"Implementation of a new bathing pactice"

Embodiment design for a new bathing product

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SUS LAB NWE

TU Delft Delft University of Technology

// Executive Summary

During the course of this graduation thesis, the main activity has been to generate a clear embodiment structure that can serve as a foundation for introducing into the market the Splash concept as it has been developed in the past years.

In this process, the conceptual and abstract practice of Splashing, a rather hard to define form of bathing that can be considered a crossover between showering and flannel washing, served as a basis for creating the embodiment structure. Previous research by Kuijer [5,6], Knupfer [2]and others has developed, described and shaped this practice into one that required a unique bathroom appliance to truly come to life and to perhaps enter into the market at a later stage.

To this end, a series of conceptual designs was drafted and a full-scale, fully functional prototype was made and later evaluated by means of usage tests.

The result is a technical framework, a design proposal that can be applied to it, and a set of recommendations for further steps to take for furthering the development of the product and for marketing this product in an appropriate way.

During technical evaluation of the product prototype, it became evident that the heating system does function as projected. However, participant experience was quite contradictory to the measured radiation heat results.

Other than that, user experience during the testing sessions indicated that the design direction that was adhered to during this graduation does appeal to people in several ways.

Not all of the participants would directly consider using the product in their own home or to replace their existing showering routines with Splashing, but there was a clear enthusiasm about the less tangible aspects of the practice of Splashing.

In terms of optimization it seems that the most important aspect to improve in any further development phase of the Splash would be to improve the efficiency and thermal comfort experienced as a result of the designed integrated heating system as presented in the prototype and design proposal.
This seems like it is very achievable given the design at hand and the testing platform that the new prototype embodies.

In terms of marketing, it seems like there is still quite a bit of work left to do in order to clearly define the actual market of the product in a sensible way. This thesis report, and especially Appendix D do outline an onset to this.

To conclude, it seems that this project has lead to results that are suitable for further development and could present the onset of the development of a marketable product, taking into consideration that several aspects of the product need further development or investigation.

// Preface and Acknowledgements

This graduation doesn't only mark of a journey and complete my studies at the Faculty of Industrial Design Engineering in Delft, but also leads to the start of my professional carreer for which this journey has been a defining path.

In the last two years of my studies, my ambition changed from persuing to become a designer to becoming an entrepreneur. Looking for opportunities to make this ambition into a reality, searching for an appropriate graduation project to suit my future vision was important to me.

By chance, I came across a vacancy for a thesis project within the TU Delft through Lenneke Kuijer, who was previously involved with the Splash project. She convinced me of the project and the challenges that it posed and enthused me to take on this project as a graduation project. She proved to be a helpful and critical mentor troughout my graduation

I would like to thank my mentor Lenneke Kuijer and chair Daan van Eijk for supporting and guiding me troughout this project in a very pleasant and professional manner and for being critical when it was needed.

Also, thanks to Suslab NWE for supporting the Splash project and for financing the prototype that was built during this graduation project.

Intially, it seemed plausible that a company could result from this graduation thesis and this definately sounded like a promising opportunity to me at the time. In retrospect, it was a major factor in choosing the project.

During the graduation however, another project I was involved with grew on me more and more and ended up as the most dominant issue in my mind. This did not always perfectly align with my graduation and even slowed it down considerably.

At the time of writing I am now starting up my own business that results from this other project that demanded my attention. I would like to thank my businesspartners and friends Pratap and Lennart for their perceverance and their patience.

Special thanks go to Andras Fuzy for helping me during the fabrication and assembly of the prototype, providing an extra helping hand whenever he could. Of course I would like to thank the participants to my user tests for their time and interest.

And of course I would like to thank my parents Leo and Ineke and my wife Simona for always supporting me throughout my studies and for believing in me.

// Table of Contents

// Project Description

Introduction

In different cultures, people bathe using different rituals and artifacts and have varying perceptions of how the practice of bathing is supposed to be shaped, both its' physical aspects and in the more abstract sociological aspects of it. Based on research by Lenneke Kuijer [5,6] (PhD candidate) and a thesis project by Linus Knupfer [2] the goal was to further develop and position in the market a novel bathing concept that saves water and radically changes the way the bathing practice is perceived and acted upon by the user. The starting point for this project is a conceptual product framework that has the potential to deliver the before-mentioned changes in bathing behavior. In essence, the concept as it is shown in figure 1 consists of a mirror, a water-container in which water for washing is available and a small hand-shower for rinsing. For thermal comfort, IR-heating elements (top) are used. The layout of these components and their combined functions facilitate the user to wash/bathe using a basin of water instead of fast-flowing water, allowing for reshaping the ritual of bathing itself, while using up to 66% less water [11]. Further development of the concept into a marketable business is the aim of the assignment. Ideally, this project would eventually results in the development of a business-plan and start-up of a company based on the design proposal presented at the end of this thesis. Research and prototyping funds have been offered by Suslab. The prototype and all results from this project will be property of Suslab and the TU Delft.

Figure 1: Linus Knupfer's design

Graduation Assignment

PROBLEM DEFINITION

The work that was presented by Linus Knupfer in his work preceding this thesis project presented a conceptualized and designed framework for a sustainable bathing appliance of which a prototype was made. Due to promising results during testing of the prototype, it served as a good starting point for a new project in which the marketability and optimization of the design would be the major focus of attention.

An appropriate marketing approach and business model for actually putting the product on the market would have to play a pivotal role in the process of this project as to make it more viable as a marketable product. Based on the strategic positioning of the product in the market, the product was to be further developed in terms of its ergonomic, technical and aesthetic aspects. Additionally, it was deemed desirable to present an onset to a business-plan or business model that fits the design and marketing vision.

PROCESS

The initial phase of the work was the analysis phase, in which literature research and market research were the main pillars. In order to get a clear view of the scope of the project and its contexts and the opportunities that it can fulfill in the market, this is an essential phase for developing any new product.
The position of the product within the market was one of the major points of attention before being able to define the design direction of the product.

