 3].
+	*Urbanisation*	• Worldwide 1.3 million people move to cities every week. This is an increasing amount and will increase to 58% of people living in cities in 2025. In 2050 this will be around 66%[2].
	Mega cities	• The amount of mega cities will increase. It is forecasted that in 2015 more than 36 mega cities will exists over the world. Controlling these cities can be seen as controlling a whole country.
	Asylum seekers	• Conflicts in the world cause peeks in the amount of asylum seekers in the Netherlands[3].
	Culture diversity	• Their will be more culture diversity in cities caused by more people that immigrate and emigrate[4].
Ecological		
	Temperature	• Average temperature will rise in the upcoming decade[1].
+	*Environment*	• Companies are more investing in environmental related subjects.
	Natural resources	• The demand for natural recourses will increase (e.g. water, energy, metals and food) with the growing world population and the global prosperity[5].
+	*Increasing awareness*	• People are getting more conscious about their consumption. People seek out ways to make positive decisions about what they buy and look for a solution to the negative impact[6].
	Eat healthy	• 55% of the Dutch population indicates that they want to eat more healthy food. Additionally, they are critical of what kind of food they buy[7].
Political		
	Tax system	• A new tax system is proposed by the new government and is planned to be introduced in 2019. Especially people with high and middle income benefit from this new system. A person with a gross annual salary of 40,000 euros will receive a tax benefit of approximately 1200 euros[8].
+	*Reduce emissions*	• Government is aiming to reduce the CO2 emission by regulation for companies9. In 2016 the Dutch government has accepted the climate agreement of Paris. In 2023 16% of all the energy need to come from sustainable energy recourses[10].

Economics		
Potentiality	Subject	
	Financial recovery	• Sings of financial recovery become more visible after the crisis. However, economic uncertainty as well as pressure on government spending continues to exist[1].
	GDP growth	• After the crisis, the gross domestic product (GDP) per capita is grown (a measurement tool for the prosperity in a country). Additionally, the GDP per capita of the Netherlands is currently the highest of all European countries. Compared to 2015 the GDP growth with 2,2%[10].
+	*Sold houses*	• The amount of sold houses is stabilized compared to 2006 which was just before the crisis. Moreover, in the cities Amsterdam and Utrecht the amount of sold houses is equal to the amount of 2006 or is even surpassed[11].
+	*New houses*	• Nearly 54 thousand newly built homes are registered which is equal to a growth of 11% in 2016 compared to 2015[11].
+	*Renewable energy*	• The production of renewable electricity from wind, biomass, solar and hydroelectric power increases. This is an increase of 15% compared to 2015[12].
+	*Web shops*	• Amount of web shops increases which is a growth of 4.4% over the last 10 years. Additionally, the amount of Dutch consumers that bought products at European web shops has been increased with 25% compared to 2015[12].
+	*Professional market*	• Turnover of the professional market has increased with 6.5% over ten years. Snack bars experienced the largest growth[13].
+	*Recycling processes*	• Economy systems are slowly more focussed on consumer goods that have a new sustainable destination (recycling process)[13].
Social		
	Getting older	• Man and women are getting older. Additionally, the difference of the average life expectancy between man and women is also getting smaller. Elderly do not only life longer. They also life longer independently and less often in nursing homes[14].
	More visits	• Hotels, hostels and bed and breakfast are having more visits[14].
+	*ICT skills*	• More people are getting basic ICT skills with a computer and internet[14].
+	*Internet Acces*	• Smartphones and laptops are becoming the most important appliances to access internet. 80% own a smartphone and 75 % own a laptop[14].
	Internet purchase	• Purchases by Internet are increasing. In 2016 73% of the Dutch population, older than 12 bought something on internet. This is an increase of 4% compared to 2012[15].
+	*Aware*	• People are getting more aware of topics such as animal welfare, environmental friendly product and global food shortage. Therefore, new alternatives will be sought[16].
	Ethical consumption	• The Western world becomes more aware of their lifestyle which is not in line with protection of the environment. For example, people are more often buying products out of their won region and therefore contribute to a more sustainable world. The same counts for kitchen equipment[16].
+	*Customization*	• People are feeling more unique and part of a certain target group. With this, they want to distinguish themselves from other by personal and customized products[17].
+	*Digital civilians*	• There will be more digitalization services and more personal data traffic[17].

Technological		
Potentiality	Subject	
+	*Connection*	• An increase of internet penetrations. Furthermore, the accessibility of internet increases especially in the age group of 45 years and older. Additionally, people are become more connected with each other (this is also caused by socials trends like for instance the growth of Facebook and Instagram)[1].
+	*Big data*	• An increase of opportunities with big data[1]
+	*Social media*	• More influence of social media[1]
+	*Smart cities*	• Big cities are growing towards smart cities. They invest for instance in the development public transport systems, online platforms that make the organization more effective and efficient. A downside of this is the vulnerability of cyber-attacks and other ways of digital crime. Other examples are the investment in district heating, solar energy projects and urban agriculture[18].
+	*Smart living*	• People are getting more appliances that can be connected with each other. This is also related to developments related to the Internet of Things[18].
	Artificial intelligence	• Artificial intelligence and machine learning are becoming bigger. These developments anticipate on the calculation processes, big data, cloud-technologies and advanced algorithms[19].
	cyber-attacks	• At least 20% of companies with at least ten employees have been affected by the impact of cyber-attacks. This is a trend that will increase when government and companies do not invest to prevent this[20].
+	*Touch and displays*	• The use of displays and touch functionalities will be more used in the kitchen environment[21].
+	*Material finishes*	• Products with different finishes such as the Black Quooker tap are fashion trends in the kitchen area[21].

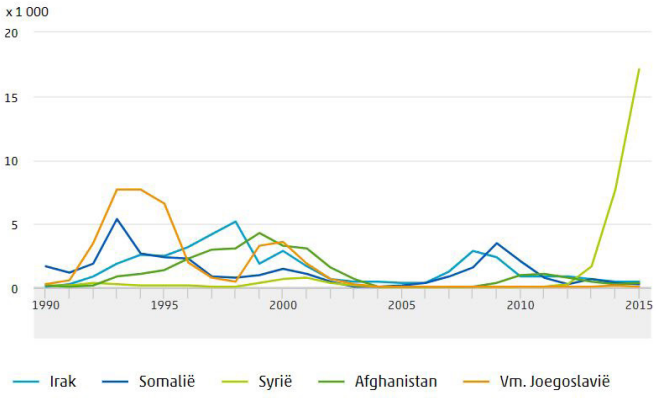
Kitchen trends		
Potentiality	Subject	
+	*Customization*	• People want have a freedom of choice in which they can customize products to their own needs[22].
	Features	• Extra features such as sparkling, chilled en boiling water[22].
+	*Professional*	• Having products that look professional meaning that products belong to restaurant equipment. Additionally, functionalities are connected to a professional way of features. People want to have different kinds of sprays and/or pressure coming out the spout[22].
+	*Colour black*	• Black is the new white[23].
	Living room	• Kitchens that are part of the living room[23].
+	*Indoor gardening*	• People want to cultivate their own vegetables which are part of the indoor gardening trend[23].
+	*New materials*	• People are looking for new materials. Additionally, Etnic nature colours and objects are becoming more preferred[23].
+	*Digital appliances*	• More people are using their smart phones or other digital appliances while they are preparing the food in the kitchen[24].



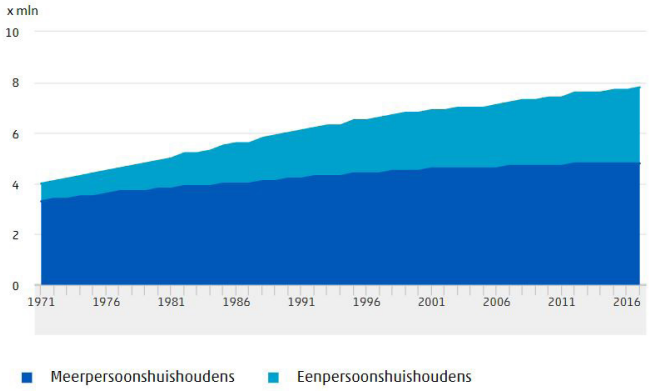


Aandeel bedrijven (≥10 werkzame personen) met ICT-incidenten, 2016

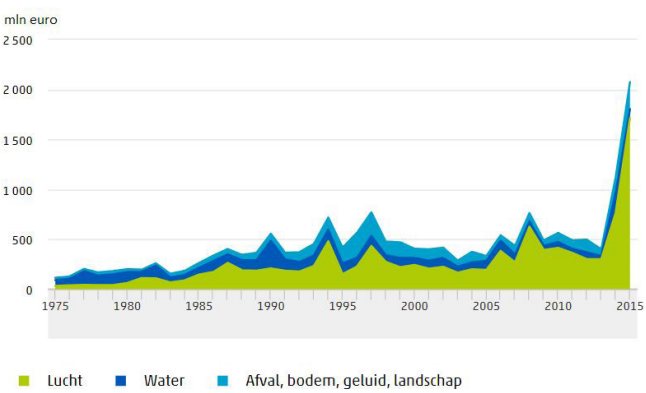
Immigratie van asielmigranten



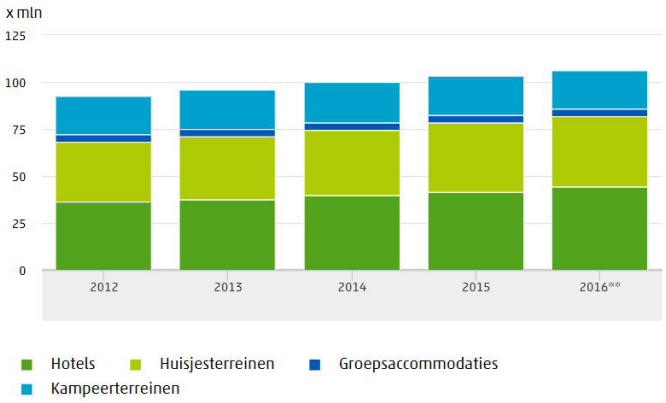
Huishoudens, 1 januari



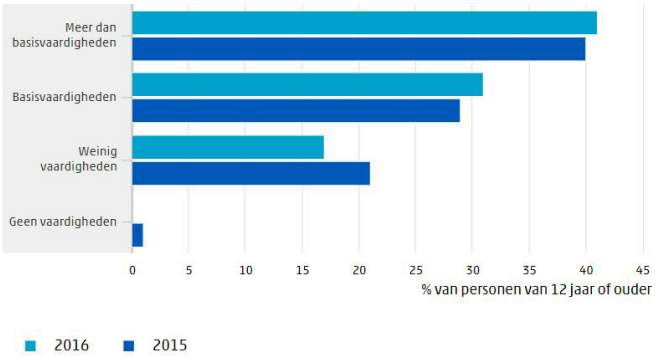
Milieu-investeringen van bedrijven



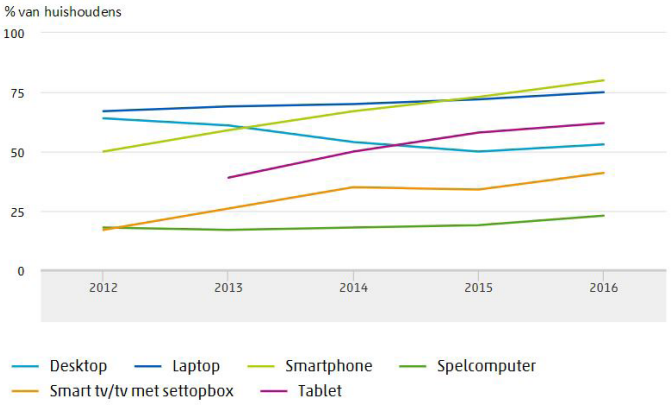
Overnachtingen in Nederlandse logiesaccommodaties



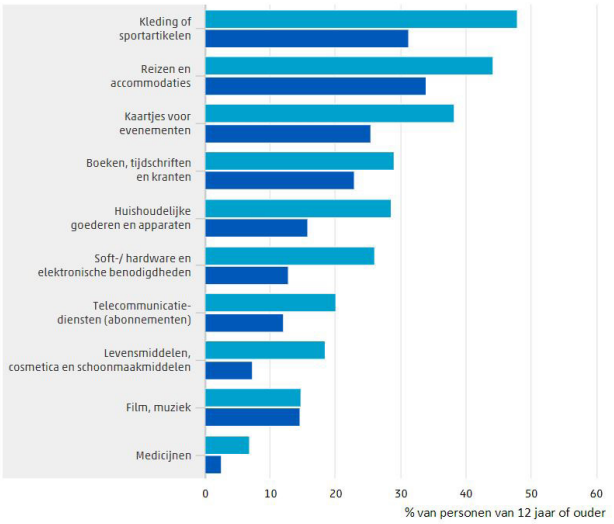
ICT-vaardigheden



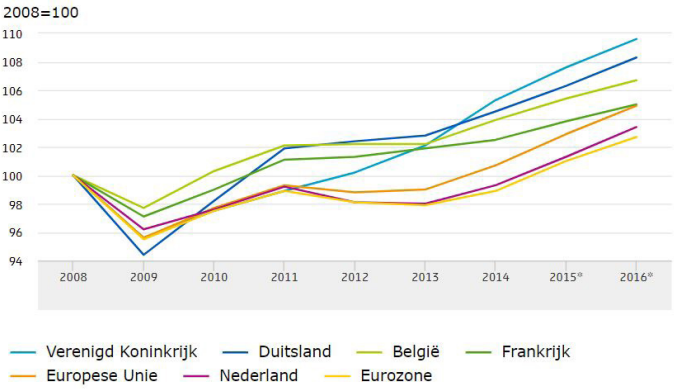
Aanwezigheid apparaten om mee te internetten



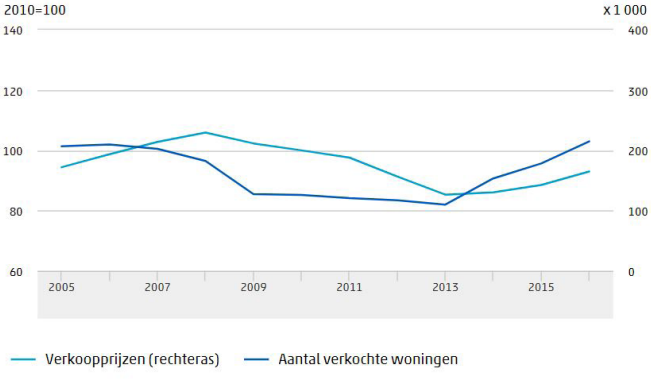
Aankopen via internet



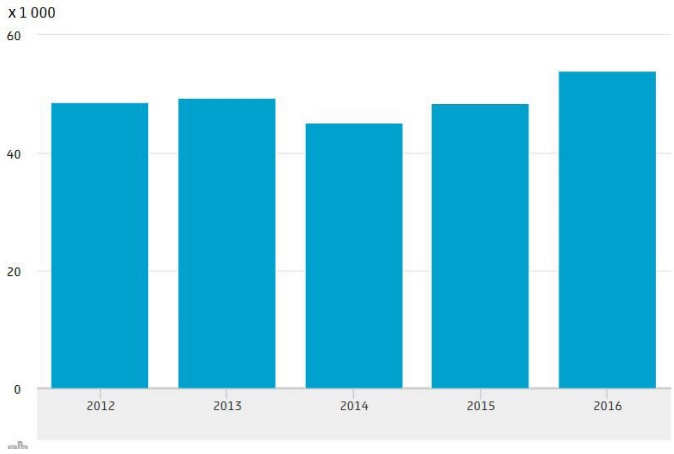
Bruto binnenlands product (bbp)



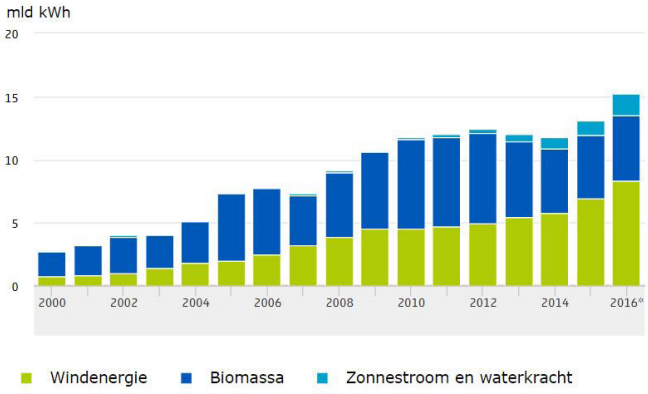
Bestaande koopwoningen



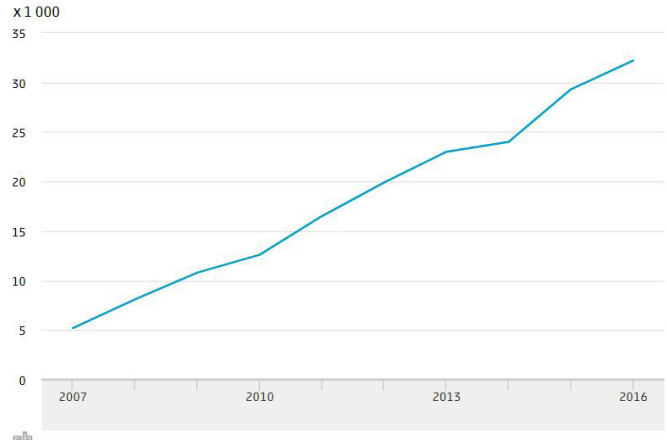
Nieuwbouwwoningen



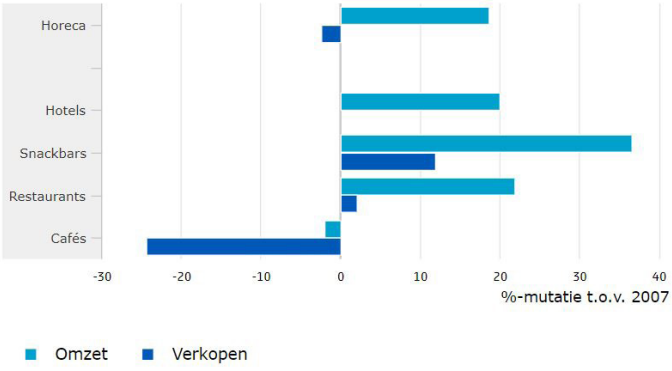
Productie hernieuwbare elektriciteit



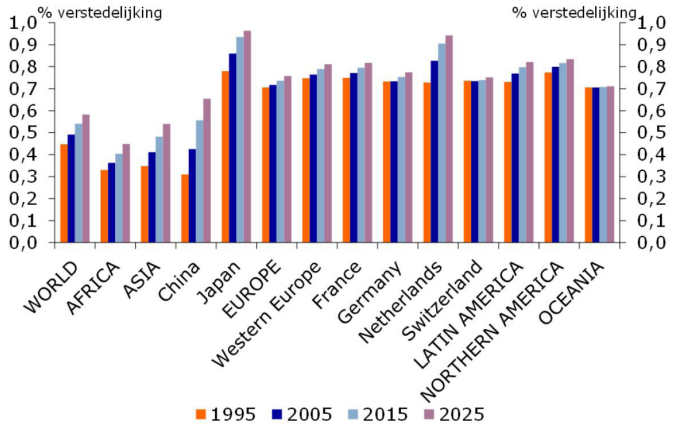
Aantal webwinkels



Omzet horeca, 2016



Figuur 6: Steeds meer mensen in steden



Appendix J - Technology; Smart materials

It has been forecasted that the use of smart materials will show a sustained progress since more research will be carried out on this topic. This will make the use of smart materials more realistic for commercially use (Deshmukh, 2016).
Using smart materials in products developments can create real innovation which simultaneously can lead to an added value in product design. Additionally, this innovation can lead to a strong competitive advantage which is relevant for Quooker in order to stay market leader in the market of boiling-water-taps (related to the vision of Quooker).
As mentioned earlier, a various amount of applications can be found with smart materials. This also means that multiple problems or issues can be solved when designing a feature or product for Quooker.
In this Appendix, research will be carried out on different types of smart materials. In addition, an overview off all product properties will be made in order to make a proper selection of a smart material. This selection will be done based on the unique capabilities of the material, and will be used to develop a feature or product that takes full advantage of those material capabilities.

Explaining the defenition
The category name 'smart materials' is a common name for a wide group of different substances. The definition 'smart materials' explains materials with specific properties, meaning that they react to specific changes in its environment by itself. These external stimuli relate to changes in temperature, light or mechanical loads, etc. Their materials viscosity, colour, or shape etc. is changed by these externalities (Talbot, 2003). However, the definition of smart materials has been expanded over the years. These materials also related to materials that receive, transmit, or process a stimulus and respond with an effective action (Kamila, 2013). Other papers explain a simplified definition of smart materials which is inherent to the capability to convert one form of energy into another (Lane & Craig, 2017).

Why smart materials?
First of all, this subject has been chosen by the interest of graduate student himself. Smart materials are a magical phenomenon and can create special environment that can add value to the experience at that moment. Therefore, designing with smart materials has been found to be very interesting for this graduation project.
Secondly, smart materials are not only able to add value to the user. They can also create an advantage in other fields. Smart materials can for instance decrease manufacturing, operating and maintenance costs, reduce weight and improve system performance. This describes the infinite possibilities with smart materials.
With this in mind, a lot of interesting opportunities are possible to create a valuable feature or product for Quooker. Moreover, integrating smart materials can maintain the market position of Quooker.

History
A various amount of smart materials have been developed over the years. A first discovery was found when a material became electrically polarized (resulted in a large electric field) by the application of heat. This was discovered by Rochelle Salt in 1824. Over the years more materials with changing behaviour have been discovered and have been further developed.
Below, a list of materials have been listed and explained. Additionally, the materials have been clustered into groups of functional behaviour or types. The clusters are related to the findings in the paper written by Toomey, 2017.

Sensors and actuators
Materials can be classified into two different groups. Smart materials can either be sensors and/or actuators which is related to their behaviour change. Sensors are materials that respond to a physical stimulus, such as a change in temperature, pressure, or illumination. In addition, it transmits a resulting signal that can be used for monitoring or operating control.
Actuators are materials that respond to a stimulus in the form of a mechanical property change such as a dimensional or a viscosity change (Lane & Craig, 2017).

• Material classes

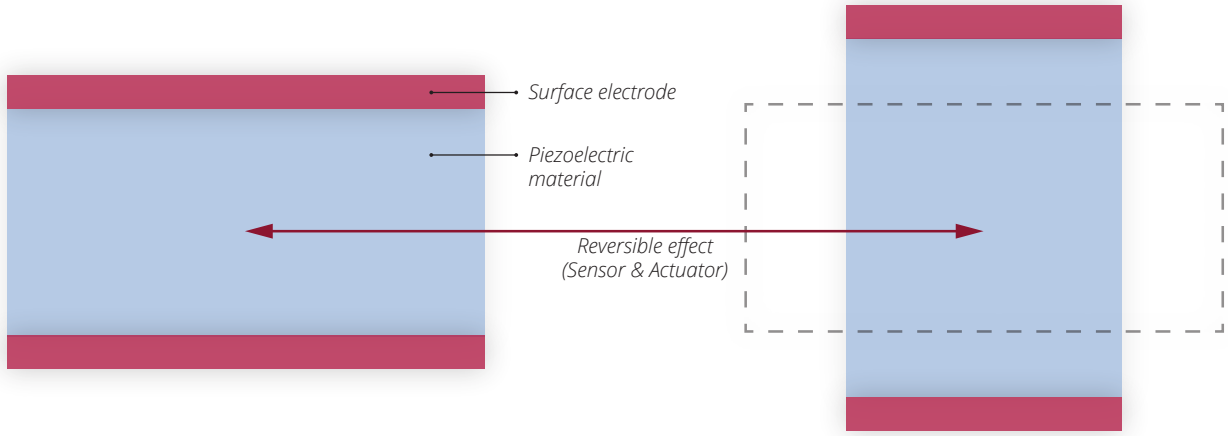
Piezoelectric Materials
Piezoelectric Materials are materials that can produce a voltage when stress is applied. Additionally, this effect also applies in the reverse manner. This means that voltage across the sample will produce stress within the material.
With the characteristics in mind, piezoelectric materials can be applies in structures to bend, expand or contract when a voltage is applied.

• Stimulus
1) Electric current or 2) Mechanical Strain

• Response
1) Mechanical Strain or 2) Electric current

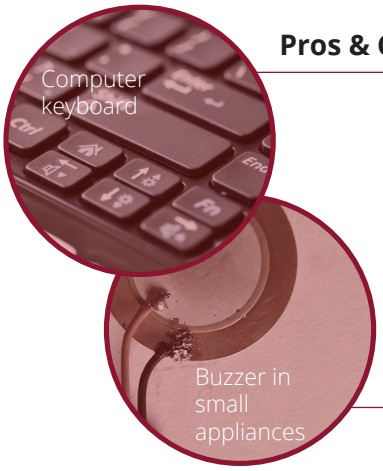
Piezoelectric sensors and actuators are widely used. In general, piezoelectric materials are used in optical-tracking devices, magnetic heads dot-matrix printers, computer keyboards, high-frequency stereo speakers, accelerometers, micro-phones, pressure sensors,

Piezoelectric, Electrostrictors & Electroactive polymer materials



Input:
1) Electricity
2) Strain

Output:
1) Strain
2) Electricity



Pros & Cons - Common applications

+ *Fast sensors and actuator*
+ *Highly reliable*
+ *Lightweight*
+ *Applicable for rugged usage*

- *Limited strain*
- *High driving voltage required*
- *Only used for dynamic pressure sensing*

- *Optical-tracking devices*
- *Computer keyboards*
- *High-frequency speakers*
- *Accelerometers*
- *Micro-phones*
- *Pressure sensors*
- *Transducers*
- *Igniters for gas grills*

transducers and igniters for gas grills.

Electrostrictors

Electrostrictors are, like the effect with piezoelectricity, materials that are able to convert electric pulse into a mechanical output. This effect can be seen as a dimensional change when an electric field is applied. A funny fact is that this electrostriction effect occurs in almost every material. However, the induced strain is usually too small to be used in practise.
Electrostrictive materials are preferred to be used in environments where temperature can be stabilized (within a range of approximately 10°C). The main difference between Electrostrictive materials and piezoelectric materials is the way they respond upon reversing of the electric field. Piezoelectric materials can be elongated and compressed while Electrostrictors only exhibit an elongation.

• Input
1) Electric current or 2) Mechanical Strain

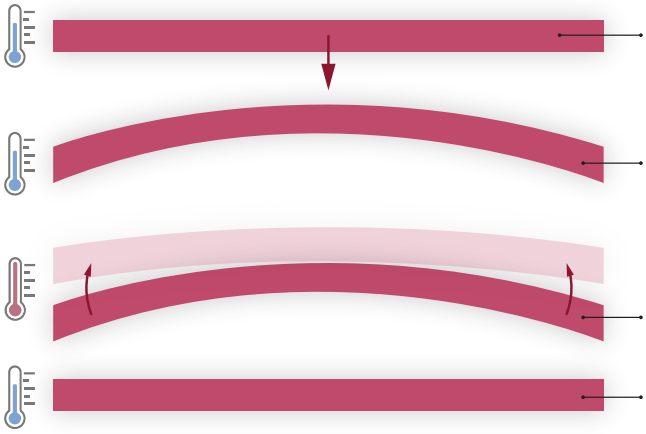
• Output
1) Mechanical Strain or 2) Electric current

The number of applications has been very low so far since piezoelectric materials have an advantage in multiple aspects over electrostrictive materials.

Electroactive Polymers

Like the earlier described material classes, electroactive polymers are polymers that undergo shape and/or

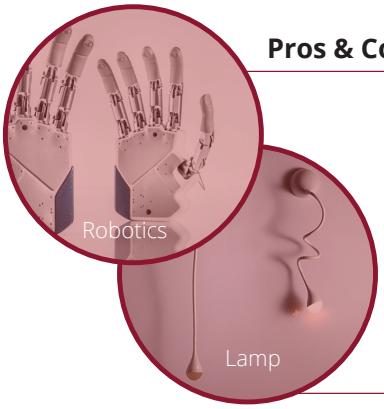
Shape memory alloys and polymers



Input:
Temperature change (in environment or wired)

(Actuator)

Output:
Mechanical Strain (original memorized shape)



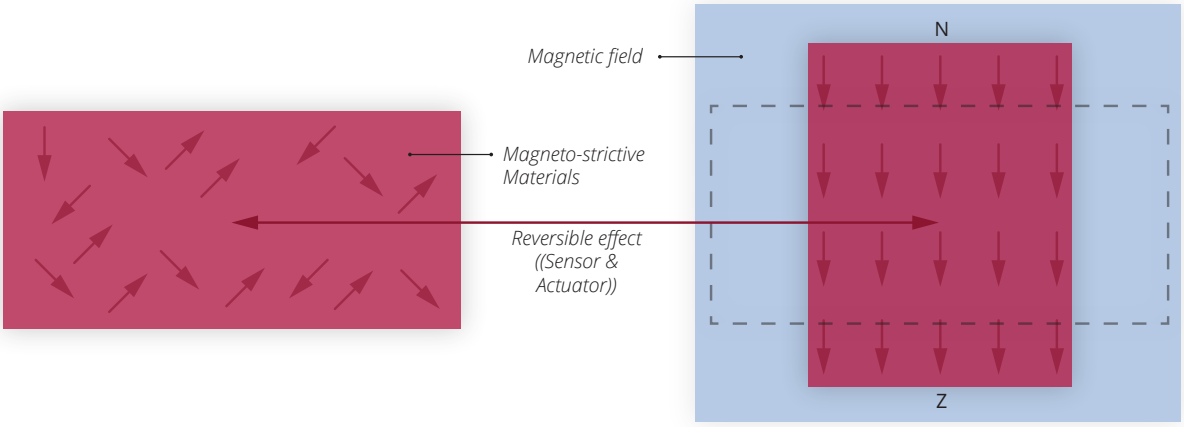
Pros & Cons - Common applications

+ Relatively low costs
+ Reliable
+ Noiseless
+ Low driving voltage
+ uses 'energy from environment'

- High driving voltage required
- Low response speed
- It behaves non-linear

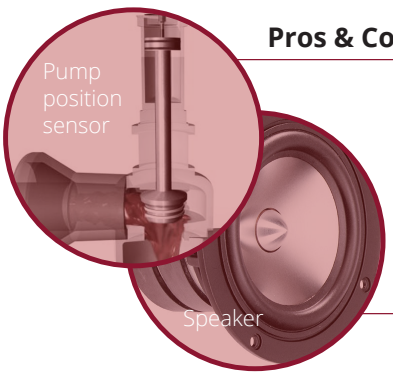
- *Robotics*
- *Automotive*
- *Fire protection*
- *Temperature control devices*

Magneto-strictive Materials



Input:
1) Magnetic field
2) Strain

Output:
1) Strain
2) Change in Magnetic Field



Pros & Cons - Common applications

+ Generation and detection of mechanical stresses
+ Non-contact sensing ability
+ Low non-linearity

- Energy conversion is lower compared to Piezoelectric material

- *Noise control*
- *Ultrasonics*
- *Speakers*
- *Drills*
- *Pumps*
- *Torque sensors*

dimensional change in response to an applied electrical field (Das, 2017).
The advantages of these materials are the rapid response time (within milliseconds) and have a high mechanical energy that can be created. Additionally, they have a long operation time. However, the required voltage is also quite high.

• Stimulus
1) Electric current or 2) Mechanical Strain

• Response
1) Mechanical Strain or 2) Electric current

Electroactive polymers have been generally used for actuation. They have unique capabilities which are related to low-moduli high strain capabilities and the ability to conform to surfaces of different shapes. These features make them attractive for applications such as wearable sensors and interfaces. Shape memory alloys and polymers
Shape memory alloys and polymers are materials responding on temperature change in its environment. The word "memory" reflects the ability to "remember their original shape. As an example, after deformation in a cold state, the shape can return to the original shape when heating up the material above its transition temperature. Shape memory materials can be activated in two ways. The temperature around the material can be done thermally or electrically. In both ways, the goal is to heat the material above its transition temperature in order to recover its original shape. During this transition, the material is able to deliver a great amount of work output (strain). (Bhaumik & Bhaumik, 2017) (Rutten, 2003).

• Stimulus
Temperature change

• Response
Mechanical Strain

Shape memory materials are generally used in engineering applications. When the material reacts on thermal changes, the material can be used as sensor. As an example, applications can be found in fire protection which closes windows or opens sprinkler valves). Note that the benefit of the input is that it does not require an additional power supply.

Additionally, when the material is activated by an electric current (which is given on command of a controller), the material can be seen as actuator. Common applications can be found in the automotive industry (door locking mechanism).

Magneto-strictive Materials

Magneto-strictive materials are materials with magnetostriction which involves ferromagnetic materials. This causes a change in shape or dimensions when an external magnetic field is applied to the material called magnetization. The reverse effect can also happen when applying a mechanical strain. This is called Piezomagnetism.
Magnetostrictive materials can be used as sensors and actuators. Note that the efficiency of energy conversion of magnetostrictive materials are generally lower compared to piezoelectric materials.

• Stimulus
Magnetic field

• Response
Mechanical strain

Most magnetostrictive sensors and actuators are used in a variety of application. Applications can be found in: transducers, transformers, MEMS, vibration and noise control, linear motors, adaptive optics, ultrasonics, speakers, drills, pumps, and position and mechanical torque sensors. Additionally, within this material category, terfenol-D is exclusively used due to its properties (Lane & Craig, 2017).

Electro- and magneto-rheological fluids

Electro- and magneto-rheological fluids materials both experience a change in viscosity when the material is exposed to an electric field. In normal state the liquid is a thick fluid (similar to motor oil). When an electric field is applied, the fluid can change to a nearly solid substance. The material class is named to the change of rheological behaviour on microstructure level which is related to the increasing resistance to flow with an increasing electric field. Additionally, the change can take place within a few milliseconds and is a fully revisable process. Electro-rheological materials distinguish themselves by responding to an electric field instead of a magnetic field. A benefit from the materials is the use of such response fluids reduces complexity of devices. As an example, controllable valves become unnecessary because the flow properties of the fluid can be controllers here (Rutten, 2003).

• Stimulus
1) Magnetic field 2) Electric field

• Response
VIscosity change

Common applications can be mainly found in control system such as servo valves, shock absorbers, clutches and brakes.

Pyroelectrics

Pyroelectric materials are thermal detectors. When the material is exposed to temperature fluctuations, the material produces an electric signal. This temperature change can for instance be created by the absorption of light. In conclusion, Pyroelectrics become electrically polarized when a temperature change is applied. Benefits include the low production costs for fabrication and a good stability. However, the material is also known from tis brittleness which is a weak spot (Rutten, 2003).

- Stimulus

Temperature change

- Response

Electric current

Pyroelectrics are very often used for infrared detection in surveillance and targeting applications.\

Electro- and photoluminescent materials

the effect of luminescent (light emission) means that the material is able to emit light by either in electrical input or the absorption of light. For electroluminescent (EL) materials, the light will be created by applying a voltage across the electrodes. The rapidly charged phosphor crystals in the material emit radiation in form of visible light.
Additionally, photoluminescent materials also emit light as earlier explained. They emit light after absorption of photons.

- Stimulus

1) Electricity 2) Light absorbtion

- Response

Light emission

Electro- and photoluminescent materials have common application related to communication and aesthetic aspects. Examples can be found in nightlights, decoration (in clothing), but also in watches that can light up in the dark ("Electroluminescent Lamps - How They Work & History", 2017).

Chromics

Chromic materials consist of a variety of sub materials. The binding factor between all these materials is that they change colour when exposed to different kinds of aspects. The following materials are part of this "chromic" group: Electrochromics, thermochromic inks and paints, photochromism, halochromics and piezochromics.
With this in mind, materials can respond on for instance to an exposed chemical, electricity, PH-value change, strain etc. Next to the change in colour, some of the sub materials can change into a transparent material.

- Stimulus

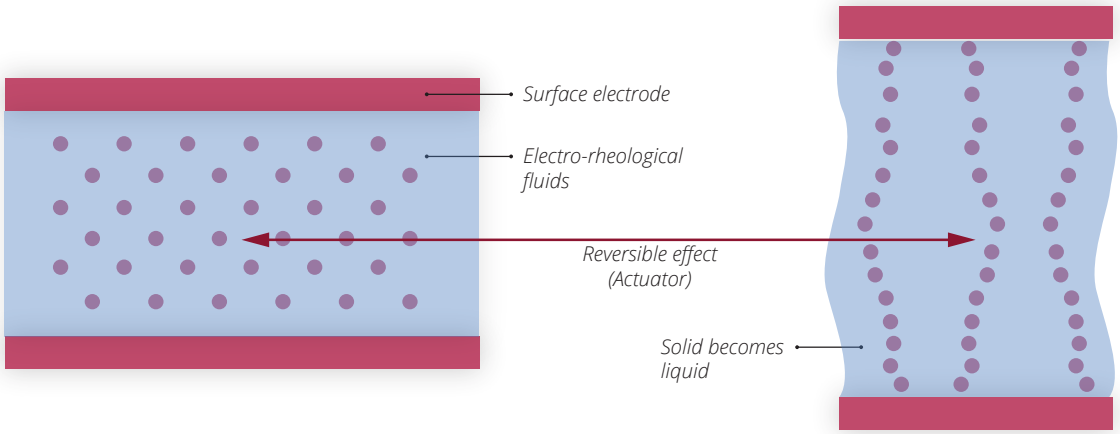
1) Electric field 2) heat 3) light absorbtion 4) etc.

- Response

Light emission or change

Common application in this material class can be found in for instance in warning devices. In addition, they are also used as decoration.

Electro- & Magneto rheological fluids



Input:		Output:
Electricity Magnetic field	⟶	Viscosity change

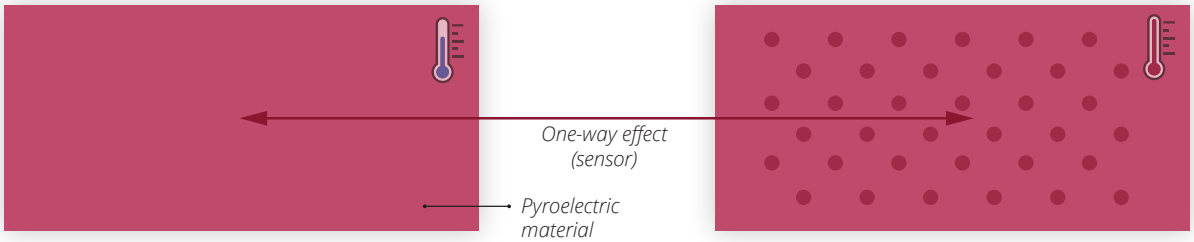
Pros & Cons - Common applications

+ Rapid and reversible response
+ Reduces the complexity of devices
+ Low s friction or flow losses
+ Low maintenace required

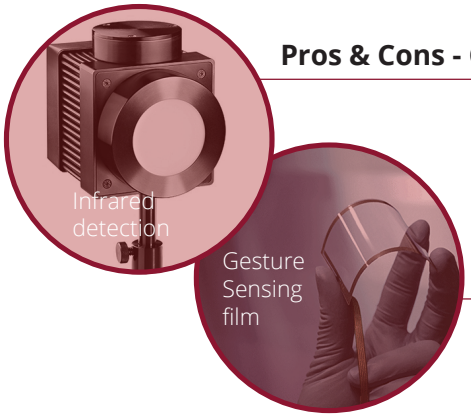
- Low achievable maximum yield stress
- Relatively large amount of active ER fluid is needed
- High voltage power supply

- *Servo valves*
- *Shock absorbers*
- *Vibration dampers*
- *Hydraulic systems*
- *Clutches*
- *Brakes*

Pyroelectrics



Input:		Output:
Temperature change	⟶	Electricity



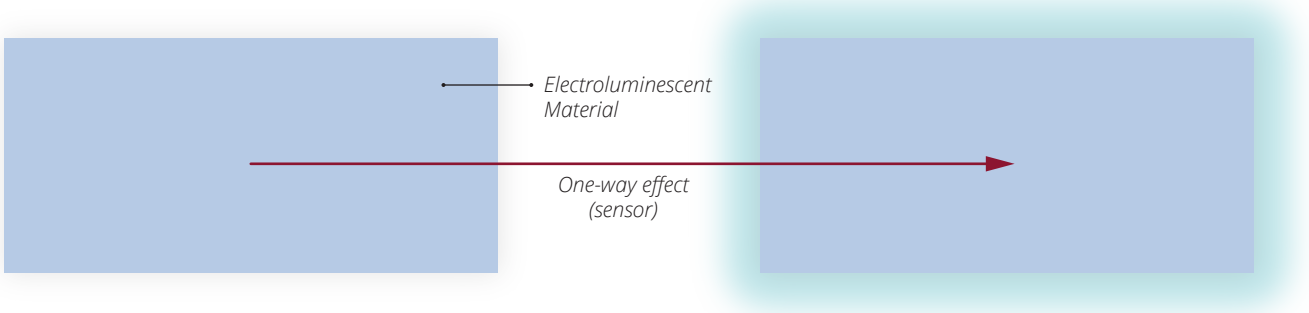
Pros & Cons - Common applications

+ Low cost processing
+ Good stability
+ Low cost

- Brittleness

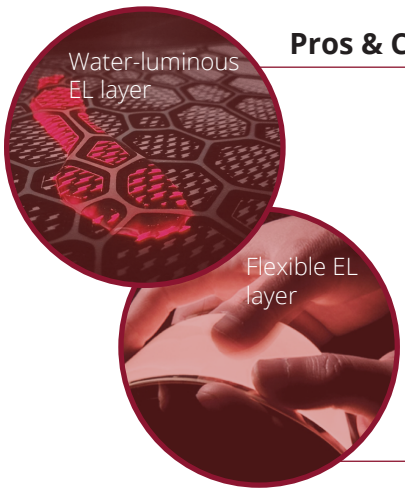
- *infrared detection*
- *targeting applications*
- *temperature-related measurements tools vehicle monitoring*

Electro- & Photoluminescent materials



Input:
Electricity
Light absorbtion

Output:
Light emission



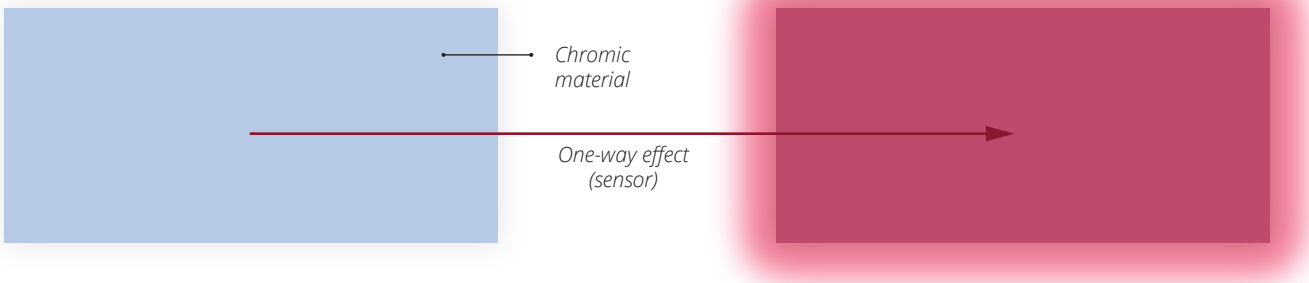
Pros & Cons - Common applications

+ *Very thin and flexible*
+ *Waterproof*
+ *Low wattage*
+ *No external circuitry required*
+ *Lightweight*
+ *good quality from all view angles*
+ *High temperature range*

- *Phosphor has limited lifespan*
- *Low lumen output*

- *Nightlights*
- *Decoration (clothing)*
- *Watch illumination*
- *Medical tool display*
- *Billboards*

Chromic materials



Input:
Heat
Electricity
Light absorbtion

Output:
Light emission or change

Pros & Cons - Common applications

+ *Ease of fabrication*
+ *Very thin*
+ *Lightweight*
+ *Waterproof*

- *Not sufficiently stable to withstand thousands of hours of outdoor exposure*

- *warning devices*
- *smart window applications*
- *paints*
- *thermal overload warning indicators*
- *smart packaging light and thermal management*

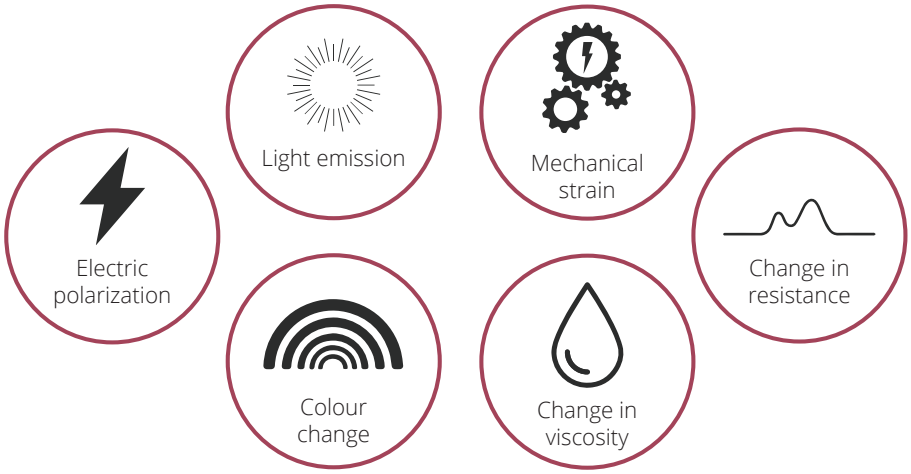
Conclusion

After analysing smart materials, 16 different smart material classes have been found that respond to different stimulus. Additionally, the analysed materials also react in a certain way which can be seen as the materials response. Below, a table has been created with an overview of the different material classes. Both the stimulus and the response of the material are described as well. The aspects of the stimulus and response are relevant and can be used as deasign handles.