In order to do this, a vision was outlined for the product and its role within the domain of the bathroom and in order to more clearly define the target customer. This, together with a study performed to evaluate the potential for marketing a sustainable product in a sensible manner, lead to a proposed marketing strategy for the product.
This in itself was used to spark the synthesis phase, in which the actual design alternatives are being conceived and iterated into feasible concepts. After developing a multitude of idea's structured in a morphological chart, several concepts emerged, one of them being picked as a direction to further develop.
This further iteration lead initially to the design of a prototype which served as a testing platform for the developed technology and for assessing how actual users perceive the product and the interaction with it.

The prototype was funded out of the Suslab budget, with the intent to use the prototype for showcasing or further development of the end-result of this product in the future.
The goal was to assess, using the prototype and the design proposal that is presented as a final result, how suitable the product that was developed actually is for the proposed customer segment and in terms of the technical functionality of the product. This lead to a number of recommendations and a proposed pathway for further development of the product and the technology it embodies, which are presented in the final chapter of this thesis report.

RESULTS & DELIVERABLES

The main document provided is this thesis report, which holds all relevant process-related material, showing the evolution of the design itself based on relevant factors and the development of the marketing and implementation plan.
Additionally to the report, one A1 format poster was delivered and can be found in the TU Delft repository, summarizing all relevant aspects of the project in an orderly and clear manner.

At the very end of the graduation period, an oral presentation will be held in front of an audience in order to formally finalize the graduation procedure. A high definition prototype was constructed. The prototype, user tests and evaluation thereof, along with the design proposal presented in this report, provide insight into the state of the design at the end of this graduation project.
A list and description of all relevant stakeholders is persented in Appendix A.

1 // Analysis

The analysis section summarizes the research phase preceding the design phases of this thesis project. It gives insight into the background of the Splash project in terms of prior work that has lead up to the concept. Also, it attempts to explain why these existing and currently predominant bathing practices are suboptimal and hint to opportunities for a new product category that the Splash can become the archetype of. Factors that are important here relate to energy efficiency, sustainability in general and marketing aspects.

1.1 HISTORY OF SPLASHING

This graduation thesis is a result of ongoing work at the faculty of Industrial Design Engineering of the TU Delft. In 2008, the LIVING LAB project took place. This was a EU funded project researching human interaction and sustainable innovations for domestic context in particular. Since the TU Delft was part of this LIVING LAB project, a Msc thesis assignment was given to and executed by Harish Karakat [1] at the faculty of Industrial Design Engineering.

The goal of Karakat's assignment was to take the ideas from a 2008 pilot study by LIVING LAB as input for developing a bathing practice that is "an alternative to the commonly found showering and bath-tub bathing practices in Europe". [1, Karakat, 2009, p.8]
At the time, Sealskin (a manufacturer and supplier of bathroom products) was involved in the project as well in an advisory role.

Karakat's design was the first design shape that was given the name "Splash". It was conceptualized using input from user tests and an iterative and explorative search for a suitable concept shape for the product. Karakat's main focus was on Sponge washing (dry) and Bucket washing or Splash (wet), using these two principles as main characteristics for the new bathing practice. The design that was the result of Karakat's thesis is shown in figure 2 and figure 3.
It presents a uniquely shaped set of bathing utensils designed into one coherent product configuration. As can be seen, two different surface textures were presented. A washing basin is the core of the product, providing water to the user and focusing all interactions that require water to one area. The seat facilitates a comfortable seated position for the user. While bucket washing as such was at this stage in the design phase no longer an integral part of the product configuration, a scoop attached to the water-bowl provides the opportunity to "splash" water on the body for rinsing.

Figure 2: Karakat's Design

Figure 3: Karakat's Design

Figure 4: Knupfer's Design

A second graduation thesis was done in 2011 by Linus Knupfer [2], who developed the Splash concept further, making it a more integral product. The work of Karakat preceded this project, the user test executed with Karakat's prototype being the starting point for the design of Knupfer.
Figures 4 and 5 show Knupfer's design.

Its shape is fundamentally different from the earlier version of Splash, the product being wall-mounted and thus requiring more rigorous renovation of the bathroom. However, the product is designed so that as little work as necessary is required in order to limit the boundary that the consumer needs to overcome for purchasing the product and installing it in their houses.

But not only the shape is different, the functionality is also different, the most prominent difference being the presence of a hand-shower that is pushbutton activated, meaning that the flow is cut of as soon as the user lets go of the showerhead. Furthermore, the wall-mounted console is height-adjustable so that the perfect height can be set for the user to comfortably wash either standing up or sitting down on a stool.

The "Splash-bucket" from Karakat's design has been implemented in the form of a beaker that sits in the worktop surface of the

Figure 5: Knupfer's Design

console. Knupfers' recommendations for further development of the concept include conducting market research and market segment identification, long term prototype testing with a set of test-subject in order to analyze usage patterns and work on ergonomic and aesthetic aspects in order to fit with the determined target market.

1.2 BEHAVIOR CHANGE

In the light of environmental concerns, changes in consumption patterns and the way in which products perform during their entire lifecycle are desirable in many product categories. The difficulty is often not a technological one, but one that relates very much to perception and interpretation by consumers. Changing one type of behavior into another, more desirable state, is not as simple as applying new principles to old product or just changing the complete product and marketing thereof to align with this new envisioned functionality. This section elaborates on different strategies that might be relevant to the further development of the "Splash" concept up until

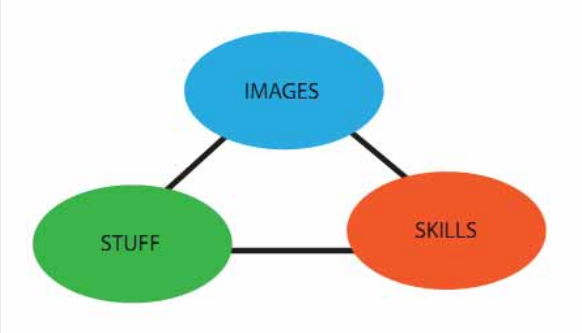


Figure 6: Practice theory

PRACTICE THEORY

One model that attempts to formulate a way of interpreting and working with the less tangible aspects of interaction between people and their day-to-day surrounds is that of practice theory. It was first introduced by Elisabeth Shove[3] and divides practices into three defining categories of values that define a practice; Stuff, Images and Skills.

Stuff includes technologies, products and all other physical aspects related to the practice such as tools. Images describe the meaning that a certain practice has for the user or the outside world and determines what is perceived as 'normal' practice. Skills are the abilities that a person has or has learned through a social process that help perform the practice.

Practice theory is very much a sociological theory, but has been investigated by various scholars (Shove [3], Hards [4] , Kuijer [5,6], etc.) as a methodology suitable for eco-design. This is because it focuses especially on the less well understood and problematic relation between individual values (for instance environmental ones) and action by the individual, often referred to as the value-action gap. While in other models or existing approaches view this relationship as one-dimensional, practice theory examines it with more attention for sociological and psychological aspects of this relation.

In her 2011 article, Sarah Hards investigates the potential of practice theory to bridge the divide between psychological methodologies, which generally take an individually-oriented approach towards behavior changes and their sociological counterparts who gravitate more towards gradual transitional but structural change. One of the observations she makes is that "people seem to need to reconcile competing demands of 'normality' and 'sustainability', which seems to indicate that at least socially, there is still a stigma concerning sustainable practices.

Hards concludes with a few observations that seem to indicate a need for a more holistic approach for reshaping practices in a more sustainable way. Most importantly, it becomes clear that influencing individual behavior and awareness is not sufficient for transforming the practices these individuals perform. They are very much related to culture (on every scale imaginable), social power and infrastructure.

Rebound effects often occur when attempting to intervene in practices by means of modification of its context or accessories that are required to perform it. Lenneke Kuijer[4] introduces and evaluates a methodology based on social practice theory as described above, that can be used to help design products so that rebound effects are limited and new opportunities are identified based on insights generated from the envisioned end-user. Co-design lies at the center of her described method and also helped form the basis of Splash.

1.3 THE HISTORY OF BATHING

The practice of bathing is one that has undergone a lot of change in history. The Romans for instance saw bathing as a communal activity, bathing in bathhouses providing with a place to socialize and even to facilitate political discourse [7].
In most of Western Europe, Christianity and Judaism also had influence on bathing rituals, communal bathing being accepted as common practice for centuries.
Islamic countries also have a rich tradition of

Figure 7: Communal bathhouse

ritualistic communal bathing, cleanliness being a value essential to Islamic culture.

It has been suggested, although it is unclear whether this is true, that communal bathing was reintroduced in Western culture by crusaders bringing it back to Europe. Other theories are that they came back for political and social reasons from within Western Culture [7].
In the East, Japan for instance has a long tradition of communal bathing, especially in hot springs. This was predominantly facilitated by Buddhist temples before the 17th century, public baths becoming common only after that.

Although information about historic bathing practices from before the 17th century are not clear, the most important influence on bathing practices that can be identified is social context, and more specifically those of religious origin. What this seems to point to is that the attitude towards cleanliness, bathing and washing historically was related mainly towards social rituals[9].

These social ritual baths were so popular that the church allegedly formed regulations to limit people from excessive indulgence in bathing. As long as it did not interfere with a regular productive life, it was socially acceptable. What is especially notable is that bathing in bathhouses was apparently not related to wealth, even poor citizens being able to bathe daily.

Throughout Europe, different kinds of bathhouses were common. For instance, vapor or steam-baths were the most popular especially in Eastern Europe. Usually, this involved placing hot stones in a tent or closed or wooded bathhouse, splashing them with water to create a steam-bath, much like a modern sauna. Afterwards, a cold bath was used to cool down again.

During the time of the Renaissance, bathing rituals changed due to the general conception that 'miasmas' brought about decease by entering the pores of the skin during bathing or steam-baths.

1.4 CURRENT BATHING PRACTICES

As much as bathing has historically varied among cultures and geographic locations, it still is a practice that is very much governed by local customs. Therefor it only makes sense to describe a few distinct and different modern bathing practices among different cultures. Although throughout this project, focus will be on the Western European market predominantly, insights from other bathing practices can provide useful insights into exploring a redesign of a current common practice.

SHOWERING

The relatively new practice of showering has been integrated of the lives of most Western households in the past 70 years or so. In practically all modern housing in the Netherlands, a shower is the standard for bathrooms. In older buildings, especially those build before the 50's, shower cabins or even bathrooms were not integrated into the design of the average home. Before that time, communal bathing was a practice that was also still very much commonplace, especially in the cities. [8]

As natural gas connections and convection heaters became available to virtually all households in the late 60's, many of the old washing and grooming practices were changing with those developments. Hot water was no longer scarce and as such, personal washing routines that were previously dominated by having to be careful with water now changed into a situation in which water could be used for pleasure and in abundance.

BATHING

Bathtubs never really became that wide-spread in the Netherlands, mainly due to small bathrooms that were often retrofitted into old-style houses. Shower-cabins however became commonplace for almost all Dutch

households, quickly replacing old habits like visiting communal baths or washing with cold water or multiple family members sharing the same water. A change in available utilities brought about a major change in values and images related to bathing, eventually changing the entire practice of bathing for most of the population.

Bathing rituals are deeply cultural, but also very much a personal affair. It seems that it is hard to change ritualistic behavior without a very convincing product or service on offer. Splash as a concept has so far been an attempt to do exactly that: to provide a sustainable alternative for existing and standardized bathing rituals, showering being the most common one. This presents a big challenge not only in the design of the product itself and the way that the design steers or induces behavior, but also for defining a sensible marketing approach for it.