In the figure below, all material classes have been clusters since some of them have an overlap related to their stimulus and response. From this overview, it can be concluded that six responses appear which can be used as design handles. Additionally, these "design handles" will also be used to combine these responses with search areas.

Smart materials		
Material Class	Stimulus	Response
• Piezoelectric Materials	1) Electricity or 2) Strain	1) Strain or 2) Electricity
• Electrostrictors	1) Electricity or 2) Strain	1) Strain or 2) Electricity
• Electroactive Polymers	1) Electricity or 2) Strain	1) Strain or 2) Electricity
• Shape memory alloys	Temperature change	Mechanical strain
• Shape memory polymers	Temperature change	Mechanical strain
• Pyroelectrics	Temperature change	Electricity
• Magneto-strictive Materials	1) Magnetic field or 2) Strain	1) Strain or 2) Magnetic field
• Electro-rheological Fluids	Electricity	Change in viscosity
• Magneto-rheological fluids	Magnetic field	Change in viscosity
• Electroluminescent Materials	Electricity	Light emission
• Photoluminescent Materials	Light absorbtion	Light emission
• Electrochromic Materials	Electricity	Light emission/ color change
• Thermochromic inks and paints	Temperature change	Light emission/ color change
• Photochromism	Light absorbtion	Light emission/ color change
• Halochromic	Change in PH-value	Light emission/ color change
• Piezochromics	Strain	Light emission/ color change

Material responses



Appendix K - SWOT analysis

Strenghts

Chapter: 1.1 Quooker
- Quooker has gained thirty years of knowledge on boiling water taps over the years.
- Components that are outsourced are fabricated by different manufactures to keep the product specifications secret in house.
- All components are assembled in Ridderkerk. This makes the process time very efficient and effective.
- Quooker controls all incoming products.
- Quookers sells their product over multiple countries which give them a competitive advantage.
- Innovation, refinement, adjustments and optimizations are at the core of the company.
- Quooker provides high quality service.

Chapter: 1.2 Product portfolio
- Quooker delivers a various amount of high quality boiling-water-taps that fulfil the needs of the customer.
- Quooker is able to develop innovative products to stay competitive.
- Quookers is gradually becoming a category name.
- Quookers is very innovative oriented.
- Older Quooker versions last long due to its mechanical functioning.
- Quooker has product extensions next to their core products (e.g. soap dispenser and filter)

Chapter: 1.3 Working principle
- Quooker can guarantee 100C that comes out of the tap.
- The tank is relatively sustainable due to the high-vacuum insulation. Therefore, Quooker is more sustainable than competitors.
- Quooker offers a good service to their customers.
- The system of Quooker holds around thirty patents.
- A regular household could save up to 171 euros and 7049 litre of water a year.
- Quooker is integrated with safety features that work properly.

Chapter: 1.4 Vision generative session
- Employees are on one line with each other when talking about the core values of Quooker.

Chapter: 1.5 Internal stakeholders analysis
- Quooker is focussed on e recycling system in order to throw away less parts. The SWAP project is a good example for this.
- The R&R department can easily give feedback on product failures/improvement to the R&D department.
- Quooker has integrated safety features in a subtle way (without creating an overkill of functionalities)
- R&D team is improving their taps by making them consist of less components (e.g. The Flex tap is an improvement from the Fusion).
- Quooker creates an environment where everybody feels they are part of the team.
- The integrated the lean approach which makes the production process more efficient.
- Almost all components are developed in-house. Therefore, Quooker is a unique design (e.g. benefit is that most parts have a one way fit which cannot be assembled incorrectly).
- Departments are positioned close to each other which makes the process time very effective.

Chapter: 2.1 Customers & End users
- Most of the customers owning a Quooker are very satisfied with the product and service. They can't without it anymore.
- Quookers product has a higher quality compared to competitors (e.g. providing exact 100C boiling water)
- When buying new kitchen appliances, the Brand Quooker is well known by customers.
- All combinations of water are coming from only one tap.
- Boiling water is coming through a separate (Teflon) hose. This enables the user to touch the tap without burning their hand on the material.

Chapter: 2.2 Competitors analysis
- Quooker provides exactly 100 degree boiled water out of the tap.

Weaknesses

Chapter: 1.1 Quooker
• Components are manufactured in China. It happens otften that these componenets are not in line with the technical specs.

Chapter: 1.2 Product portfolio
• Most of the parts are uniquely designed for the Quooker which results in high costs.
• A one-product portfolio is vulnerable for external influences.

Chapter: 1.3 Working principle
• Combi tanks are more difficult to install compared to the pro tank. In general, installation help from an experiences installer is required.
- Quooker is a unique product consisting of unique elements that are developed by Quooker. This -results in high production and developments costs.
- Quooker has a limited production capacity

Chapter: 1.5 Internal stakeholders analysis
- sustainable projects started only a year ago. Current sustainable projects are not fully operating yet.
- Currently, finding the specific error takes a lot of time and is not very effective caused by Quookers system which is not “smart”.
- the product is difficult to disassemble without damaging it.
- Sometimes new intentions from R&D are not discussed with other department such as the R&R department.
- Errors in the hose of the Flex tap are often experienced by malfunctioning of the magnet sensor.
- The current water jet is does not have a constant water pressure
- for every error (also small ones) the service team needs to come by which results in high costs.
- Quooker does not have specific details on how their customer uses the Quooker system (e.g. amount of water used, electricity, etc.)
- People without a Quookers think the Quooker consumes a lot of water and energy which results in high costs after purchase.
- People without a Quooker think the system is not safe enough.
- Quooker only has a 3-1 combination launched whereas competitors already extended their portfolio with 4-1 and 5-1 combination taps.
- Some of the Quooker parts are difficult to assemble or need to assembled by hand which results in a high production time.
- The production cannot produce the amount of Quookers that are being sold.
- Quooker controls their incoming components which should be carries out by the manufacturer. This is an unnecessary action. Additionally, a lot of components do not meet the technical specs.
- the fast growing company results in multiple improvements in the product which is difficult for the service team to keep up to date.

Opportunities

Chapter: 1.3 Working principle
- Quooker could focus on installation aspects in order to make the installation less difficult.
- Quooker could more advertise on their sustainable aspects.

Chapter: 1.5 Internal stakeholders analysis
- Quooker could anticipate on aspects to let the customer know how to clean the product in a proper way.
- Quooker could emphasize more on sustainable projects in order to higher its revenue from this division.
- Quooker could make the product more “hufterproof”. In this way, customers can continue to clean the Quooker with strong soaps.

- Quooker could give courses to kitchen dealer in order to avoid incorrect installations by done their plumbers.
- make Quookers product “smart” in order to find specific errors more easily.
- More communication between departments (before the product is put in production) could avoid product errors.
- Focus on younger groups that want to differentiate themselves (like early adapters). They look for new features or technologies and want to show this to their friends.
- think about ways to pre-program the amount of water a customer wants to have.
- Smart materials could be used to reduce production costs by reducing the amount of parts integrated in one product.
- make a solution in order to keep the water pressure that comes from the tap constant in every region.
- Sustainable aspects could be better communicated to the customer. Quooker could also anticipate on real life feedback related to the consumption (this can be related to IoT related developments).
- Safety features can be made clearer to the customer (especially for people who do not own a Quooker).
- Detect errors in the product before the customer will face them.
- let customers solve errors in the products themselves.
- get a better overview of how customers are using the Quooker system (make Quooker smart).
- Keep plastics separated when recycling the parts of the Quooker. In this way, the quality of the plastic does not degrade.
- New technologies enables moulds to be made from plastic which can reduce production costs (for both prototyping and end products).
- Almost all kinds of problems can be solved with smart materials. However, some smart materials are difficult to commercialize due to high costs production or low benefit outcomes.
- Create a new system in which taps are easier to install for plumbers in the UK. This could also be solves by a better communication towards dealer in the UK.
- Develop a product or feature which can easily be assembled.

Chapter: 2.1 Customers & End users
- Focus on kitchen dealer aspects to promote the product (most of the customer buy their Quooker at the kitchen dealer).
- Focus on friend and/or family aspects to promote the product (most people are inspired by this target group before purchasing the Quooker).
- Develop a Quooker for the lower price segment.
- Focus on young adults. In this segment cleaning baby equipment is an important aspect related to hygiene.
- The lower social class could be a potential target group when showing sustainable aspects of Quooker (this target group is more concerned about consumption aspects).
- People who are moving, get a new kitchen or remodel their kitchen are a potential target group.

Chapter: 2.2 Competitors analysis
- Quooker could focus on features to give feedback to the use with respect to the consumption of water and electricity.
- Quooker could provide more special liquids from to tap. However, improvements should also be made on the interaction since more functionality will be added.

Chapter: 2.3 Market trends
- Quooker can design products with the focus on the growing aging society.
- Create an added value for single households as a target group.
- Creating products with focus on environmental awareness since people are getting more critical on these (sustainable) subjects.
- Reducing the amount of CO_2 emissions to become in line with regulations set by the government.
- More houses and new houses are being sold. Along with this, new kitchens will be installed with new equipment.
- Anticipate on the growing market of getting renewable energy obtained from wind, biomass, solar and hydroelectric power.
- Focus more on online shoppers.
- Focus on the professional market which is growing.
- Pay attention to recycling systems and try to incorporate this in Quookers product life cycle.

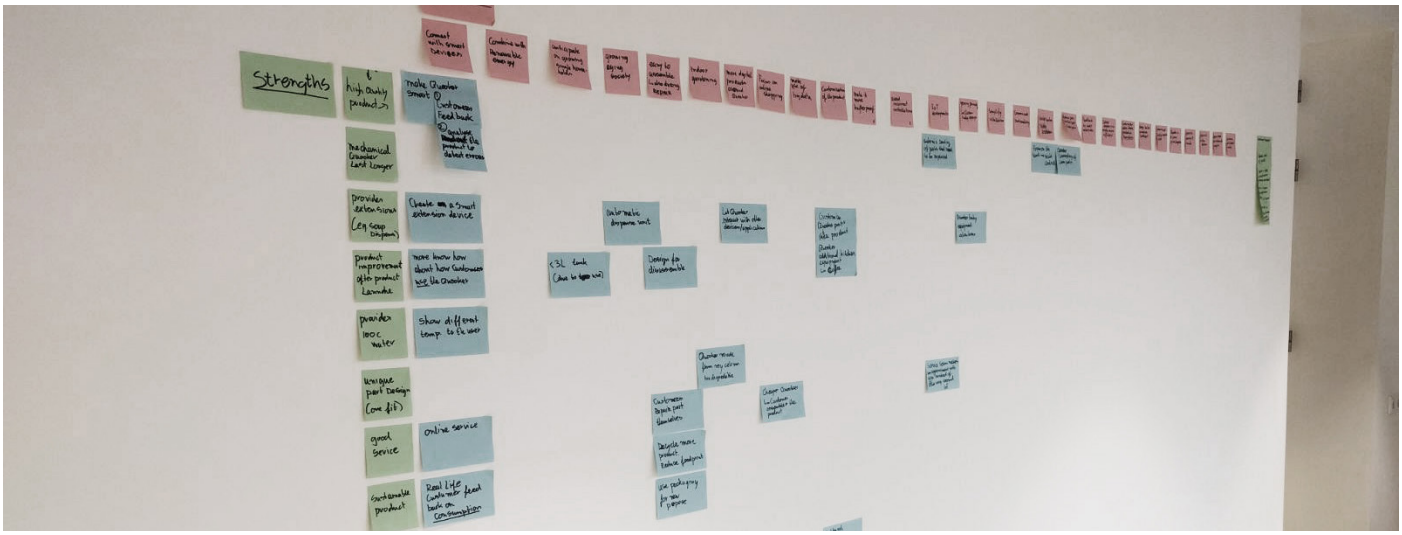
- More people are getting basic ICT skills with a computer and internet. In the same area, smartphones and laptops are becoming the most important appliances to access internet.
- Customized products can help customers to feel part of a certain social group and distinguish themselves.
- Products will be more digitalized and connected with each other which help the efficiency of the information flow (internet of Things). Also, people above 45 years more often use internet.
- People are more connected with each other in which the social media like Facebook, Instagram etc. play a major role.
- Big data becomes more available and can be progressed more easily.
- Interactions with products or done by displays and touch more often.
- Anticipate on the trend of indoor gardening
- More people are using their smart phones or other digital appliances while they are preparing the food in the kitchen.

Threats

Chapter: 1.5 Internal stakeholders analysis
- people clean their Quooker with strong soaps which damage the internal parts.
With more electronics involved multiple things can happen:
    - overkill of featurs
    - cyper attacks
    - the past has shown that electron procuts of Quooker lst horter compared to mechanical controlled taps.
- The water quality in the Netherland is very good. However, In other countries the quality is lower and can cause a lot of scale which can damage the internal components.
- Competitors already launched taps with more than 3-1 combinations and are further developing multifunctional products.
- With more and more Quookers sold, the buffer is running out which can result in a delivery delay to customers.
- The amount of employees that can work has reached a peak. This means that the production technologies should be up scaled soon which are related to which investments.
- Mentality of employees will be influenced negatively when Quookers grows further rapidly.
- People with less space in their kitchen are not able to place the 5-1 combination tap which requires multiple tanks that need to be installed underneath the sink.

Chapter: 2.1 Customers & End users
- Quooker is positioned in the higher price segment. Therefore, the Quooker is only provided for the higher social class.
- Quookers requires more space underneath the sink when launching the 5-1 combination tap. Customer needs to have enough space for this.
- Customers see Quooker as a luxury good which is not a first need in the kitchen.
- Quooker is not able to deliver the right amount of Quooker taps. This might result in delivery deployments to the customer.
- With more and more Quookers sold, the buffer is running out which can result in a delivery delay to customers.
- Quooker is luxurious good people do not really need.
- With new feature extensions the Quooker tank will take away more cabinet space underneath the sink.
- Interaction with the product causes --> intreactie moet verbeterd worden zeker bij de 5-1 knop

Chapter: 2.2 Competitors analysis
- Some competitors (e.g. Grohe, Franke & Floww) have already launched a 4-1 or 5-1 combination tap.
- Some competitors are able to provide the customer feedback on the consumption. They slowly taking the lead in the IoT integrated in their taps.
- Competitors do have the same product as Quooker does (boiling water, sparkling water etc.). Quooker needs to distinguish themselves by staying innovative and market leader.

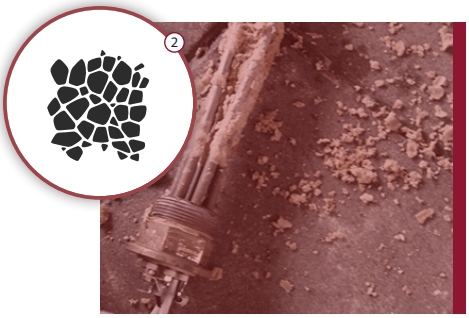


Picture taken from the wall where search areas have been created

1) Product extensions

In this direction new products will be launched to extend the product portfolio of Quooker. Multiple directions within this area can be chosen from. Think of the extension by means of a coffee machine. A coffee machine also uses boiled or warm water with a certain pressure that can be provided by the Quooker tank. Other directions could be the use of merchandising products in order to improve or broaden the brand name of Quooker.

It is hard to define the potentiality of this direction since no specific target group has been selected. Moreover, the use of smart materials is also questionable.

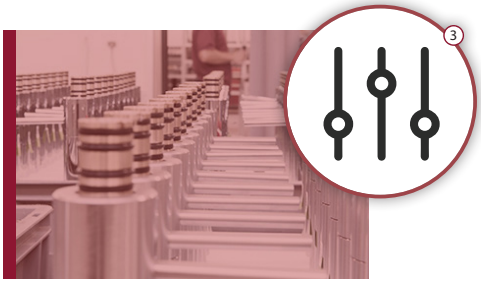


2) Scale control

As earlier has been found, scale is one of the main enemies of the Quooker. Scale for instance, causes the heating element in the tank to deteriorate to a state that it cannot be used anymore. The speed of deterioration is related to the region where the Quooker is installed. As an example, in Germany and the UK Quookers deteriorate way faster due to the bad water quality. Smart materials can play a role by measuring the amount of deterioration or prevent scale that will attach on the heat element.

3) Customization of parts

The customization of parts is related to the trend of being part of a social group (see chapter “market trends”). Along with this, people want to select a separated parts that are related to their own social group. By creating their own ‘product’, people are more willing to buy a product. A disadvantage of this search area is that the overall production cost might increase.



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4) Automatic dispenser

This direction is focused on the trend of the growing aged society. People in this group are more frightened by the boiling water and need a safe and stable environment to work in. Currently, two hands are needed to operate the Quooker. One hand to activate the dubble-push-turn button, the other hand to hold your cup. Quooker could think of a design in which the tap automatically dispenses water out of the spout putting down the cup with a pre-programmed amount of water that comes out of the tap. With this, no hands are needed while activating the boiling water. Additionally, this can be perceived as more safe and reflects the needs of this target group.

5) Design for sustainability

Analysing the trends of sustainable awareness in different areas has let to this search area. Currently, more and more products are being designed taking into account sustainable aspect. This can for instance be related to multiple levels of being sustainable. In this area, people could think of 'green design' in which the focus will be on the total amount of energy used or the footprint during the product life cycle. Other directions could be made in recycling systems. Within this area, Quooker already started with their own project called the "swap" project in which refurbished tanks are being sold instead of thrown away. In conclusion, Quooker could not only be sustainable in the product usage but also in its product design itself.

Smart materials could be integrated in this area by using less material in components since the smart material can fulfil multiple functions. Furthermore, it can be discussed what kind of benefit will be added and to who. Sustainability sometimes comes along with higher costs (higher production costs or expensive recycling/return system).

6) Quooker baby equipment

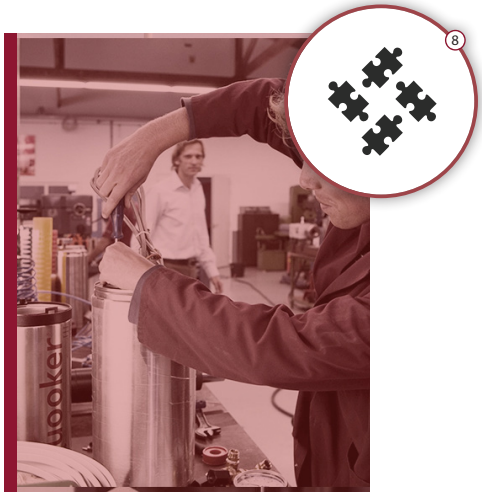
It has been found that young parent might be a potential target group (see Customer & Users section, chapter 2). Young parents have baby equipment that need to be hygienic in order to keep their baby healthy. Quooker could anticipate on baby equipment or product extensions in order to make this process of cleaning baby equipment more comfortable. It is yet unknown how to integrate smart materials into this search area.

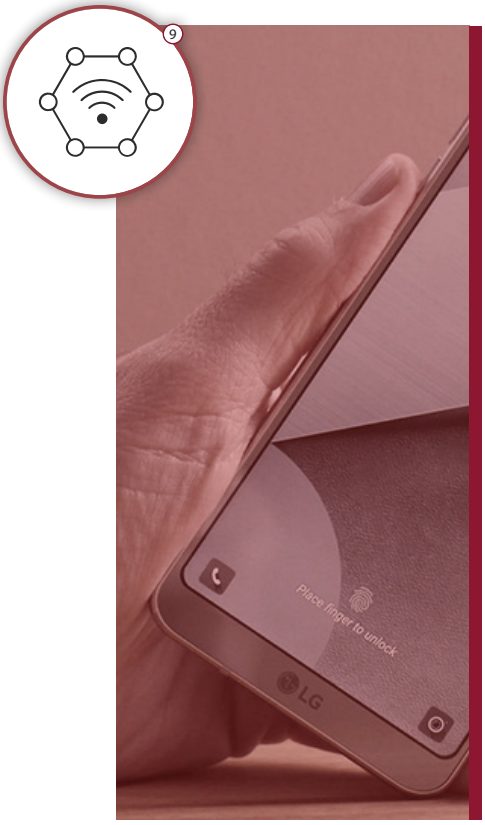
7) Quookers mindset

Another interesting insight that has been found during the interview of different stakeholders is the rapidly growing company (on average 10% per year since 2010). Here, several people mentioned negative aspects that came along with this growth. As an example, people felt not part of the Quooker family anymore (which is an important value for Quooker). In this scenario, people went to home straight after 5 o'clock although there were still some small tasks left to reach a daily target. Another example explains the lack of communication between some departments which causes frustrations and an ineffective workflow.

8) Design for disassemble

Disassembling of the Quooker is not a difficult task . However, disassembling the Quooker without damaging is way more difficult and might be a potential design direction.
In this direction, the service and repair department can work more easily which has been found as a preference (see stakeholders map, chapter 1). Other benefits could be in line with customer related aspects. Parts that need to be replaced could now be repaired by the customer him- or herself.
The disadvantage of this direction is that it involves the whole current product of Quooker which has been developed and improved over the years. Therefore, it might be very difficult to make any changes in the design.





9) Smart Quooker

Currently, Quooker is not a smart product. Making Quooker a smart product can result in two potential benefits. First of all, customers feedback on consumption can be provided. Moreover, customers could for instance have a view on the water and electricity consumption. In this way, the system can show how sustainable Quookers really is.
Secondly, a smart Quooker could make the progress of finding product related errors easier. Currently, this takes quite some time which is related to high costs.
Additional features of a Smart Quooker could be the connection to other devices and application. In addition, the system could show the user the actual temperature that comes out of the spout (or other temperature for making tea).
Smart materials can be integrated by using them as measurement tools.

10) Safety of the Quooker

Safety of the Quooker plays a major role in the decision making of the purchasing process. People are afraid of burning their own hands or think it will not be safe for their children. Although this area can be more related to marketing aspects (safety aspects are already integrated in the Quooker product), there are still possibilities in this area to further improve the safety impression and interaction. This might lead to more purchases of people who currently have their doubts.
Important in this area is that the product should not have an overkill of features to prevent the customer of burning their hands. As Ivo Legel, product manager R&D, earlier explained: “Safety should be communicated in a subtle way”.
Smart materials can be used on the level of giving feedback to the user. Obvious solutions could be the use of material that emits light or changes in colour to make customers aware of dangerous situation.

Appendix L - Converging methods

Below, an explanation of the ten directions have been given which eventually have been positioned in the value matrix. Also, a first analysis have been described in which is explained how SMs could have an added value in the proposed direction.

1) Product extensions
In this direction, a lot of different possibilities can be thought off. When analysing the strengths of Quooker, one example could be to create a tool that shows that Quooker provided exact 100C boiling water (a colour changing or a light emitting material). Within this direction it is relatively difficult to find the business potentiality. However, it has been concluded that Quooker wants to stay focussed on the boiling water tap segment and does not want to extend their product portfolio (Peteri, 2017). The reason for this is that an extension of the product portfolio will generally result in more difficulties related to for instance production, distribution and service aspects.
Lastly, the amount of possibilities in this direction also results in a lot of possibilities.

2) Scale control
Within this direction, a smart material (SMs) can be used to measure the amount of scale inside the tank and give feedback to the end-user when to replace or clean the tank. However, it has not been found what kind of SMs can be used to measure this. Additionally, shape memory alloys or polymers might be used as a heating element in order to "shake off" the scale by small movements.
Finding a solution on this topic could be very potential for Quooker since this is one of the main problems why Quookers breaks down after a certain amount of time.

3) Customization
Multiple possibilities with SMs are possible in this direction. By making use of SMs, the end-user could think of choosing their own tap colour. This could for instance be established by electroluminescent (EL) materials that can emit different kinds of colours. Questionable is whether SMs can create a real (functional) impact within this direction. Also, the business opportunity might also not relevant since the aspect "functionality" is an important value (See chapter; Vision generative session).

4) Automatic dispenser
In this direction, the focus is more focussed on the extension of functionalities. In order to anticipate on safety aspects (insight end-users) or the focus on elderly people (social trend), it could be relevant to design a tap that automatically can dispense water. In this way, people do not need their hand anymore.
When analysing on the integration of SMs, it can be concluded that SMs might be used in some mechanisms. However, it is questionable if the integration of SMAs can add a real value here. Therefore, this direction seems relatively less relevant.

5) Design for sustainability
When analysing this direction, it can be concluded that it is relatively difficult to find any valuable design applications with integrated SMs. However, the direction is in line with the mission of the company ("with care for our people and environment"). Furthermore, it is questionable whether this direction can have an impact on business aspects. In brief, Smart materials could be integrated in this area by using less components since the smart material can fulfil multiple functions. Furthermore, it can be discussed what kind of benefit will be added and to who. Sustainability sometimes comes along with higher costs (higher production costs or expensive recycling/ return system). Overall, this direction seems relatively not very potential.

6) Baby equipment
As explained before, it has been found that young parent might be a potential target group due to hygienic reasons that can be solved with the Quooker (see Customer & Users section). SMs can simply be used as warning signals. However, in this scenario, Quooker should extend their product portfolio which is not preferred since this direction is not the core business of Quooker. Therefore, it is not certain whether SMs can play a major role in this direction.

7) Quookers mindset
Although this is an interesting direction, it is hard to find SMs potentiality since outcomes are more focussed on managing and organisational solutions which is intangible. However, from a business perspective, this could be relevant to maintain Quookers steady growth in the upcoming years.

8) Design for disassembly
Within this direction, shape memory materials can play an important role in the design of disassemble. As an example, parts can be assembled by deforming the materials. Additionally, by heating the material the connection can be opened again without damaging the components. This is found to be an important aspect (See internal stakeholders analysis). From a business perspective, this direction is might be not very relevant since it only focuses on the avoidance of damage during the dissembling process. Therefore, it can be concluded that this direction might not result in a major impact. Note that that is already a relatively concrete idea. Therefore, the amount of SMs possibilities is low.

9) Smart Quooker

As earlier explained in chapter "search areas", this direction has two potential business aspects. First of all, end-users could have feedback on their water and electricity consumption. Secondly, a smart Quooker could help the service team to digitally "scan" the product to detect errors in a more efficient way. In order to make Quooker smart, different values need to be measured. This could be established by SMs. Water is one of the core elements in the product of Quooker and additionally a good conductor. With this in mind, the amount of water can be measured. Moreover, this could be extended to an IoT based design. Furthermore, focus can also be put on maintenance aspects. As an example, when the tank feels warm from the outside makes clear that the tank has a leakage. This could be made visual for both the customer but also for the service employee. However, form a critical perspective, the question is whether smart materials are really needed in this search area. Moreover, it might be cheaper and a smaller risk to integrate other "common" materials or systems as measurement tools. In conclusion, this direction has a certain potentiality for both, the business aspects as well as the integration of SMs.

10) Safety aspects

As earlier explained, safety aspects is an important value for the end-user. Therefore, this direction is a potential business direction. In this area, SMs can play an important role by warning the customer in a certain way. Colour changing elements are obvious solutions. However, this could still be a relevant and innovative solution to improve the interaction within the field of boiling water taps.

Smart materials can be used on the level of giving feedback to the user. Obvious solutions could be the use of material that emits light or changes in colour to make customers aware of dangerous situation. Therefore, SMs can play an important role in this direction and is therefore analysed to be relatively relevant.

A summarized overview of the potentiality is shown in the table below. Note that the directions are reflected on a scale from 1 to 5 (-- is equal to 1 and ++ is equal to 5).

In the figure below, all directions have been reflected* on its business opportunity and SMs relevance. This figure is eventually used to create the value matrix.

*: Note that it is relatively difficult to validate the combination of business opportunities and SMs in a very detailed way in this phase of the design process (e.g. a validation on additional costs, manufacturing details etc. is not included). It has been decided to not incorporate additional characteristics such as material costs and/or manufacturing etc. with a reason. Namely, more aspects can lead to more limitations which can be seen as a negative aspect for the design process. Therefore, SMs are only reflected on their material properties; whether the material response can be used as a solution in the proposed business opportunity.

Vaidation table

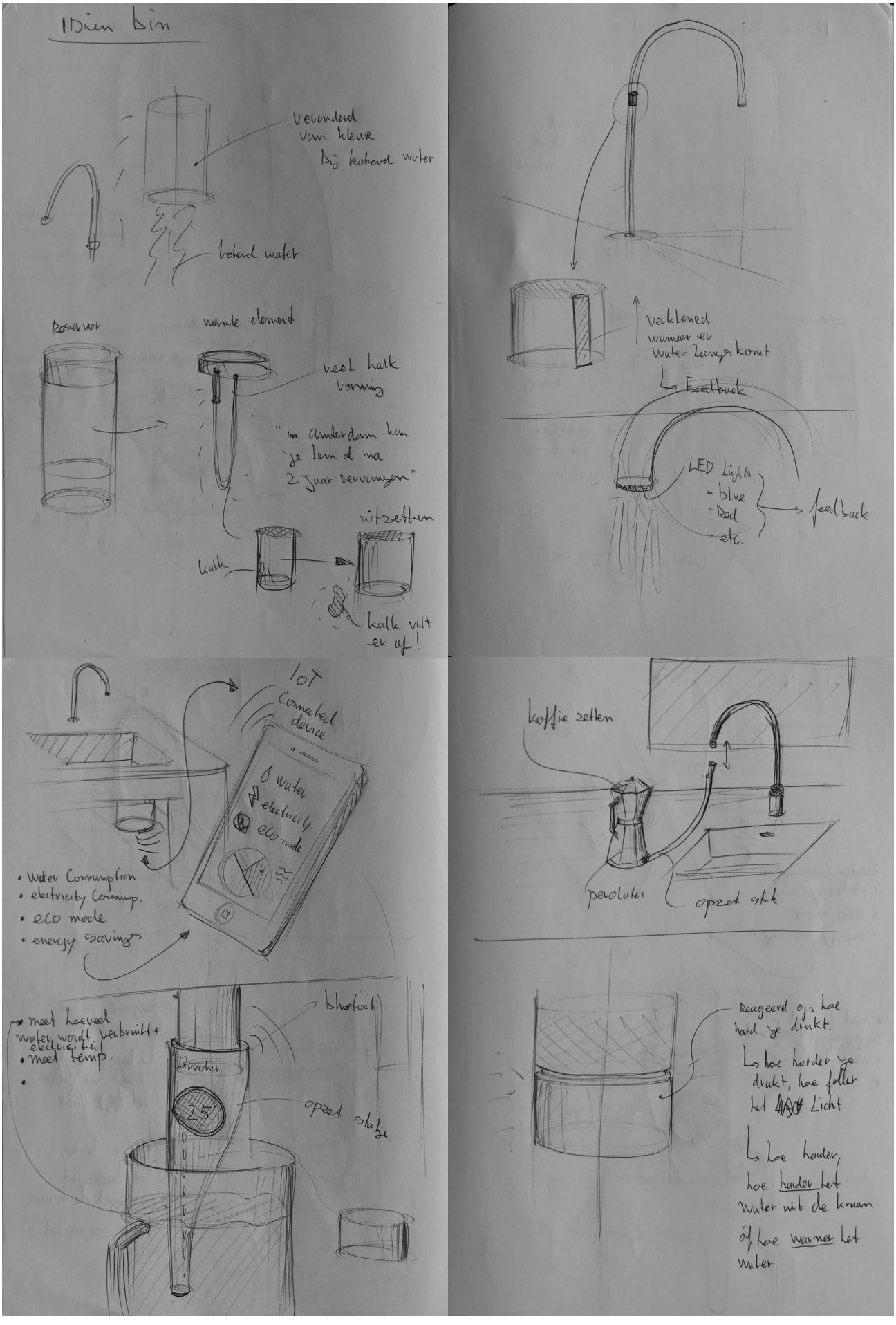
Search area	Business potentiality	SMs potentiality	Search area	Business potentiality	SMs potentiality
• Product extensions	+/-	+/-	• Baby equipment	+	–
• Scale control	+	+/-	• Growing tool	– –	– –
• Customization	–	+/-	• Design for disassemble	–	+/-
• Automatic dispenser	+/-	– –	• Smart Quooker	++	+/-
• Design for sustainability	–	+/-	• Safety of the Quooker	++	+

An overview of all directions that have been evaluated on business opportunities and SMs relevance

Clustering method

Below, two figures are shown of the clustering method in which a big white wall was used to cluster all the business opportunities to the linked segments. Additionally, first product ideas were generated and placed underneath the segments as well. The outcome was illustrated in chapter 4.2; Converging methods.

Two pictures taken durring the session of the clustering method

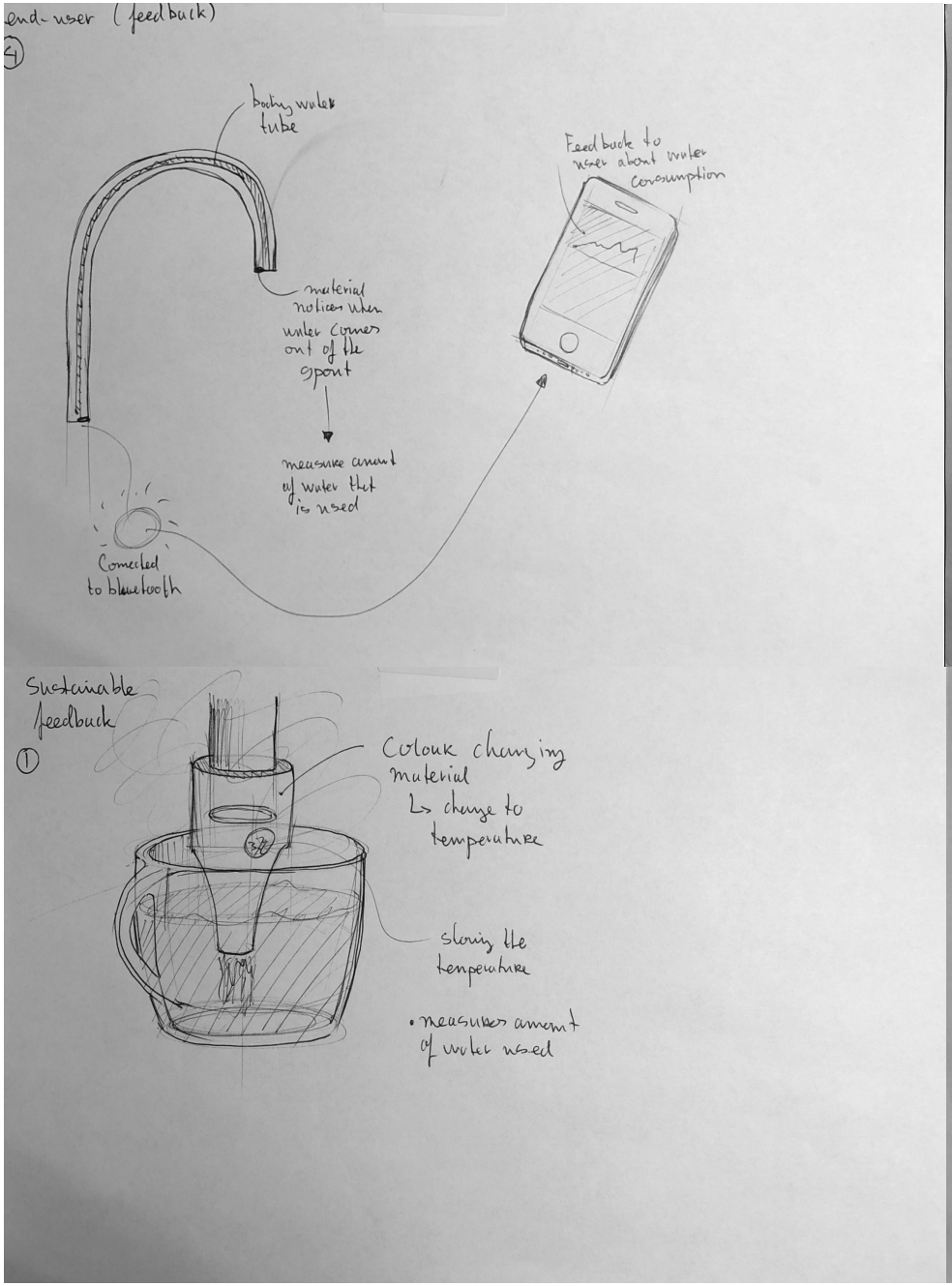

Dien bin
Verandert van kleur bij kokend water
kokend water
Reservoir
warme element
kalk vorming
"in amsterdam kan je kem al na 2 jaar vervangen"
uitzetten
kalk
kalk valt er af!
LED Lights
- blue
- Red
- etc.
feedback
IOT
Connected device
Water
electricity
eco mode
• Water Consumption
• electricity Consump.
• eco mode
• energy saving
koffie zetten
pevoluter
opzet stuk
Bluetooth
opzet stuk
Reageerd op, hoe hard je drukt.
hoe harder je drukt, hoe feller het Licht
hoe harder, hoe harder het water uit de kraan óf hoe warmer het water

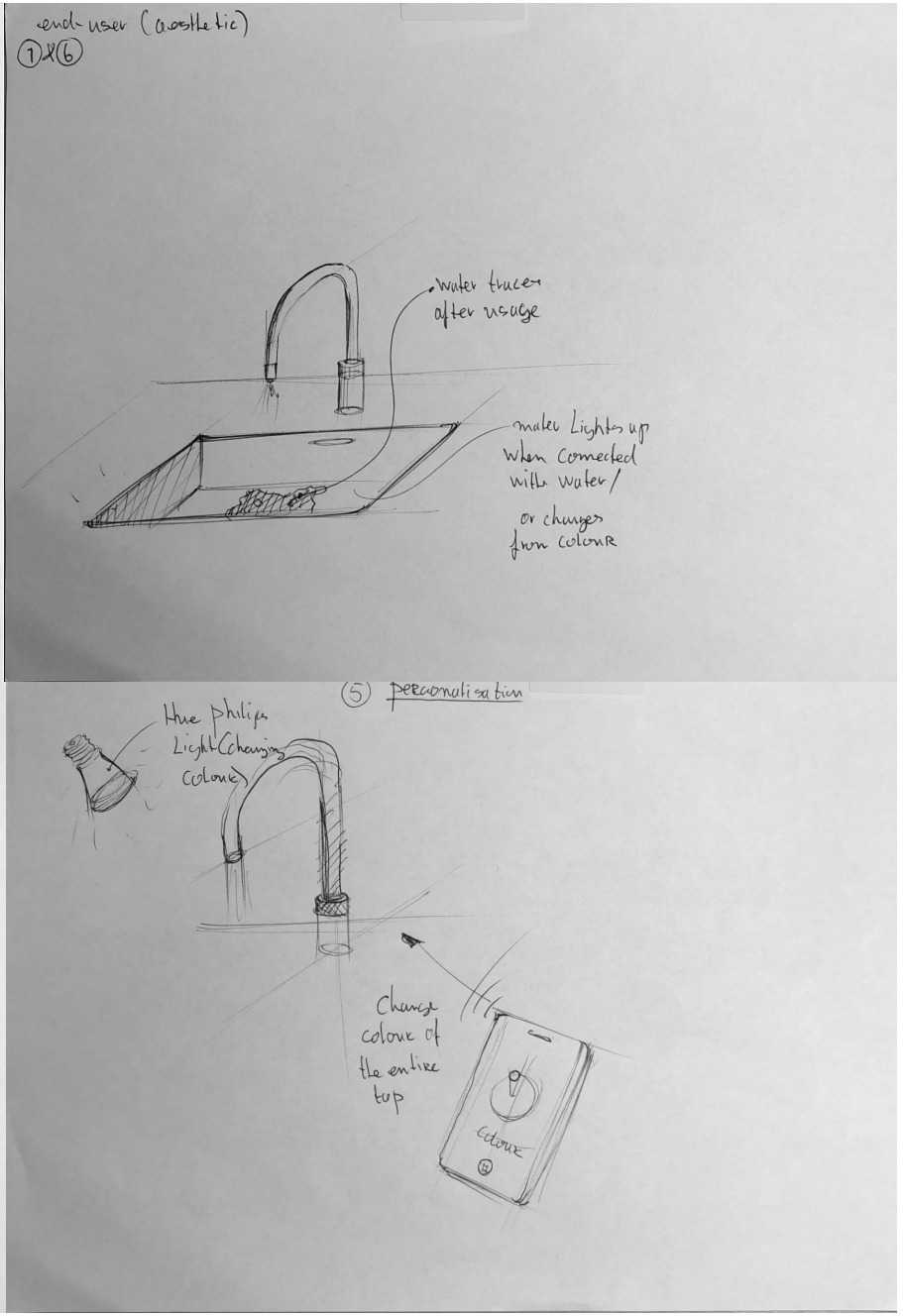
assembly & disassembly
shape memory material
Boiling
visual feedback
shape memory
change in temperature
Less splash

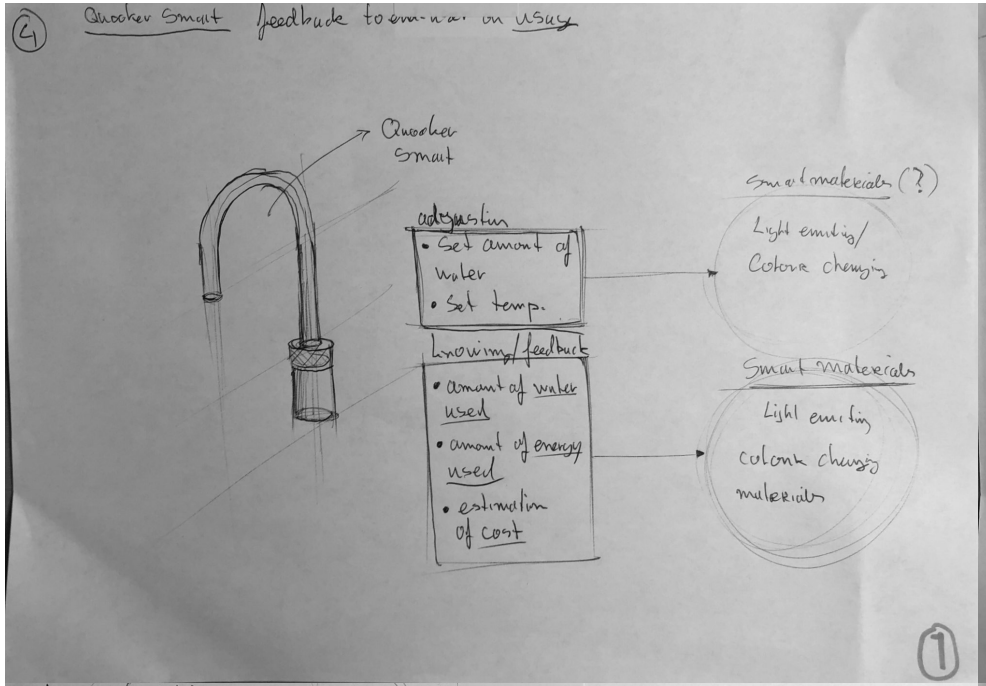
sparkling water
Cooled water
Boiled water
Redesign
"Smart push"
take apart
Bluetooth

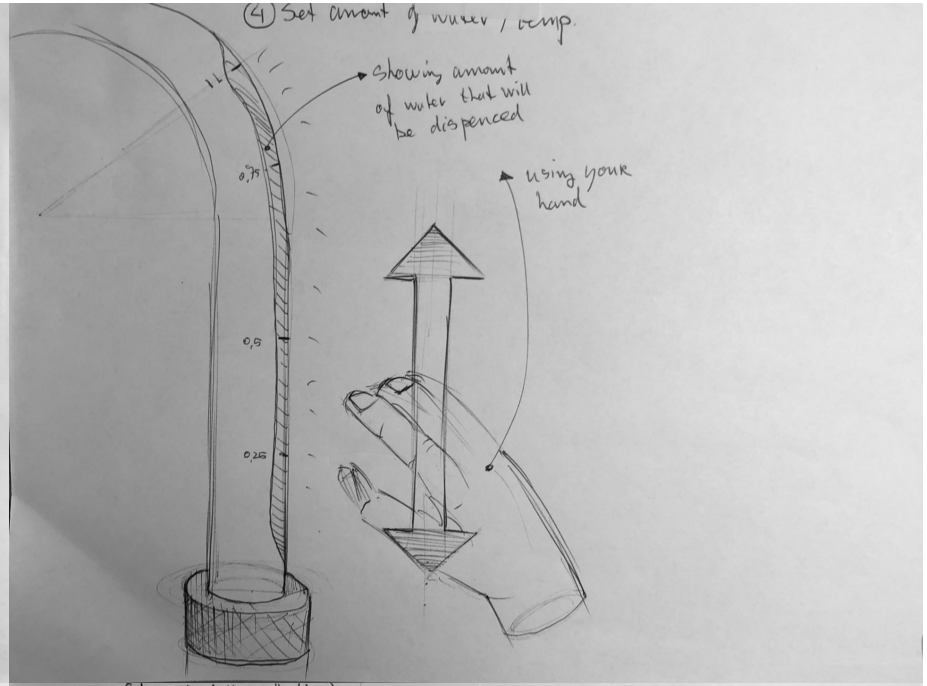
Sustainability
Sewer
Quooker Reservoire
hot water will be used to warm up the tank.
Sink

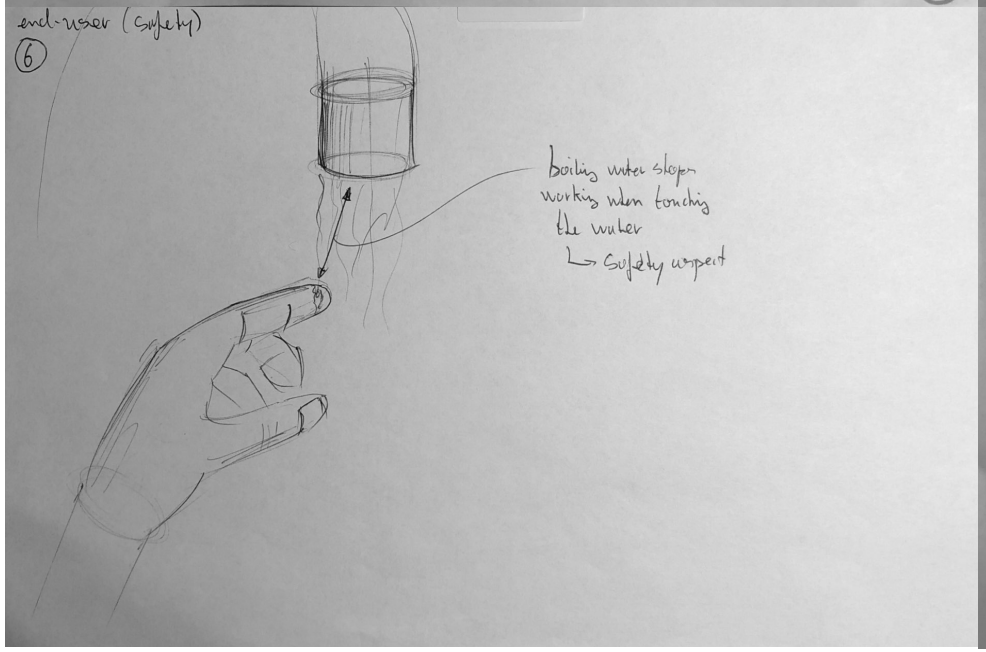
Scale control (lasting product)
heat element
scale control
shape memory material
child can't attach

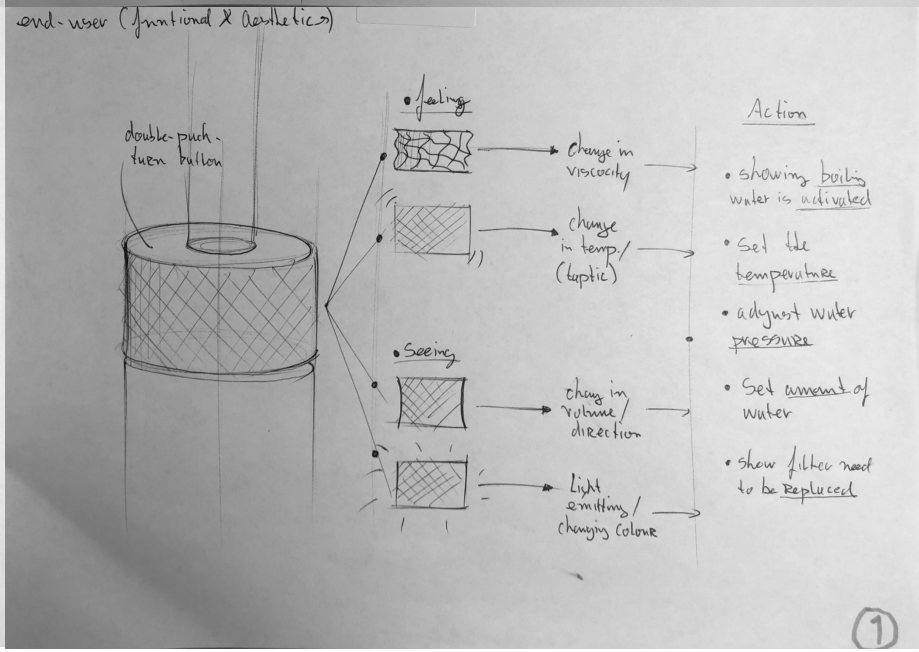

end-user (feedback)
4
Feedback to user about water consumption
material notices when water comes out of the spout
measure amount of water that is used
Connected to bluetooth
Sustainable feedback
1
Colour changing material
→ change to temperature
slowly the temperature
• measures amount of water used

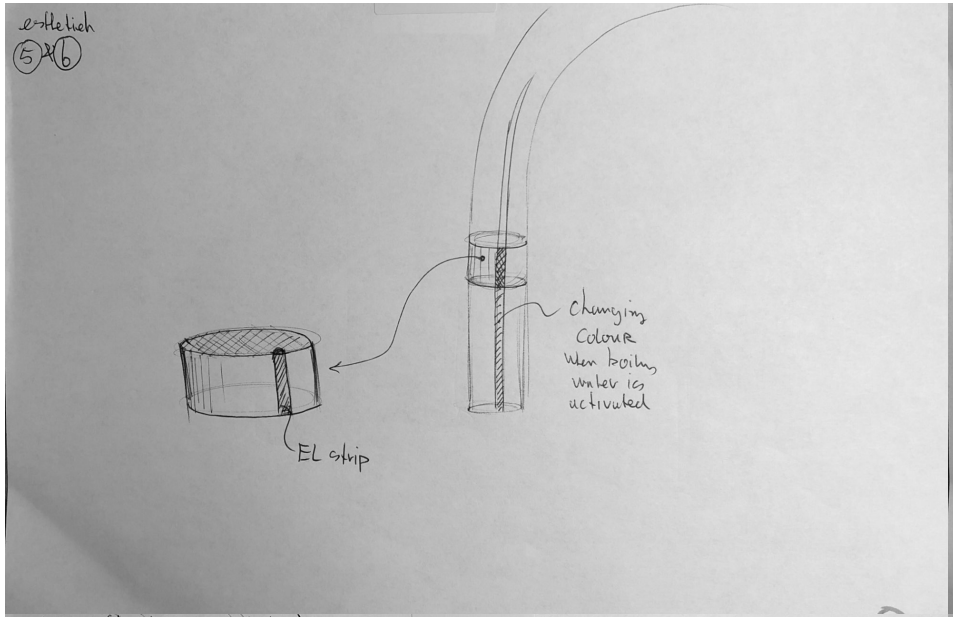

end-user (aesthetic)
1 & 6
water traces after usage
maker Lights up when connected with water/
or changes from colour
5 personalisation
Hue philips Light-Changing colour
Change colour of the entire top
Colour

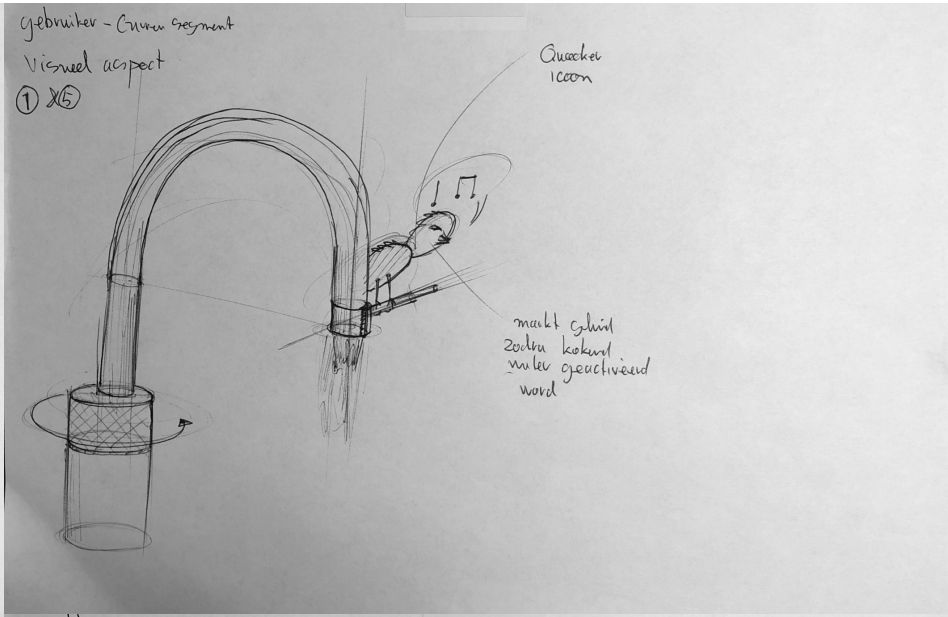

4
Quooker Smart feedback to en-u-a- on usage
Quooker Smart
adaptation
• Set amount of water
• Set temp.
knowing/feedback
• amount of water used
• amount of energy used
• estimation of cost
Smart materials (?)
Light emiting/ Colour changing
Smart materials
Light emitting colour changing materials
1

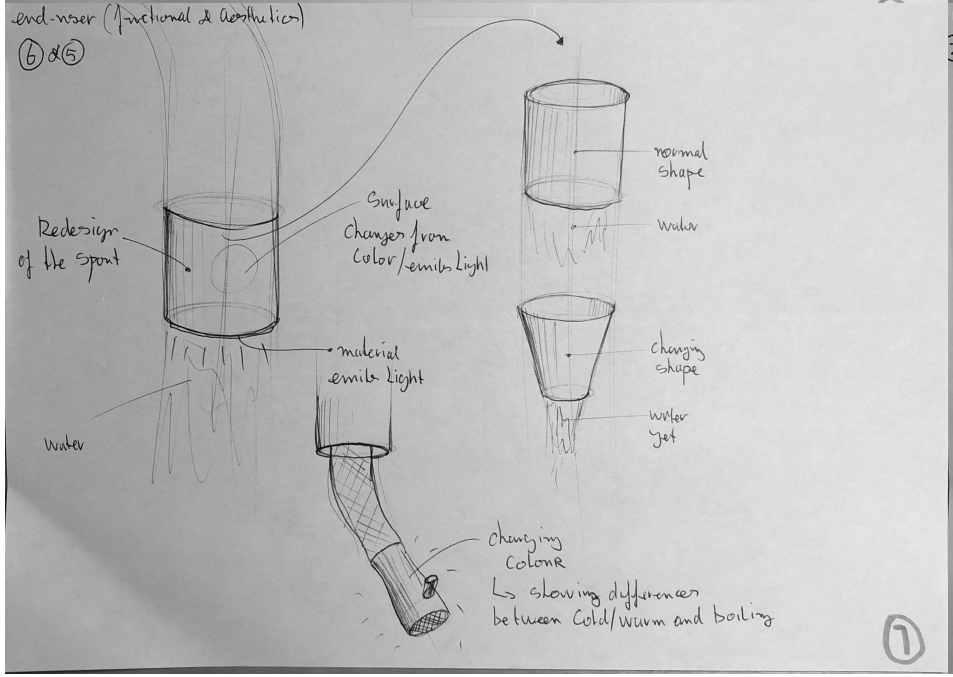

4 Set amount of water / temp.
showing amount of water that will be dispenced
using your hand
1,1
0,75
0,5
0,25

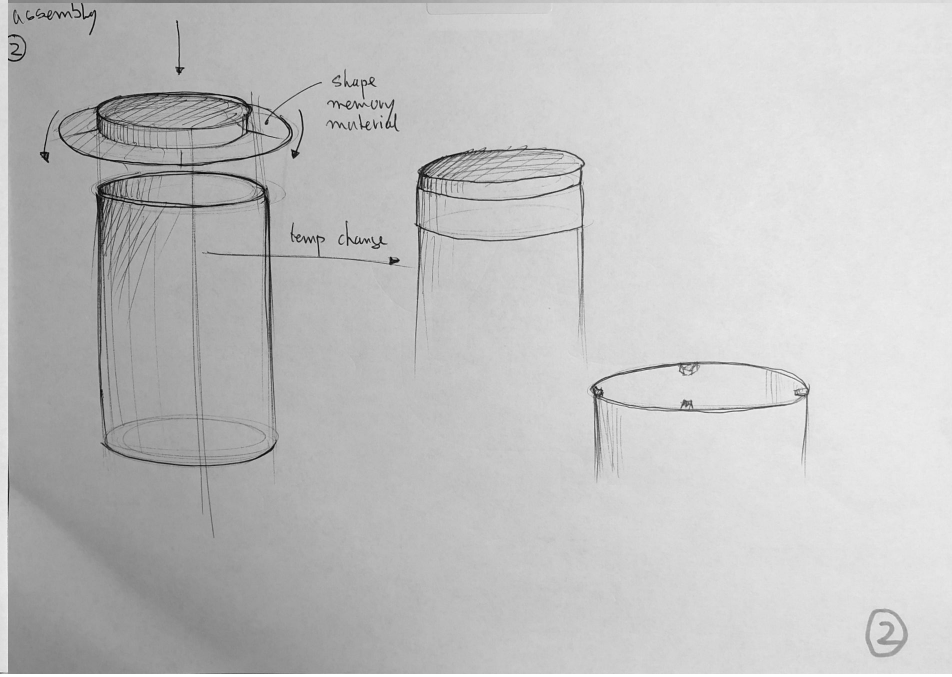

end-user (safety)
6
boiling water stops working when touching the water
↳ Safety aspect

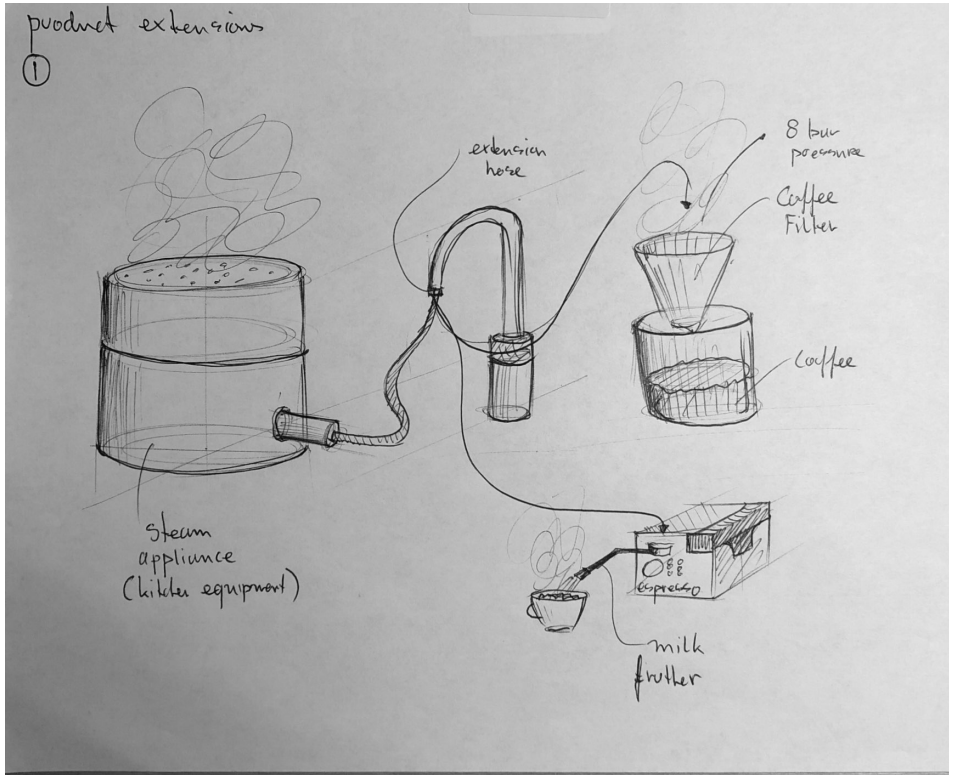

end-user (functional & aesthetic)
double-push-turn button
• feeling
change in viscocity
change in temp./ (haptic)
• seeing
chang in volume/ direction
Light emitting/ changing colour
Action
• showing boiling water is activated
• Set the temperature
• adjust water pressure
• Set amount of water
• show filter need to be Replaced
1


esthetisch
⑤ & ⑥
changing colour when boiling water is activated
EL strip


gebruiker - Groen segment
Visueel aspect
① & ⑤
Quacker icoon
markt geluid zodra kokend water geactiveerd word


end-user (functional & aesthetic)
⑥ & ⑤
Redesign of the spout
Surface changes from color/emits light
material emits light
water
normal shape
water
changing shape
water jet
changing colour
↳ showing differences between cold/warm and boiling
①


assembly
②
shape memory material
temp change
②


product extensions
1
extension hose
8 bar pressure
Coffee Filter
coffee
steam appliance (kitchen equipment)
espresso
milk frother

Appendix M - Creative brainstorm session

Session overview:

Duration: 2h

6 participants

Apparatus (& preperations):
- post-its
- Pencils/draw material
- food & drinks
- tape

Location
Wim Crouwel zaal

Criteria for idea selection:
- SMA geeft een meerwaarde aan de oplossing van het probleem
- Financieel haalbaar/produceerbaar/ realistisch
- past binnen product range van Quooker

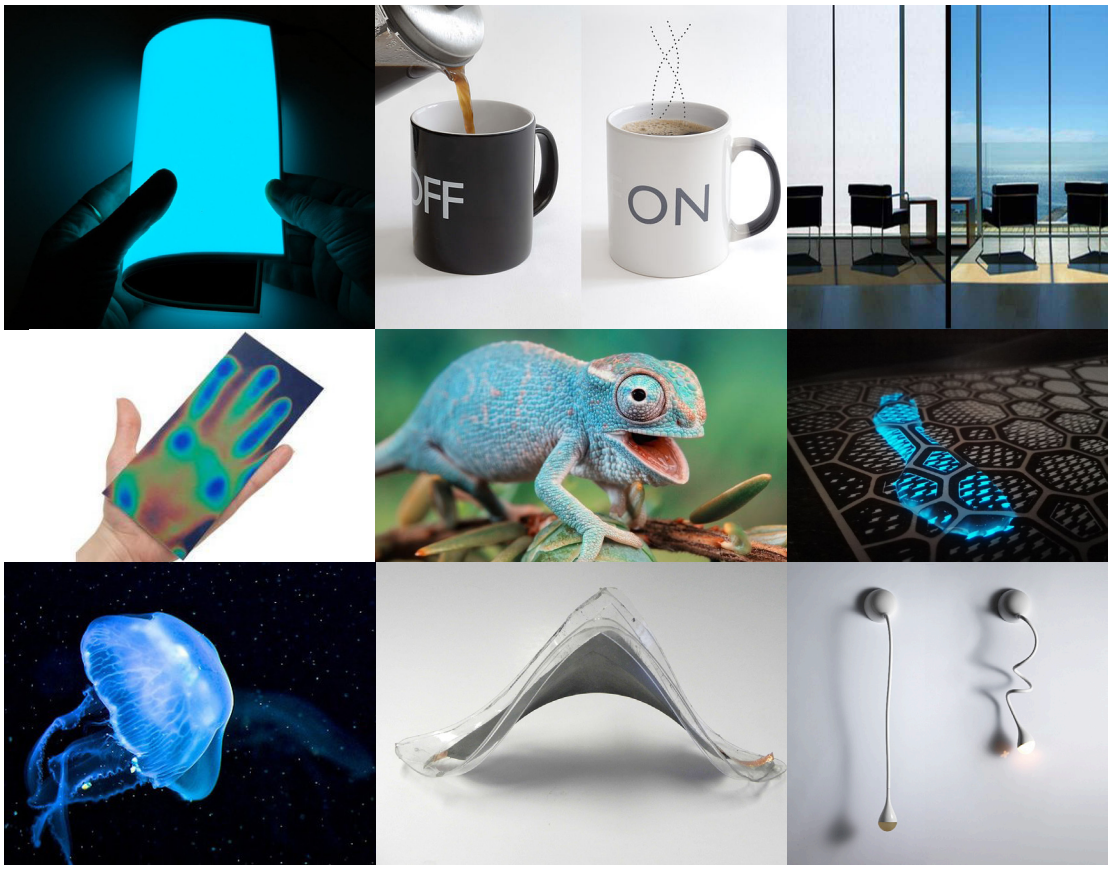
Goal
Getting inspirational ideas in which both the created search areas and smart materials are combined. The session should end with three promising ideas that are chosen by the participants.

Energyzer: Jumpen doe je zo! tutorial https://www.youtube.com/watch?v=E-gnrXsQmh0

Stimuli: Basic information about the Quooker product explained to the participants (print-out)

On top: abstract versions of the search areas (left) and Smart materials (right)

Below: several pictures given to participants to stimulate them during different phases of the brainstorm



Below, the session plan is shown which describes the main elements step by step.

Planning creative brainstorm_Smart materials				Session duration: +/- 2h
17:00	Ice breaker/ Energizer	Jumpen doe je zo		5 min.
17:05	Case explanation	Explaining the goal, company, SMAs	Explaining the different SMA types	15 min.
17:20	Rules description			1 min.
17:21	Purge	Write down first ideas on post-it's	Quooker related ideas	5 min.
17:30	**Break**			**10 min.**
17:20	Explanation Search areas			1 min.
17:40	First round: gambling with opportunities	First throw: pick te related "SA" card. Then, select one or more SMAs to combine and create an idea	Present the idea after each round briefly	7 min.
17:50	Second, third & fourth round: gambling with opportunities	Second, third and fourth throw. Same activity as the first round.	Post-it's will be put on the wall	24 min.
18:10	**Break**			**10 min.**
18:20	Categorizing the best ideas	Participants put two dots on post its	Three best ideas will be chosen to continue with	10 min.
18:30	Making three groups of two persons	Divide to ideas over the groups	Work out the idea to a concept	20 min.
18:50	Present the concepts to each other			10 min.
19:00	Ending of the session			5 min.

Method

1) Doing an energizer in order to get activate the brains of participants before the actual brainstorm. doing the tutorial :"Jumpen doe je zo"

2) Explaining: what is Quooker. Briefly going through the graduation process and explain why I need student's creativity in this phase. What is the goal of the session. Furthermore, explaining the basic principles of smart materials. Participants get to know more about material classes and their stimulus and response. With this knowledge, they will be able to generate ideas in this creative session.

3) Rules description: get everyone on one line based on expectation management etc.

4) Purge: Write down all the ideas on post-its. This will be done to start the next brainstorm part with an empty head. --> break

5) After the break the search areas will be explained. Three of them are created from problems that have been found during the analysis. The other three search areas are created from the external analysis (e.g. trend analysis).

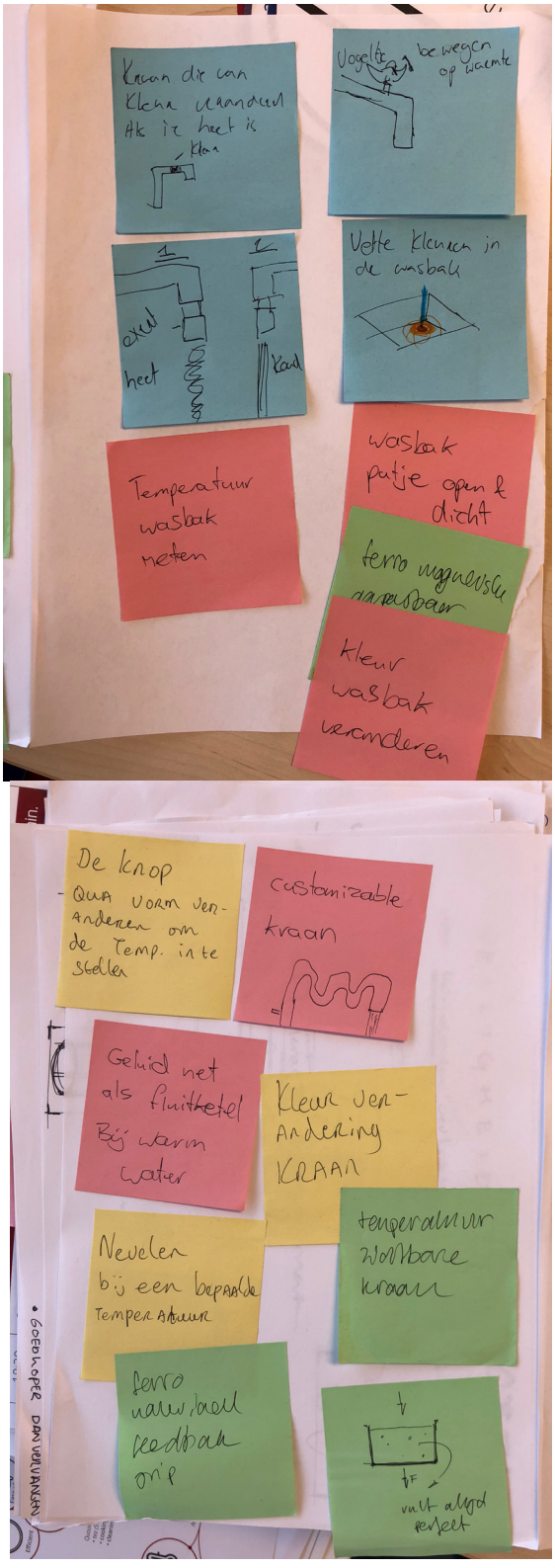
6) four rounds of brainstorms will be conducted. As a first step, a participant selects a search area. Secondly, a smart material card can be chosen to combine with. With the two inputs, participants need to create first ideas that will be drawn on an a4 paper. After each round, everyone briefly explains their idea. These steps will be repeated four times. In this round, quality is more important than quantity since the subject of smart material could be hard to fast produce tangible ideas. In addition, participants are familiar to the facilitator. The facilitator knows that participant prefer to have more time to generate ideas. --> break

7) the brainstorm steps of step 6 results in 24 different concept ideas that will be clustered. Participants take a pen and put dots on the a4 paper they think is the best. Criteria will be explained as well in order to know how the selected the best ideas. As a final result, three ideas should be selected to continue with.

8) In groups of two, participant will elaborate on the ideas in order to develop them towards a concept. At the end of this step, participants will present their concept directions.

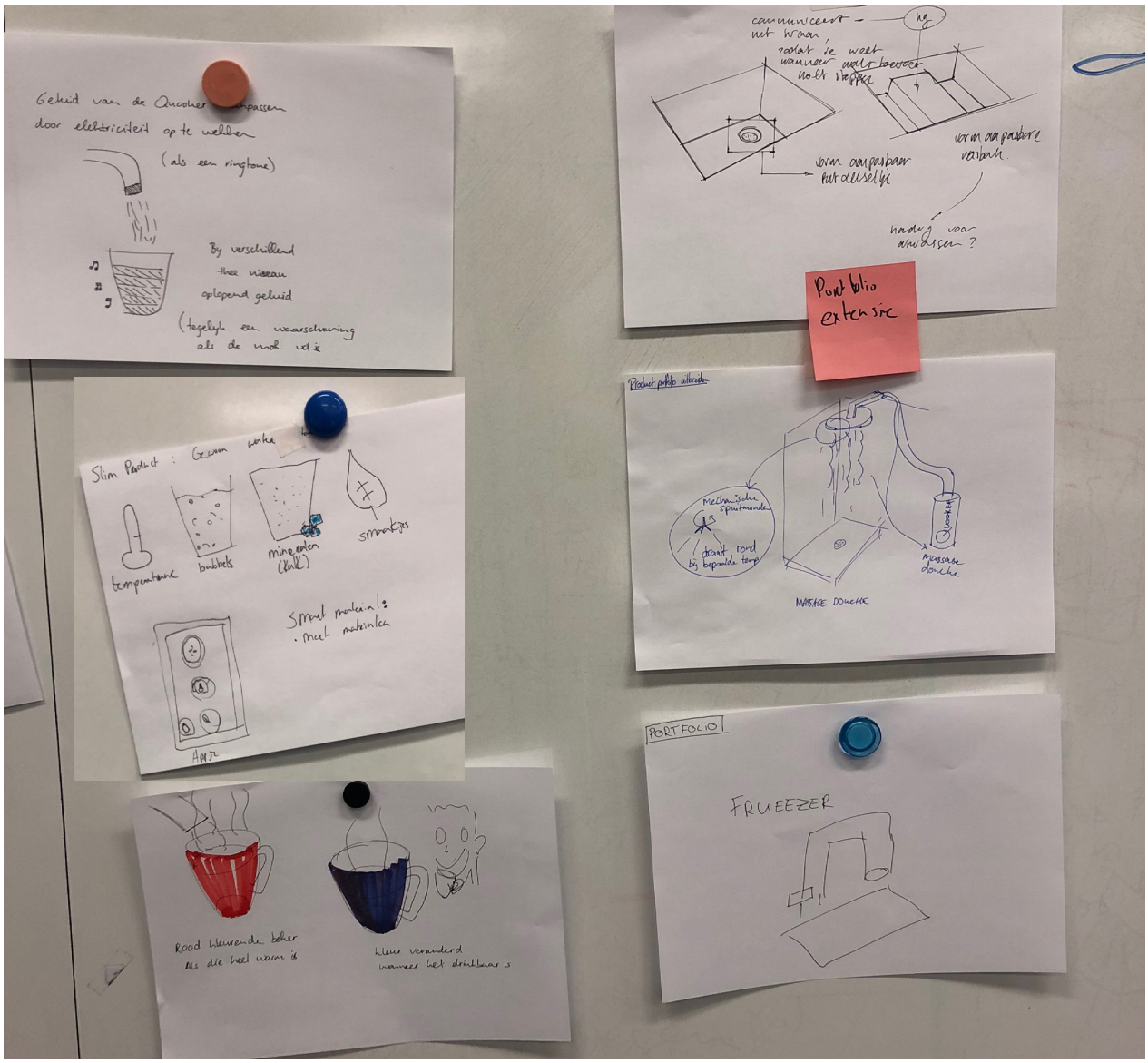
Results

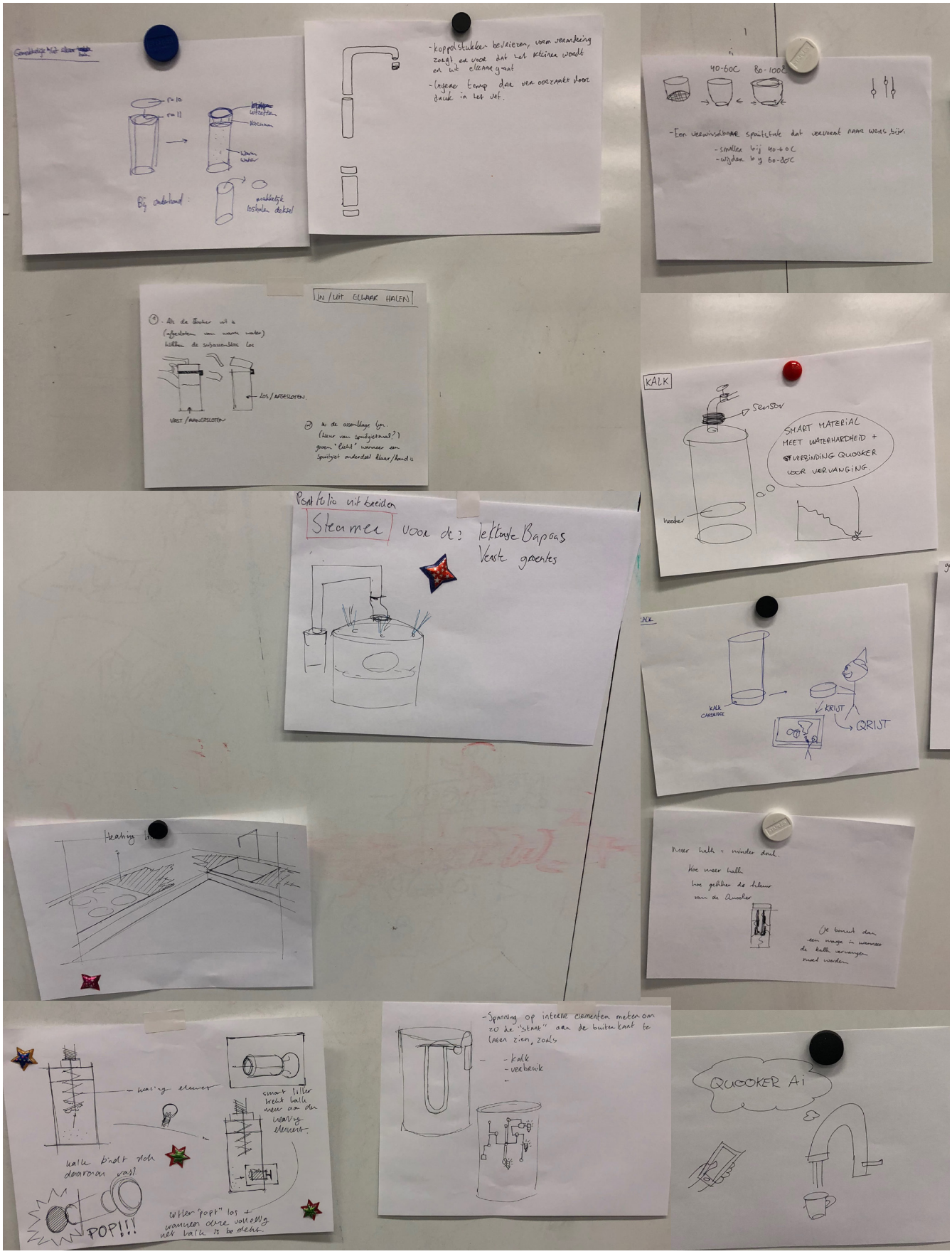
With the creative brainstorm session, multiple ideas were created that could be used as interesting product direction for the next phase. Within the session, two phases were used to create ideas. The first one could be seen as a warm-up phase which was related to a 'purge" to get first ideas on paper and empty the mind. This part of the session resulted in random and out of the box ideas. Ideas were written on post-its and are shown below.



In the second phase, ideas were created by combining the search areas with smart materials. Within this part, ideas were made more concrete and detailed. Additionally, this phase resulted in 24 different product ideas. Afterwards, the ideas were clustered by keeping in mind the earlier stated criteria. During the brainstorm, participants were stimulated with different pictures (animals with smart textures) displayed on the LCD screen. Additionally, they were also stimulated by focussing on for instance other parts of the product life cycle (how to improve the product in its production phase etc.).

Ideas of the second phase are shown below:

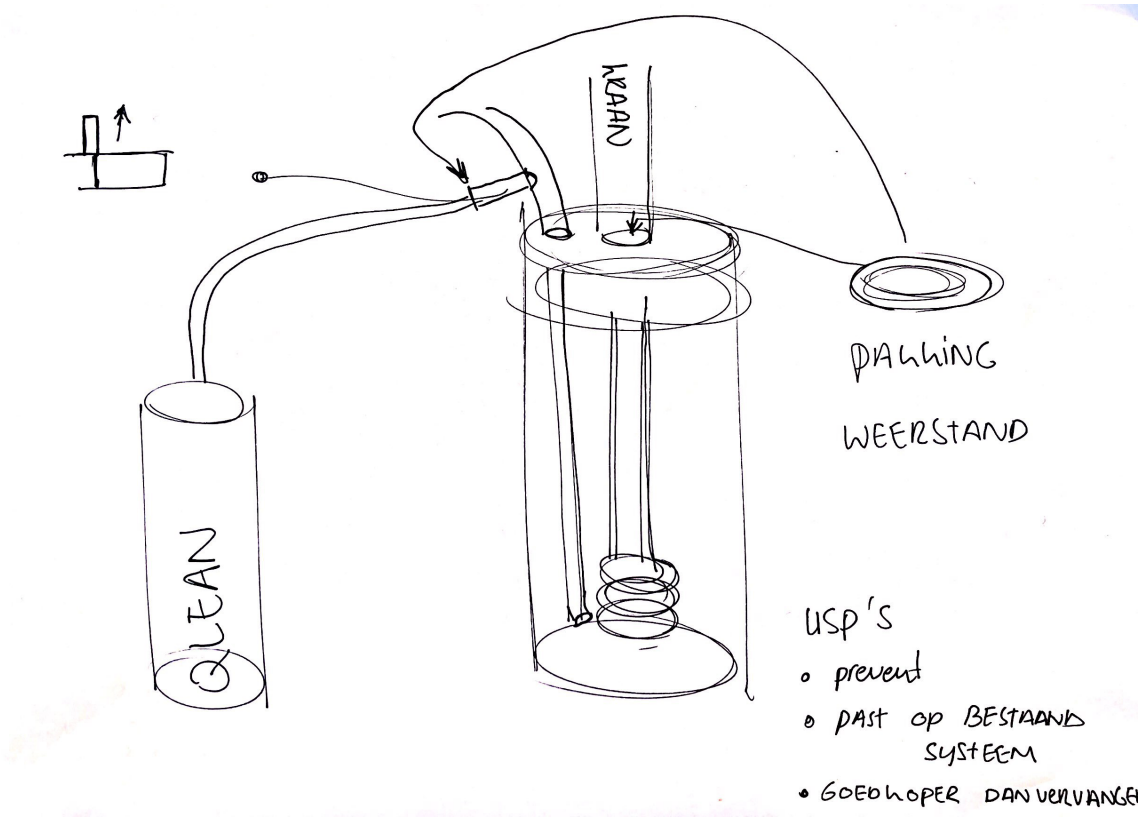



IN/UIT ELWAK HALEN
KALK
SENSOR
SMART MATERIAL MEET WATERHARDHEID + VERBINDING QUOOKER VOOR VERVANGING
KRIJT
QUOOKER AI
POP!!!

After the selection, multiple ideas we combined that could fit with each other. This part resulted in three main direction. Additionally, three groups of each two persons elaborated on a product direction by detailing and combining the ideas towards a presentable concept. The three final concepts are shown below.

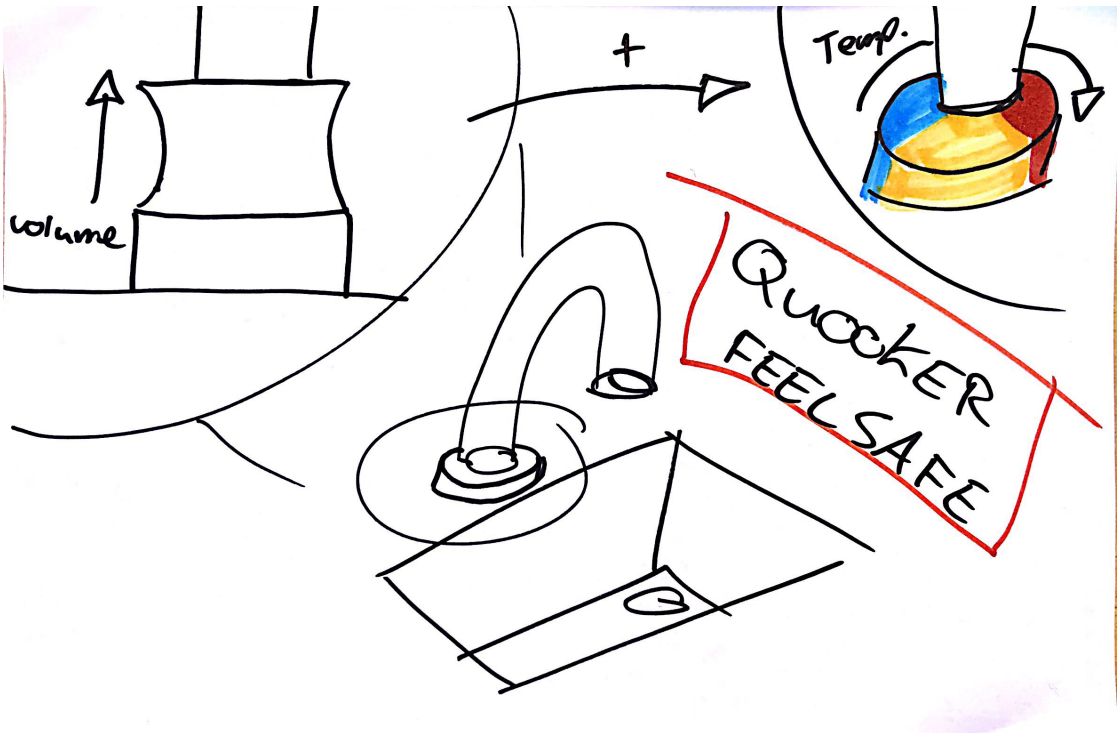
Concept 1: Qlean

Concept one is focussed on the problem with scale control. An extension is created with a tank with detergent that is connected to the input of the Quooker reservoir. When a smart material is used as measurement tool, it enables to measure when the amount of scale to too high. At the moment the level is exceeded, the Quooker will clean himself by adding a detergent to the input of the reservoir. The detergent cleans the tank from the inside and chalk will resolve. The amount of water that is then in the tank will be dispensed. The colour of this water is different which will be used to communicate to the user that the Quooker is in its "cleaning mode". At this moment, the user can't drink the water.
USP's: reservoir last longer
SMA benefit: used as measurement tool. Scale in the water will be measured by a SMA.



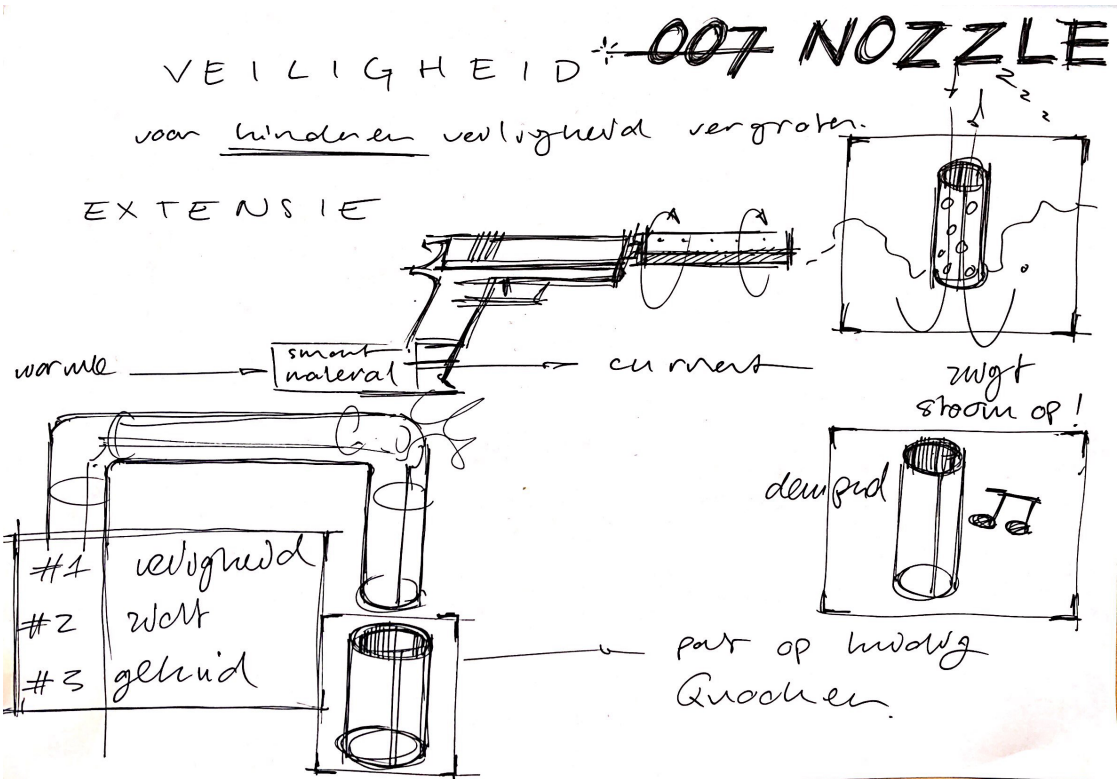
Concept 2: Quooker feel safe

The "Quooker feel safe" is focussed on a redesign of the boiling-water-button. This button can be squeezed to adjust the exact temperature and the amount of water coming out of the tap. This will partly be realized by digital components. When the user squeezes harder, the temperature will be warmer. The shape of the button also changes when squeezing the button. When squeezing harder, the button will rise a bit. The more the button comes up, the more water will be regulated. The exact amount of water is communicated on top of this button by measurement stripes.
USP's: improvement of feedback to the end-user. The end-user can regulate the temperature and amount of water more easily.
SMA benefit: colour changing material for temperature indication & shape changing materials to change the shape of the button.



Concept 3: 007 Nozzle

This concept is focussed on safety aspects. A nozzle can be put on the spout of the tap which can be seen as an extension. The nozzle creates multiple benefits: 1) By changing temperature, the smart material will generate electricity (Pyroelectrics). 2) it will also take away the vapour that is created by the boiling water. With this, visibility of the interaction will be improved. 3) Lastly, the nozzle is designed in such a way that it will damp the noise when boiling water is activated.
USP's:



Appendix N - Tinkering process

In this Appendix, a tinkering process have been conducted on four different Smart materials. Additionally, the different materials will be analysed on a detailed level.

First, a brief overview will be given on the different types of EL, the working principle and more important, the characteristics of EL material that can serve as 'design handles'. Furthermore, samples of EL material has been made in order to understand the materials behaviour.

Electroluminescence (EL)
In general, non-thermal generation of light is classified under luminescence. Luminescent materials, also called phosphors, can emit light. Within this classification, a various amount of materials exist that can emit light such as the earlier explained photoluminescent material that absorbs light in order to emit light.
Electroluminescence (EL) is an optical and electrical phenomenon which is able to generate the emission of light caused by an electric current or electric field ("Electroluminescent Lamps - How They Work & History", 2017). The figure on the adjacent page shows the different materials that are used to build up an regular EL sheet.