WATER EFFICIENCY

According to a 2010 TNS/NIPO investigation [10] on water consumption patterns, 100% of the 1200 participants possessed a shower. The average water consumption of the Dutch consumer is over 120 L per day, of which close to 50 L per day is used for showering (TNS/NIPO 2010). While since 2007, the total water usage of showers has declined from 49,8 to 48,6 L/day, the water consumption due to showering has risen with 23% since to 1992. Demographic and technology-driven factors seem to be responsible for this. A notable observation is that between 2007 and 2010, it seems that a stabilization of consumption levels has occurred.

For the frequency of showers, a similar trend can be observed, long term comparison showing a clear rise from 0,69 to 0,75 times per day between 1998 and 2010, while in 2007 the frequency was 0,80.

It is believed that this slight reduction in the past few years is at least partially the result of the increased penetration of water saving showerheads, which have now penetrated precisely 50% of showers. While the water throughput per minute is only marginally less, (7,4L/m as compared to 8,0 for a regular showerhead), the impact on the long term can be significant.

However, this number is ambiguous, as other research (Uneto-VNI) shows a difference of up to 1,8L/minute with non-water saving showerheads using up to 8,7L/min. Average water use reported by both sources are close together at 7,7L/min (TNS NIPO) and 7,8L/min (Uneto-VNI). The savings resulting from the use of watersaving showerheads is partially offset by the rising penetration of comfort or rainshowers, which use twice the amount of water per unit of time (14,4L/min).

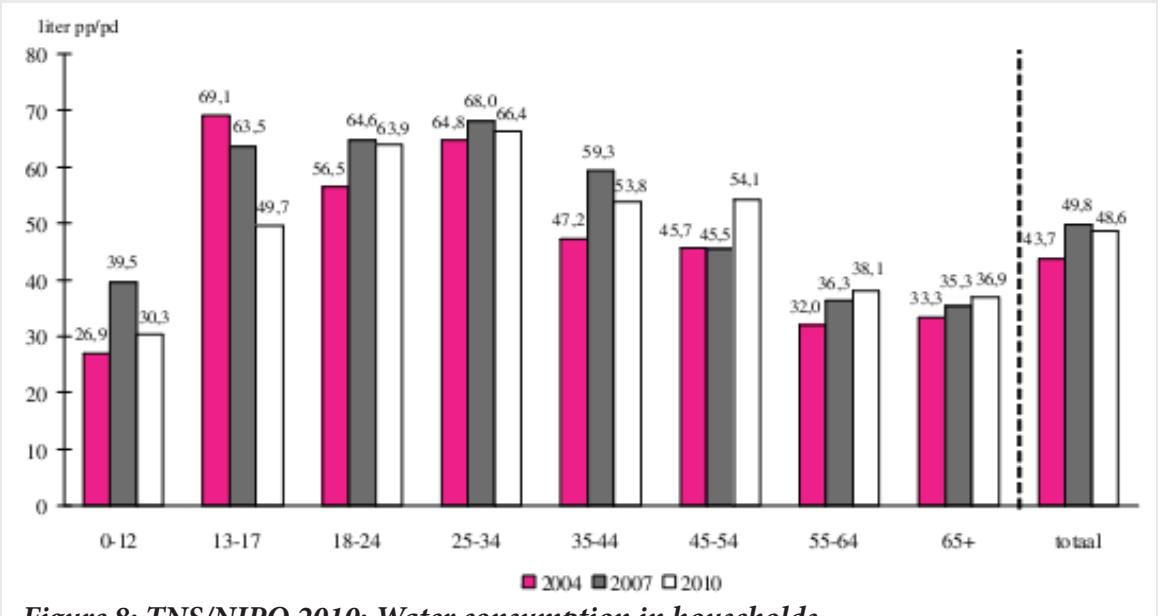


Figure 8: TNS/NIPO 2010; Water consumption in households

Bron: TNS NIPO, 2010

douche	A (hoog)	B-boven	B-onder	C	D (laag)	totaal
frequentie	0,7	0,8	0,7	0,8	1,1	0,8
gebruiksduur za/zo	7,3	7,8	9,0	8,4	7,4	8,0
gebruiksduur doordeweeks	7,3	8,1	8,5	8,7	8,6	8,2
waterbesp. douchekop	47%	48%	57%	55%	54%	51%
douche met extra sproeiers	1%	4%	3%	4%	8%	4%
liters waterbesp. douchekop	7,4	7,4	7,4	7,4	7,4	7,4
liters gewone douche	8,0	8,0	8,0	8,0	8,0	8,0
liters comfortdouche extra sproeiers	14,4	14,4	14,4	14,4	14,4	14,4
waterverbruik douche	42,0	47,9	48,2	51,2	72,3	48,6

Figure 9: TNS/NIPO 2010; Water consumption in households

While the penetration in 2010 was only 4% up from 3% in 2007, it is an interesting development. Also interesting is that especially among young adults (18-24) comfort showers are especially popular (twice the average). This seems to be reflected also in the water-usage per age group as indicated in the diagram below.

Interestingly enough, the 13-17 year olds seem to be using significantly less water in recent years. Reports of children going trough puberty using vast amounts of shower-water, which have been voiced more than once during the course of the project by various people, cannot be reflected by these numbers.

Another demographic trend that came forward from the TNS/NIPO report is that low-income households use significantly more showering water at 72,3L/day per person as compared to the 48,6L average.