Types of EL
The occurrence of luminescence can be divided into two different working principles: High field EL and Injection EL such as the common used LED light.
For high field EL an electric field is being used to light up individual particles via ionization and high energy impact excitation. In addition, the material either consists of a powder phosphor or a thin film phosphor. However, for injection EL a charge injection is used to light a phosphorescent crystal (Vij, 2004). This principle can for instance be found in LED lighting. The difference between the two types of EL also makes a difference in technical specifications. For high field EL, a larger surface with a low/medium brightness can be achieved in comparison to an Injection EL (LED) where a small surface with a high brightness is more effective (Kim et al., 2012).

Tinkering process
As proposed in the material driven design, a tinkering phase should be included in order to get more familiar with a new material that is unknown to the designer. According to this, an EL sheet sample has been made by the researcher. Furthermore, several EL sheets have been ordered in order to compare the EL materials with each other.
In brief, the goal for this exploration was to gain a better understanding of the material behaviour and the different materials of layers needed. The samples have been made at the design lab of the faculty of Industrial Design Engineering in consultation with an EL material expert. The different steps to build up the first sample are describes below:
The tinkering process
In total, two different samples have been made during the tinkering process. The first sample has been made to get familiar with the different steps that need to be carried out to build up the material. In the second sample, a new design was made in which 'boiling water' was symbolized.

In the first steps, all materials were gathered. Below, a list of required equipment is stated:

- UV/Phosphor mixture
- Inverter
-Clamps 2x
- Mixing stick
- UV lamp
- Aluminium foil
- Scraper
- ITO PET
- Vinyl
- Flat work-surface

Several steps have been made in order to make the first sample. These steps are described below:

Step 1
In the first step, a design need to be made in illustrator that will be used in a vinyl cutting machine. Vinyl parts of the design need to be removed that are not needed. These parts will be filled with the UV phosphor mixture.

Step 2
The vinyl sheet need to be carefully placed on the ITO side of the ITO PET sheet.

Step 3
The sheet need to be fixed to the work-surface in order to avoid the design to slide. Meanwhile, the UV/phosphor needs to be mixed properly before the application. Note that Phosphor particles will sink to the bottom after a minute. Therefore, this required stirring to create a homogeneous mixture.

Step 4
In step 4, the mixture need to be applied above the cut-out on top of the vinyl. In order to spread the mixture properly, a scraper need to be used with medium pressure. It is important that that cut-out is fully covered by the mixture in order to achieve the best quality.

Making and testing my own sample EL sheet.

Step 5
The design need to be placed underneath a UV lamp for one minute. This will result in a 'tacky' outside layer and will be used to bond the aluminium foil in the next step.

Step 6
Once the UV mixture is partially cured the piece of aluminium foil can be placed on top. Within this step, it is important to keep as little air as possible between the foil and the mixture. For this, it is possible to press down the foil with quite some force. Note that this is done to remove trapped air and decrease the distance between the electrodes which increase the electric field strength.

Step 7
Turn around the design in such a way that the aluminium slide is touching the working-surface. In this position, it needs to be placed underneath a UV lamp for another two minutes. Once the mixture is fully cured, remove the additional aluminium. This is important to avoid aluminium touching the ITO side of the ITO PET (avoid a short electrical circuit).

Step 8
In the last step, the clamps need to be attached, one clamp touching the ITO side, and one clamp touching the aluminium. After turning the design, the design should emit light when turning on the inverter.

Design advantages
A more elaborated documentation of the design advantages of EL materials is described below:

Light properties
The light that is emitted by an EL sheet can be seen as a uniform light which is the result of a top and bottom electrode. Furthermore, the EL sheet has the same brightness and intensity in every corner of a complex shape. This can be a benefit relating to the visibility, avoiding glare or blinding light.
Moreover, the light emitted by EL is instant which means that no time is needed to start the emitting light in contract to other light sources (e.g. energy saving lamps).

Flexibility
The different layers that are combined allow the sheet to be flexible. All layers, including thin flexible electrodes, flexible dielectric materials and a canvas base material all with a very low thickness result in a flexible surface. Additionally, the different thin layers allow for folding, rolling and keeping it in almost every position.

Thickness
The thickness of EL sheets can be made very thin. As explained before, the material consists of multiple layers, each with a different function. However, all these layers are fabricated very thin resulting in a total sheet thickness between 0.1 and 0.5 mm (comparable to the thickness of paper). Additionally, this low thickness results in several advantages such as the material to be lightweight, low volume and flexible.

Endurance
EL materials are shock and vibration proof material due to its solid state technique of emitting light. Moreover, the different components used in the material are not fragile and are applicable in surroundings with low or high temperatures. Although the material should be kept away from direct sunlight, high or low temperatures are not a problem for electroluminescence. Furthermore, another drawback is the degradation of the light intensity which results in a 50% light intensity reduction after 700 to 3200 hours.

Screen printing
Screen printing is the fabrication method of EL materials which allows the design to be adaptable. This means that different materials (phosphors) can be combined in

the layers resulting in different colours that can be used or different functionalities that can be created. Also, screen-printing is possible on many different materials such as on plastic or metals which can be seen as an advantage. Moreover, the fabrication of the EL material can be done manually and is therefore relatively high accessible.

Non-directional

The light of an EL material is non-directional due to the particle size, the orientation of the Phosphor and the electroluminescent centres. The position of a person in perspective to the electroluminescent surface has no influence on the brightness. This is the same from every point of view. Therefore, designing with EL materials allows the designer to have form freedom related to the shape and orientation of the material.

Surface area and form

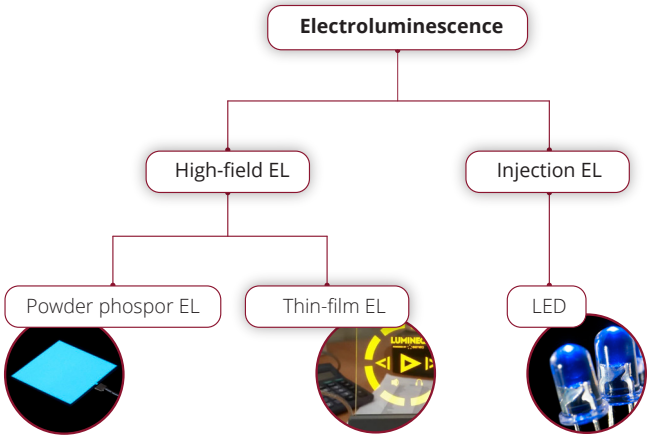
First of all, EL material provides a large surface that emits light by itself. This can be done without the need for an external light source which can be seen for the majority of the available lighting sources which have a fixed spot (e.g. a bulb, LED or fluorescent tube). Some of these light sources can emit a larger surface, but are mostly matte surfaces and are lit by an external light source.
Second, EL material makes it able to make custom 2D designs which can be fabricated. With this in mind, complex shapes including holes and thin pathways can be lit.

Temperature

Traditional light sources such as light bulbs, LEDs or florescent lamps have the downside of generating heat while emitting light. However, EL materials also produce heat but due to its large surface and thin layers, it can easily lose its heat. Subsequently, EL sheets are cool to touch caused by the relatively low temperature which can be seen as an advantage (related to interaction design).

Design limitations

Several design limitation also revealed during the analysis next to the design handles that have been described form the literature study. Design limitation have been supplemented with findings from the tinkering process. Below a brief overview of the design limitations have been described:



Low brightness

It has been found that EL materials have in general a low brightness compared to conventional light sources such as LED light. Most EL sheets are currently used for back-light units and not for example for spot lights. This is due to insufficient performance which can be related to low brightness and efficiency (Kim et al., 2012). Moreover, from the tinkering process this aspects also has been concluded. For example, when holding the EL sheet in a bright environment it is hard to see whether the material is emitting light.

Degradation of intensity

From characteristics of the EL materials, it has been found that the light intensity degrades relatively fast. A 50% light intensity reduction occurs in general after 700 to 3200 light hours. This is equal to 30 and 130 days respectively.
High voltage and frequency
EL materials require a high voltage and frequency in order to create the required electrical field to emit light. This result in the use of additional components such as inverters. From the tinkering process it has been analysed that these inverters have relatively large dimensions (60x60x30mm) and also make a very high frequency sound when the EL material is turned on.

Moisture sensitive

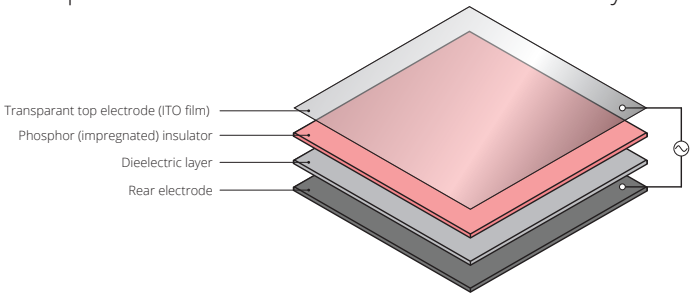
It has been found that a AC powdered EL material is highly sensitive for moisture. Additionally, this results in a degradation of the phosphor reaction which reduces its lifetime. Moreover, sunlight also reduces the lifetime of EL material. However, as discussed before, EL materials are hardly used in bright environments.

Colours

There is only a limited amount of colours available of phosphors. Research is still established in this area and should result in more available colours.

Costs

Currently, EL materials are relatively expensive compared to conventional light sources such as LED materials. This is of course a logical consequence of the market dynamics that are influenced by the demand and supply of a particular materials. EL materials is a relatively new



material and is yet not extensively produced which result in a higher price compared to LED's that are worldwide produced. During the tinkering process, several samples were order. A 10x10mm EL sheet costs 30 euros which is relatively expensive.

Insights

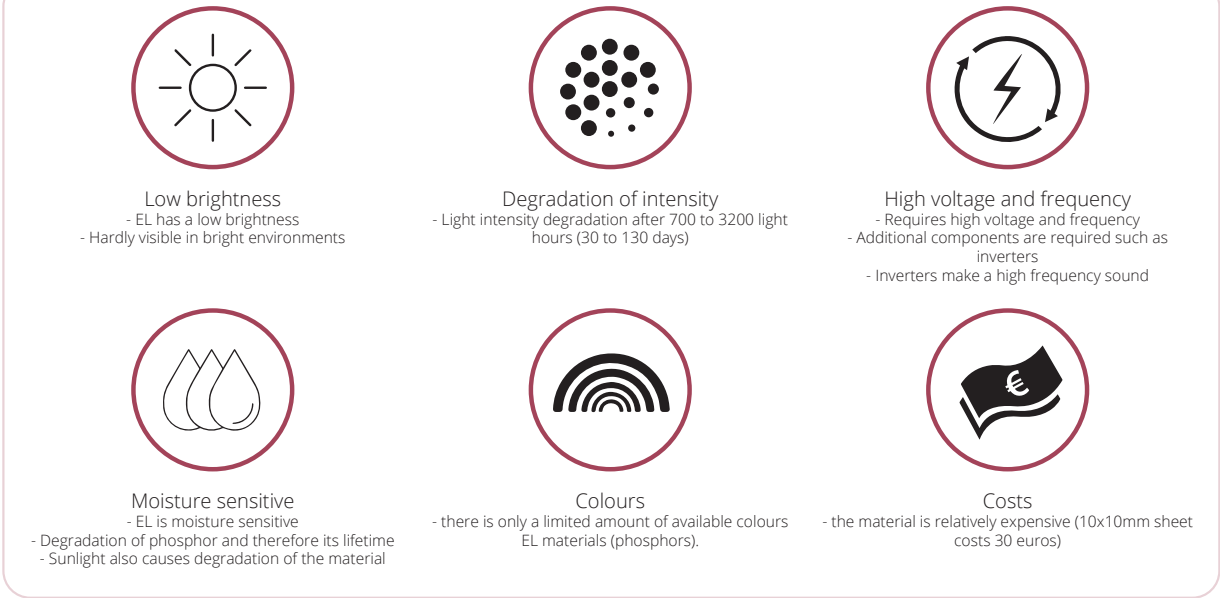
Several insights have been obtained from the tinkering process. First of all, the sample shows the ease of making complex shapes. Different rounding's and objects within the lighting area were included which shows the possibility of making an own design with only one EL material. Furthermore, the materials can be made very thin and is therefore very lightweight. Also, the material is flexible and makes it easy to bend and even fold the sheet without a material failure. Furthermore, the quality of the sample is experienced very low. Different light spots within the material were experiences which could be related the phosphor that was not evenly distributed during the building process. Additionally, the light intensity is also low which could be a difficult aspects for an actual integration of the material.

Design advantages & limitation

Material properties have been researched by a literature study and the tinkering process. From this analysis advantages and limitation have been found to be relevant for the design process. The main findings are summarized in the figure below.

Design advantages

Design limitations



Design advantages and limitations

Piezoelectrics

Piezoelectric materials are materials that can produce stress when a voltage is applied. Additionally, this can be translates to a vibration to give the user feedback. This is also known as haptic feedback. A large amount of piezoelectrics are currently used in buzzers (the materials vibrates on a certain frequency). However, few applications for haptic feedback has been found. Only a few specialized companies (e.g. MIDÉ engineering solutions) are specialised in the integration of piezoelectrics. However, the applications are not used for haptic feedback purposed but for cooling purposes (the vibration frequency causes a certain airflow).

Moreover, a batch of samples have been ordered from a company (Images SI Inc.) based in America in order to establish a tinkering process with piezoelectrics. Unfortunately, this batch was never delivered. Additionally, due to time limitations of the graduation project, piezo electrics were replaced with vibration motors in order to create the same effect.

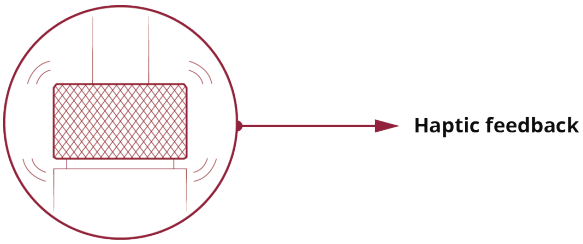
A simple prototype has been made from the knurl-knob with an integrated vibration motor (see figure below). The prototype gave a realistic feeling of what vibrations can do with a design. Additionally, the use of vibrations could be used as feedback and could therefore be relevant when continuing with direction 1.

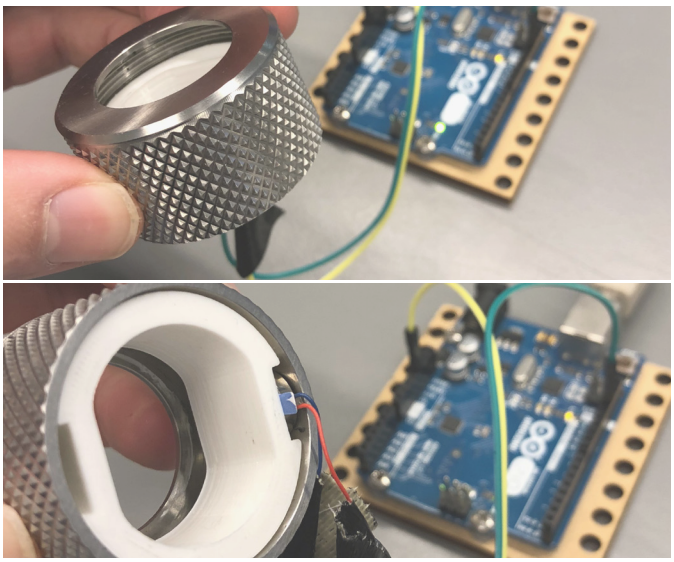
Thermochromics

Thermochromics are materials that change from colour when exposed to for instance water or sunlight. The use of these materials turn to an application that respond to water since this is one of the main elements that is used by the Quooker. When reflecting thermochromics from a critical perspective, it has been concluded that thermochromics are not widely applicable within this direction. The only location where thermochromics could be integrated is at the spout of the outlet which comes in touch with water. In addition, thermochromics only respond when it comes in touch with water meaning that it only will give feedback when for instance boiling water is already activated. Within these aspects, feedforward is more important than feedback since users can be alarmed before the action. In conclusion, thermochromics might not be relevant in direction 1 and might only be used as an extra feature which is rather a 'gimmick' than a functional addition.

Shape memory materials

Shape morphing products might be relevant for the direction ' design for (dis)assembly' and 'Scale control' in which the material can change from shape. Further research should be carried out in order to know whether shape morphing materials can be the solution in one of the two directions.





Testing with haptic feedback inegrated in the knurl knob

Testen with shape morphing materials

Appendix O - Expert consultations

In this appendix, all findings of the expert consultation will be presented. First, the outcomes of interviews with to experts from Quooker will be discussed. Second, outcomes from the three experts in the field of smart materials will be presented.

Scale control

In this part, more research will into the subject of scale deterioration. Two experts have been approached for an interview. Below, the main conclusion are stated. In the second part, interviews have been worked out.

The heat element & temperature sensor

The problem of scale deterioration was not only located in the heat element but was mainly caused by the relation between the heat element and the temperature sensor. Moreover, the heat element actually never breaks down which was initially anticipated. One of the experts thinks that the main problem can be solved by making a proper conductive material. With this in mind, it is questionable whether SMs will be still relevant within this topic.

Scale characteristics

Additionally, it appeared that different scale varieties have been found that are part of the problem. These scale varieties have different characteristics and therefore behave differently. Since the know-how on this topic is low, more research should be carried out. Questions like; "how do the different scale varieties attach on the heat element and rvs tube" and "why does scale type X attaches only on the heat element and scale type Y only at the RVS tube" would be relevant research questions. These aspects are not totally in line with the scope of the graduation project. The figure below shows some pictures of the scale problem. Note that different types of scale are clearly visible by the texture and colour (upper picture shows a reservoir used in Denmark, middle one is from Germany and bottom one is from the UK).

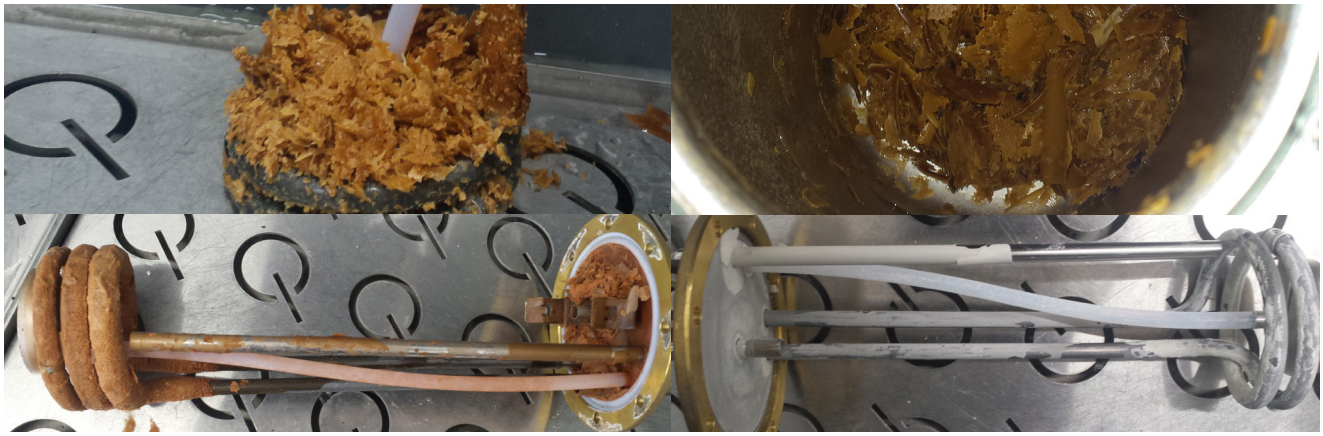
When analysing the insights gained from expert consolations it can be estimated that research in the above mentioned topics will result in additional time that is needed for research. Moreover, this will result in more delay of the project which is not preferred due to time limitations of the graduation project.

Interviews

Two experts of Quooker in the field of scale control has been interviewed to find out more about the characteristics of the current problem. For the interview (base on a semi structured interview), several questions were prepared that are stated below:

- what is scale?
- why is scale involved in heating reservoirs?
- how bad is scale?
- how tough is scale when it is attached on the heat elements?
- what are current methods of avoiding scale? (or other segments/markets)
- advise on the design direction

- Scale is a phenomenon that appears in water when changes appear in temperature or pressure. Scale is a hard and chalky deposit that for instance appears in electric kettles and hot water boilers. In addition, the structure of lime scale can be very different from one place to another. Therefore, it also shows different characteristics/properties. Some lime scales are for instance less hard and break off the heat element more easily.
- the main problem in the Quooker reservoir is actually not related to the heat element. However, the lime scale is built upon the heat element, but breaks off after a certain time period (based on the structure of the scale). In addition, the amount of lime scale falls down in the reservoir that slowly grows in size. The main problem right now is that the amount of scale built up and affects the sensor that determines the temperature inside the reservoir. When Scale has built up to the level of the sensor, the sensor is not able to measure the right temperature anymore which might result in an



internal error. Also, by the scale that is attached on the heat element, more energy is required to heat up the water to the same temperature since the scale kinds of insulates the heat element.
In order to solve the problem, lime scale need to be somehow removed from the reservoir. Currently, it would be very interesting to know how much scale is built up in the reservoir. Secondly, it is interesting to regulate to size of the lime scale. Based on this, it is interesting to find ways to make the lime scale "grains" smaller which makes them easier to dissolve.
- Currently, Quooker provides a scale control extension that extremely lowers the amount of scale that can be created inside the reservoir.

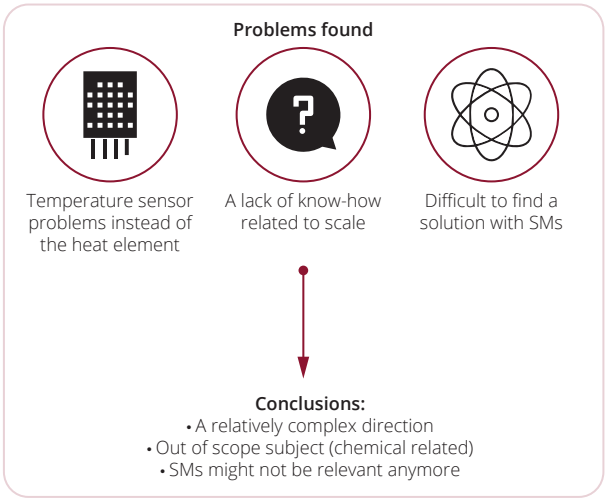
Second Interview with Employee Service & Repair

An expert of Quooker in the field of scale control has been interviewed to find out more about the characteristics of the current problem. An employee of Service & Repair has been interviewed. He works at the return and repair department and receives a lot of broken reservoirs that are affected by chalk. The following insight have been gained from this interview:

- most of the reservoirs that are broken down are coming from Denmark and the United Kingdom due to the bad water quality in these countries.
- There are a lot of different scale varieties. For example, In the UK, the scale is relatively thin but has really small grains. Moreover, the scale is most of the time attaché on the heat element only. In Denmark however, the scale is way bigger and can be seen as flakes. Moreover, the flakes are in general more attached on both the heat element but also the temperature sensor.
- the main problem why reservoirs detect an error is related to the temperature sensor. The temperature sensor measures the temperature in the bottom and upper part of the reservoir. By determine the temperature difference, the system know when to heat up the heat element and when not. Furthermore, the temperature sensor is placed in a small tube (RVS) which is a good conductor. When too much scale is attached on the tube, the scale works as a insulator and results in that the RVS materials won't be a good conductor anymore. Simultaneously, this results in that the sensors cannot measure the right temperature anymore which causes errors.
- when errors appear within 2 years, the end-user has the right to get a new reservoir from Quooker based on the two year of guarantee that is given by Quooker. Currently, this costs Quooker a lot of money which can be seen as a big problem.
- the sensor on the bottom part of the reservoir it precisely places above the heat element. This is very important since a small displacement of the sensor can already cause an error.
- also, scale builds up in the reservoir. After a few years (related to the region where the Quooker is installed) the amount of scale can be so much that result in the displacement of the sensor. As explained before, this results in errors.
- a relevant option for a smart material could be to think of holding the heat element and the sensor precisely in position. In addition, it is more relevant to think of other materials that avoid scale deterioration. The RVS tube could also be redesigned and bend.
- in general, we actually do not know everything of the scale appearance. There are so many different sorts that behave differently. In addition, we do not exactly know what causes the errors. Overall, making a solution in this segment might take a long time since it is a difficult topic where multiple people already have tried to find a solution.

Conclusion

Several conclusions can be made after the meetings that were held with the two experts. In general, it has been concluded that the direction of 'Scale control' is a very difficult direction which is related to three problems. First of all, the problem is bigger than initially anticipated. Moreover, the problem appeared to be a combination between the heat element and the temperature sensor and therefore the subject might be more complex. Secondly, a lack of know-how on scale results in additional time needed to fully understand the problem. Moreover, these topics are either very technical or chemical related which is out of scope of this graduation project (IDE aspects). Thirdly, after analysing the actual problem, it is questionable whether SMs will be still relevant within this topic which is an important criteria. An overall conclusion from this part will be made in the next chapter.



Appendix P - Expert consultations 2

Several experts with knowledge in the field of smart materials have been interviewed in order to make a validated decision on the design direction. In the previous phase, four different design directions have been selected that were derived from ideation-matrix. These four directions have been discussed with experts to find out whether the directions had any potentiality based on capabilities of smart materials.

Below several criteria have been formulated that were used as main questioned during the interview.

- potentiality of the smart material to be used in the proposed design direction
- commercially feasible (also based on technical and production aspects)
- realistic to make a proof of concept within two months?

Additional questions:
- do you have any experience with integrating the proposed smart materials? (pros and cons)
- do you have any other experts/ reference that I can use for further developments?
- what about patent regulations?

The four design directions are shown in the table below.

Expert 1:
Pim Groen Prof. W.A. (Pim) Groen
Professor of SMART Materials at Aerospace Engineering (AE) in Delft. Also Programme Manager of Holst Centre, TNO.
Interview on 11-7-2017

Direction 1
- Smart material are very applicable to use for feedback communication. In this direction, materials such as EL or OLED can be used to emit light and give feedback to the user.
- OLED: is a very new technology that is recently developed. In addition, it is actually underdeveloped and therefore relatively expensive for integration in a product. It will take up to 5 – 10 years before the OLED technology is fully developed and commercialized.
- EL materials disadvantages are that they make a high frequency sound which might be perceived as unpleasant. Moreover, they can't withstand high temperatures. This makes them relatively fragile for a long life span when integrating it in the Quooker product (material will be exposed to a lot of temperature changes/fluctuations).
EL also needs a high voltage input (200V) and creates a certain frequency (the unpleasant noise). This frequency is around 1 KH. Pim also explained that he founds the lumen output very low.
- Piezoelectric material can be used to use as haptic or taptic feedback.
- an advise is given to use EL materials to create a proof of concept only. Afterwards, for the real implementation on the market, OLED technology can be used to achieve the same result. Pim things that EL materials are already developed to a final stage in which no improvements will be made on the noise and life span of the material (or only small developments). However, OLED materials will be further developed the next 5 to 10 years and will result in a more high quality material.
- When Quooker is interested in materials such as the EL or OLED, it is possible to contact Holst BV (Pim Groen works here).

Direction 2
Direction 2 is a very risky and challenging direction. He questioned whether a full solution can be made since the Quooker consist of multiple components. When choosing this direction, a focus should be made on only one component otherwise it will be too challenging.

Direction 3
- this is a very interesting direction since no intentions on heat elements have been done in the last couple of years. Only coatings are being used in order to avoid the chalk deterioration, but this is not a "real" solution. The problem then only is postponed.
- keep in mind that the material only goes back to the original shape when the material is heated up. In a cold state, the material need to be moved again (it does not go back automatically).
- so far, the material has not found its real application in the market jet.

- the movement in cold state can be realized by for instance a spring or a mechanical motor. This could be more expensive, but is maybe cheaper than the amount of heat elements that are thrown away each year.
- this direction comes along with high risk since the solution can be guaranteed. When choosing this direction, it is possible that no result will be made to make improvements.
- the material is called Nitinol (NTI). You should do further research into this material to make a proper decision.
- you could also add an piezoelectric materials to create pulses in the heating elements to avoid chalk.

Expert 2:
Dr. ir. Tempelman, E.
Interview on 11-7-2017

During the conversation Erik Tempelman the focus was eventually mainly on the approach of how developing smart materials. Erik Tempelman has mainly be involved in the LTM project (light touch matters) and has a lot of experience with developing smart materials towards a commercialized solution. Main insights and feedback are stated below:
- the defenitiion of a material property is dangerous to discuss since people have different opinions about this. (designers see other materials properties important than material researchers)
- Also, take into account that smart material on its own can give the solution. A smart material needs to work in a system. In conclusion, a smart materials needs to have a "integration property"/ need to be integrated in a system to create an valuable action.
- keep in mind that the development of smart material integrated in a commercialized product takes on average three years.
- in order to make the development of smart material more successful, it is important to involves different people within the company (Quooker):
1) Procurement: people of this department need to be convinced by the idea and need to know whether sub-components and materials can be purchased for the amount that is needed.
2) Manufacturing engineer: the manufacturing engineer need to know whether the idea is able to produce (with current facilities) and fits the other components of the current design.
3) Senior designer: need to be convinced about the idea that fits the scope and vision of the product portfolio etc.
- try to use the LTM approach to continue with your graduation project. This is a very important approach that differentiates itself form the traditional way of design process we have learned in Delft. The LTM approach focuses on 1) specify, 2) create, 3) Analyse, 4) evaluate.
In general, it focuses on creating samples of smart materials to get familiar with the material. Moreover, the evaluation phase is important to reflect on the materials properties. As a next step, you are able to design with the gained knowledge and reflection to specify and detail the idea.
- the implementation of smart materials is in general underestimated. There is currently a large gap between the development of smart materials and the implementation.

Contact information:
AITO company are specialised in hatpic/taptic feedback people: Rene de Vries & Jockum Lonnberg (maybe misspelled)

For more help: "Maker lunch" faculty IDE (every Wednesday 12:30- 13:00)

Expert 3
Prof. dr. ir. Jansen, K.M.B.
Professor of Emerging Materials
Interview on 11-8-2017

Direction 1
Direction 1 is an interesting area which can be solved by thermochromics. This is an autonomous material that responses to temperature change without connecting it with electronics. EL is also a material that can be used, but is more fragile. Moreover, EL always needs to be connected to electronics which makes the system more fragile and sensitive for errors.
1.2 is more is more difficult. Only the feedback part can be done with smart materials. For measuring the amount of water or electricity, other sensors are required (but then smart material do not make any sense).

Direction 2
in this direction, smart material can make a difference, but it is advised to focus on one element only. The Quooker consist of multiple components that all need to be modified which could take a lot of time. Also the amount of impact that can be made in this direction might be lower compared to the other directions.
You could improve the assembling and disassembling by using shape memory allows by means of a snap connection.

Direction 3
this direction can be done by using shape memory alloys or polymers. Think of 2-way-shape materials. These are materials that can change their shape to their memory shape in two different temperature scenarios. You could also think of a Bi-metal, but this is not a smart material.
Start making samples to get more feeling of the material and make more profound decisions.

Direction	Viability	Rate	Feasibility	Rate
1	The solution is more based on market trends and would be an extension of functionalities/features that could be beneficial for the end-user.	3	Technical aspects of direction are estimated to be realistic	4
2	One of the main problems that need to be solved for the Quooker product. Therefore, this is an important aspects of the business goals.	4	Technical aspects of direction are estimatedto be very complex.	1
3	The solution is based on an internal 'problem' that could be improved (Improving (dis)assembly aspects). However, solving the whole problem takes relatively a lot of effort since the Quooker product consists of quite some parts that probably all need to be adjusted (not costs effective).	2	Technical aspects of direction are estimatedto be complex.	2

Overview of the ratings per direction

Appendix Q - List of requirements

Cluster	#	##	Requirement (R) / Wish (W)	Keyword	Describtion	Source	Test method	To be varified within this project
1. Performance								
	1,1		R	Electrically controlled	The cooled, sparkling and boiled water function should be electrically controlled.		Prototype test	yes
	1,2		R	Max 12V	The product operates on a maximum of 12V.	Norm study Quooker	Prototype test	yes
	1,3		R	Guarentee	Product should last for at least 5 years or 780.000 repetitions.	Internal analysis	Durability test	no
	1,4		R	Water resistant	The product should be water resistant.	Internal analysis	Prototype test	yes
	1,5		R	Max bend	The tap should have a maximum bend of 1 degree when a force of 8.8Nm is applied.	Norm study Quooker	Measurement with 'Faro meet-arm (Quooker)'	no
	1,6		R	Flow rate	The flow rate of cold warm and mixed water must be continuously adjustable.	Norm study Quooker	Flow rate test	yes
	1,7		R	Flow rate	The flow rate of boiling water should be at least 2.5 litres per minute and a maximum of 3.5 litres per minute (unless water pressure is less than 2 bar or higher than 2.6 bar).	Norm study Quooker	Flow rate test	no
	1,8		R	Flow rate	The flow rate of cooled and sparkling water should be at least 2.5 litres per minute and a maximum of 3.5 litres per minute (unless water pressure is less than 2 bar or higher than 2.6 bar).	Norm study Quooker	Flow rate test	no
	1,9		R	Flow rate	The flow rate of cold, warm and mixed water should be at least 7 litres per minute and a maximum of 15 litres per minute (unless water pressure is less than 2 bar or higher than 8 bar).	Norm study Quooker	Flow rate test	no
	2,0		R	10 years	Moving parts of the mechanism should be resistant to wear over the time period of 10 years (with an average total use of 20 minutes per day).	Norm study Quooker	Durability test	no
	2,1		W	Cold and warm	The cold and warm water functions should be controlled mechanically	Internal analysis		
2. Materials								
	2,1		R	Temperature	Components that come in touch with water from the Quooker reservoir should withstand temperatures from at least 110°C for a maximum of 5 minutes per 20 minutes.	Norm study Quooker	Material characteristics	yes
			R	Temperature	Components that come in touch with cold, warm or mixed water need to withstand at least temperatures between 4°C en 70°C.	Norm study Quooker	Material characteristics	yes
	2,2		R	Moisture	Materials and mechanism should withstand all forms of moisture.	Norm study Quooker	humidity test (48h) by KEMA Keur	no
	2,3		R	Liquids	Internal components of the mechanism that come in touch with water need to withstand water with the PH-value of a minimum of 5 and a maximum of 9.	Norm study Quooker	Material characteristics	yes
	2,4		R	Corrode	Materials do not have the characteristic to corrode or hold moist and bacteria's.	Norm study Quooker	Material characteristics	yes
	2,5		R	Water spillage	Water spillage is minimized to <1% of required amount	Norm study Quooker		no
	2,6		R	Material finish	The product should be available in three different finishes (e.g. chrome, brushed chrome and stainless steel.)	Norm study Quooker		no
			R	WRAS	Materials integrated in the tap that come in touch with water used for consumption need to be approved by WRAS (or a similar institution the country in question).	Norm study Quooker	Testing on NEN-EN 817:2008 – Artikel 5.1	no

3. Product use								
	3,1		R	Novice users	The product should allow novice users (not familiar with the Quooker product) to understand the product within 5 seconds with minimal instructions.	User tests	User test	yes
	3,2		R	Activate	The product should be able to activate the cold, warm, cooled, sparkling and boiled water function.	User tests	User test	yes
	3,3		R	Both hands	Both left handed and right handed people should be able to control the functions comfortably by as many test subjects as possible	User tests	User test	yes
	3,4		R	One hand	The product allows activation with one hand only.	Norm study Quooker	User test	yes
	3,5		R	Comfortable activation	Interface can be comfortably activated by users aged between 16-67 for 20 interactions a day by as many test subjects as possible.	User tests	User test	partly
	3,6		R		Elderly people aged above XX should be able to ...			
	3,7		R		Children aged below XX should be able to			
	3,8		R	Activation	A functions should be activated within 2 interaction steps.	User tests	Prototype	yes
	3,9		R	70°C	The outlet of the tap should not become warmer than 70°C (especially when boiling water is dispensed).	Norm study Quooker	Prototype	yes
	3,10		R	Robustness	Controlling the different functions should be experienced as robust.	Norm study Quooker	User evaluation	yes
	3,11		W	Amount of actions	The product should require a minimal amount of actions to activate a function.	User tests		
4. Product Interaction								
	4,1		R		The interaction should be intuitive.			
		4.1.1	R	More intuitive	The product interaction should be perceived more intuitive than the current interaction (first introduction of the Cube).	User tests	User evaluation	yes
		4.1.2	R	Selected function	The user should know which function is selected before the activation.	User tests	User evaluation	yes
		4.1.3	R	Distinction	The interaction of functions should have a clear distinction.	User tests	User evaluation	yes
		4.1.4	R	Increasing order	Functions should be categorized and communicated in an increasing and consistent order.	User tests	User evaluation	yes
		4.1.5	R	Intuition	Haptic and visual aspects should mainly be integrated for the selection phase of a function.	User tests	User evaluation	yes
		4.1.6	R	Red colour	The colour red should be used for either the warm or boiling water function.	User tests	User evaluation	yes
		4.1.7	R	Blue colour	The colour blue should be used for either the cooled or cold water function.	User tests	User evaluation	yes
		4.1.8	R	Green colour	The colour green should be used for the sparkling water function.	User tests	User evaluation	yes
		4.1.9	R	Urgency	The feedforward and feedback of the functions cold, warm, cooled, sparkling and boiling should be categorized from low to high urgency respectively.	User tests	User evaluation	yes
						User tests		
	4,2		R	Selection	The product should be able to let users make a selection before the activation.	User tests	Prototype	yes
	4,3		R	Boiling water	Two repetitive actions need to be established to activate the boiling water, unless the boiling water was dispensed less than 10 seconds ago.	Norm study Quooker	User evaluation	yes
	4,4		W	No looking	The user should be able to activate all functions without looking at the product.	User tests		
	4,5		W	Movement	People should activate a function with a downwards movement.	User tests		
	4,6		W	Line of sight	The action and reaction of a function should be in one line of sight.	User tests		
	4,7		W	Maintain functions	The cold, warm and boiling water functions should be maintained us much as possible.	User tests		
	4,8		W	Association	Feedforward and feedback communication should be associated with functions as much as possible.	User tests		

5. Safety								
	5,1		R	Children	Childers below the age of XX should not be able to activate the boiling water function.		User test	yes
	5,2		R	Hazard	No ragged or sharp edges creating a hazard for the user in normal use or during user maintenance.	Norm study Quooker	User test	yes
	5,3		R	Temperatures	No excessive temperatures above 44 degree Celcius should be experienced in normal use.	Norm study Quooker	User test	yes
	5,4		R	Temperatures	User touch parts should not exceed a temperature rise above the 44 degree Celsius.	Norm study Quooker	User evaluation	yes
	5,5		R	Burn	The product avoids the user to bring hand or arm in line with the boiling water outlet of the spout.	Norm study Quooker	User evaluation	yes
	5,6		R	Electric shock	The product should protect the user from getting an electric shock (class 1).	Norm study Quooker	Prototype	yes
	5,7		R	Accident	Functions cannot be activated accidently by the user during normal use.	Norm study Quooker	User evaluation	yes
6. Maintenance								
	6,1		R	Cleaning	The product should be able to be cleaned by hand with water or cleaning products.	Norm study Quooker	Prototype	yes
	6,2		R	Ingression	The product provides protection against harmful ingression of grease, acids or cleaning liquids (IP21).	Norm study Quooker	Prototype	yes
	6,3		R	Detachable	Product should be detachable for maintenance or replacement.	Internal analysis	Prototype	yes
	6,4		W	Maintenance	Maintenance should be as little as possible.	Internal analysis		
	6,5		W	Cleaning	The product should require as little cleaning as possible.	Internal analysis		
7. Aesthetics								
	7,1		R	Form language	The form language of the product should be in line with the current Quooker product range (minimalistic Jiri style).	Internal analysis	User evaluation	yes
	7,2		R	Stainless steel	Use Stainless steel 316 for steel parts.	Norm study Quooker	Prototype	yes
	7,3		R	Integrated in the tap	All functions should be integrated in the tap.	User test 1	Prototype	yes
	7,4		R	Logo	A Quooker logo need to be visible on the tap.	Norm study Quooker	Prototype	yes
	7,5		R	Colour and Texture	All visible parts must have the same colour and surface texture, unless the distinction is functional (e.g. use-cues)	Norm study Quooker	Prototype	yes
	7,6		W	Two types	The tap should be available in at least two form (squared & round) and finishes types (without the need of additional assembly steps)	Norm study Quooker		
8. Regulations								
	8,1		R	Wrong position	Fixing in wrong position of handles, knobs indicating position of switches or similar components is not possible.	Norm study Quooker	Prototype	yes
9. Production & Assembly								
	9,1		R	Integrated	Product should be attached or integrated to taps of the current product portfolio.	Internal analysis	Prototype	yes
	9,2		R	Current facilities	The product should be able to be produced with current production facilities of Quooker (Quooker in-house production policy)	Internal analysis	Prototype	yes
	9,3		R	Batch size	The product should be able to be produces at least 190 times per week (based on a sales target of 10.000 parts).	Internal analysis	Validation with Quooker expert	yes
	9,4		W	Parts	The product should consist of as little parts as possible	Norm study Quooker		
	9,5		W	Sharp roundings	The components that will be assembled should not contain sharp rounding's in which an assembler can hurt him or herself.	Norm study Quooker		

Appendix R - Research interaction design

In this part, a more thorough explanation will be given on the different levels of interaction. Additionally, the Quooker product has briefly be analysed based on the given information. Note that the Cube is related to the two additional functions that will be integrated (cooled and sparkling water).

Coupling between action and reaction

As described before, it is advised to reinforce a natural coupling by unifying the action and reaction as on many aspects as possible. However, a full unification might be difficult to achieve in some electronic products since in general more functionalities are involved. Moreover, this could be undesirable to achieve because intuitive interaction needs to be balanced with technology, ergonomics, production costs or aesthetics.
Overall, it is most important that the information that is given to the user is guiding the user's actions towards the intended functions. This is where feedback and feedforward comes in. Within these two aspects, three types of information can be distinguished and are related to 'functional', 'augmented' and 'inherent' aspects (Wensveen at all., 2004):

Feedback and feedforward

The aspects 'feedback' is a well-known design principle in interaction design. Feedback can be seen as a way of information return from the result of a process or activity. Within the field of interaction design, this seems to be interpreted as 'any type of returned information will do'. Moreover, feedback can be seen as information that occurs during or after the user's action. However, feedforward offers information before the action of the user. When reflecting the Cube, the most relevant information is positioned in the 'feedback' area (e.g. LED light turns on when activating a function). In the following parts, specific aspects of the Cube will be more elaborated.

Functional feedback

Functional feedback is related to information that is directly related to the function of the product. Functional feedback is therefore defined as the information generated by the system when performing its function(e.g. sound, light or motion). As one product can have multiple functionalities and features, functional feedback should be viewed in respect to the needs, intentions and desires of the user. It is the effect in the world the user wants to achieve. When functional feedback cannot be naturally coupled to the user's actions additional information is needed. The only functional feedback that appears from the Cube is the water that comes out of the spout. During this stage, the end-users sees and hears the water which can be seen as a form of feedback.

Augmented Feedback

Augmented is related to feedback that is not directly coming from the action itself (which is called inherent feedback), but from an additional source. Since the information is not coming from the action itself, but from an additional source, augmented feedback appeals more to the cognitive skills of the user instead of appealing to the perceptual motor skills. These aspects are usually added in products to inform the user about the internal state of the system (e.g. indication of stand-by, waiting, sleeping or processing). When analysing the Cube, the LED light can be related to augmented feedback. The light colours blue when activating the cooled or sparkling water function (note that the sparkling water function is a blinking light compared to the non-blinking light of cooled water). However, when activating the boiling water, the LED colours red.
When critically looking at the feedback of the LED, there is just a moment of feedforward given to the end-user. Moreover, the activations of the cooled, sparkling and boiled water consist of multiple actions. During the first action (just before the actual activation) the LED lights up. However, from the designers perspective, this all relates to feedback since the user is not able to make any selection or go back after the first time the LED lights up (there is one interaction flow for the activation where the LED reacts on).

Inherent Feedback

Inherent feedback is feedback that appeals primarily to the perceptual motor skills of the user and shows information that is returned from acting on the action possibilities. This can also be seen as feedback that is arising from the movement itself. Designers do not consider only the visual appearance of a control but also its sound, touch and feel. An example of inherent feedback from the Cube is related to the knurl-knob. In order to activate the different functions in the knurl-knob, the knob need to be moved (double-push-turn for boiling water). This action need to be established for both the activation and deactivation of a function and is related to inherent feedback since the end-user feels a certain force/resistance while operating the knob. The same however counts for the activation of cold and warm water. In this case, end-users are stimulated to turn the handle from the cold to warm position. Activation is done by pulling up the handle. Both actions give the end-user a certain feeling which can be relate to inherent feedback.

Functional Feedforward

Functional feedforward goes beyond the action possibilities and their specific purpose and instead informs the user about the more general purpose of a product and its functional features. Therefore, these aspects can be more related to for instance product semantics and on making functional parts visible in the product. This could help the user about the functionality

of the product. After analysing the Cube, it appeared that no functional feedback is currently included.

Augmented Feedforward

Augmented feedforward is related to information that the user receives from an additional source about the action possibilities, or the purpose of the action possibilities which appeals to his cognitive skills (for example through words, pictograms or spoken words). For the Cube, no augmented feedforward is included.