Another interesting observation from the report is that urban citizens tend to use up to 20% more water for showering when compared to non-urban citizens. Also, the frequency of daily showers is 45% higher in non-western immigrants in the Netherlands

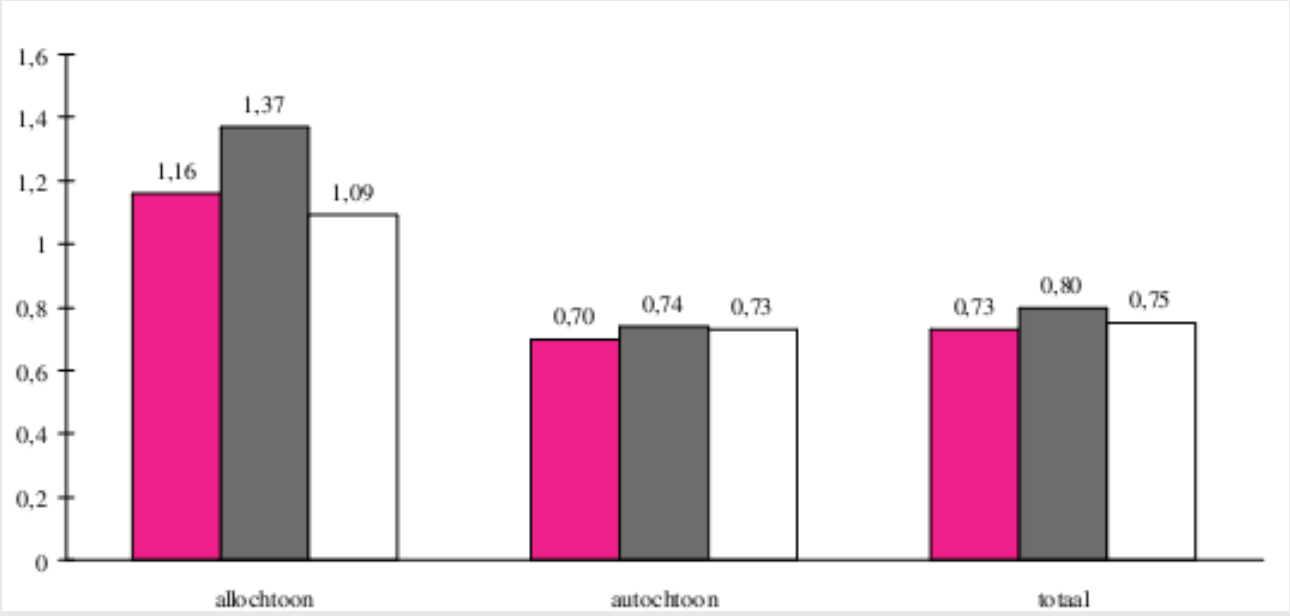


Figure 10: TNS/NIPO 2010; Water consumption in households

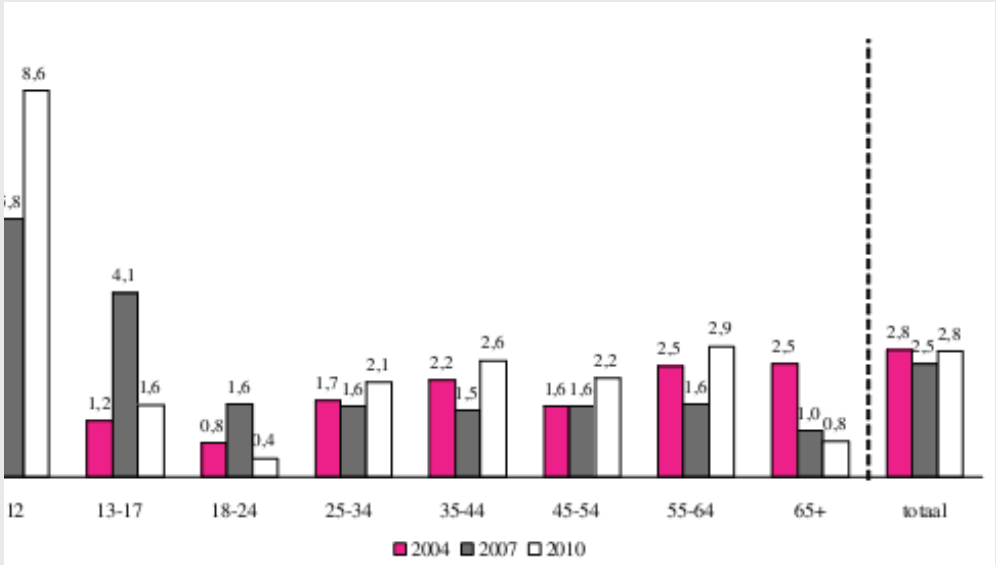


Figure 11: TNS/NIPO 2010; Bathing

Bron: TNS NIPO, 2010

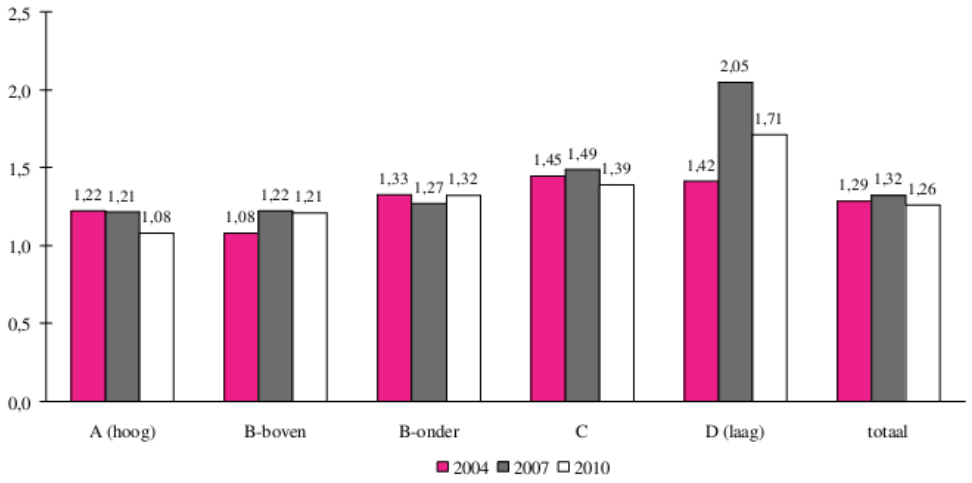


Figure 12: TNS/NIPO 2010; Washstand

Bron: TNS NIPO, 2010

(figure 10). This seems to indicate that indeed, showering and bathing rituals are often very much linked to culture or even religious background.