Inherent Feedforward

Inherent feedforward, like inherent feedback is related to the action possibilities of the product and the perceptual motor skills of the person. It is the information that communicates what kind of action is possible (pushing, rotating, sliding) and how this action can be carried out (the amount of force that is possible, which parts of the body etc.). Again, both the handle and the knurl-knob are clear examples of inherent feedforward. First of all, both elements can be seen as a use-cue since it directs the end-user towards a certain interaction. The surface finish of the knurl-knob clearly communicates that functionalities can be activated from this knob (visual appearance). Also, touching the knob communicated a certain quality (or a certain urgency level) which might be corresponding to a more special function like for instance boiling water. Moreover, the circular shapes of both the handle and the knob communicates turning possibilities to the end-user.

Conclusion

In this Appendix, a literature study have been established and helped to get a deep understanding of interaction design which is a very important aspect in de chosen design direction. First of all, it has been concluded that it is important to involve intuitive aspects in the design of the tap in order to avoid dangerous situations and let end-users smoothly use the tap at any time.
For an intuitive design, it is important as a designer to exploit the users pre-existing knowledge by looking for familiar interaction patterns. The Quooker Cube is not a totally new product that will be introduced on the market. However, only additional features such as sparkling and cooled water will be added. Other taps already involve cold, warm and boiling water with a specific interaction patterns (e.g. the double-push turn button). These interactions with the previous introduced functionalities need to be taken into account for the feature that will be designed in this project. Therefore, it is concluded that the existing interactions of functionalities will probably be carried out in the same way in the new design in order to avoid confusion to the user. Changing the existing interaction might result in more confusion and therefore dangerous situations which need to be avoided. Additionally, other pre-existing knowledge of the user needs to be investigated as well (this will be researched during a user test in a next chapter). Additional literature studies from Wensveen, et all showed a framework of aspects that can be used to make a design more intuitive. Within the six aspects that were given, it is important to find a certain unity between the action of the user and the reaction of the feature. Furthermore, the information that is given to the user should guide the user's actions towards the intended function. This can be achieved by using feedback and feedforward which exist of aspects that can be used to create a well interaction framework.

The Cube has further been analysed according to the gained knowledge of interaction design. Several conclusions can be made. First of all, it has been concluded that the total amount of feedforward and feedback is very low. Only the LED light is added in the design in order to communicate the different functions. Moreover, it has been analysed that this LED light is based on feedback and not feedforward. From the designers perspective, feedforward might be more useful since end-users will be informed about their actions before they actually activate a function such as boiling water. The difference between feedforward and feedback should therefore be research in a user test. Conversely, it is also understood why the Quooker tap includes few feedforward and feedback aspects. This probably has to do with the aesthetic value that Quooker wants to express. The more aspects are integrated in the tap, the less minimalistic the tap probably will be experienced (see chapter; product portfolio for a better understanding of the form language of Quooker). Furthermore, it is also concluded that the difference in activating the three different functions are quite similar to each other which might be perceived confusing.

As an overall conclusion, it is seen that the Cube is missing aspects in order to make the design fully intuitive. Therefore, it has to be find what kind of aspects need to be used and integrated in order to integrate the five function in an intuitive way. These aspects will be further research in the next chapters.

Appendix S - User test 1; Position & Location

In this Appendix, user test 1 will be more elaborated. First the research questions, method and procedure will be described. Second, a summarized overview of the outcomes will be presented. Last, notes that were made during the test have been described as well.

Research question

The goal of this user test is to find out how to communicate five different functionalities in more intuitive way. For this, two different research questions are formulated:

1. What is the preferred position of the five functions?
2. How are different interactions experienced?

Method

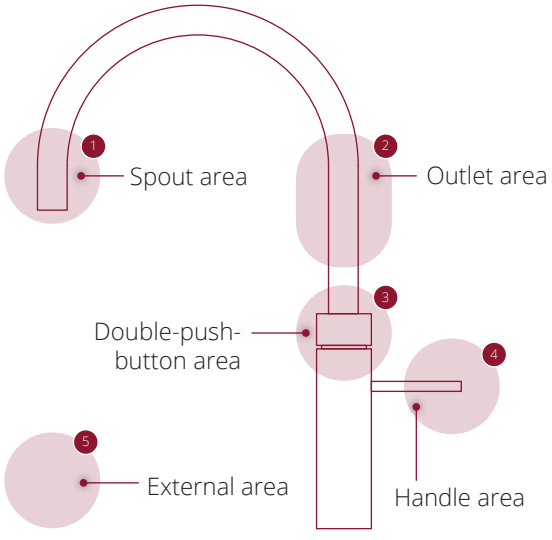
The user test was divided in two different parts which are related to the above mentioned research questions. In the first part, several concepts were used to validate the different positions of the five functionalities. As being explained before, the five different functionalities include cold, warm, boiling, sparkling and cooled water. In the second part, several 'options' of interactions were being carried out and validated by participants.

In total, ten participants were involved in this user test. Additionally, this group of participants were divided in two equal groups; group 1: five participants that are familiar with the Quooker tap (all employees at Quooker BV) and group 2: five participants without any pre-knowledge of the Quooker tap. Note that the aspects of pre-existing knowledge is important to take into account since it can influence the results of the user test (see chapter Interaction design). Moreover, taking into account the pre-existing knowledge of end-users has led to the decision to keep the cold, warm and boiling water function unchanged. Therefore, both the location and the interaction for these functions were kept the same in order to avoid more confusion. Additionally, only the sparkling and cooled water functions (the special functions) were changed in the concepts.

Three different models were used to let participants interacts with the five different functionalities. For this, three models were made (see figure below) in which the five functionalities were integrated. Note that these models do not stand for the three different concepts. They only act as models to symbolize the different positions that could be made.

The models were created by categorizing the functions on safe and unsafe scenarios. In addition, these functionalities were positioned at different parts on or around the Quooker tap.
Model 1 was related to the Quooker tap that will be introduced in 2018 which is called the 'Cube'. Therefore,

Concepts	Seperated functionalities	Area
Model 1; *Combine*	C W	4
	CL SP B	3
Model 2; *Safe and unsafe*	B	3
	C W CL SP	4
Model 3; *Seperate*	B	3
	C W	4
	CL SP	2 & 5



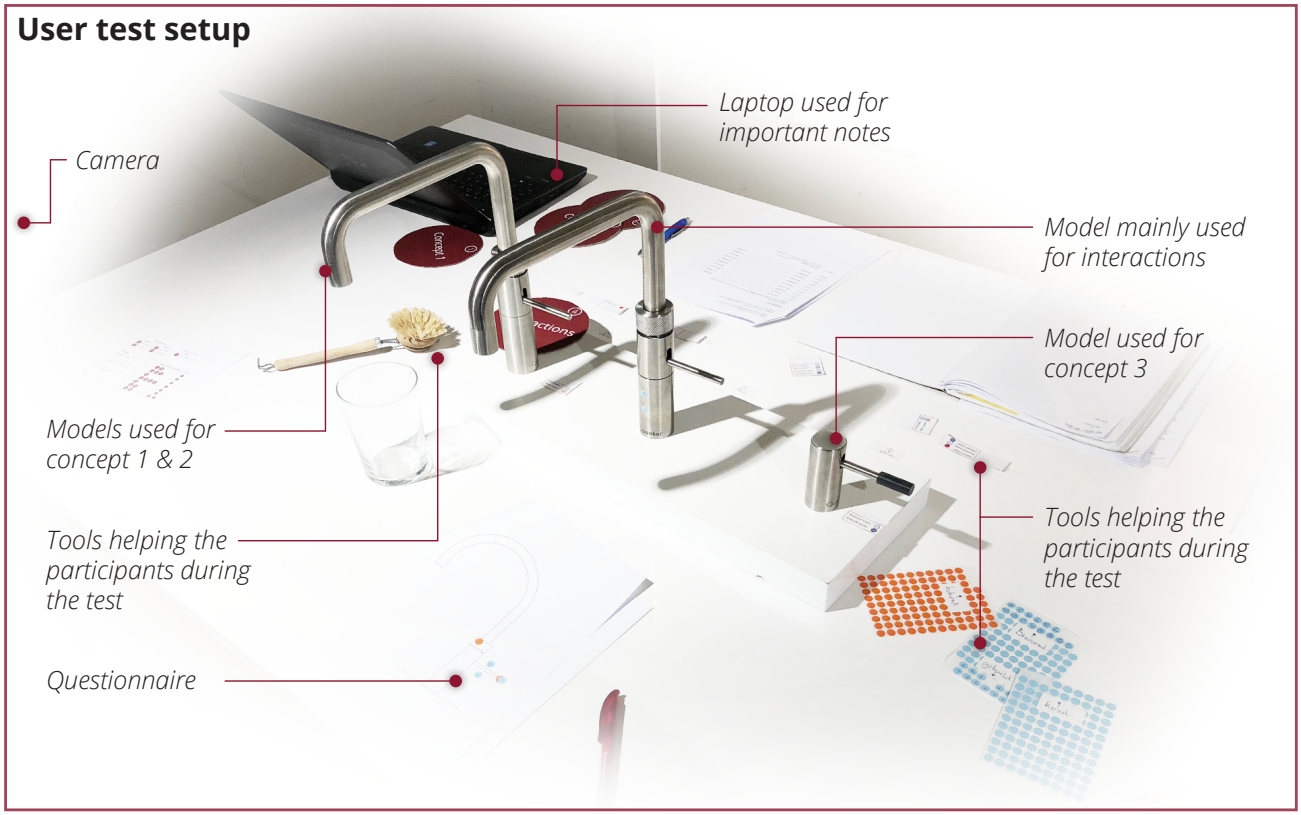
Safe scenarios

Regular
- C Cold water
- W Warm water

Specials
- CL Cooled water
- SP Sparkling water

Unsafe scenarios

Boiled
- B Boiling water



User set up

this concept can be seen as the null-situation or reference model.
In concept 2, the special functions were placed in the handle instead of the knurl-knob. The selection and activation of the special functions were made by 'rotating' the handle. In the third concept, the special functions were separated from the tap. In this concept, the special functions were placed in an external control device.

In order to validate the different positions of functionalities, a questionnaire was used (see followed up pages). In this questionnaire, open questions were asked. Additionally, participants were asked to give a rating for every question in order to stimulate them to think more thoroughly about their decision. Moreover, in this way it was easier to reflect concept 2 and 3 with the null-situation (concept 1).

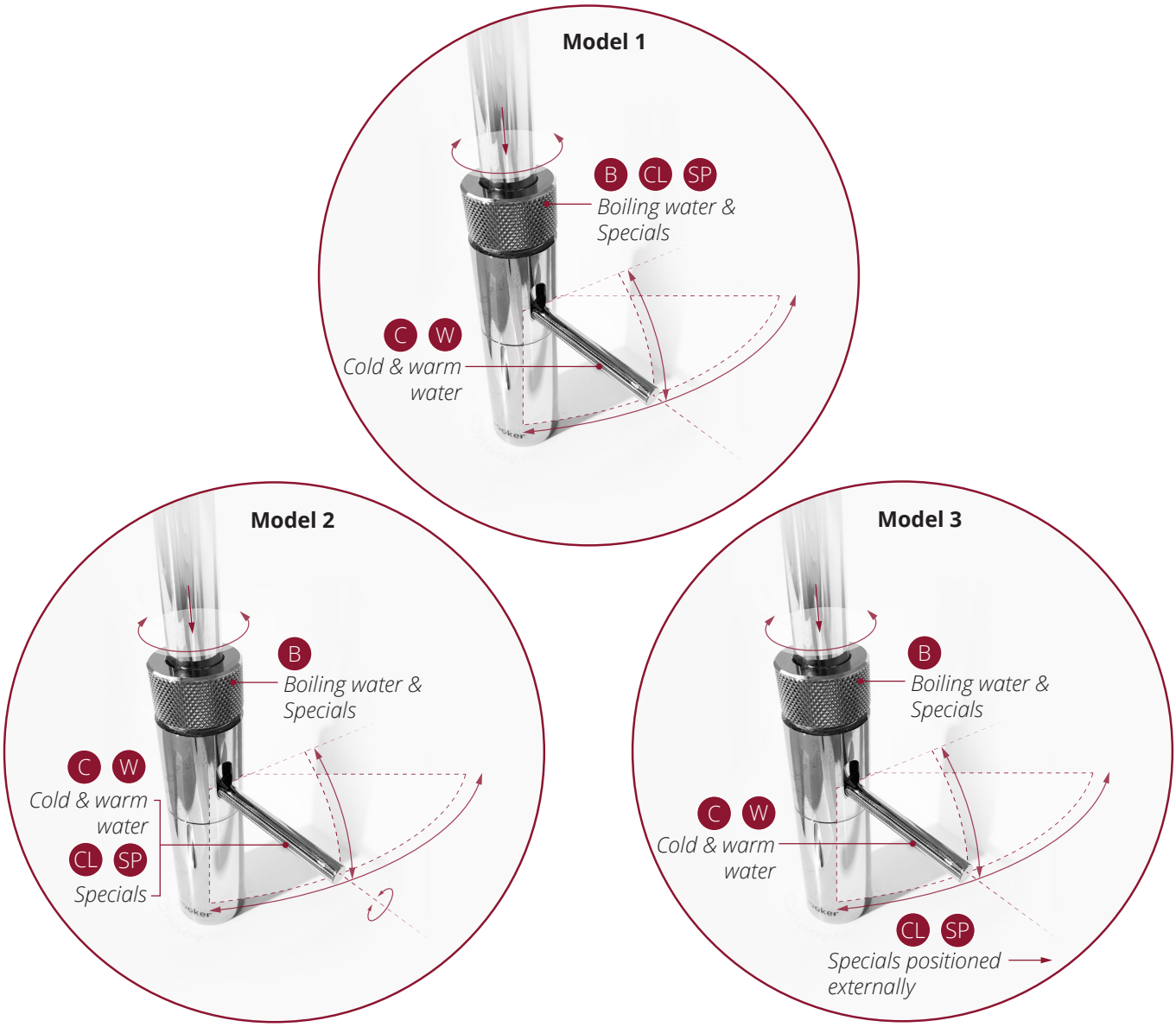
In the second part of the user test, ten different interactions were validated by participants in order to find out the preference of different interactions that were related to the different functionalities. These interactions were related to pushing, pulling, lifting, rotating/turning and moving interactions.

In order to let participants feel at ease and familiar in the context of using the different functionalities, several pre-actions were asked to be carried out before all the parts of the user test. For example, participants were asked to pour a cup of tea or wash their hands to get familiar with the positions and interactions of the different concepts. Also, participants were helped with different tools describing which functions were positioned at what location (see figure above).

Results (summarized)
In this part, results of the user test are described. As being explained before, the user test was a qualitative test in which participants filled in a questionnaire giving a rating to the questions. In addition, for every question, participants were asked why they choose that rating in order to start an open discussion. Therefore, the results are two folded. First of all, the ratings gave a first impression how different positions of functionalities and interactions of the concepts were experienced (note that the outcomes and/or statements made in this part are not grounded due to the small number of participants). Second, the open discussion resulted in personal arguments and/or quotes.

Validation of boiling, sparkling and cooled water function (the Cube)
First of all, the outcomes revealed that the three functions integrated in the knurl-knob are generally experienced too confusing. This is related to the combination of safe and unsafe functions. In addition, the interaction of function in the knurl-knob are almost similar to each other which is confusing.
"ones I did boiling water in my cup which was already filled with 'ranja'", said participant 2 (group 1). The rating in result table also revealed this. Here, the interaction of the Cube was scored second last (option 7).
Additionally, results show that there is a clear difference

between ratings given by familiar Quooker users (group 1) and participants that are not familiar with the Quooker tap (group 2). Participants in group 1 score concept 1 on both an intuitive position and interaction relatively higher compared to participants from group 2. This is respectively 4.8 over 3.8 for position and 4.6 over 2.6 for intuitive design (See table results on the adjacent page).
Furthermore, it seems that there is no problem with the position and intuitive interaction of the functions cold, warm and boiling water. This can be related to the fact that cold and warm water is something coming from pre-existing knowledge as participant 6 explained: "***the interactions of warm and cold water need to be maintained because I am really familiar with these interactions".*** The same appeared for the boiling-water function. However, this was in general experienced by participants from group 1.
Moreover, most of the participants (both from group 1 & 2) experienced the activation of the boiling-water function in a logical way. "The activation of the boiling-water function is most difficult of all functions, but really fits the function of boiling water because boiling water is very dangerous. Therefore, this interaction can be made more difficult". Furthermore, the interaction was also experienced to pre-existing knowledge as participant 10 explained: ***"The interaction is related to the opening of a chemical bottle which is also integrated with a childproof cap".***
Several participants from group 1 explained that they do not prefer the activation of the sparkling water in the Cube. This



Above, an overview is given of the three different models that have been used which included different positions of functions. Note that the position and interaction of model 1 is equal to the tap that Quooker will introduce on the market. Therefore, this model can be seen as the null-situation and is used as comparison model.

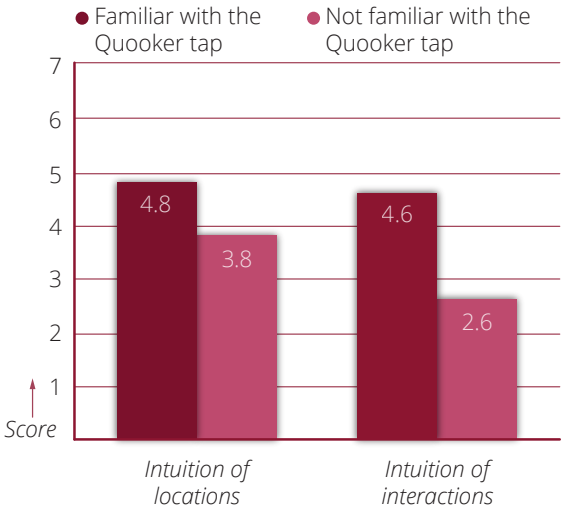
is related to the fact that they need to push down the knurl-knob for a relative long time (about 1 second) before a reaction was made by the product (seen as feedback). However, one participant from group 2 explained a logical way of interaction: "it feels like you inject CO2 when pushing down the knurl-knob for a second which feels logical to the function".

Validation of concept 1, 2 & 3
Concept 2 was preferred most with respect to the intuition of the location(sparkling and cooled water integrated in the handle) (Concept 2, 3 and 1 with respectively scores of 5.3, 4.6 and 4.3). Furthermore, concept 3 was preferred most with respect to the intuition of interaction (Concept 3, 2 and 1 with respectively scores of 5.0, 4.6 and 3.6). However, participants from Quooker preferred concept 2 over concept 3 on this topic.

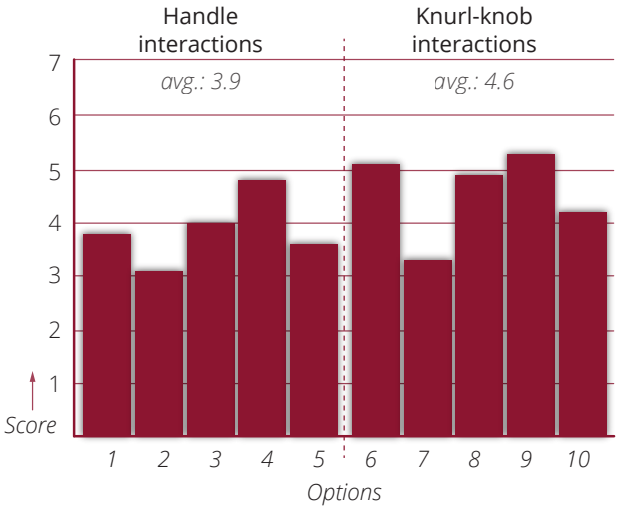
Validation of Interactions
In general, participants preferred a one-step activation, expect for the boiling-water function. For the boiling-water activation, participants in general prefer to make a selection first before the activation (two-step activation). Other participants also described the downside of a one-step activation. ***"When I make a mistake during my action, the function will be 'spilled' since there is no turning back anymore"*** as participant 7 described.

Participant 10 explained that the interaction also might be related to the purpose of the function. "I would like to interact easily with a function when a function is used often". This participant also explained that she would like others to use a function/the tap when you have for instance people over at your home. In this scenario, functions need to be well understood, also by people who are not familiar with the Quooker product as she explained: ***"you don't want to be the only one who can control the Quooker tap when you have a birthday party at your home".*** She also described: "the less a function is used, the harder it is to remember the way of interaction for that particular function".
However, participant 2 explained that for certain 'special' functionalities such as the sparkling and cooled water, the interaction can be made special as well. ***"the interaction with a function can be made 'special' when the function itself is also 'special'"***, said participant 2.
Participant 1 described her thoughts related to the positions and interactions of functions. First of all, she explained that the size of the handle was not representing the four different functions from concept 2. Second, she described that she prefered a solution that avoids the scenario of keeping your hand underneath the spout. "When activating a function, I'm afraid of keeping my arm underneath the spout", said participant 2. She also explained that she preferred to have both the action and reaction in one line of sight. Furthermore, she coupled the interaction (the activation) of 'rotation' to the

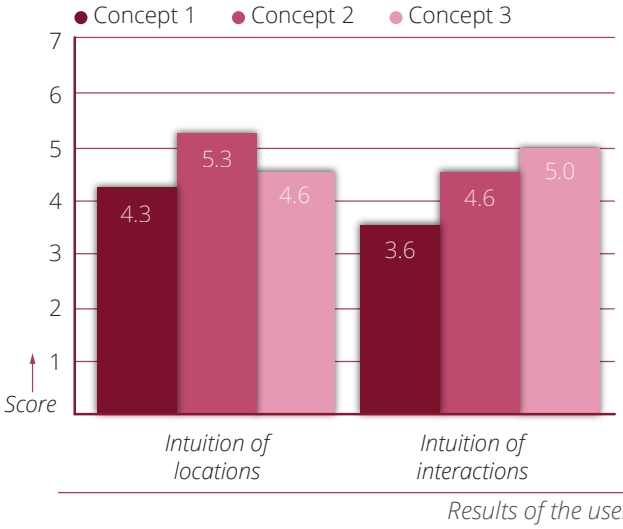
Rating of location & interaction of the Cube



Rating of interaction options



Rating of concept 1, 2 & 3



Results of the user test

opening of an 'regular' water tap which can be related to pre-existing knowledge. However, other participant related the rotating interaction to the interaction of 'selecting' something.

Results (notes taken during the user test)

In this part, results of the user test are described. As being explained before, the user test was a qualitative test in which participants filled in a questionnaire giving a rating to the questions. In addition, for every question, participants were asked why they choose that rating in order to start an open discussion. Therefore, the results are two folded. First of all, the ratings give a first impression how different positions of functionalities and interactions of the concepts are experienced (note that the outcomes and/or statements made in this part are not grounded due to the small number of participants). Second, the open discussion resulted in personal statements and/or quotes.

When first analysing the results of the 'Cube', it can be seen that the position and interactions score relatively low. This is related to the following outcomes:

- three functions integrated in the knurl-knob are generally experienced too confusing due to:
    - interaction are almost similar to each other. (same way of moving/activating (s-shape), only small variations in time and repetition)
    - unsafe functions (boiled water) are combined with safe functions (sparkling and cooled water) "ones I did boiling water in by cup which was already filled with 'ranja'": explained by participant 2.
- the interactions in which boiled, sparkling and cooled water are combined, scored second last (Option 7 in table results).
- there is a clear difference between scores given by familiar Quooker users (group 1) and participants that are not familiar with the Quooker tap (group 2). Participants in group 1 score concept 1 on both position and intuitive inaction relatively higher compared to participants in group 2. This is respectively 4.8 over 3.8 for position and 4.6 over 2.6 for intuitive design (See table results).
- Some participants experienced some difficulties and therefore confusion when interacting with the cold and warm water handle since no use cues are used.
- it seems that there is no problem with the position and intuitive interaction of the functions cold, warm and boiling water. This can be related to the fact that cold and warm water is something coming from pre-existing knowledge as participant 6 explained: "the interactions of warm and cold water need to be maintained because I am really familiar with these interactions". The same appeared for the boiling-water function. However, this was in general experienced by participants that were already familiar with the Quooker tap.
- Moreover, most of the participants (both familiar and not familiar with the Quooker tap) experienced the activation of the boiling-water function in a logical way. "The activation of the boiling-water function is most difficult of all functions, but really fits the function of boiling water because boiling water is very dangerous. Therefore, this interaction can be made more difficult". Furthermore, the interaction was also experienced to pre-existing knowledge as participant 10 explained: "The interaction is also related to the opening of a chemical bottle which is integrated with a childproof cap".
- Several participants from group 1 explained that they do not prefer to activation of the sparkling water in the Cube. This is related to the fact that they need to push down the knurl-knob for a relative long time (about 1 second) before a reaction is made by the product (feedback). However, one participant from group 2 explained a logical way of interaction: "it feel like you inject CO2 when pushing down the knurl-knob for a second which feels logical to the function".

When reflecting on the ratings given by participant, the following results can be described:

- participants prefer a one-step activation, expect for the boiling-water function. For the boiling-water activation, participants in general like to make a first selection before the activation (two-step activation). Other participants also described the downside of a one-step activation. "When I make a wrong action, the function will be 'spilled' since there is no turning back anymore" as participant 7 described.
- Concept 2 was preferred most related to the position of functions (sparkling and cooled water integrated in the handle) (First concept 2, 3 and 1 with respectively scores of 5.3, 4.6 and 4.3).
- Concept 3 was preferred most related to an intuitive interaction (First concept 3, 2 and 1 with respectively scores of 5.0, 4.6 and 3.6). However, participants from Quooker preferred concept 2 over concept 3 on this topic.
- the experience with the knurl-knob is preferred for the special functions compared to the interaction with the handle when combining multiple functions (See ttable results). The interactions with the knurl-knob have a score of 4.6 compared to 3.6 of the interactions with the handle.
- the highest score for interaction is related to option 9; selecting using the knurl-knob and activating by pushing the handle down. Activating by pushing down has the highest score within the segment 'Handle interactions' (option 4).
- using two buttons to make a selection for sparkling or

cooled water scores second best (option 6).
- selecting and activating with the knurl-knob scores third best (option 8)
- most of the participants explained that they experience a less intuitive interaction when sparkling and cooled water is integrated.
- the boiling-water function scores higher when it is integrated as a standalone function. Conversely, when multiple functions are integrated in one component, then the functions scores lower.
- in general, it can be seen that the interaction becomes more intuitive when less functions are integrated in one component (e.g. only boiling water in the knurl-knob is seen as an intuitive interaction)
Lastly, the open discussion resulted in additional results described below:

- during the open discussion, several participants mentioned the different layers in which functionalities could be categorized. Functionalities could be separated from each other by thinking of the aspects safe/unsafe, temperature range, amount of use etc. In general, cooled water has been seen as an extension of cold water. Furthermore, sparkling water has been seen as really something special.
- it was also mentioned that it was preferred to activate a function only in one way (e.g. integrated the specials in the handle might result in the possibility to get warm sparkling water which is not preferred).
- Several participants also described their thoughts on interactions with the tap. Participant 10 explained that the interaction also might be related to the purpose of the function. "I would like to interact easily with a function when u function is used often". This participant also explained that she would like others to use a function/the tap when you have for instance people over at your home. In this scenario, functions need to be well understood, also by people who are not familiar with the Quooker product as she explained: "you don't want to be they only one who can control the Quooker tap when you have a birthday party at your home". She also described: "the less a function is used, the harder it is to remember the way of interaction for that particular function".
However, participant 2 explained that for certain 'special' functionalities such as the sparkling and cooled water, the interaction can be made special as well. "the interaction with a function can be made special when the function itself is also special", said participant 2.
- Participant 1 described her thoughts related to the positions and interactions of functions. First of all, she explained that the size of the handle was not representing the four different functions from concept 2. Second, she described that she prefers a solution that avoids the scenario of keeping your hand underneath the spout. "When activating a function, I'm afraid of keeping my arm underneath the spout", said participant 2. She also explained that she preferred to have both the action and reaction in one line of sight. Furthermore, she coupled the interaction (the activation) of rotation to the opening of an 'old' water tap which can be related to pre-existing knowledge. However, other participant related the rotating interaction to the interaction of making a selection.
- In general, using two different button to select either sparkling or cooled water was positively reflected related to an intuitive design. However, most of the participants doubted whether this solution would be aesthetically responsible.

Participant no. : Male / Female Age: Familiar Quooker user: yes/no

Concept 1

Vraag 1.1 (concept 1)
*Zitten de verschillende functies voor je gevoel op de **juiste positie**?*

Geen goede positie 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Goede positie

Vraag 1.2 (concept 1)
***Hoe intuïtief** is de combinatie van handelingen bij elkaar?*

Niet intuïtief 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 zeer intuïtief

Vraag 1.3 (concept 1)
*Vind je de volgende **handelingen passen bij de functie**?*

Koud water	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Warm water	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Kokend water	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Bruisend water	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Gekoeld water	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend

Showing the questionnaire that has been used during the user test (stimulus)

Concept 2

Vraag 2.1 (concept 2)
Zitten de verschillende functies voor je gevoel op de juiste positie?

Geen goede positie 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Goede positie

Vraag 2.2 (concept 2)
***Hoe intuïtief** is de combinatie van handelingen bij elkaar?*

Niet intuïtief 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 zeer intuïtief

Vraag 2.3 (concept 2)
*Vind je de volgende **handelingen passen bij de functie**?*

Koud water Niet passend 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Zeer passend

Warm water Niet passend 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Zeer passend

Kokend water Niet passend 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Zeer passend

Bruisend water Niet passend 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Zeer passend

Gekoeld water Niet passend 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Zeer passend

Concept 3

Vraag 3.1 (concept 3)
*Zitten de verschillende functies voor je gevoel op de **juiste positie**?*

Geen goede positie 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Goede positie

Vraag 3.2 (concept 3)
***Hoe intuïtief** is de combinatie van handelingen bij elkaar?*

Niet intuïtief 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 zeer intuïtief

Vraag 3.3 (concept 3)
*Vind je de volgende **handelingen passen bij de functie**?*

Koud water Niet passend 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Zeer passend

Warm water Niet passend 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Zeer passend

Kokend water Niet passend 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Zeer passend

Bruisend water Niet passend 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Zeer passend

Gekoeld water Niet passend 1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7 Zeer passend

Positie en functie

Vraag 1.1 (Positie en functie)
*Welke functies moet **gescheiden** worden van elkaar?*

Vraag 1.2 (Positie en functie)
*Welke functies moeten volgens jou **gecombineerd** worden?*

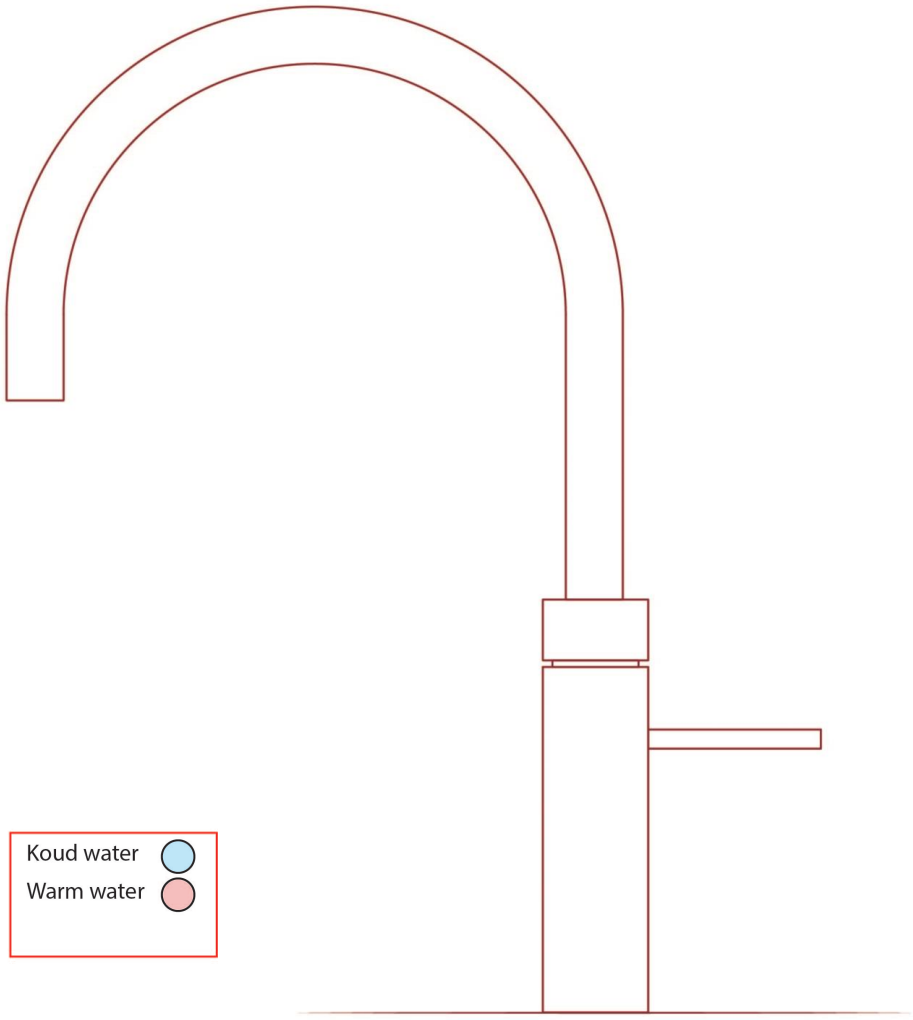
Interactie

Vraag 1 (Interactie)
*In hoeverre past de **manier van handelen** bij de functies bruisend en gekoeld water?*

Optie 1	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Optie 2	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Optie 3	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Optie 4	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Optie 5	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Optie 6	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Optie 7	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Optie 8	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Optie 9	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend
Optie 10	Niet passend	1 ——— 2 ——— 3 ——— 4 ——— 5 ——— 6 ———7	Zeer passend

Optie 11 Omcirkel je voornaamste voorkeur: optie 1 / optie 2
Optie 1: directe reactie na actie (1 stap)
Optie 2: eerst een selectie maken, dan een actie (2 stappen)

Participant no.:



An illustration of the Quooker tap. Participants were able to make their 'own design' by pasting in stickers of the different functions on the illustration.

Concept 1

Kokend water

Bruisend water

Gekoeld water

Koud water

Warm water

Concept 2

Kokend water

Koud water

Warm water

Bruisend water

Gekoeld water

Concept 3

Kokend water

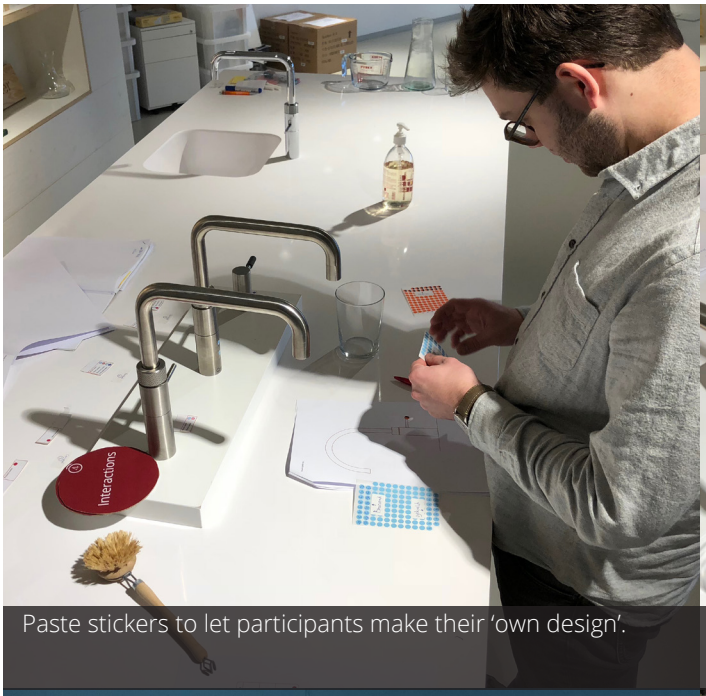
Koud water

Warm water

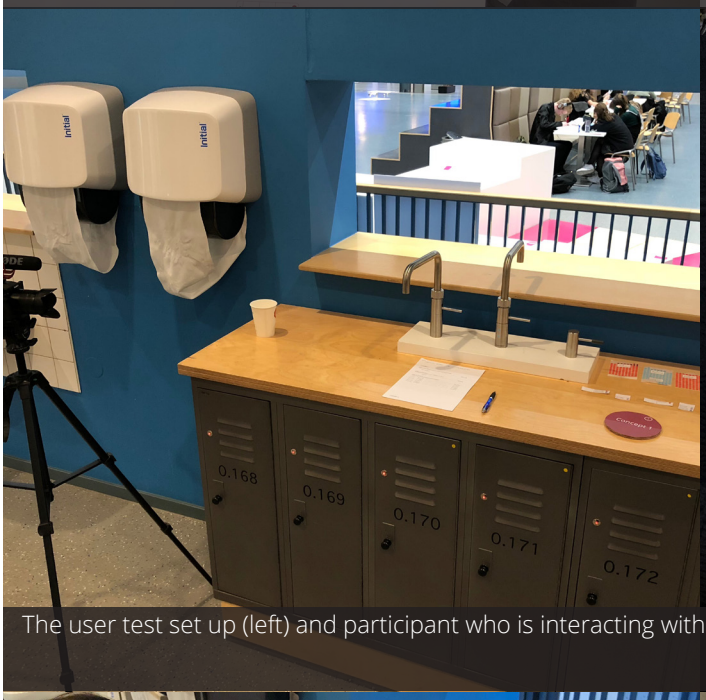
Bruisend water

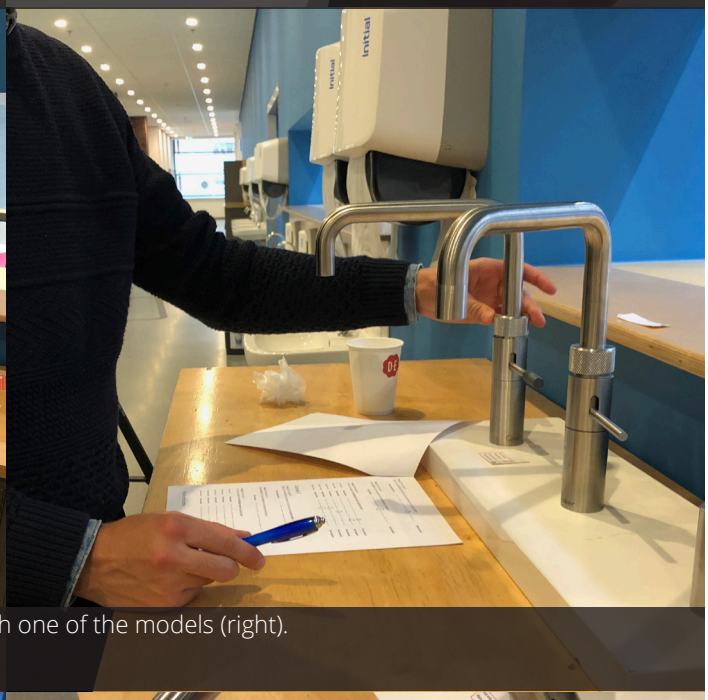
Gekoeld water

These cards were used for the different models in order to help participants help to remember which function was positioned at what place.



Paste stickers to let participants make their ‘own design’.



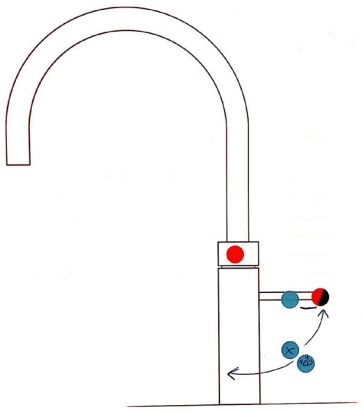


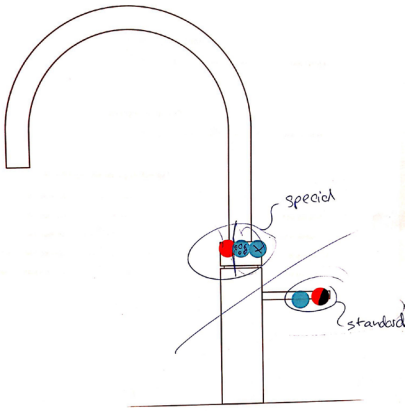
The user test set up (left) and participant who is interacting with one of the models (right).

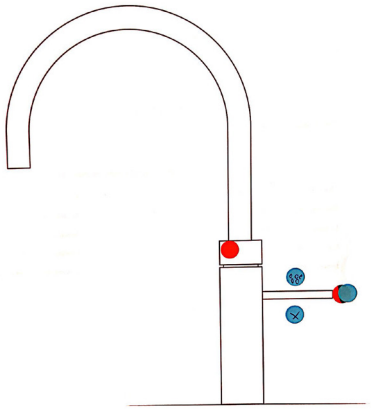
Participant filling in the questionnaire (left) and participant making notes while making an ‘own design’ (right).

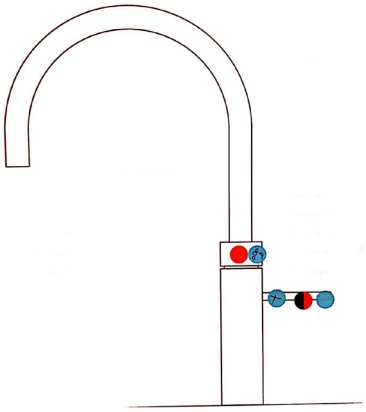
#	Gender	Age	with Quooker	1.1	1.2	Cold	Warm	Boiling	Sparkling	Cooled	2.1	2.2	Cold	Warm	Boiling	Sparkling	Cooled	3.1	3.2	Cold	Warm	Boiling	Sparkling	Cooled	1	2	3	4	5	6	7	8	9	10	Option	position	intuition
1	Male	22	yes	5	5	6	6	4	4	5	6	6	6	6	6	5	6	6	6	6	6	6	5	6	5	4	6	5	5	5	5	3	4	2	2 en 3	4.3	3.6
2	Male	23	yes	3	6	7	7	2	2	2	3	3	5	5	3	3	3	5	6	7	7	2	2	2	4	2	3	3	2	4	4	3	3	1	1	3	1 en 3
3	Male	31	yes	6	5	7	7	7	5	5	7	7	7	7	7	7	6	7	5	7	7	7	5	6	5	3	6	3	6	6	6	6	6	1	1	2	2
4	Male	28	yes	5	5	7	7	7	5	6	6	6	7	7	7	5	6	3	4	7	7	7	5	6	4	4	5	4	4	5	5	5	5	1	2	2	2
5	Male	27	yes	5	2	7	7	5	3	3	6	4	7	7	5	1	1	5	4	7	7	5	2	2	2	1	2	3	1	6	2	7	5	1	2	2	2 en 3
6	Female	23	no	5	2	7	7	5	4	5	3	4	7	7	5	6	6	6	6	6	6	6	6	6	4	5	3	2	4	5	3	5	4	3	1	3	3
7	Male	22	no	5	3	3	3	6	6	2	5	5	3	3	6	4	4	6	5	3	3	6	4	4	7	2	4	5	4	3	5	4	3	2	1	3	2 en 3
8	Male	24	no	2	3	6	6	4	4	4	5	4	6	6	4	4	4	4	3.5	6	6	4	4	4	4	4	5	6	4	4	2	1	7	7	5	2	2
9	Male	24	no	4	2	6	6	2	2	2	6	3	6	6	6	4	4	6	7	6	6	6	5	5	5	2	3	6	6	6	7	2	1	7	5	1	2 en 3
10	Female	25	no	3	3	5	5	6	2	4	6	4	6	6	5	2	7	5	4	6	6	5	5	2	2	2	2	3	6	2	4	2	4	7	4	1	2 en 3
		24.9																																			
		Average		4.3	3.6	6.1	6.1	4.8	3.5	3.6	5.3	4.6	6	6	5.4	4.3	4.5	4.6	4.95	6.2	6.2	5.3	4.8	4.3	3.8	2.8	4	4.8	3.6	5	3.8	5.4	4.8	3.8			
		Quooker		4.8	4.6	6.8	6.8	5	3.6	4	5.6	5.2	6.4	6.4	5.6	4.2	4.4	3.8	5	6.8	6.8	5.4	4.2	4.6	3.8	3.4	4	4.8	3.6	5.2	2.8	4.4	5.8	4.6			
		non-Quooker		3.8	2.6	5.4	5.4	4.6	3.4	3.2	5	4	5.6	5.6	5.2	4.4	4.6	5.4	4.9	5.6	5.6	5.2	5.4	4.6											1 step	7	
																																			2 step	3	
																									Handle actions					Knurl-knob actions						
																									1	2	3	4	5	6	7	8	9	10			
																									Action	3.8	3.1	4	4.8	3.6	5.1	3.3	4.9	5.3	4.2			
																									Rating										concept 1	4.3	3.6
																																			concept 2	5.3	4.6
																									Handle actions										concept 3	4.6	4.95
																									Rotate actions												

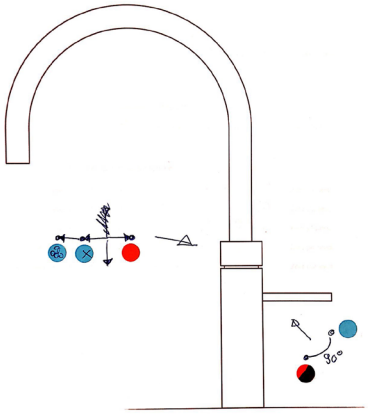
Showing the results worked out in Excel

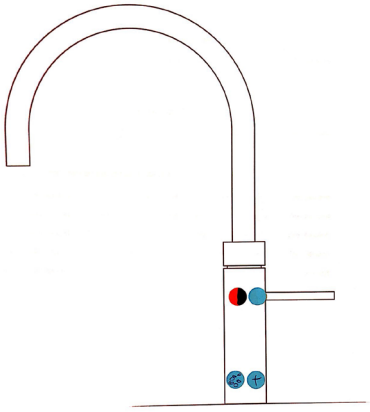


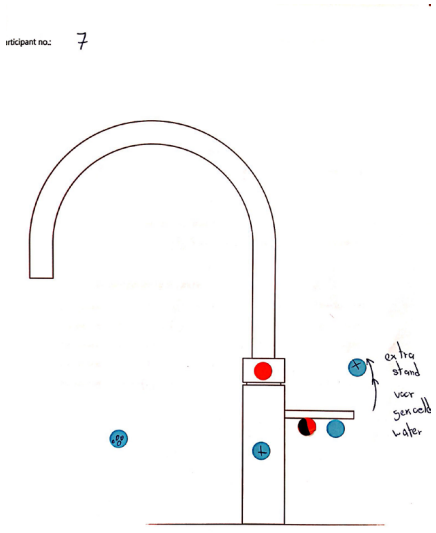


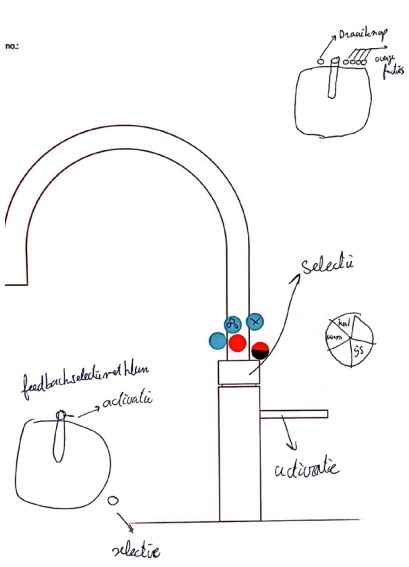


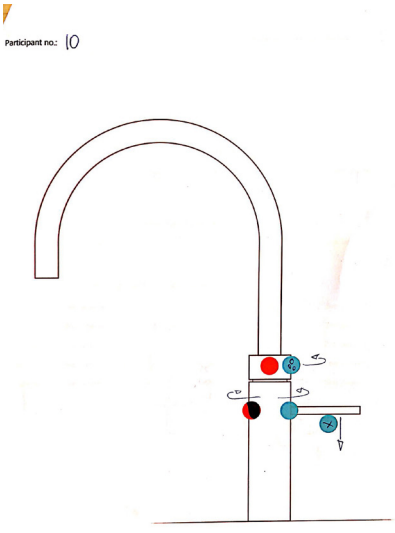


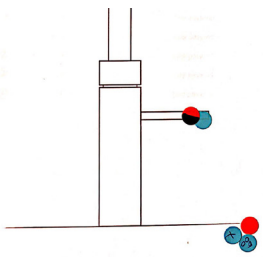












Participants were able to make their 'own design' by pasting in stickers of the different functions on the illustration.