BATHING

Bathing in a tub is regarded, especially in the Netherlands, as rather luxurious and time-consuming. While 39% of households do own a bath, the average bathing frequency is 0,05 times per day. In larger households (3+ people), baths are more common at 55%. Especially young children (12-) are more frequent bathers at 0,16 times per day (figure 11)

The average daily water consumption resulting from using a bath for the Dutch consumer is only 2,8 L per day.
A regular bathtub fills to approximately 114 liters, being relatively demanding in terms of water and energy (heating) requirements. On top of that, 1/3th of all bathers do regularly shower after taking a bath and rinse the tub as well, using at least 10 more liters.

WASHSTAND

Not a very popular means of washing nowadays, washing at a washstand does usually use relatively little water when compared to the popular alternatives (figure 12). On average, the washstand is used 1,26 times a day for either washing, brushing teeth, wet shaving or other activities. The lower income classes do use the washstand significantly more often (up to 1,71 times a day).
Also, elderly (65+) use the washstand significantly more, consuming 30% more water at the washstand.

SPONGE BATHING

Sponge bathing is not often regarded as an acceptable or suitable bathing practice. Newborns and bed-bound elderly are most often sponge bathed, giving the practice an image that is not desirable for many. However, in terms of water consumption, a good sponge bath can use as little as 1 liter.

While it is hard to find any solid data from literature, early testing with Linus' Splash prototype indicates that many people do see a sponge as a useful addition to their washing rituals, especially when this ritual takes place at a washstand or similar setting without flowing water.

A negative aspect of sponge bathing might be hygiene issues caused by a sponge being shared among people.

STATE-OF-THE-ART

In order to familiarize with spectrum of bathing products available and the state-of-the-art technologies that are being used and under development, examples of such products and technologies were mapped. This served primarily as an inspiration for designing and is not directly relevant for this report. For an in-depth analysis of current state-of-the-art bathing products, please refer to Appendix M.

To shortly summarize the analysis presented in Appendix M, it can be said that there are various product categories that present products aimed at saving water. Interesting examples of original technologies are a shower-concept that heats water by means of kinetic energy of flowing water, mist showers to wet the body or devices that power electronic equipment by powering them from the kinetic energy of the water. However, most of these are relatively insignificant either in the effect that they have on actual use (watersaving showerheads, hourglasses to time showertime) or in the relevance to the user.

In terms of heating technologies, the only interesting examples that are relevant seem to be Infrared heating, low-temperature radiators and heat-exchange systems to win back energy.
In terms of bathroom trends, there seems to be a clear trend towards natural materials such as wood, but also towards appliances with multiple water-outputs, such as waterjets.

For the more high-end markets, there is a clear focus on highly energy and water consuming devices focused on wellness and care, while the more "natural" and cleanly designed washstands and showers show little innovation. As such, it does seem like there is a lack of innovation of products that are designed to appeal to young people that like cleanly designed appliances and that save water, however, this is hard to substantiate.

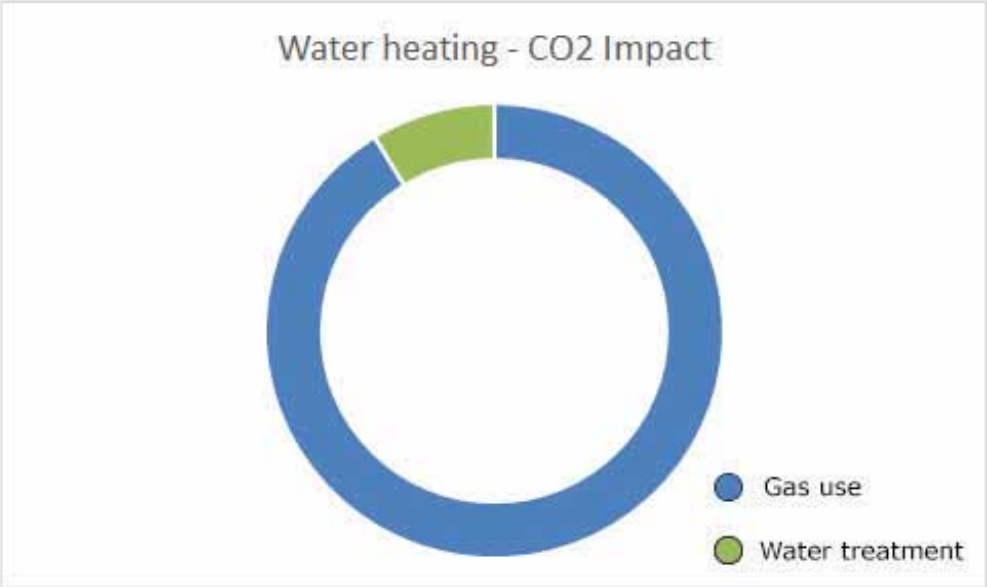


Figure 13: CO2 impact of showering; impact of gas and water use

ENERGY USE

If we assume water consumption levels of 2010, 48,6L/pp/pd, with an average shower rate of 0,75 per day translates to almost 65 liters of water per shower session10. Assuming that the water temperature for showers is about 38 °C and that water needs to be heated from a base temperature of 15 degrees, about 0,24m2 of gas needs to be burned to heat this 65 liter. Burning 1 m2 of natural gas releases 1780grams of CO2, whereas water treatment requires about 1,5kWh per m2 of water, each kWh having a CO2 impact of 420 grams. For calculations, refer to Appendix F.

The CO2 output of the consumption of this gas is 427 grams, while the CO2 output for water-treatment of this water only accounts for about 41 grams. This means that, if only considering the CO2 output as a reference for ecological impact, 91% if the impact is accounted for by the heating as illustrated in figure 13.

As noted by Knupfer in his graduation report [2], a regular shower of 64L accounts for 0,55mPt (Ecopoints) when just considering the environmental impact of producing and disposing of the potable water that is being used for showering.

Next to that he notes that by using an HR heater to heat the water up to a temperature of 38 degrees from a temperature of 10 degrees, 8,575MJ of energy are consumed. This not only costs 30 eurocents per shower, but when converted in mPt (milli-ecopoints), the heating itself accounts for 385mPt. This means that in terms of sustainability, heating of water has 700 times the environmental impact when compared to just the delivery and use of the water that is being used.

Similar observations have recently been made by Unilever, concluding that three-quarters of the environmental impact that their grooming products have are related to the use of hot-water by the end-user, Unilever claiming to focus on drastically reducing this effect in the future.

For Splash, reducing the use of hot-water is especially relevant as it provides the change to drastically reduce the environmental impact of the average household. In trails with the existing prototype, measurements show a reduction of up to 70% in the consumption of water used during a bathing session, which would be very significant.

Important to consider in the design and evaluation of the concept is whether or not the use of IR heating would significantly increase the comfort in the user in order to justify the amount of energy dissipated by the panels, which will partly offset the environmental benefit of the appliance despite the water-savings that are achieved. Other means of heating might be far more efficient.

When analysing the currently prevalent bathing practices, showering seems to me the most widepread and thus will serve as a good benchmark for evaluating the Splash.
We can say that in general, in the Netherlands, 64L of water is consumed during showering, the heating of this water alone accounting for 91% of the CO2 impact of a shower session.

It seems that instead of just focusing on waterconsumption, it may be far more relevant to focus on reducing the amount of energy and thus CO2 that is required for a bathing session using

Figure 14: Bathroom Electrical zoning illustration

the Splash as compared to showering.

Also, reduction in water use already realized in Linus Knupfer's design seems to be a good indication of what can be achieved and would probably be hard to improve on without having a significant impact.

1.5 THE BATHROOM AS A DESIGN CONTEXT

Bathrooms exist in a lot of different configurations across the world. Even in a small country like the Netherlands, bathroom layouts can differ quite significantly. This section describes relevant regulations that apply and ends with a proposed context that serves as a base context for this project.

ELECTRONICS

In the Netherlands, regulations documented in NEN1010 [11] present a thorough and complete framework for implementation of bathroom electronics systems. When considering installing electronical equipment into the bathroom, the zoning rules need to be taken into account, which are described below and illustrated in figure 14.

Zone 0:
This zone is located inside the bath or shower and (including the floor) is the most restricted zone in terms of electronic device application. Appliances used or installed here must be SELV (Separate Extra Low Voltage), which is at most 12V AC or 30V DC, according to NEN1010:701.5511.

Appliances must have a waterproof rating of IPX7 (IP67), which means that they can be fully submerged without danger. It seems that application of higher voltage should be allowed given that just one product is powered and that proper electronic safety systems are in place. However, the complexity of regulations for this requires expert consultation in order to safely design for this purpose.

Zone 1:
Zone 1 is the next safety zone, including the wall to which the bathtub or shower cabin is mounted, up to a heights of 2.25m. IPX4 (IP44) is the minimum waterproof rating required. However, in the case that water jets might reach the device, IPX5 (IP55) is the minimum requirement. SELV and 240V lighting may be applied in this zone, given that a 30mA residual current device is used to protect the circuit in case of a short-circuit.