Appendix T - Haptic & Visual feedback

In this appendix, user test 2 will be discussed more thoroughly. First the research questions will be explained again. Furthermore, the method and results will be described. Last, an elaborate conclusion will be drawn from the results.

Research questions

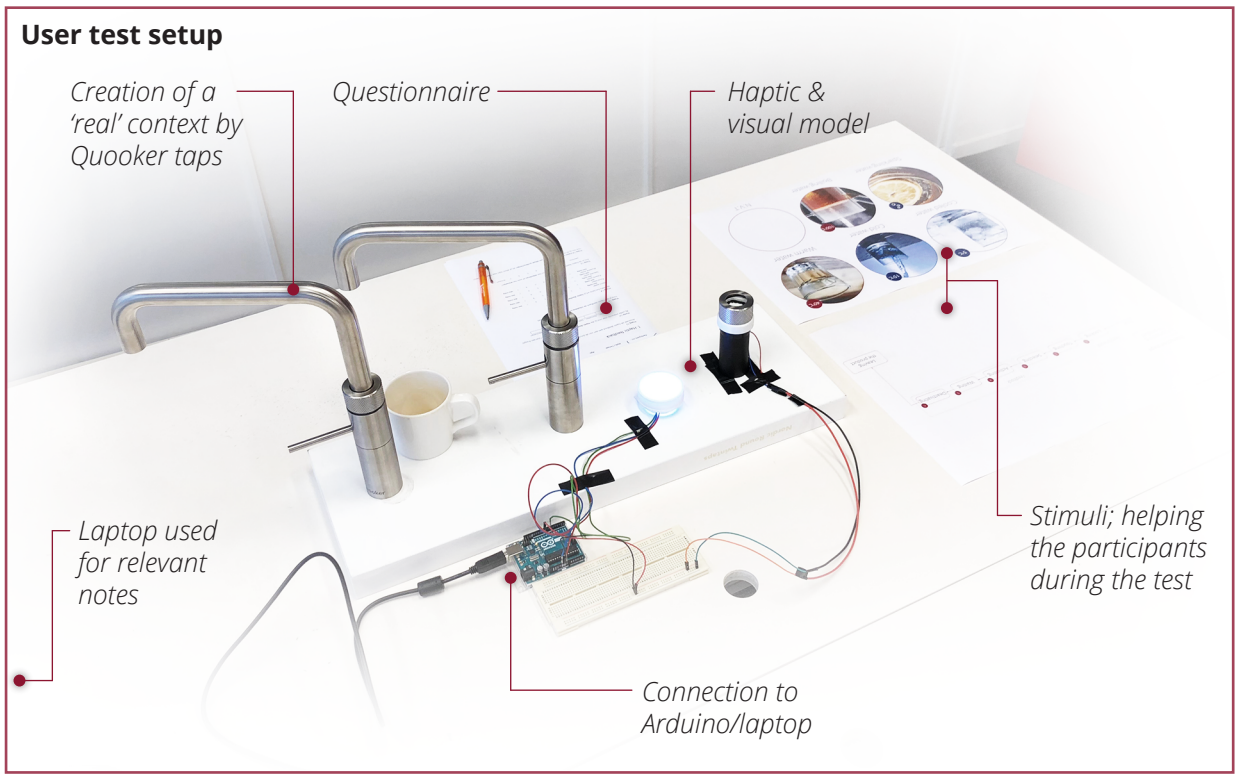
The goal of this user test is related to the research question aiming to find out how to integrate the five different functionalities in a more intuitive way. For this user research two main research questions are formulated:

1. How can haptic aspects contribute to a more intuitive design?
2. How can visual aspects contribute to a more intuitive design?

Note that in this user test only haptic and visual aspects are incorporated. Of course, more aspects could be taken into account that could be used to make the interaction more intuitive (e.g. auditory feedback). However, the focus of haptic and visual aspects is based on the capabilities of SMs. Moreover, the SMs piezoelectrics is related to a way of giving haptic feedback whereas the SMs EL is related to a way of giving visual feedback. Furthermore, the amount of aspects tested in this user test also makes the user test not too complex. Also, from a designer's perspective, adding aspects such as auditory feedback is not in line with the design aspects of the Quooker product (Viability aspect) since the Quooker products appear to be very minimalistic (see chapter 1.2; Product portfolio). Therefore, additional aspects such as auditory feedback can result in an overkill of information to the end-user.

Method

As explained before, the user test was divided into two parts; haptic and visual aspects. Two different models were made in order to mimic both aspects (see figure below). The development and programming of these models is described on the next pages. For an overview of the test setup, see figure below.
In total, eight participants (employees of Quooker B.V.) participated. In user test 1, 'external participants' (not familiar with Quooker) also participated since the position and interaction of functions are directly coupled to pre-existing knowledge. However, the way of questioning of haptic and visual feedback in user test 2 seems not directly related to previous Quooker products. However, it could be interesting to test with 'external participant', but due to time limitation it has been chosen to continue the test with employees of Quooker only. Testing with 'external participants' would take at least one extra day and will result in a delay.



An impression of the test setup, showing the different stimuli used during the user test.

In the first part of haptic feedback, participants were asked to make associations between the haptic feedback and one of the five functions. When no relation was felt, participants were also able to select none of the options. Additionally, participants were asked where haptic feedback would create the most impact related to the interaction steps. In relation to this question, participants were also asked to give a rating whether haptic feedback was needed to be integrated for a specific function or not.

Within the visual part of the user test, participants were firstly asked to make colour relations with one of the five functions. Likewise, participants were asked what was communicated by the visuals which for instance had to be coupled to 'a warning sign' or the product is 'in progress'. Also, participants were asked again to give a rating whether the feedback was needed to be integrated for a specific function or not. However, this time for visual feedback. For all the questions, a questionnaire was created in which participants gave answer to the questions.

Below, the relation between the three aspects mentioned by Wensveen at all. Are briefly described:
Dynamics: speed, acceleration & force aspects are translated into the frequency and amplitude differences for both haptic and visual feedback in this user test (e.g. differences in amount of pulses or intensities, next pages-for an overview of all simulations that were used)
Modality: the focus is only on 'sight' (visual) and ' touch' (haptic)
Expression: The expression of different simulations of both haptic and feedback can add value to the expression of a particular function (e.g. participants might relate a strong pulse to boiling water that comes strongly out of the spout).

Results

In this part, results of the user test are described. As described earlier and like it was described in user test 1 as well, the user test was a qualitative test in which participants filled in a questionnaire giving a rating to the questions. In addition, participants were asked for their opinion and argumentation in order to start an open discussion. Therefore, the results are two folded. First of all, the ratings gave a first impression how haptic and visual feedback is perceived by the participants (note that the outcomes and/or statements made in this part are not grounded due to the small number of participants). Second, the open discussion resulted in personal arguments and/or quotes.

Haptic and visual model

For both the haptic and visual feedback a model has been made to mimic both aspects.

Model 1 (haptic feedback)
In the first model, haptic feedback has been integrated by using a vibration motor. The vibration motor was placed in a 3D printed part and as a whole integrated in the knurl-knob of the Quooker (see figure on adjacent page). In addition, the knob was integrated on an additional part in order to simplify the interaction with participants.

The vibration motor has been connected with an Arduino in order to program different simulations. The code used in Arduino is a very simple code which only describes a digitalwrite with a high power over a certain time period continued with a low powered digitalwrite (power goes off) for a certain time period.

Model 2 (visual feedback)
For the second model, visual feedback has been integrated. This model consist of a 3D printed know (can be rotated) and an integrated light system (NeoPixel with 16 LED's) that was connected to an Arduino, again to program different simulations with light and colours.

Simulations
As described before, different simulations have been made with Arduino. The overview of the different simulations are illustrated on the next pages of this appendix. In the illustration, it can be seen that differences are made in amplitude, pulse time, pulse delay, intensity, frequencies and colour (only for visual feedback).
In addition, the different simulation are based on the earlier described three aspects, 'dynamics', ' modality', 'expression'.

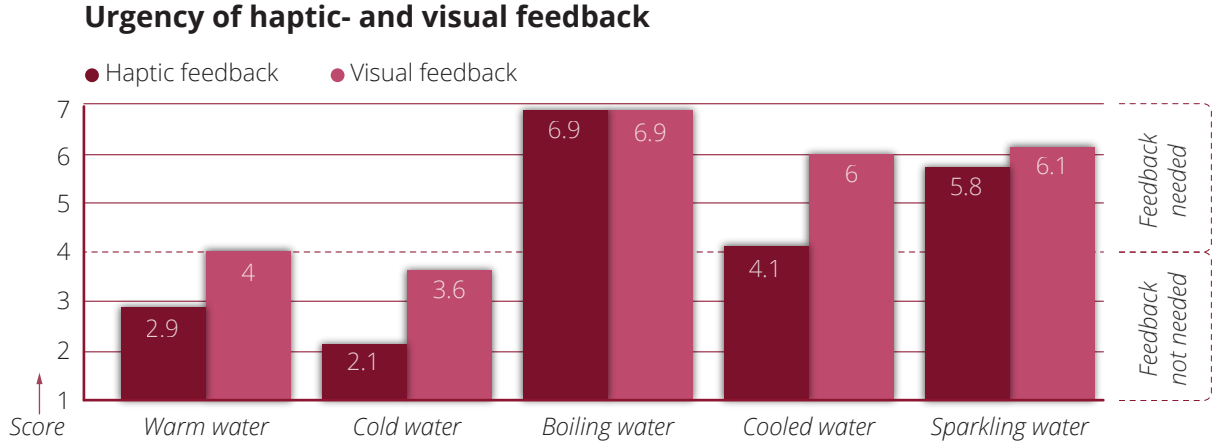
Showing several pictures of user test 2 (two models, the test set up, and two participants participating).

Results

Open discussion
When analysing the results from the open discussion, it can be seen that most of the participants explained the importance of the relations between the functions in which feedback is given (both visual and haptic). The feedforward and feedback given for each function are coupled to each other and should have an 'increasing order' to make a clear distinction between the functions as participant 2 described: "the feedback should be integrated in an increasing order". As an example, he described that the warm water function is more important than the cold water function. With this in mind, the feedback should be in line with this as well. In relation to the discussion with participant 2, participant 4 explained the same principle: cold water can be seen as the '0-situation' since 'nothing' is added to this water. All other functions can have a more special way of feedback since other functions have a certain added value compared to the cold water (e.g. heat is added to create warm or boiled water and CO2 is added to create sparkling water).
Participant 1,2 and 3 described this 'increasing order' related to the haptic and visual feedback. "higher frequencies and amplitudes feels like more alarming or more importance", said participant 1. Participant 2 explained that the shorter the pulse time is, the more important the feedback is perceived.
Another clear result is that most of the participants want to receive both the haptic and visual information during the selection phase. This is the only phase in which you can still adjust the selection as participant 3 described: "during the selecting phase, you can 'feel' which function will be activated"
Participants also described their association to certain functions. Participant 1 for instance described the relation between multiple haptic pulses and the sparkling water function. "with sparkling water, you feel and hear the bubbles which correspondents with this haptic feedback" said participant 1 (reflecting on simulation 6, haptic feedback). In addition, participant 1 also describes the relation between the white colour and sparkling water since sparkling water comes out the spout in a white colour. Other participants did not directly couple certain haptic feedback to a function. However, they related it to other communicational aspects as participant 2 explained: "the double pulse feels like making a selection". Participant 5 said: "it feels like I am receiving all kinds of notifications.
Lastly, most of the participants concluded that, except of the sparkling function, it might be difficult to mimic a function with haptic feedback. It was explained that haptic feedback is in general used to 'emphasize' an action meaning that it is not often used to directly mimic characteristics of a function since haptic feedback is limited by touch only. However, haptic feedback certainly adds value to other aspects as participant 3 explained: "a user can talk to other people while navigating through the selection of a product".

Questionnaire – haptic feedback
First of all, results show that haptic feedback can in general only be coupled to the sparkling water function. Most of the participants have difficulties to associate most ways of haptic feedback to a specific function.
Furthermore, results show a clear result in the preference to receive haptic feedback during the selection phase instead to activation phase.
Lastly, it becomes clear that participants choose the boiling water function as most important to receive haptic feedback (see figure below)

Questionnaire – visual feedback
When analysing the visual part of the user test, it be-



Showing the urgency of haptic and visual feedback linked to the five function (based on the outcome of the user test)

comes clear that the colour green is generally related to the sparkling water function (8 from the 8 participants). In addition, the colour white was not directly related to one specific function. Participants related the colour white to both the sparkling and cooled water function.
Furthermore, the frequency and amplitude of the light is related to different urgency levels. The more frequencies and the higher the light intensity is, the more participants related the simulation to the boiling water function.
Furthermore, a blinking light is in general related to the phase of making a selection (6 from the 8 participants). In addition, light with a relative long pulse time is related to the phase of being in progress. Lastly, the light simulation which can be seen as a breathing pulse is in general related to the phase of stand-by.

When combining the different results of the questionnaire it can be seen that most participants prefer visual feedback over haptic feedback. In addition, there is also a clear result related to the importance of haptic and visual feedback for each function. The result shows that participants prefer haptic and visual feedback the most for the boiling water function (average rating of 6.9 out of 7). Thereafter, sparkling water and cooled water. It also becomes clear that no feedback is necessarily preferred for cold and warm water function. These two functions score below a rating of 4, which means that feedback is not needed.

Conclusion
Several conclusion can be drawn when analysing the two research questions with the results of user test 2.
In general, it can be concluded that haptic and visual aspects are both aspects that could improve the interaction in an intuitive way. However, they need to be integrated in a proper way.

First of all, it has been concluded that feedback should be integrated in a consistent and increasing order. This can be related to the 'urgency' per function in which the boiling water function is for instance perceived most urgent compared to the other four functions. Subsequently, haptic and/or visual aspects can be manipulated by higher frequencies (multiple pulses), higher amplitudes (higher intensity) or a shorter pulse time in order to higher the perceived urgency. In relation to this, it has been concluded that boiling water is perceived most urgent which can be related to the danger that can appear when activating the boiling water. Thereafter, the sparkling and cooled water functions are urgent as well. However, the urgency of these functions is probably not related to danger, but can be related to the added value as a function itself. As an example, CO2 is added to the cold water which creates sparkling water and energy is needed to cool down the water in order to create cooled water. Additionally, it is also concluded that the cold and warm water function not necessarily need any feedback. However, this was not the same outcome as in user test 1 where participant explained their difficulties with selecting cold and warm water which was sometimes confusing (they mixed up the two functions).
The increasing order of functions described above can be related to the literature of Baldwin and Lewis (2013) which described the difference in (alarm) urgency using different modalities. With this in mind, it can be concluded that haptic feedback can create feedback on a higher urgency level which, in this case, should be relate to the boiling water function. Moreover, visual feedback appears to be on the lower urgency level and could therefore be used for the cold and warm water function.
Another useful insight has been created based on feedback and feedforward. Here, it has been concluded that feedforward is the most important part of the interaction steps in which haptic or visual aspects need to be added. A fundamental reason for this is that people are able to change their selection before activating it which makes the interaction design more safe (important aspects, see LOR.

Lastly, when analysing the association that participants made, several conclusion can be made as well. First of all, it is concluded that participant make an association which is based on the characteristics of a specific function. However, this characteristic needs to be in line with one of the aspects created by haptic or visual feedback. From this point of view, it is concluded that visual feedback could be more useful to make associations with a specific function compared to haptics. However, this does not mean that haptic feedback is not appropriate anymore. Moreover, it has been concluded that haptic feedback could be more useful to communicate the 'state of being' meaning to communicate that a user is for instance 'selecting' or 'activating' something. From a designers perspective, it is estimated that visual feedback is a strong way of communicating a function and that haptic feedback can support and improves the interaction further (e.g. a tap with only haptic feedback will probably not perceived as an intuitive interaction). Therefore, haptic and visual feedback needs to be combined in a proper way in order to support each other and thereby improve the entire interaction. In addition, it is important to, where possible, integrate associations since this can result in less effort and fewer cognitive recourses as it was earlier described by Ulfvengren, 2003 (chapter 6.3; Interaction design).
Insights and conclusion described above will be used to generate concept ideas and criteria for the next design steps.

Cooled water

Cold water

Warm water

Sparkling water

Boiling water

N.V.T

Showing the urgency of haptic and visual feedback linked to the five function (based on the outcome of the user test)

1.1.ino | Arduino 1.8.5

File Edit Sketch Tools Help

1.1.ino §

```
void setup() {

pinMode(8,OUTPUT);

digitalWrite(8,HIGH);
delay(80);//100ms aan
digitalWrite(8,LOW);
delay(150);//100ms aan



} //eind van de functie

void loop() {


}
```

Showing the Arduino code used for the two models (part 1)

sketch_jan17a | Arduino 1.8.5

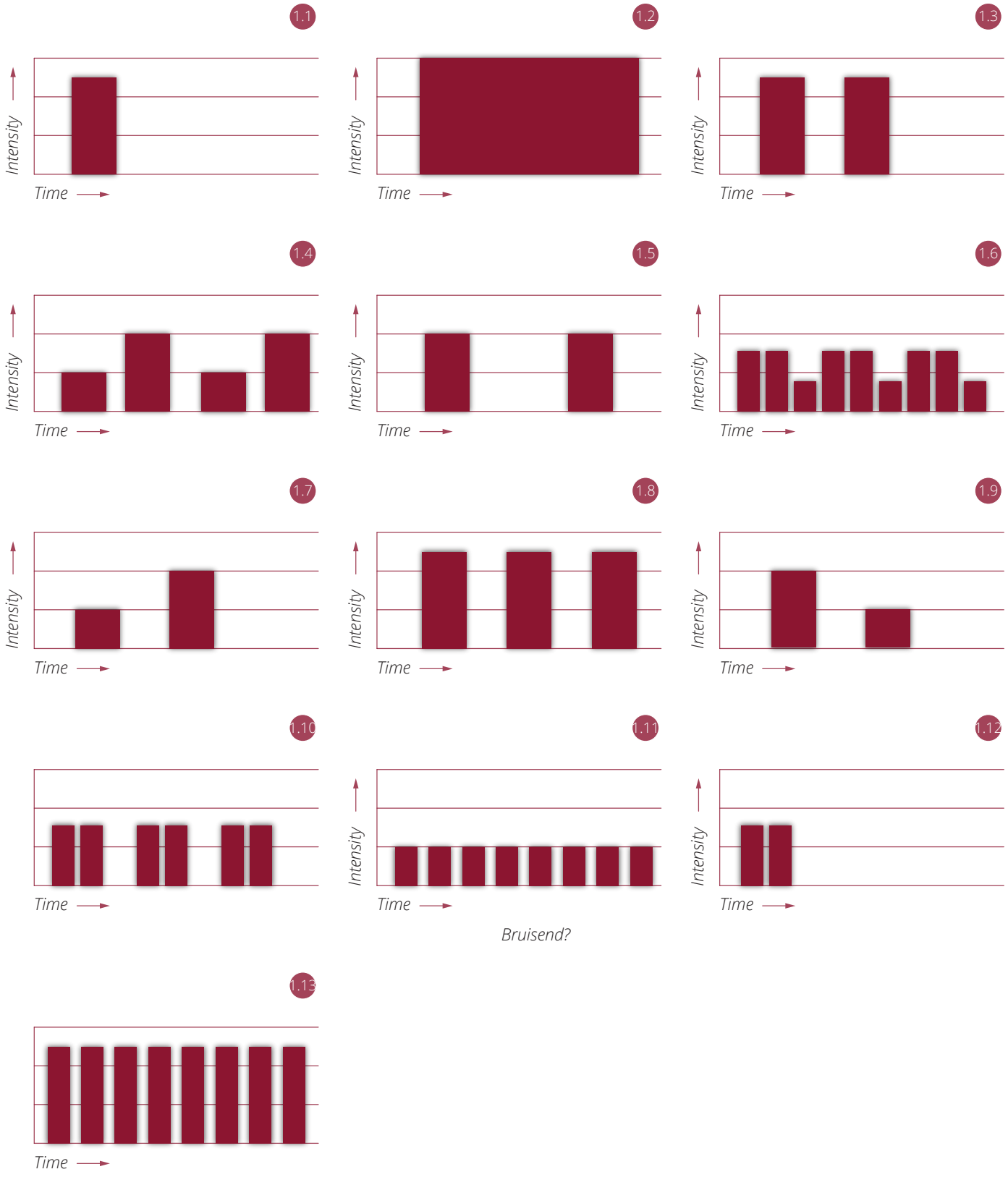
File Edit Sketch Tools Help

sketch_jan17a §

```
#include <Adafruit_NeoPixel.h>
#define PIN 6

// Parameter 1 = number of pixels in strip
// Parameter 2 = pin number (most are valid)
// Parameter 3 = pixel type flags, add together as needed:
//   NEO_KHZ800  800 KHz bitstream (most NeoPixel products w/WS2812 LEDs)
//   NEO_KHZ400  400 KHz (classic 'v1' (not v2) FLORA pixels, WS2811 drivers)
//   NEO_GRB     Pixels are wired for GRB bitstream (most NeoPixel products)
//   NEO_RGB     Pixels are wired for RGB bitstream (v1 FLORA pixels, not v2)
Adafruit_NeoPixel strip = Adafruit_NeoPixel(16, PIN, NEO_GRB + NEO_KHZ800);

void setup() {
  // put your setup code here, to run once:

  strip.begin();
  strip.show(); // Initialize all pixels to 'off'

  for (int i = 0; i < 16; i++)
  {
    strip.setPixelColor(i, 250, 0, 0);// rode kleur
    strip.setBrightness(20);
    strip.show();
  }
delay(2000);
  for (int i = 0; i < 16; i++)
{
  strip.setPixelColor(i, 0, 0, 0);
  strip.setBrightness(20);
  strip.show();
}
delay(500);

  for (int i = 0; i < 16; i++)
  {
    strip.setPixelColor(i, 0, 255, 0); // blauwe kleur
    strip.setBrightness(20);
    strip.show();
  }
delay(2000);

  for (int i = 0; i < 16; i++)
{
  strip.setPixelColor(i, 0, 0, 0);
  strip.setBrightness(20);
  strip.show();
}
delay(500);
}
void loop() {
  // put your main code here, to run repeatedly:
}
```

Showing the Arduino code used for the two models (part 2)

Haptic feedback

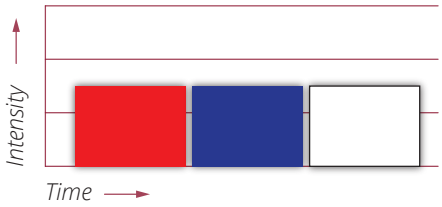


Bruisend?

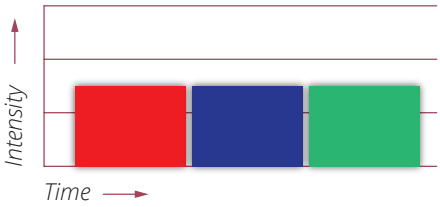
Showing the different Arduino codes illustrated in a visual. On this page the different haptic simulations are displayed. On the adjacent page, the visual simulation are displayed.

Visual feedback

2.1



2.2



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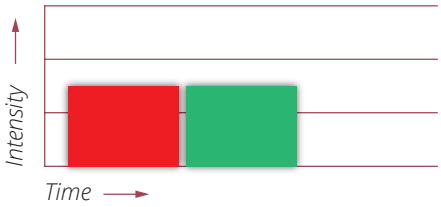
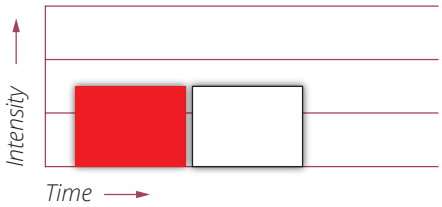
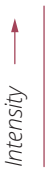
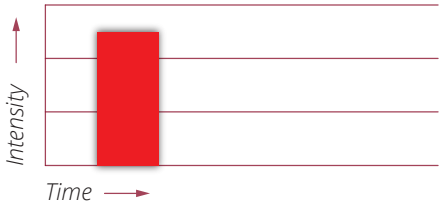


2.4

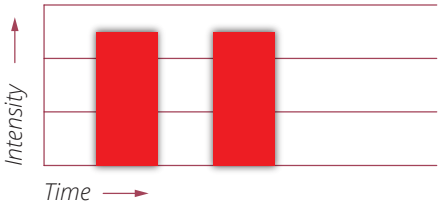




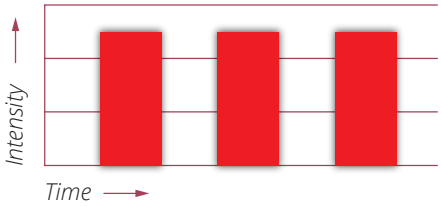
4.1



4.2

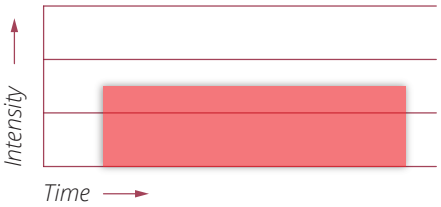


4.3

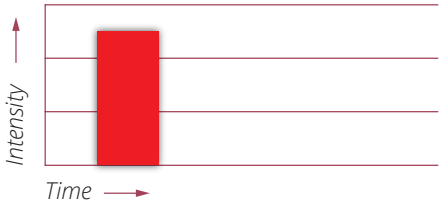


4.4

4.5



5.1



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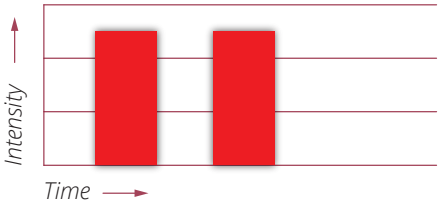
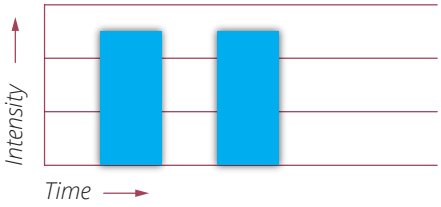
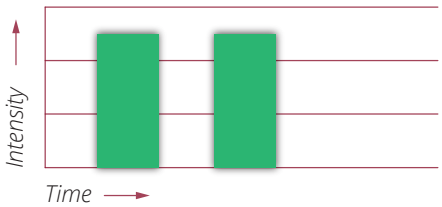


5.3

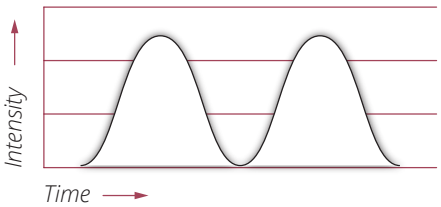


5.4



5.5

5.6



Participant no. : Male / Female Age:

1. Haptic feedback

Vraag 1.1
Associeer de haptic feedback aan één van de functies.

Vraag 1.2
*Bij welke interactie stap vind jij dat **haptic feedback** het best tot zijn recht komt? (zet een kruisje)*

Bekijken – Aanraken – Selecteren – Activeren – Wachten - Deactiveren

Vraag 1.3
Vind je dat haptic feedback de **intuïtieve interactie** verbeterd? (omcirkel)

Ja / Nee

Vraag 1.4
*Bij welke functie(s) wil jij **haptic feedback** krijgen? (omcirkel)*

Warm water
Niet nodig 1 2 3 4 5 6 7 Wel nodig
Koud water
Niet nodig 1 2 3 4 5 6 7 Wel nodig
Kokend water
Niet nodig 1 2 3 4 5 6 7 Wel nodig
Gekoeld water
Niet nodig 1 2 3 4 5 6 7 Wel nodig
Bruisend water
Niet nodig 1 2 3 4 5 6 7 Wel nodig

Vraag 1.5
Zou je de haptic feedback willen krijgen voor het **selecteren** of voor het **activeren**?

Selecteren 1 2 3 4 5 6 7 Activeren

Vraag 1.6 (open vraag)
Hoe zou jij de verschillende **functies van elkaar onderscheiden** als je alleen kijkt naar haptic feedback?

Showing the questionnaire that has been used during the user test (stimulus)

2. Visual feedback

Vraag 2
Welke combinatie aan functies zie je achter elkaar verschijnen?

Vraag 3
welke kleur hoort bij welke functie? (vul een kleur in)

Cooled water	
Cold water	
Warm water	
Sparkling water	
Boiling water	

Vraag 4
Maak een keuze tussen de functie warm of kokend. (omcirkel)

1. Warm / Kokend
2. Warm / Kokend
3. Warm / Kokend
4. Warm / Kokend
5. Warm / Kokend

Vraag 5
Wat communiceert het licht? (omcirkel)

1. 'waarschuwen' / 'selectie maken' / 'selectie activeren' / 'In progress' / 'stand-by stand'

2. 'waarschuwen' / 'selectie maken' / 'selectie activeren' / 'In progress' / 'stand-by stand'

3. 'waarschuwen' / 'selectie maken' / 'selectie activeren' / 'In progress' / 'stand-by stand'

4. 'waarschuwen' / 'selectie maken' / 'selectie activeren' / 'In progress' / 'stand-by stand'

5. 'waarschuwen' / 'selectie maken' / 'selectie activeren' / 'In progress' / 'stand-by stand'

6. 'waarschuwen' / 'selectie maken' / 'selectie activeren' / 'In progress' / 'stand-by stand'

Vraag 6
*Bij welke interactie stap vind jij dat **visuele feedback** het best tot zijn recht komt? (zet een kruisje)*

Bekijken – Aanraken – Selecteren – Activeren – Wachten - Deactiveren

Vraag7
Vind je dat visuele feedback de **intuïtieve interactie** verbeterd? *(omcirkel)*

Ja / Nee

Vraag 8
*Bij welke functie(s) wil jij **visuele feedback** krijgen? (omcirkel)*

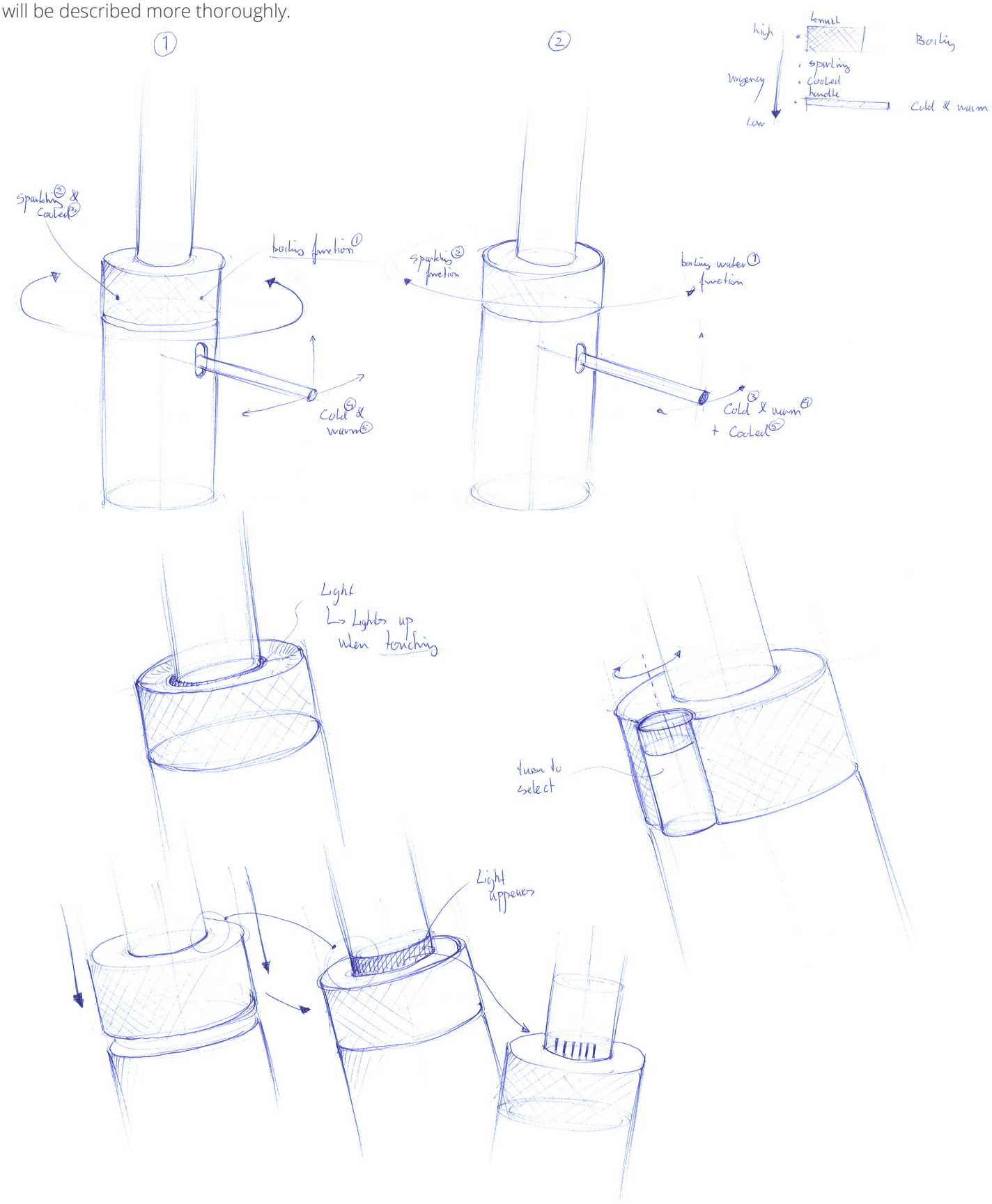
Warm water
Niet nodig 1 2 3 4 5 6 7 Wel nodig
Koud water
Niet nodig 1 2 3 4 5 6 7 Wel nodig
Kokend water
Niet nodig 1 2 3 4 5 6 7 Wel nodig
Gekoeld water
Niet nodig 1 2 3 4 5 6 7 Wel nodig
Bruisend water
Niet nodig 1 2 3 4 5 6 7 Wel nodig

Vraag 9
Zou je visuele feedback meer toepasbaar vinden voor het **selecteren** of voor het **activeren** van een functie? *(omcirkel)*

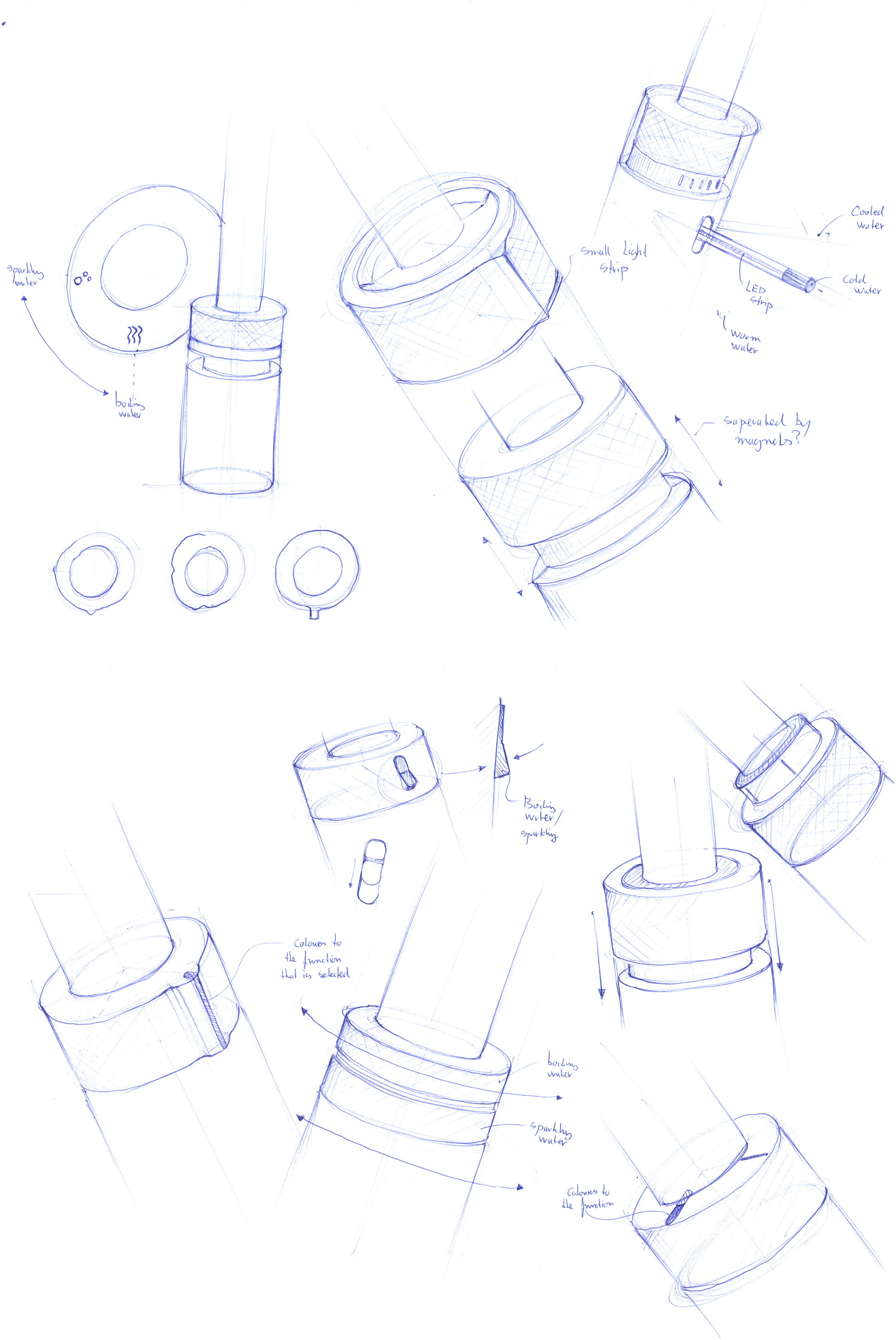
Selecteren 1 2 3 4 5 6 7 Activeren

Appendix U - Ideation

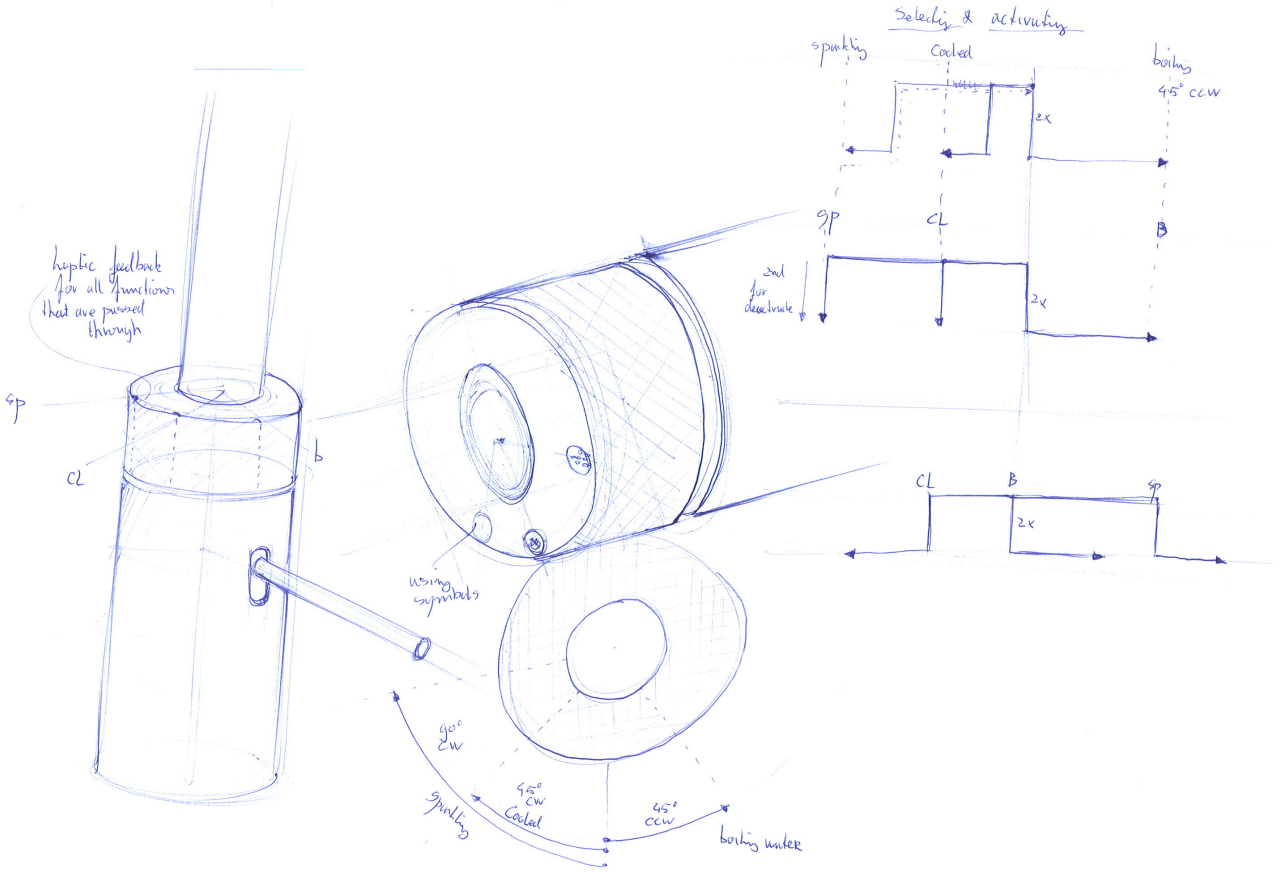
In this Appendix, first several sketches will be shown from the ideation phase. Second, characteristics of the four concepts that were generated in the ideation phase will be described more thoroughly.



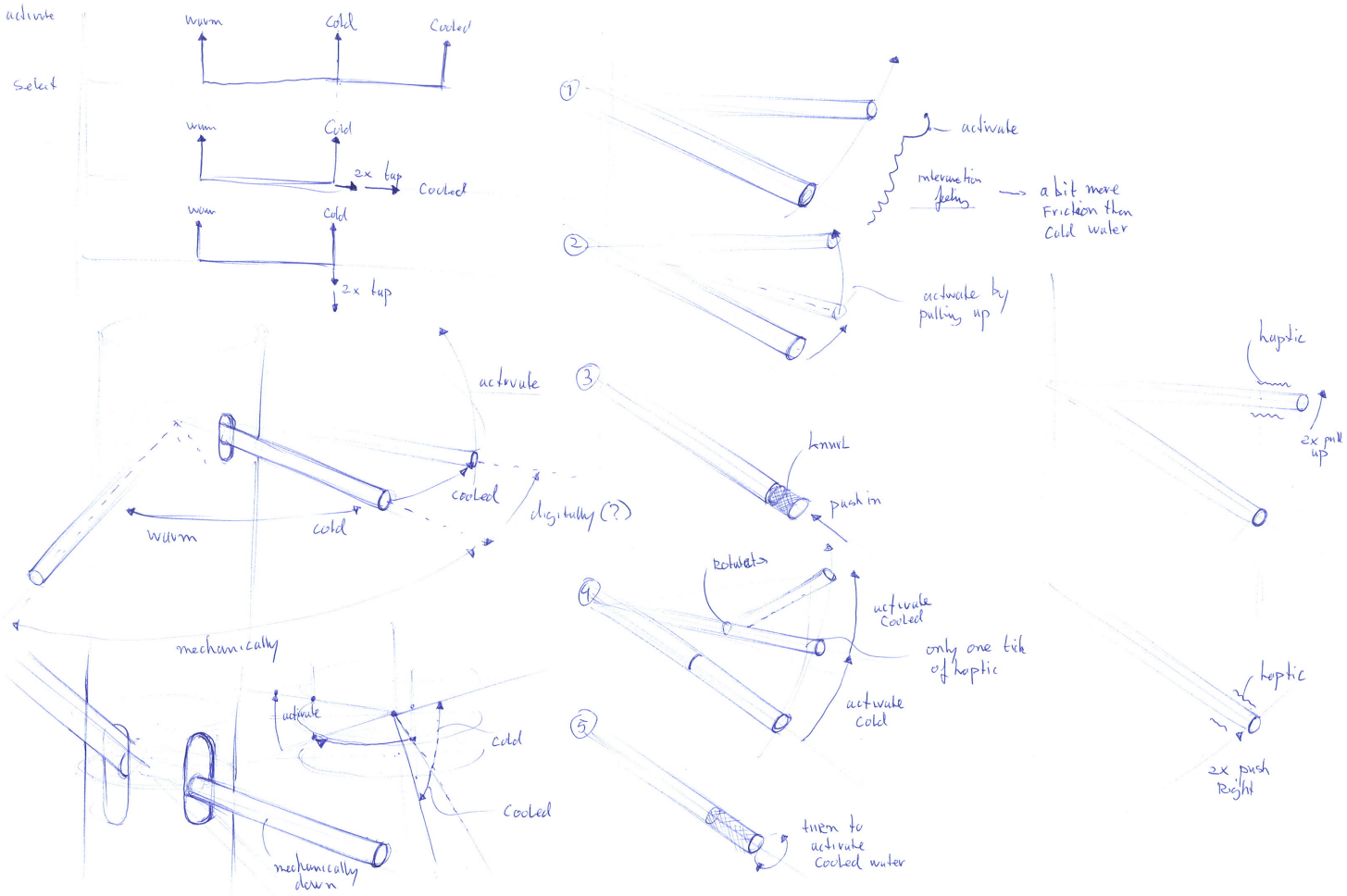
2.

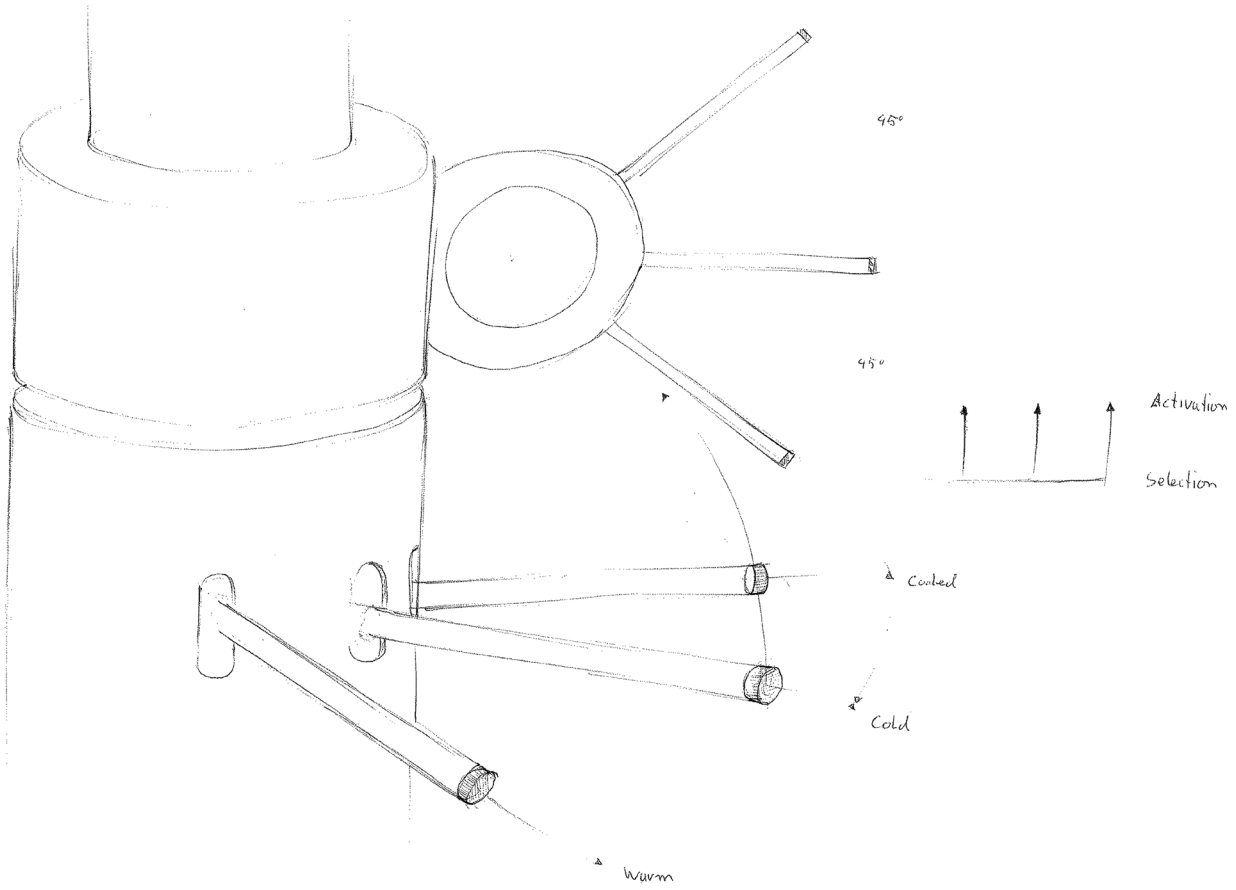

sparkling water
boiling water
Small Light Strip
Cooled Water
LED Strip
Cold Water
Warm Water
Separated by magnets?
Boiling water/ sparkling
Colours to the function that is selected
boiling water
sparkling water
Colours to the function

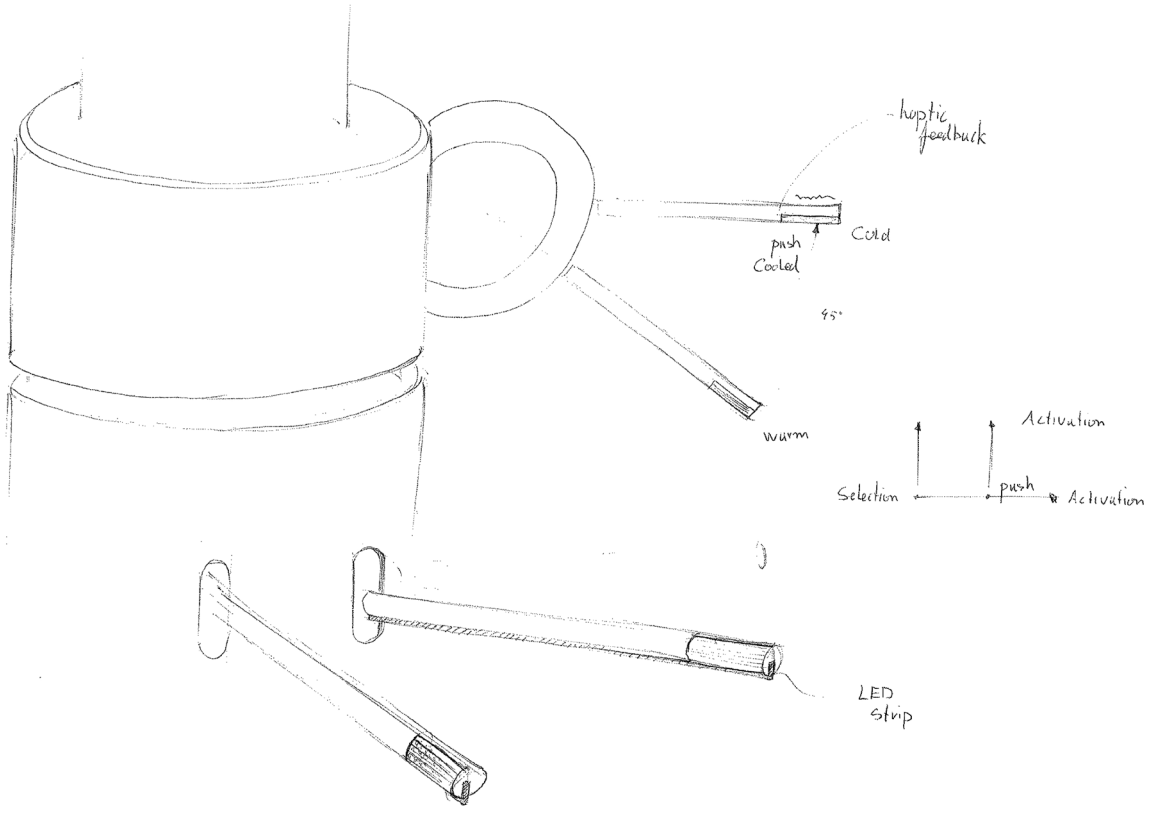
2.

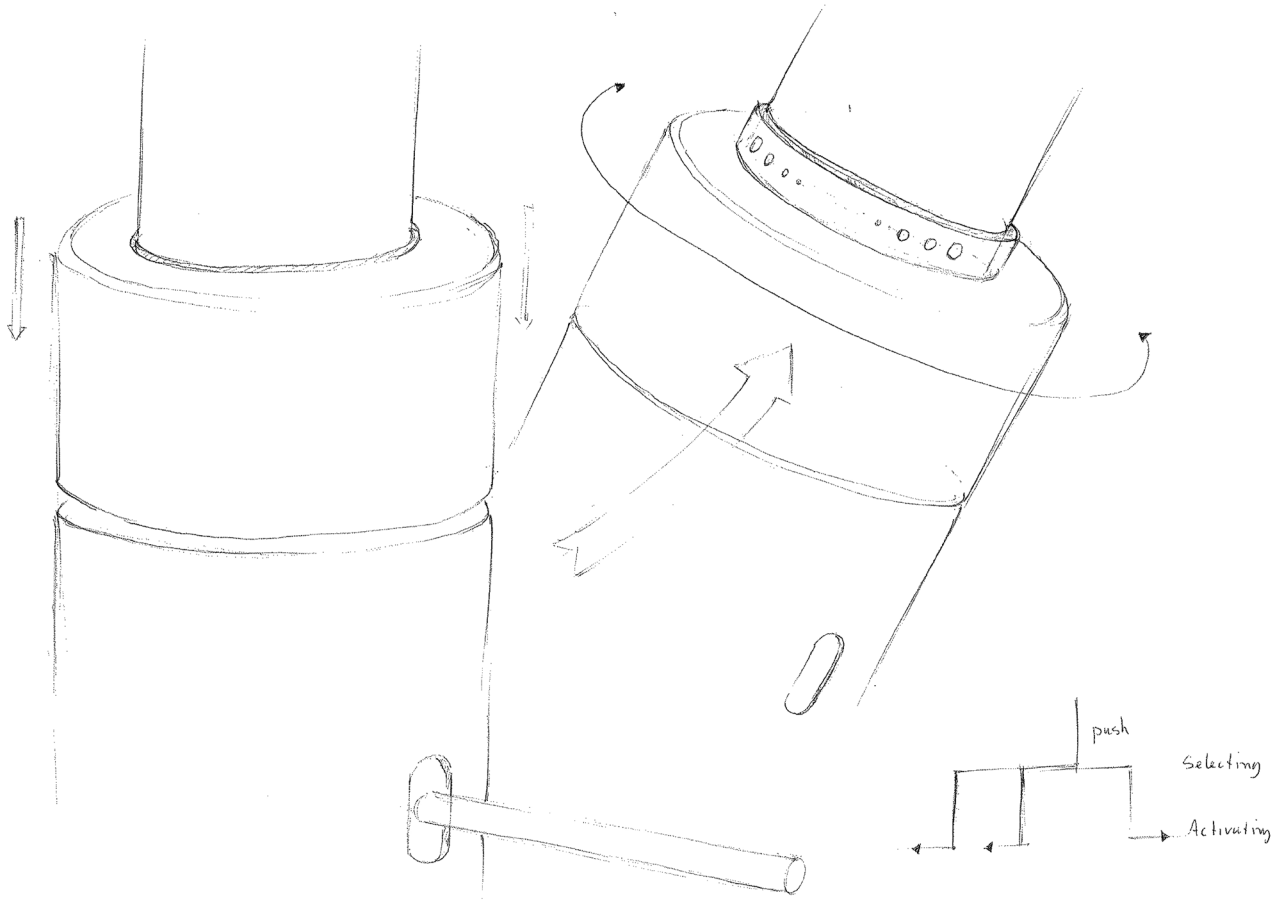

Selecting & activating
sparkling
Cooled
boiling
45° ccw
2x
SP
CL
B
2nd for deactivate
haptic feedback for all functions that are pressed through
using symbols
90° cw
45° cw
Cooled
45° ccw
boiling water

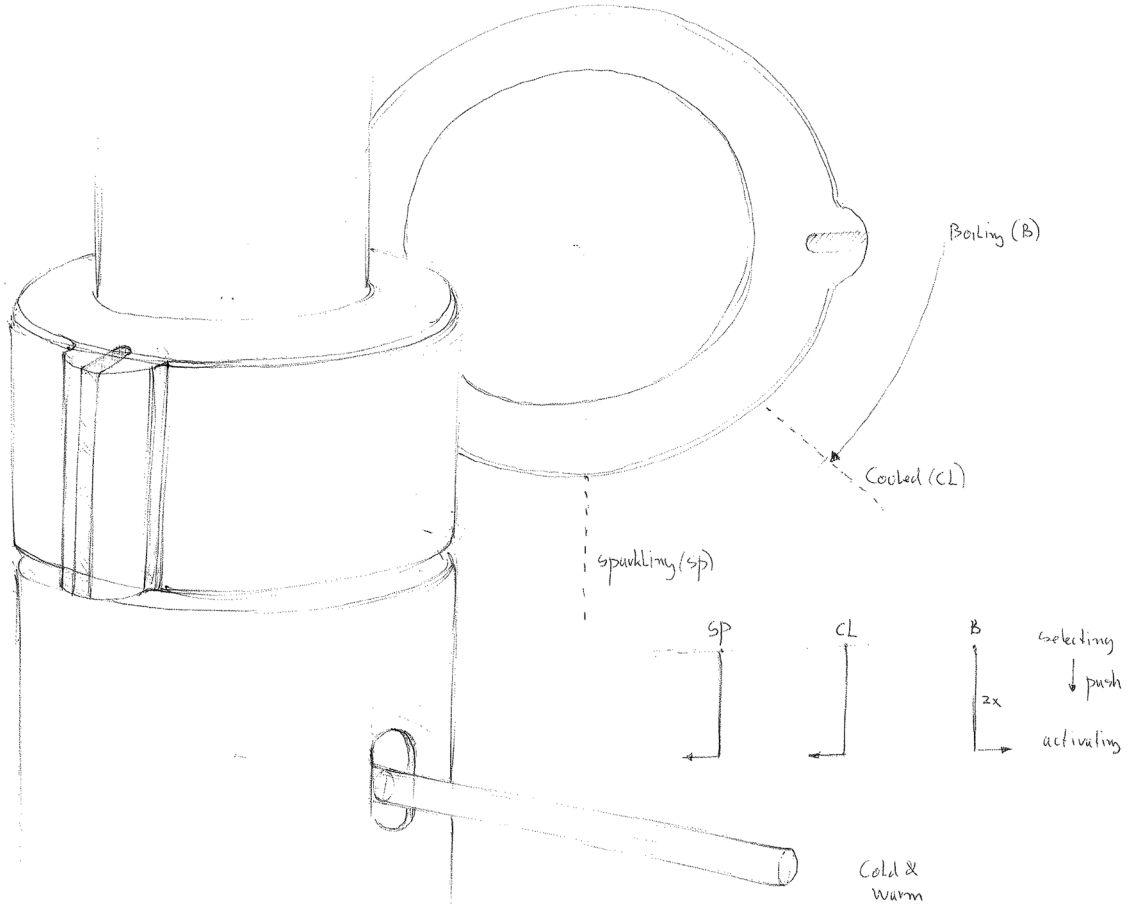
2.


activate
select
warm
Cold
Cooled
2x tap
activate
intervention feeling
a bit more Friction than Cold water
activate by pulling up
knurl
push in
Rotate
activate Cooled
only one tick of haptic
activate Cold
turn to activate Cooled water
cooled
digitally (?)
mechanically
mechanically down
haptic
2x pull up
2x push Right


45°
45°
Activation
Selection
Cooled
Cold
Warm


haptic feedback
Cold
push
Cooled
45°
Warm
Activation
Selection
push
Activation
LED
Strip


push
Selecting
Activating


Boiling (B)
Cooled (CL)
Sparkling (SP)
SP
CL
B
Selecting
push
2x
activating
Cold &
Warm

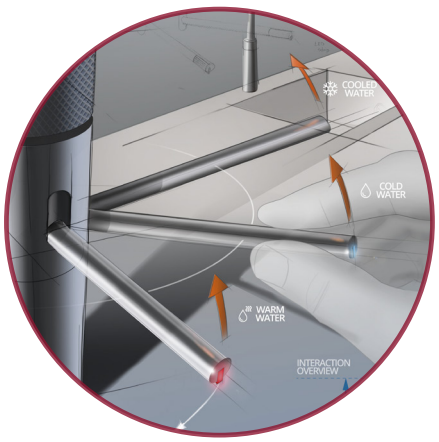
The characteristics of the four concepts that were generated in the ideation phase have been described more thoroughly. The description is given below:

Concept 1

- Both the cooled and sparkling water functions are integrated in the knob.
- A selection can be made by turning the knob. In this way, the light, which is integrated in the knob, will change from colour according the function that is selected.
- Activate the functions is done by pushing and turning the knob clockwise. This is a clear difference to the activation of boiling water in which the interaction is maintained (double-push turn counter clockwise).
- For this concept, mainly the knob need to be adjusted. However, more electronics will be integrated in the knob which could result in a higher rate of failure.
- Visual and haptic feedback is integrated in the knob. For every selection that is made, the user will feel haptic feedback.

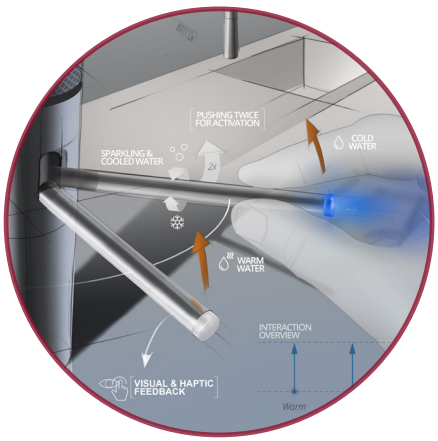
Concept 2

- In this concept, the cooled and sparkling water functions are 'hidden' and become visible when interacting with the tap. Symbols of the function become visible when pushing down the knob.
- A function can be activated by pushing down twice. The activation of boiling water is maintained.
- Main adjustments are made in the outlet and the knob.
- The design becomes more minimalistic because of the hidden features.



Concept 3

- In this concept, the cooled and sparkling water functions are both integrated in the handle.
- Both functions are mechanical controlled. Activating is done by pushing up the handle.
- Visual feedback is integrated showing a small light on the end of the handle.
- Adjustments need to be made in the middle part of the Quooker tap. Moreover, the cartridge which is connected to the handle need to be replaced. For this, Quooker is dependent on the suppliers offer.



Concept 4

- In this concept, all functions are controlled in a digital way.
- Both visual and haptic feedback are integrated in the handle.
- A selection can be made by rotating the handle. Activating is done by pushing the handle counter-clockwise. During this action, the user perceives haptic feedback for every push he or she executes.
- Visual feedback is mainly visible by the reflection in de hand of the user.

Appendix V - Validation meeting

In this appendix, the validation meeting will be more elaborated.

Design criteria
The same criteria have been used as during the validation by the researcher. De criteria used during the validation meeting is shown below:

Design criteria

- **Financieel**
  De kostprijs, aantal arbeidsuren, totale extra kosten/kosten vermindering, etc.
- **Onderhoud**
  Zo min mogelijk onderhoud/service, robuustheid & bestand tegen vloeistoffen, gemakkelijk schoon te maken door gebruiker, etc.
- **Assemblage & productie**
  Gebruik van huidige faciliteiten, 190 stuks productie per week, zo min mogelijk onderdelen, etc.
- **End of life**
  Metalen en kunststoffen onderdelen scheiden.
- **Toekomstmogelijkheden**
  Mogelijkheden tot uitbereiding of vervanging van functies.

Procedure
In the first part, a presentation as given about the graduation project.
In the second 'interactive' part of the validation meeting, employees of Quooker gave critical feedback on the concepts. During the feedback, it has been concluded that it was too difficult for the employees to specifically give feedback on each criteria. Due to the level of elaboration it was difficult to for instance be specific on comparing the concepts on assembly aspects or production costs. Therefore, criteria were taken together as inspiration (improvised during the session). Additionally, advantages and disadvantages were written down on posts it's and put on the wall to create a clear overview.

Results
Several notes have been made during and after the validation meeting. The notes have been cluster and are shown on the adjacent page.

Showing the different steps of the validation meeting

Concept 1
+ goed toepasbaar op huidige kranen
+ in lijn van de uitstraling van Quooker
+ relatief weinig kwetsbaarheid, meer robuust ontwerp
+ de kartel knop blijft het icoon van Quooker wat in dit concept terug komt

- onveilige functies zitten bij veilige functies
- discrepantie tussen selectie en activatie (mogelijkheid dat je op meerdere manier een functie kan activeren)

- Complex mechanisme (oa zorgen dat discrepantie tussen selectie en activatie vermeden wordt) → de vraag is of dit überhaupt gemaakt kan worden.

Concept 2
+ licht aan de bovenkant is altijd te zien
+ relatief duidelijk om een keuze te maken (en te zien)

- je ziet de symbolen pas als je de knop indrukt → is soort van feedback
- je kan niet zien in welke stand hij staat voordat je begint met de bediening
- te veel druk handelingen
- moeilijk schoon te maken
- moeilijk aanpasbaar voor de toekomst

Concept 3
+ directe feedforward bij je hand (van het lampje)
+ veilig en onveilig gescheiden → handhaving van pre-knowledge

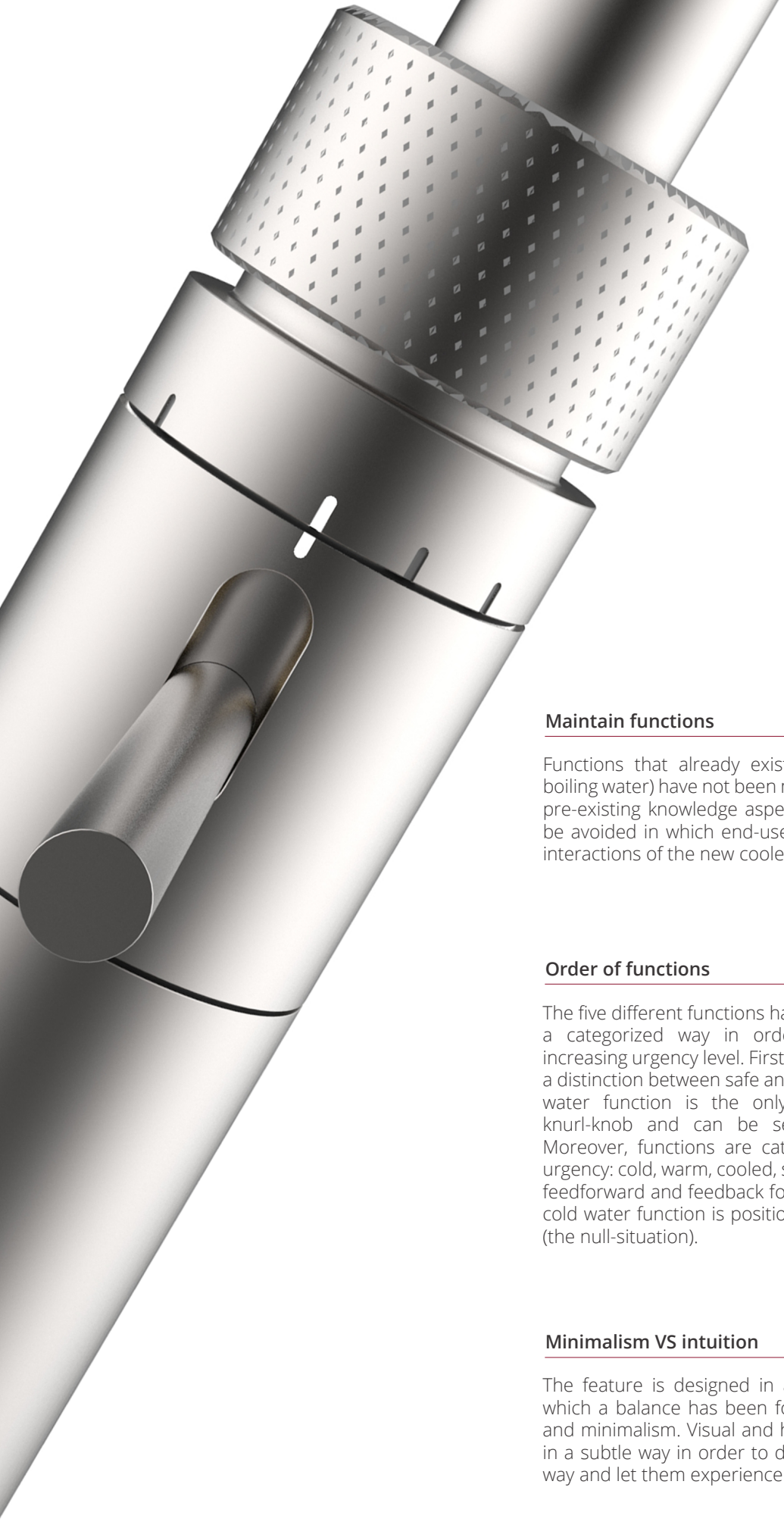
- bruisend en gekoeld water moeten altijd digitaal worden aangestuurd. Hoe wordt dit dan mechanisch verwerkt?
- storingsgevoelig door geïntegreerd lampje.
- de verwachting is dat het een normale mengkraan is en niet voor specials.
- maakbaarheid → afhankelijk van de leverancier en of er überhaupt cartridges zijn met 4 inputs.
Onderhoudsgevoelig → wordt vaak gebruikt en komen zware krachten op, veel beweging.

Concept 4
+ mogelijkheid tot integratie met reservoir hub (elektronisch mengventiel van ruben)
+ veel mogelijkheden tot uitbereiding
+logisch rang orde (koud → kouder)
+ veilig en onveilig gescheiden → handhaving van pre-knowledge

+**verkoop verhaal beter?**

- niet direct zichtbaar dat specials in de handel verwerkt zijn.
- kwetsbaar en fragiliteit (ook fragiele bediening, klein pookje)

Analysing the different post-it's



Maintain functions

Functions that already existed (cold, warm and boiling water) have not been modified according to the pre-existing knowledge aspects. In this way, confusion will be avoided in which end-users are only introduced to the interactions of the new cooled and sparkling water function.

Order of functions

The five different functions have been integrated in a categorized way in order to anticipate on an increasing urgency level. First of all, the design clearly makes a distinction between safe and unsafe functions. The boiling water function is the only function integrated in the knurl-knob and can be seen as an unsafe function. Moreover, functions are categorized from a low to high urgency: cold, warm, cooled, sparkling and boiled water (see feedforward and feedback for specifications). Note that the cold water function is positioned straight towards the user (the null-situation).

Minimalism VS intuition

The feature is designed in a minimalistic way in which a balance has been found between intuition and minimalism. Visual and haptic feedback are integrated in a subtle way in order to direct the end-user in the right way and let them experience a safe and intuitive interaction.

Appendix W - Quooker Spark

Reflection on design handles
In this Appendix, the Quooker Spark will briefly be reflected on the design handles since the concept is mainly developed by these aspects. Figure on both pages, shows an overview of the main aspects linked to the design handles.

5 integrated functions

All functions are integrated in one tap instead of separately. Competitors currently also provide additional functionalities. However, competitors did not exceed to integrate all functionalities in one tap. Therefore, the integration of 5 functions can be seen as a competitive advantage.

Feedforward & Feedback

Visual and haptic feedback have been integrated and are based on feedforward and feedback. In the design, the main focus has been put on feedforward. In this way, end-users can always make a selection first before activation. With this, the design explicitly anticipated on safety aspects. Furthermore, this won't result in any spillage of water.

One-step activation

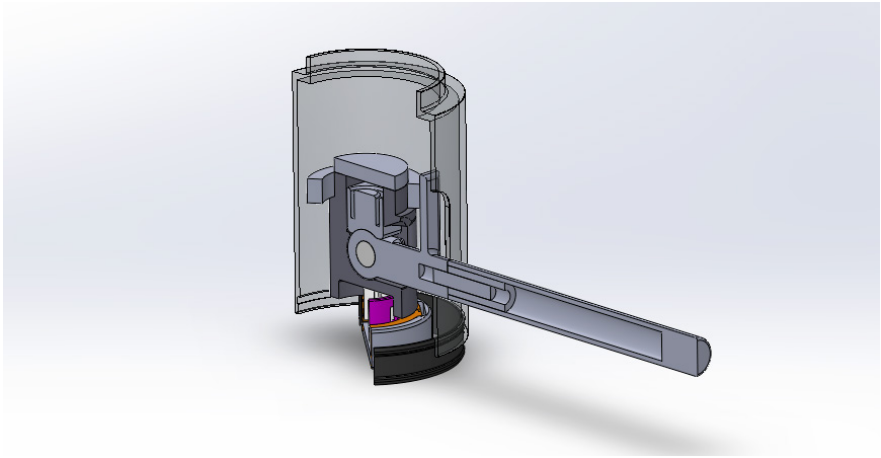
The end-user is able to clearly see which function is selected due to the position of the handle and the integrated visual feedback (LED lights). The end-user can directly activate a function (one-step activation) nn case the user has a function in mind which is already selected on the tap. Note the upper LED only lights up when an unity is created with the lower LED light which rotates between the four functions.

Appendix X - Integrated design

In this Appendix, the design that has been developed will be more elaborately. In general, the focus of the mechanism is put on making the translation from mechanical activation by the user to a digital signal in order to activate the functions digitally. In the figures below, the working principle of the mechanism has been explained.

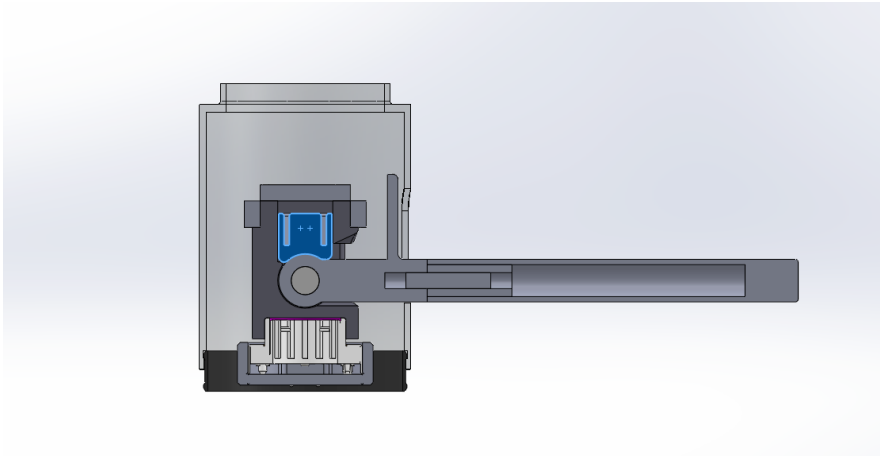
Selection 1

In the figure, it can be seen how the handle is rotated. The mechanism is attached to the rotary encoder which measures the rotational movements of the handle. In this way, the system is able to detect which functions is selected.



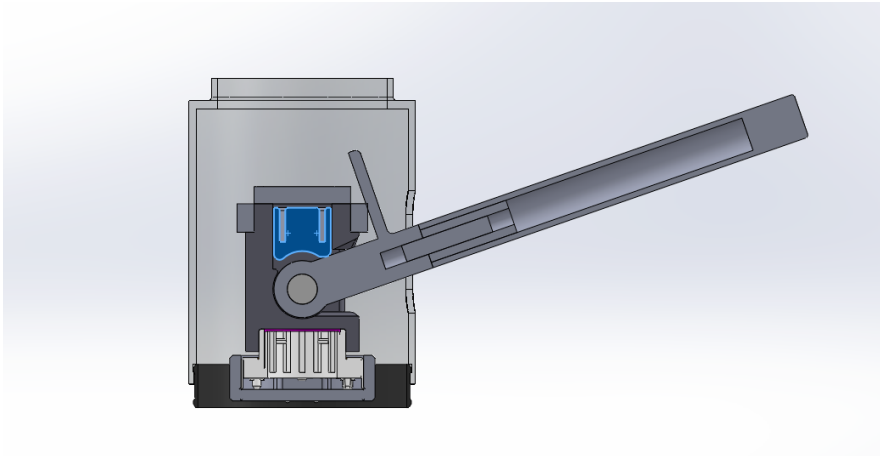
Selection 2

In the scenario, the handle is put down meaning that no activation is carried out yet.

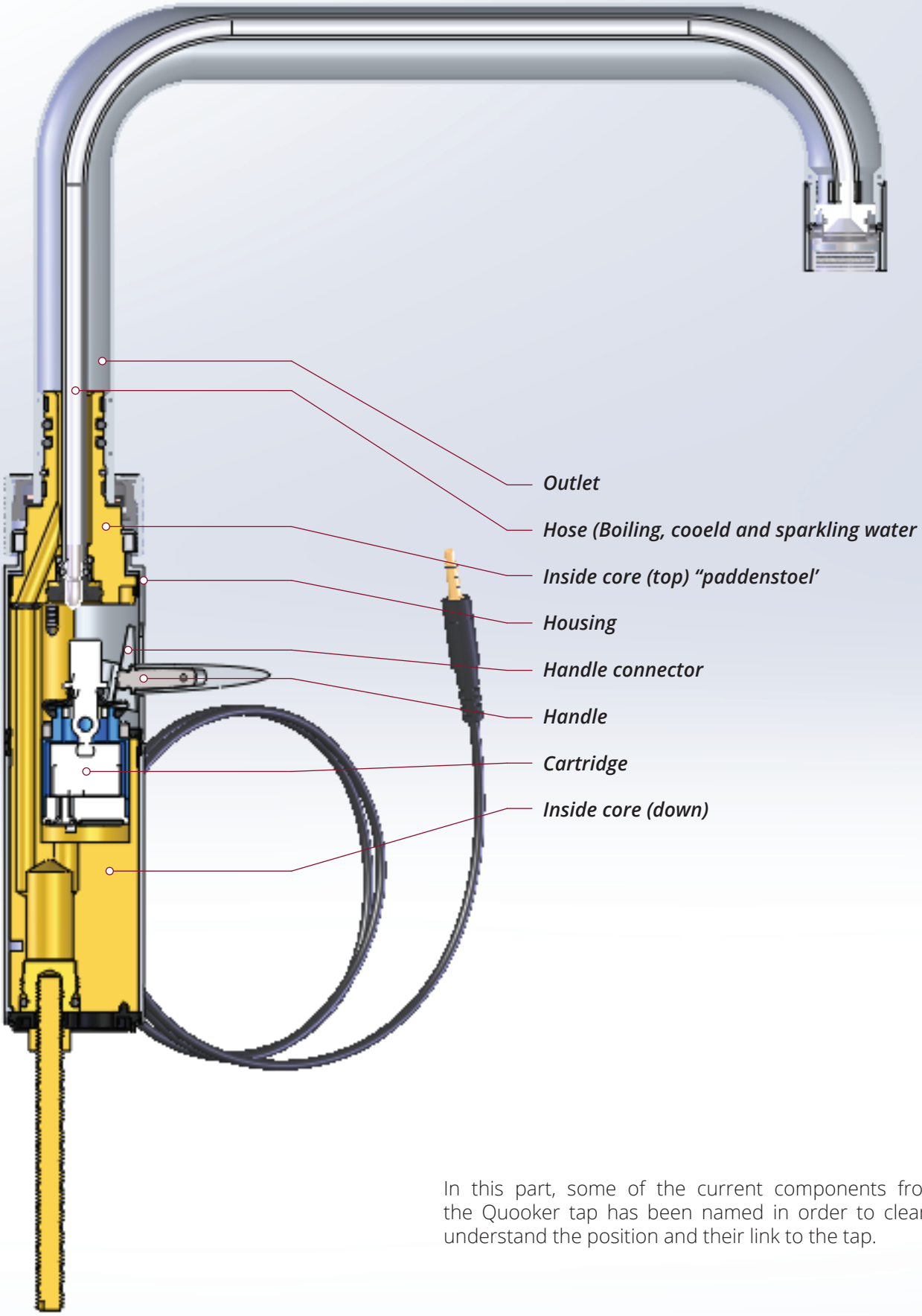


Activation

In this scenario, the handle it pulled up meaning that a function is activated. Keep notice of the blue marked part which moves up according to the movements of the handle. Furthermore, a magnet is integrated in the blue market component. Subsequently. The hall-sensor is integrated above the magnet and fixated. Therefore, the movements of the magnet are notified and measured. In this way, the system is able to detect when the handle is pulled up and when a function need to be activated.

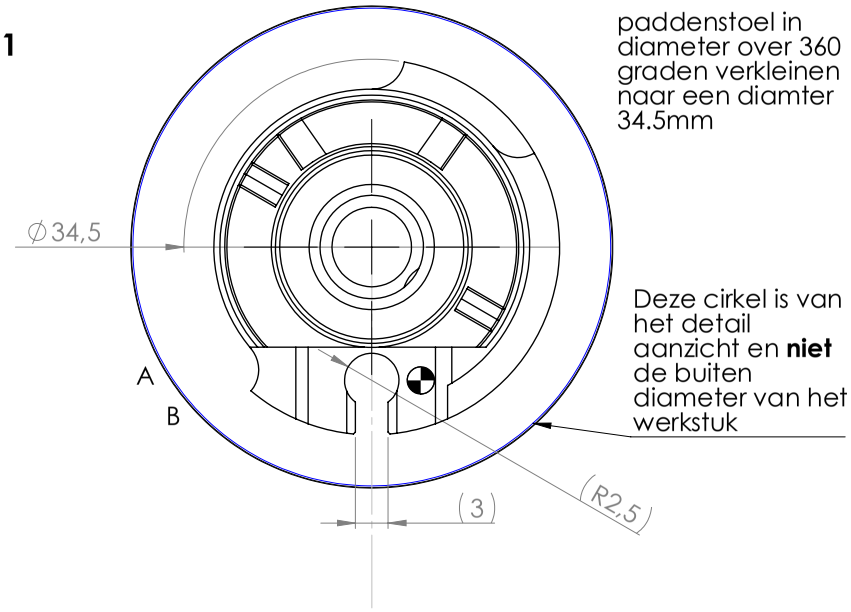


Appendix Y - Proof of concept

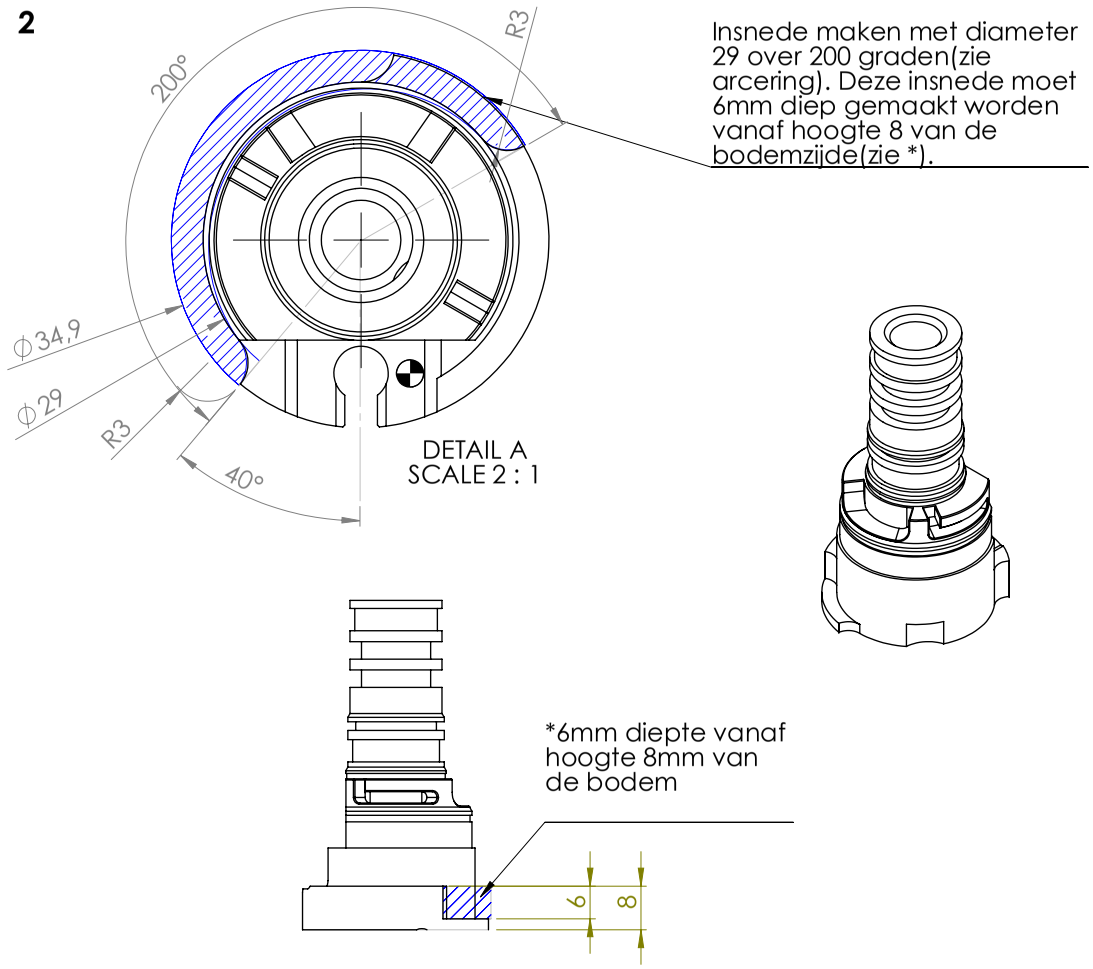


In this part, some of the current components from the Quooker tap has been named in order to clearly understand the position and their link to the tap.

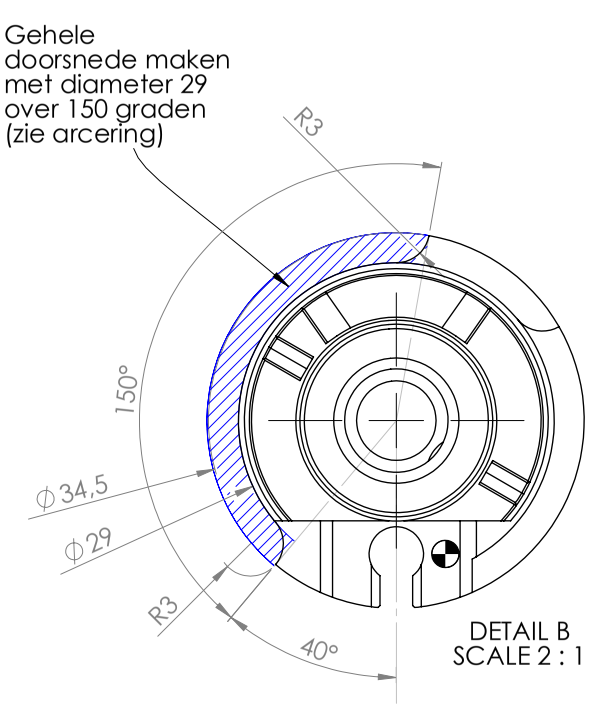
1



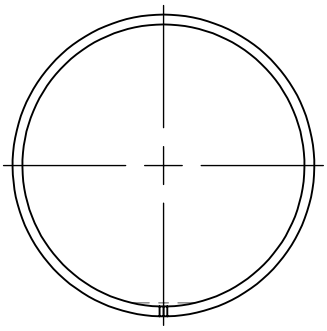
2

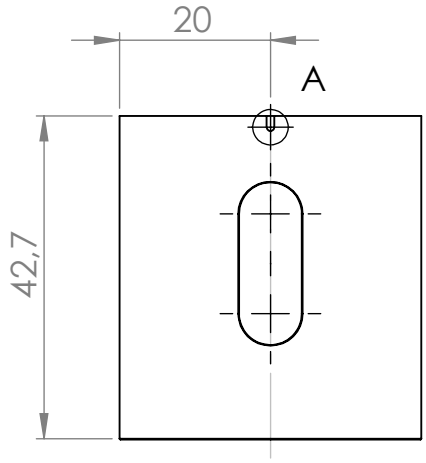


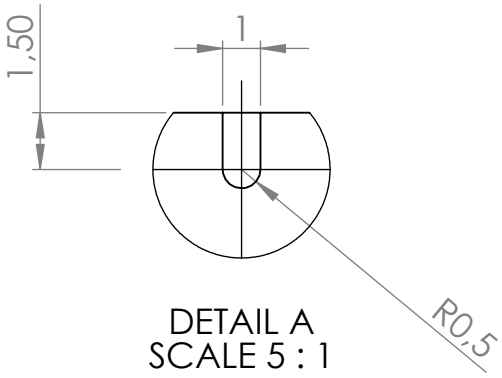
3



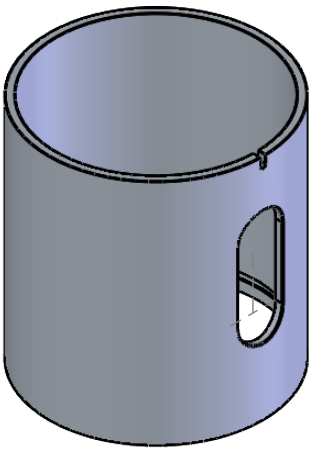
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR:		FINISH:		DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION
	NAME	SIGNATURE	DATE		TITLE: Uitloop aansluiting NF paddenstoel aanpassing	
DRAWN						
CHK'D						
APP'V'D						
MFG						
Q.A				MATERIAL: CuZn39Pb3	DWG NO.	A3

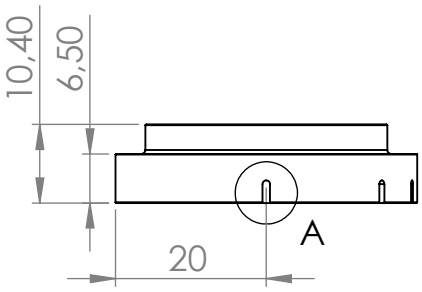


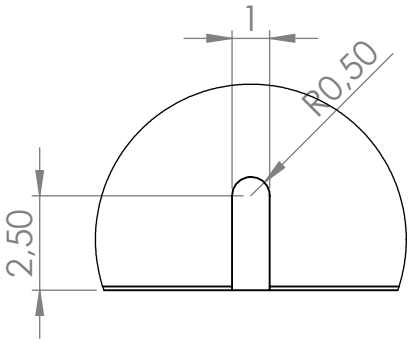




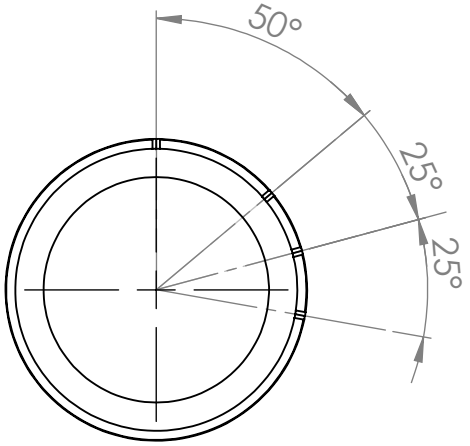
DETAIL A
SCALE 5 : 1

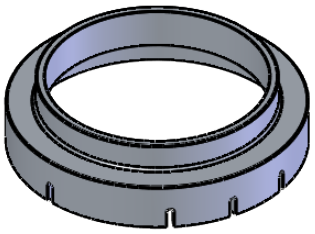






DETAIL A
SCALE 5 : 1

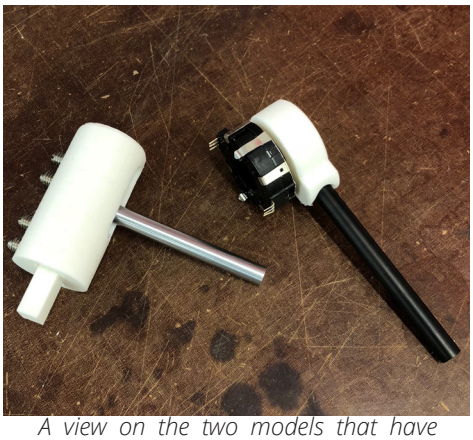




In this part, several pictures are shown which are based on the main prototype steps taken in the chapter 'proof of concept'.

An iteration of prototypes in which different principles of the 'tilt' positioning has been tested. (in this case a horizontal moving handle)

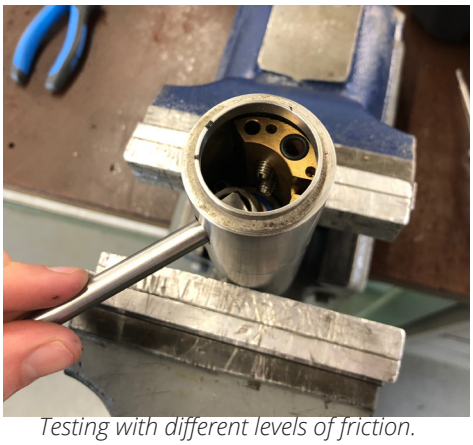
Testing the handle which is attached to a rotary encoder.



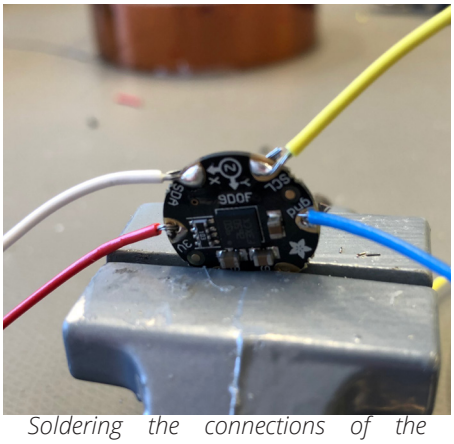
A view on the two models that have been prototyped.

A view on the inside tap where the ball spring plunger is attached.

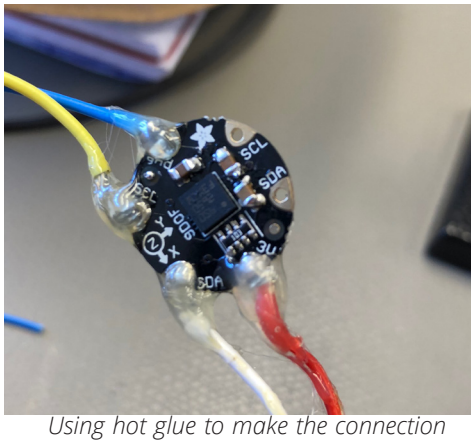
Attaching the housing.



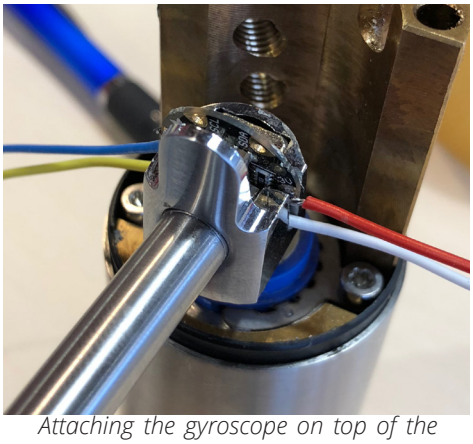
Testing with different levels of friction.



Soldering the connections of the gyroscope.



Using hot glue to make the connection less fragile and protect it from a short-circuit.



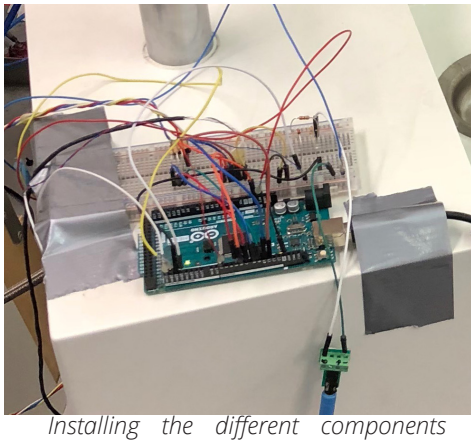
Attaching the gyroscope on top of the handle connector.

Make an additional attachment for the 'paddenstoel' component in order to clamp it in the milling machine.

Attaching the attachment on the 'paddenstoel' component.

A view on the milling process.

Showing the cavity used to direct all the wiring.

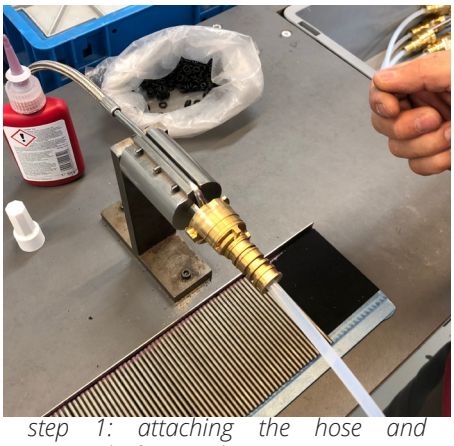


Installing the different components with wires to the Arduino.

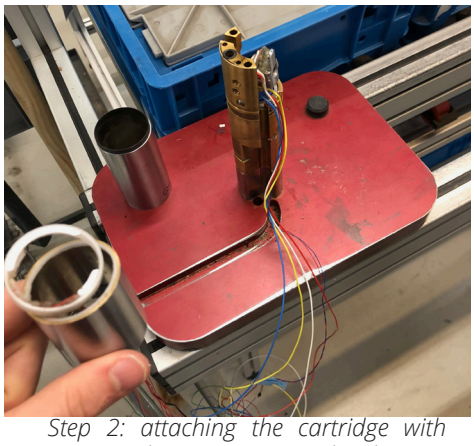
A view on the final prototype.

Assembly of the prototype

On the adjacent page, several pictures are shown which represent the different steps in which the prototype has been built up. Note that the prototype has been built up in the actual production hall/assembly line of Quooker.



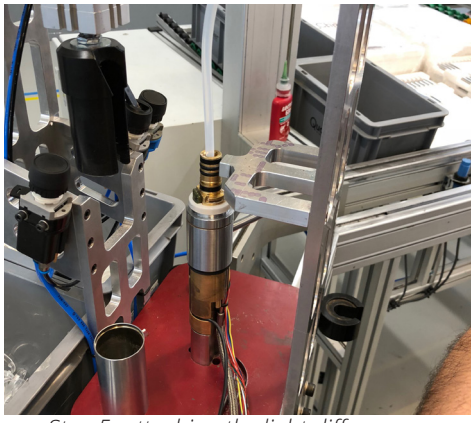
step 1: attaching the hose and screw shaft into the core component (paddenstoel) of the tap.



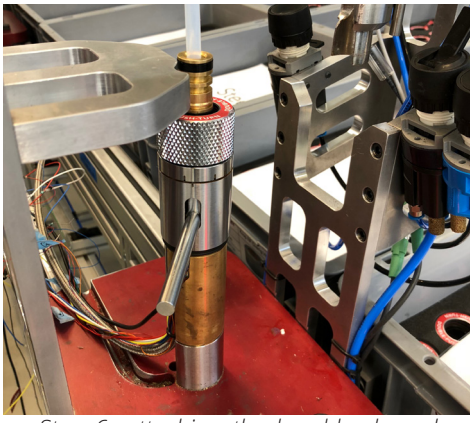
Step 2: attaching the cartridge with integrated gyroscope and vibration motor.

Step 3: combining the two core components of the tap with the screw shaft.

Step 4: attaching the first housing (top) and position the wiring.



Step 5: attaching the light diffuser.

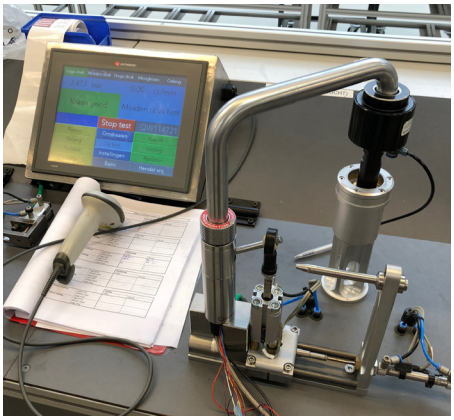


Step 6: attaching the knurl-knob and the handle.

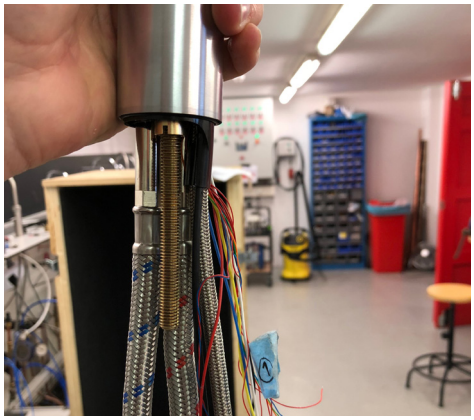
Step 7: attaching the outlet on the tap.

Step 8: testing the system on any errors.

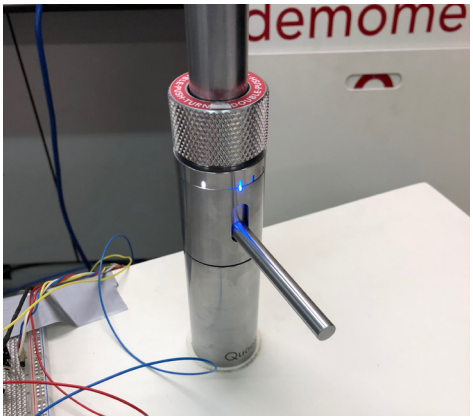
Step 9: attaching the housing (down).



Step 10: testing the tap on functionality (on air pressure).



Step 11: attaching the cold and warm hose.



Step 12: installing the tap on a kitchen table.

Appendix Z - Cost price

In this Appendix, an elaborated documentation is presented of the cost price calculation. The calculation has been worked out in Excel (see figure adjacent page).

Keep in mind the following aspects that have been used during the calculation.

- Component cost are derived from an expert consult (a Quooker employee of the procurement department)
- Assembly cost have been derived from an expert consult (a Quooker employee of the process optimisation department)
- costs for electronic components have been derived from an expert consult (a Quooker employee of the EPD (electronics) department).
- components with a number behind has been estimated by the research. Subsequently, the source has been provided and is shown below of this page.
- the batch size is estimated to be 10.000 products. This is derived from the amount that Quooker is going to expect to sell (related to the Cube that will be introduced).
- A multiply factor of 6 has been used. This is an estimated factor that is generally used for Quooker products/components.

Figure 1: *A picture taken during the expert consult in which every component has elaborately be discussed in order to calculate to cost price.*

Production amount (estimation)	10.000								
Product part	**Product nr.**	**Prijs/stuk**	**Stuks/product**						**Totale prijs**
Aangepaste onderdelen									
coating		€ 0,00	1						
housing (onder)	20.230.00	€ 0,00	1						€ 0,00
Uitloop aansluiting	20.433.00	€ 0,00	1						€ 0,00
Kraanhuis	20.223.00	€ 0,00	1						€ 0,00
Hendel	20.424.00	€ 0,00	1						€ 0,00
PCB	21.149.00	€ 1,00	1						€ 1,00
Inkoop onderdelen									
LED module		€ 0,50	1						€ 0,50
LED (white) 1		€ 0,26	4						€ 1,02
LED ring (bevestiging)		€ 0,22	1						€ 0,22
Resistor 2		€ 0,00	4						€ 0,00
RGB LED module 3		€ 0,14	1						€ 0,14
LED ring (bevestiging)		€ 0,22	1						€ 0,22
Wiring & connectors		€ 1,35	1						€ 1,35
Vibration motor (haptic feedback) 4		€ 0,35	1						€ 0,35
HAL-sensor 5		€ 0,21	1						€ 0,21
Rotary encoder 6		€ 1,50	1						€ 1,50
Position mechanism									€ 0,00
Bearing 7		€ 3,00	1						€ 3,00
Rotational core mechanism		€ 3,50	1						€ 3,50
Handle outlet		€ 2,00	1						€ 2,00
Cap		€ 0,15	1						€ 0,15
Rotary encoder holder		€ 0,20	1						€ 0,20
Vervangende onderdelen									
Cartridge		-€ 4,00	1						-€ 4,00
Hendel connector		-€ 2,00	1						-€ 2,00
Totale kosten onderdelen									€ 9,37
Assemblage	**Assemblage tijd (sec.)**	**Vermenigvuldigingsfactor**	**Totale assemblage tijd**	**Uurtarief**					**Assemblage kosten**
Assemblage position mechanism									
Assemblage encoder	4	4	16	50					€ 0,22
Assemblage hendel	5	4	20	50					€ 0,28
Assemblage dopje	7	4	28	50					€ 0,39
Assemblage LED modules									
LED module (boven)	5	4	20	50					€ 0,28
LED module (onder)	10	4	40	50					€ 0,56
vervangen assemblage onderdelen Cartridge			20	-50					-€ 0,28
Totale assemblage kosten									€ 1,44
Totale productiekostprijs									**€ 10,81**
Current sales price (additional functions)									€ 1.200,00
Additional sales price (proposed design)									€ 100,00
New sales price									€ 1.300,00
Percantage change									7%

Figure 1: *An overview of the cost price calculation.*

Source:

1: http://nl.farnell.com/multicomp/ovs-2101/led-2-8x0-8x1-2mm-side-emitting/dp/1716775

2: http://nl.farnell.com/multicomp/mcwr06x2200ftl/res-thick-film-220r-1-0-1w-0603/dp/2446615

3: http://nl.farnell.com/broadcom-limited/asmb-mtb0-0a3a2/led-hb-rgb-0-09w-plcc-4/dp/2401105RL?st=asmb-mtb0-0A3A2

4: https://www.alibaba.com/trade/search?fsb=y&IndexArea=product_en&CatId=100006833&SearchText=haptic+-feedback

5: http://nl.farnell.com/texas-instruments/drv5032fadbzt/hall-effect-sensor-switch-sot/dp/2773564RL

6: https://nl.mouser.com/ProductDetail/ALPS/

7: https://www.zamro.nl/product/1B768/groefko-gellager-2-zijdig-afgedicht-61801-2rs1-in-12-out-2 1-breedte-5-?SearchParameter=%26%40QueryTerm%3D%26ContextCategoryUUID%3DbusKAgAVVDIAAAF-fc2Vc1E_I%26EF000015_MMT_*

Appendix α - User validation test

In this Appendix, the user validation test will be discussed more elaborately. Furthermore, the research questions will be mentioned ones again. Additionally, the user validation will be described which included the participants, stimuli, apparatus and the procedure. eventually results will be shown which have been worked out during and after the test. Note that the test is based on a qualitative test in which outcomes are not valid. Therefore, they will give a good impression of the experienced interaction and will be used for further recommendation and research.

Research questions
For the user validation test, two main research questions have been formulated:

1) Is the proposed design interaction experiences more intuitive than the current interaction of the Quooker tap?
2) Is the proposed design experiences more safe than the current Quooker tap?

Participants
In total, ten participants participated in the user validation test. Participants were contacted via WhatsApp and selected from the network of the researcher. However, four participants were randomly chosen on the test day.
Stimuli
Several stimuli have been used for this user research.
First of all, a two physical prototypes have been made that enabled participants to realistically interact with the product. The first 'prototype' was related to the current Quooker tap (the fusion) in combination with the Cube functionalities (cooled and sparkling water). The second prototype was the prototype made by the researcher. Both prototypes were fully installed meaning that all five functions could be activated. This was carried out with a system that includes: a reservoir (boiling water), a water pump (to create water pressure in the whole system), a water reservoir (10L) and the Cube which included cooled and sparkling water.
Second, several objects such as a teacup and a dishwashing brush have been included in the test in order to symbolize realistic scenario.
Third, participants were informed by an oral explanation by the researcher.

Apparatus
All sessions were recorded by audio and video. Additionally, notes were made during the session. In the last part of the session, participants were asked several questions which are mainly related to interaction aspects.

Procedure
1) An introduction to the participants giving information of the project and the overview of the session. Note that a pilot has been carried out first in order to improve and check the test where needed.
2) An explanation of both prototype's and functions that are integrated.
In this parts, participants were introduced to the so called "two concepts" which need to be evaluated. In this way, participant perceived the two concepts as 'equal' without making presumptions about the product that could have been designed by the graduate student. The two concepts are related to 1) the current tap with integrated Cube functions and 2) the proposed design with integrated Cube functions. Note that step two, the explanation of the interaction and functions of both concept, was carried out by the research only for the first participant. From the second participant on, participants explained the interaction and functions to each other.

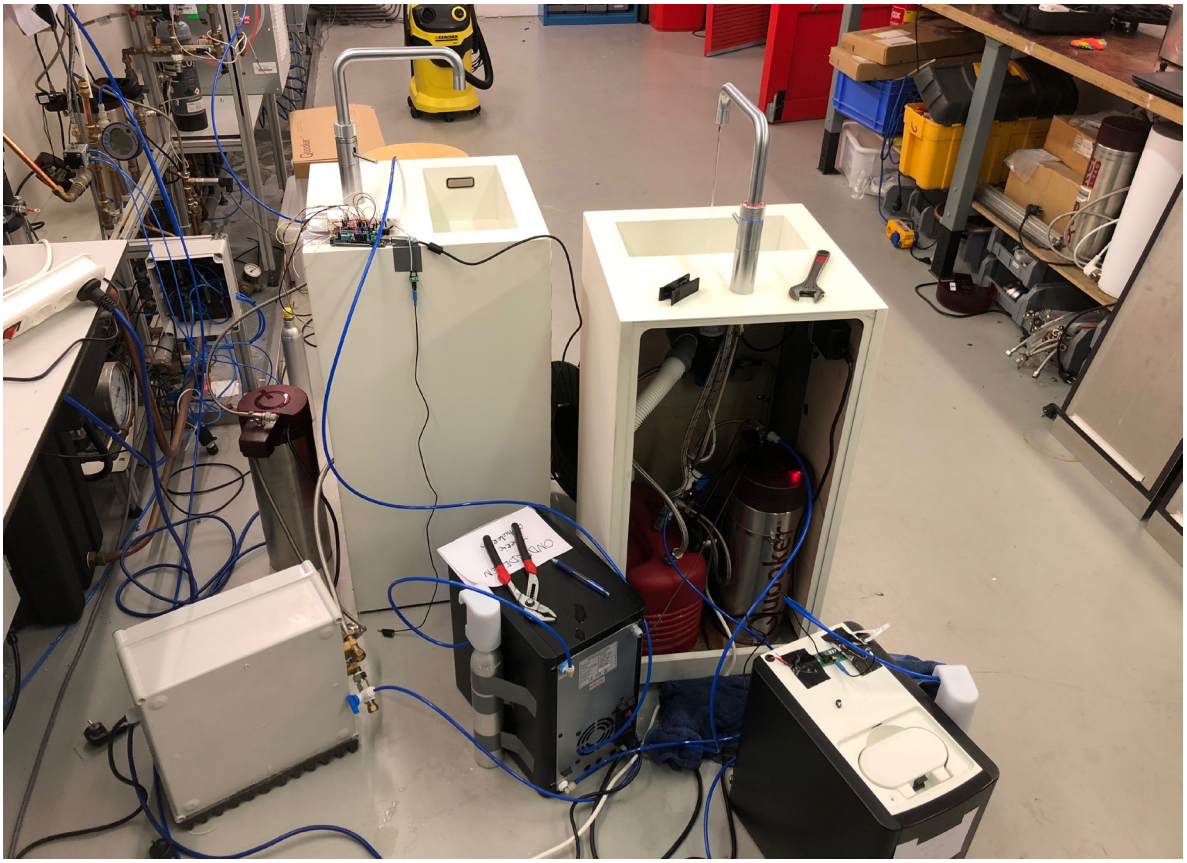
3) Several interactions/tasks that were carried out by the participant.
Several interactions were made with both concepts in a 'realistic scenario'. In this way, they became familiar with all features and interactions.
The following interactions were carried out:

- make a cup of tea (using the boiling-water function)
- washing the cup (using the mixed water function which includes cold and warm water)
- filling a glass syrup with sparkling water (using the sparkling-water function)
- filling a glass with cooled water (using the cooled-water function)

These scenarios are related to the most common interactions with the tap related to for instant preparations (see chapter 3.1; Customers & End-users).

4) Evaluating the two concepts with an semi-structured interview.
In this section, participants were asked to compare the two products with each other and answer several questions. Initially, participants were asked about their first impression of both products. Additionally, the researcher asked more detailed questions in order to make participants arguments/reasons clear. Note that participants were able to interact with both products when they were not certain about their answer.

5) During each session, notes were made of relevant insights.



Building up the two concepts for user the user validation test showing whole system behind the tap

An overview of the setup showing the two models, a laptop for notes and a camera for the video recording.

Results_User validation test

P1 (Female,25)
- Warm en koud haal ik door elkaar (concept 1). Er is geen duidelijke feedback waar warm en koud zit.
- Kokend water is makkelijk te vinden en te activeren (beide concepten).
- Bruisend en gekoeld water haal ik ook door elkaar bij concept 1. Dat kan denk ik lijden tot gevaarlijke situaties omdat de activatie erg lijkt op die van kokend water (concept 1).Bruisend en gekoeld zit een klein verschil qua activatie.
- Ik vind concet 1 iets minder mooi dan concetp 2. Concept 1 vind ik wel mooi minimalistisch.

observaties
- koud en warm water wordt door elkaar gehaald en is dus onduidelijk. Deelnemer heeft het pas door bij het voelen van het water.

P2 (Male, 27) (VIDEO)
- het is erg moeilijk om de handelingen die in de knop zitten te onhouden (concetp 1).
- Concept 2 is echt super duidelijk!
- de kokend water activatie is wel wat moeilijker, hier kan ik wel aan wennen denk ik en hoort opzich ook wel bij de gevaarlijk functie van kokend water (beide concepten).
- In concept 1 zie je niet dat er meer functies in de kraan verborgen zitten. Dat is wel een beetje gek.
- ik vind concept 1 eigenlijk wel een beetje gevaarlijk. Al die functies zitten in die knop en de handelingen lijken wel erg op elkaar.
- In concept 2 is duidelijk te zien dat er meerdere functies in de kraan verwerkt zijn. Dit maakt me dan wel nieuwschierig.
- de functies in concept 2 zijn goed geordend naar mijn idee. Ook duidelijk in welke positie je zit. Warm wordt namelijk met rood aangegeven en koud met de kleur blauw.
- bruisend is duidelijk door de trillingen die ik voel in de handel.

Observaties
- bruisend en gekoeld worden niet begrepen. Deelnemer heeft veel moeite om bruisen water te activeren. Gekoeld lukt wel (langer indrukken)
- na twee keer duidelijk uitleggen begrijpt de deelnemer pas hoe de functie echt geactiveerd kunnen worden.
- soms heeft de deelnemer de juiste handling gemaakt, alleen is het systeem niet terug naar de 0-stand waardoor alsnog kokend water wordt geactiveerd.

P3 (Male, 26)

- Bij concept 1 kan je nergens zien dat er twee extra functies aan zijn toegevoegd. Dit kan je nooit de eerste keer goed doen of uberhaupt achterkomen. Die extra functie wil je lijkt me wel communiceren als je ze gaat introduceren?
- de drie functies in de knop zijn redelijk verwarrend. Functies worden bijna op de zelfde manier geactiveerd. Je wil absoluut geen kokend water over je heen.
- de functies zijn moeilijk te onthouden laat staan te activeren.
- Ik vind concept 2 een stuk veiliger
- Handelingen zijn erg duidelijk, dit kan niet mis gaan (concept 2)
- een kind laat je nooit bij concept 1 gekoeld water tappen omdat de kans veel groter is dat hij het verkeerd activeerd (kokend water). Bij concept 2 kan een kind die onmogelijk maken (meer kinder proof).
- kokend water is wat lastiger te activeren, maar dat is beide gevallen het zelfde. Ook kan dit opzich wel omdat het een gevaarlijke functie is.
- die trillingen vind ik een fijne toevoeging, zeker voor bruisend water.

Bij de uitleg van de ene op de andere deelnemer:

- “wat fijn is is dat kokend water van de rest is afgescheiden”.

Observatie

- gebruiker heeft veel moeite met bruisend en gekoeld water activatie (concept 1)

P4 (Male, 25)

- Als een kraan 100 functies heeft, dan wil ik dat ook zien aan de buitenkant. Dit is in concetp 1 dus niet te zien helaas.
- Een kind dat bruisen water willen tappen kan makkelijk de fout in gaan denk ik.
- de functies zijn duidelijk van elkaar gediferentieerd. Vooral fijn dat kokend (onveilig) gescheiden is an de andere functeis die veilig zijn.
- ik vind de lichtjes heel subtiel in de kraan verwerkt.
- Lichtjes zijn voor mij het belangrijke en geven goed aan bij welke functie ik zit. De trillingen zijn denk ik net per se nodig.
- Bij concept 1 kan ik niet direct zien dat er ook bruisend en gekoeld water in de knop zit. Ik vind concept 1 er wel mooi minimalistisch uit zien.

Observaties

Voelt aan het water of het warm of de koude stand is. Dit is alleen niet aangegeven bij de tap. Hieruit is op te halen dat de deelnemer niet zeker weet of de handel in de goede stand staat (concetp 1)

P5 (Male, 27)

kokend water vind ik in concwetp 2 duidelijk omdat dit de enige functie is die in de knop zit. Dit voelt meer veilig.

- ik zou het intuitiver vinden als ik maar een keer hoef te drukkem bij concetp 2 voor de activatie van conetp 2.
- lichtjes van concept 2 geven duidelijk weer of het warm of koud water is.
- Ik zie van te voren wat ik geselecteerd heb en kan op basis daarvan de functies veilig activeren.
- Bij concept 1 zie je pas feedback als je de functie activeerd. Dat vind ik te laat.
- de trillingen in de handel doet me denken aan bruisend water. Ik maak hier een associatie mee.
- Concept 2 is vrij simpel te bedienen.

Concetp 2 heeft een gadget uiterlijk, maar misschien is dat wat andere mensen ook graag willen laten zien in hun keuken. Je ziet direct dat er meer functies in zitten.

- het is dat je concept 1 hebt uitgelegd, anders zou ik niet weten dat er meer functies in zitten.

Observaties

Onderzoeker moet twee keer uitleggen hoe de functie van concept 1 werken. Daarna gaan de handelingen goed.

P6 (male, 42)

Bij concept 1 ging de handeling goed. Bij concept 2 moeizamer, maar ik vind concept 2 toch intuitiever.

- concopt 1 geeft mij een minder veilig gevoel.
- in concept 2 zijn de functies goed gescheiden van elkaar. Kokend water zit duidelijk als neige functei in de knop. De rest in de handel.
- Bij concept 2 zie ik duidelijk welke functie ik ga activeren.
- in concept 1 kan ik niet zien dat er extra functie in zitten.
- Haptic feedback is niet per se nodig.

Haptic feedback voelde ik in eerste instantie niet. Ik denk daarom dat het niet echt een bijdrage heeft. Lichtjes is voldoende information. Wellicht heeft het wel onbewust geholpen, maar dat is moeilijk te zeggen

- de kleur bij concetp 1 veranderd pas als je een van de functies gaat activeren.

Observaties

handling met koud en warm bij concept 1 gaat helemaal goed (opmerklijk, want dit ging bij de vorige deelenemer niet geheel goed).

P7 (Male, 49)

- Ik had moeite met het activeren van zowel bruisend als gekoeld water (Concetp 1).
- Eerste keer is moeilijk (ik ben aan het gissen), na een paar keer activeren moet het wel lukken denk ik (concept 1)
- Ik zie geen verschil in de concepten wat betreft veiligheid omdat de activatie van kokend water voor beide concetpen het zelfde is.
- De kleur onder de kartel knop veranderd pas als je de actie al inzet. Dat is te laat.

- de leercurve van dit concept is een stuk lager dan concetp 2. Je kant dit dus makkelijk aan iemand uitleggen en kan het vrij snel begrijpen denk ik.
- De tactiele feedback is heel fijn! Zo zit je precies in een positite en shiet je niet door naar de volgedne functie.
  Bij die hoeveelheid lampjes denk ik snel aan dat het product sneller stuk zal gaan (concept 2)
- De warm en koud lijken één stand te hebben door de lichtjes. Eigenlijk zou je een kleur verloop willen hebben zodat je ziet dat je ertussenin het warm en koud met elkaar zou kunnen mixen
  bruisend en gekoeld haalde ik toch nog even door elkaar (Concept 2). Dit komt omdat beide lichtjes wit zijn. Wellicht voor bruisend geen andere kleur maken, maar miss twee streepjes boven elkaar.
  Als ik iets schoonmaak (bijvoorbeeld een pan) dan wil ik de handel zo ver mogelijk van me af schuiven (in de koude stand) zodatde handel niet in de weg staat. In de koude stand speol ik ook dingen af.
  blijf de handel altijd trillen als hij in bruisend staat? Ik denk dat dat iets te veel van het goede is.

P8 (Male, 23)

- Ik vind het de wamre en koude functie aanduiding niet heel intuittief (concept 1). Ik zou ook het warm en koud andersom doen. Naar je toe koud en van je af warm.
- Ik wilde bruisend activeren door de knop in de juiste positie te zetten en vervolgesn de handel omhoog te doen. Dat komt komt omdat ik nog een beetje ongewennig ben denk ik (Concept 1).
- De feedback dmv kleuren is duidelijk, maar je ziet het eigenlijk best wel laat. (concept 1)
- Grappig is dat bij concetp 1 de feedback verborgen wordt zodra je de functei gaat activeren. Dit zou juiost meer zichtbaar moeten worden dan. (conetp 1). Daarnaast verplaatst je je blik op het kopje, dus zie je die feedback sowieso niet.
- Ik zie de lampjes pas branden als ik al klaar ben met de handeling (concetp 1)
  Feedback in concetp 2 is heel duidelijk, en blijf je ook constant zien.
- Qua veilgheid en intuitie vind ik concetp 1 echt een stuk beter.
- Haptische feedback vind ik echt heel nice!
- De trillingen in de handel is een duidelijke link naar bruisend water (concetp 2)
- Lampje geeft niet een uidelijk verschil tussen bruisend en gekoeld. Door haptische feedback word tdat wel duidelijk.
- Met concept 2 kan je veel beter communiceren dat je twee extra functie heeft. Ik denk dat je hierdoor ook het product beter zou kunnen verkopen.
  Aan kinderen kan je concept 2 veel duidelijker uitleggen denk ik. Concepr 1 is tricky.
  - ik vind concept 2 er echt innovatief uit zien. Concept 1 ziet er uit als een normale kraan.

  Obervaties
  Koud en warm water worden door elkaar gehaald. Voordat de deelnemer bruisend water wil activeren zie je uidelijk dat hij aan het twijfelen is en goed moet nadenken wat het ook al weer was.

P9 (Female, 23)

- Concept 1 is onduidelijk met drie functies in de knop.
- In concept 2 zijn de functies duidelijk verdeel en vind ik dit concept dus ook een stuk veiliger. in concetp 2 is het heel duidelijk dat de knop alleen voor kokend is, de rest zit eronder.
- De eerste keer heb je eigenlijk gelijk al door hoe het werkt (concetp 2)
- Die lampjes vind ik wel echt fijn, je ziet wat je aan het doen bent. Dit ziet er simpel en ook duidelijk uit.
- Die tril merk je maar een beetje, je kijkt vooral waar het staafje naar toe gaat en dan helpen de lichtjes heel erg voor duidelijkheid.
- Trilling voegen niet heel veel toe denk ik.

Obersvatie
Deelnemers weet ongeveer de functie, maar activeert de functieverkeerd. Er komt gekoeld water uit.
meeste deelnemers drukken drie keer de knop in om kokend water te activeren
warm en koud gaat wel goed bij concetp 2

P10 (Female, 25)

Ik zou de handel graag verder door willen draaien naar links. Ik heb het gevoel dat warm veel meer naar links moet. Nu blijft hij in het midden steken.

ik vind het niet logisch dat er drie functies in één knop zitten. Dat vind ik niet intuitief en moet je goed onthouden.
de moeilijkheid zit hem vooral in de tijd. De ene is wat langer indrukken en de ander snel door. Het is moeilijk om die uitelkaar te houden.
Ik vind het fijn dat als ik aan de handel zit ik zeker weet dat ik mn handen niet kan verbranden.
In de ring onder krijg je goede feedback wat je geselecteerd hebt. (concetp 2). Je kan dus makkelijk nog van functie veranderen zonder dat je iets geactiveerd hebt.
door de haptische feedback weet ik beter wat ik geselecteerd heb
die haptische feedback tril en vind ik duidelijk bij bruisendwater passen.
het scale van lampjes geeft duidelijk weer dat je meerdere functies hebt
ik vind de lampjes elegant opgelost voor de hoeveelheid functies die in de kraan zitten.
Ik vind de textuur niet zo mooi op de knop. Waarschijnlijk kan je hem hierdoor wel beter bedienen als hij bijvoorbeeld nat is.
- de volgorde is redelijk duidelijk (van link, warm naar koud en kouder naar rechts).

Alleen bruisend water vind ik er net niet bij passen, maar weet niet waar hij anders geintegteerd zou moeten worden.

Observaties
heeft ook moeite met het activeren van bruisend en gekoeld water.

Appendix β - Design methodologies for SMs

It has been decided to continue with two design directions. Insights have led to a new approach which can be related to the LTM approach (later on also described as 'material driven design' approach). In the following part, this LTM approach will briefly be described and will be compared with the general view on a common design process such as the 'basic design cycle'. This exploration of different design approaches has been explored in order to create a design approach that fits the topics and goals of this graduation project.

The LTM approach

The Light.Touch.Matters. (LTM) project started in 2013. This project was a collaboration between designers and material researchers to develop a completely new generation of smart materials that could sense touch and respond with luminescence ("Light.Touch.Matters | Project, 2017). During this project, a new methodology was created that was particularly focussed on the development of the selected smart materials. Note that that LTM approach was discussed with Professor E. Tempelman before (one of the research partners of the LTM project) and that this approach was derived from the material driven design approach that was explored by professor E. Karana E., et al. (2015).

Material driven design (MDD)

In general, the MDD method consists of four main phases and is aimed to support designers to gain competences in exploring, understanding, defining and mobilizing unique material properties (as such that it will make sense), and experiential
qualities (as such that it will give sense) in design (Karana et al., 2015)

In the first step, it is described that the designer should understand the material and characterize it both on a technical and experientially level. This phase also involves 'tinkering with the material' used to find the technical/ mechanical properties and how it could be shaped and embodied in a product.
In the second phase, the designer should create a vision, a materials experience vision as an ultimate aim of the design process. They can additionally help designers to summarise various findings under a cohesive whole and guide their decisions through the process of design.
Additionally, in the third phase, the designer should find out the interrelationship between the created material experience vision and the formal qualities of materials and products. This can be established by conducting user studies.
Lastly, in the fourth phase, the designer integrates all the gained findings into a design phase in which material or product concepts will be created (Karana et al., 2015). In figure X an overview is given from the MDD approach.

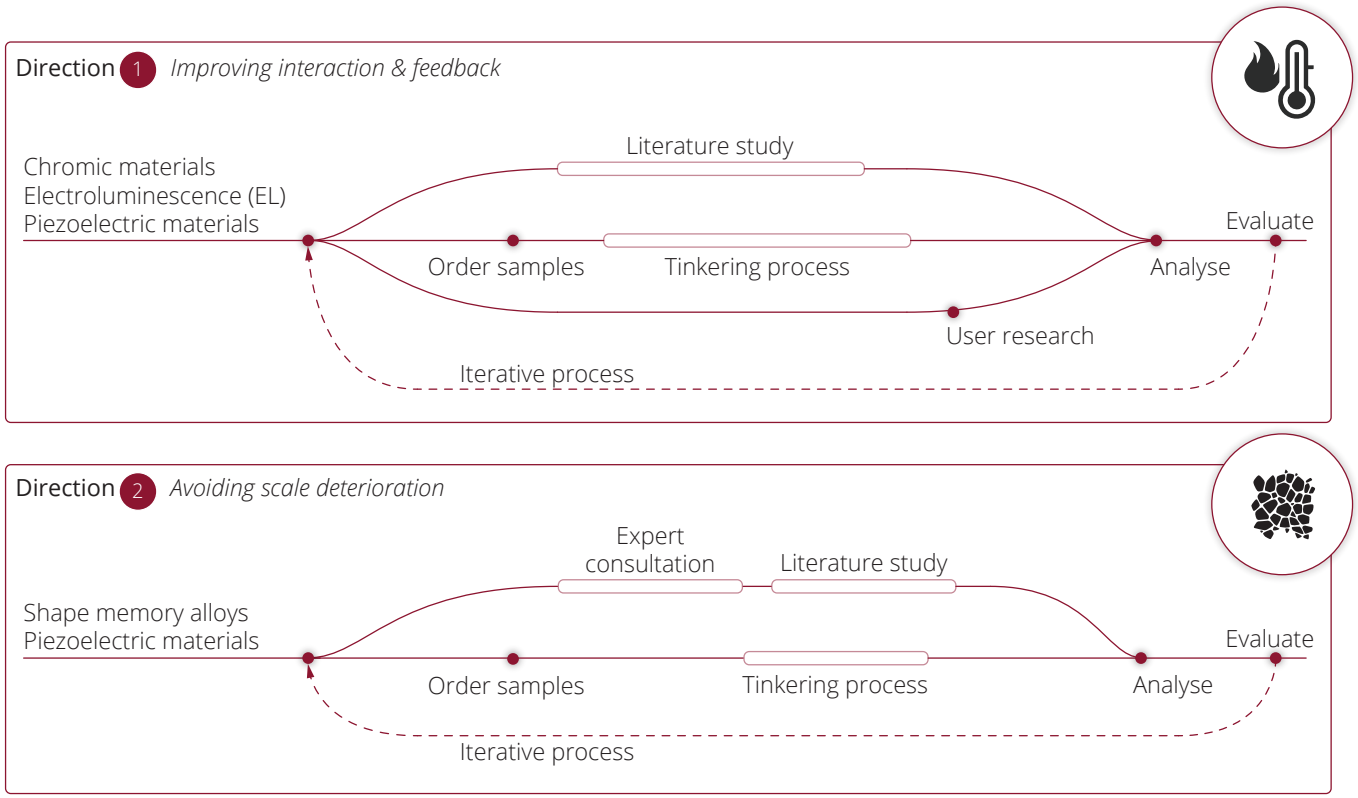
Common used design processes

It has been stated that the Basic Design Cycle (BDC) is one of the most fundamental models of designing (A Lal et al., 2011). Accordingly, throughout the courses that are given at the Industrial Design Engineering faculty at the TU Delft, this BDC approach was often used during projects and can therefore be seen as a common used design tool. Moreover, the overall approach and planning of this graduation project is mainly based on the BDC process.
The BDC (created by Roozenburg and Eekels, 1995) is a model that represents the trail-and-error process of design and consists of five main steps. The process starts with the analysis phase in which aspects will be analysed related to the design goal. Thereafter, first possibilities are generated in an ideation process which is related to the synthesis phase. In the third phase, 'simulation', the chosen idea will be further elaborated by making design drawings and a model. In the 'evaluation phase' the design will be evaluated by bringing in criteria. During the last phase, 'decision' it will be decided whether the design is acceptable (Boeijen et al., 2016).

A modified design methodology

When analysing both the LTM and the BDC approach it can be concluded that in the BDC approach, designers start making samples and prototypes in general at the end of the design process. This is related to a common design process but does not take into account the use of new material (e.g. smart materials) as it is described in the LTM approach. The LTM approach starts with exploring the behaviour of the material and continues with finding materials capabilities and properties. Moreover, it can be concluded that the LTM approach is more related to a technology driven process which means that the focus is on material development only (not taking into account the needs from the market; market pull).
In this graduation project, both the needs of the end-user as well as the use of new materials (from a technology perspective) is being combined. Therefore, a modified design process has been developed that combines market pull and technology push aspects. Moreover, the modified design process is derived from both the BDC and the LTM approach.

An overview of the modified design process is shown (see figure above). Two different design processes have been created for the two design directions. However, they are almost equal to each other. For direction 1, a user test is incorporated since this topic is more human



Own design methods for SMs

centred ('design for interaction' aspects). For direction 2, research need to be established on the scale problem more thoroughly. For this, experts will be approached.
Both processes start with a formulated design direction which is related to the BDC approach. However, the process continues by making and testing samples of the material to get a better understanding of the materials behaviour. This is related to the LTM approach and can also be described as a material driven design process. At the end of this cycle, both directions will be evaluated. Additionally, a decision will be made on a design direction to continue with. Note that this decision can be made earlier in the process when enough insights are gained to make a validated decision.

Conclusion

From the brief analysis on the LTM and BDC approach several conclusions have been drawn. First of all, the main difference between the LTM approach and the BDC approach is the way it is built up. For the BDC approach, it can be seen that only at the end of the process, designers in general start making samples and/or prototypes to validate and test the design. However, in the LTM approach, designers start the process by making samples and prototypes which is fundamental to understand the materials behaviour.
From the analysis into design processes, a modified design process has been created that fits the aspects of this graduation project meaning that the process incorporates both market pull and technology push aspects. The created design process will be used as a guideline for the next design steps and will be elaborated in the next chapters.