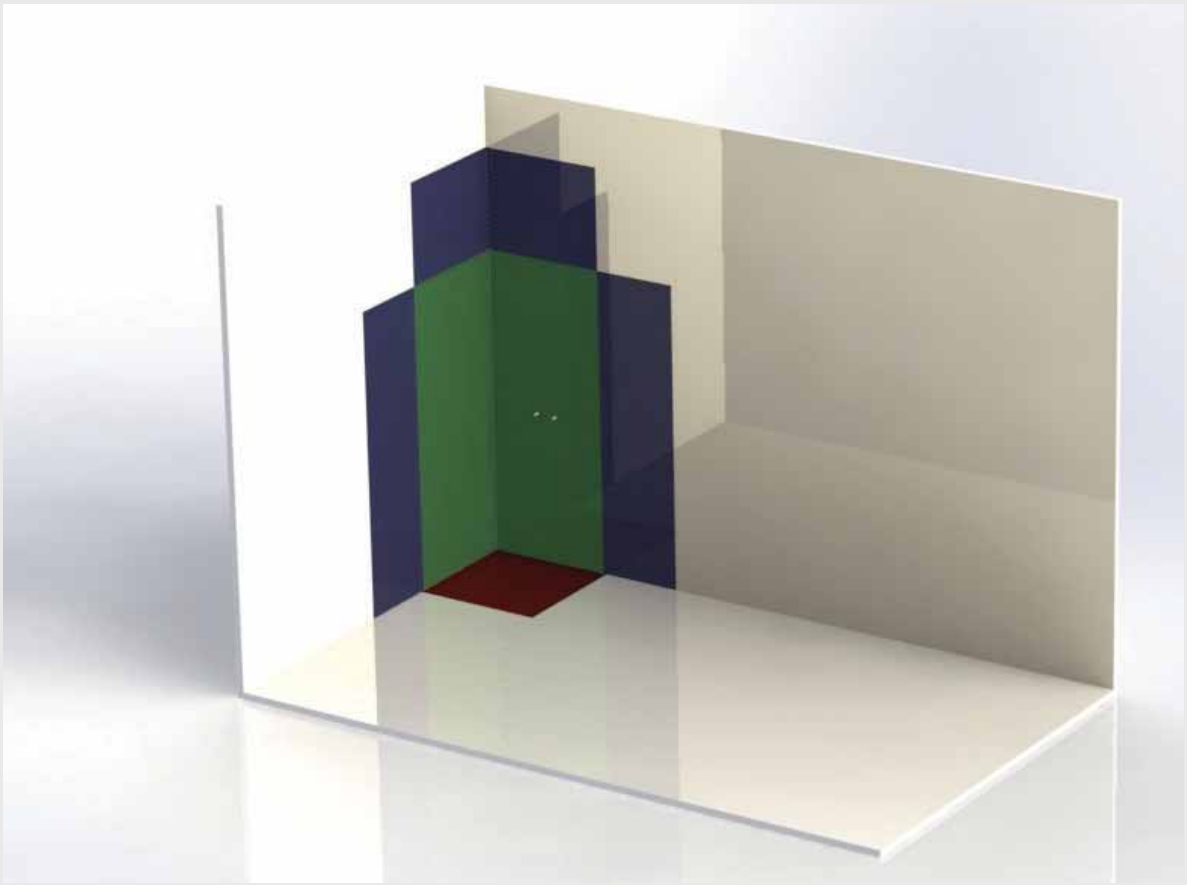


Figure 15: Bathroom Context framework

Zone 2:
This zone reaches 60cm in each direction starting from any zone 1 area but also includes the area within a radius of 60cm within reach of any tap. IPX4(IP44) is the minimum requirement, but again IPX5(IP55) is adviced. In the case that an extendable sprayhead faucet is placed on the tap location, the area of zone 2 that surrounds it is extended to 1,5m.

CONNECTING ELECTRONIC EQUIPMENT

- For all zones (0,1 &2), electronic insulation materials applied, for instance in wiring, should be able to withstand at least 500V for 1 minute.
- Electronic circuits should be connected to a circuit breaker that is activated at most at 30mA.
- o If the circuit is SELV (low-voltage) or the circuit powers only one device, this requirement doesn't apply.

Connections to electronic systems (wiring) within the zones should be embedded within the wall at 5cm or more if not SELV or a separate electronic circuit powering just one device.

Considering all of the above, it seems that connecting electronic circuits within zone 1 of the bathroom (which applies to the Splash) is possible but bound a lot to regulations and norms.

Noteworthy is the fact that it seems not allowed to mount movable or adjustable appliances within zone one if they require electricity. It remains unclear whether or not this applies just to the transformer-unit that might be required or to the entire product that it is required for.
For the scope of the project it seems wise to adhere to the basic requirement that are set in these regulations, consulting experts for detailed evaluation of the proposed design before implementation within the prototype.

WATER SUPPLY
Modern bathing faucet connections have one hot-water and one cold-water pipe that is fixed into position at a distance of 150mm apart. Older homes still sometimes have the connections at a 120mm distance, which can be compensated for by a special set of adaptors to compensate for the

difference. The standard connector size is ½".

TARGET CONTEXT
For the rest of this assignment, we will consider the context of the bathroom that the Splash will be designed for as a 3 by 5 meter space in which a shower compartment is in place, represented by figure 15.

This will be the case in many bathrooms worldwide and gives a frame of reference. A hot water output connected to a boiler is present in the wall, next to a coldwater-connection. Although in most bathrooms there is also a washstand in place, we do not consider this as a directly relevant aspect, also because the Splash could substitute this as well in smaller spaces.

It is assumed that all walls and the floor are tiled and that a drain is integrated in the floor of the shower-compartment. As mentioned earlier, implementing electronics in a way that is non-intrusive into any existing bathroom (which is what is strived for) requires taking into account the electronic zoning regulations that exist.

As a reference context throughout this project, the space illustrated in figure 15 seems to sufficiently describe the space that needs to be designed for. Also it presents a clear, visual and technical framework for analyzing and designing a system with integrated electronics components. If at all possible, it seems desirable to avoid implementing electronically powered appliances unless for for instance control panels or low-powered lighting.

1.6 CONCLUSION

The concept of Splashing has been developed at the TU Delft as a practice that can replace showering or bathing. Reasons for replacing these existing and dominant washing practices were predominantly related to saving water and also energy. In other words, sustainable motives were the reason for developing this product and as a result, the concept as it exists is designed to achieve these motives in a way that makes sense.

The reason for this graduation project was that there was a need for furthering the design of the Splash into a product that can be marketed. As such, there also was a clear need for a marketing approach and for a clear product vision that is fulfilled with it.

During the analysis phase, it became apparent that certain preconceptions about the product might have to be reconsidered. For instance, while previously the focus was very much on saving water consumption, it seems that in practice, saving energy during washing rituals is a much more effective driver for reducing the environmental impact of those rituals, especially when considering the Dutch context, where 91% of the CO2 impact of using warm water is accounted for by the energy required to heat this water.

Of course this is not the only context to be considered, but it points to an important shift in focus.

It also became quite apparent that although heating is an elemental feature of the Splash as a product, implementing this heating in a way that requires the use of electric equipment presents major challenges in its own right, drastically complicating not only the design of the product, but also the prototyping and of the product into standard a bathroom context.

It seems that in order to create a well-designed product, not only does the technical side of the design need to be well thought-trough. The marketing approach and vision that drive the product development will be essential to the successful completion of this project and to the potential of the product for future development or actual market introduction.

2 // Fuzzy front end

Not only the product side of this project is important, but also the business case and marketing aspects of the business that will be based upon this product has to be developed.

This can be seen as a separate section of the product that is not the core focus of the graduation project, but it is vital to the successful realization of the product, which is the final goal.

Usually, this is the initial stage of a design project, however since in this case, others' work precedes this project, it is executed before the synthesis phase in order to more clearly define the vision and marketing approach for the project.

The idea of Splash has already been developed by others over the past years. However, an idea alone is not a fertile business foundation.
It has to be made into a fully developed product solution. This product development is exactly where the focus of this graduation project is, finishing this development process with a detailed design and high-quality prototype.

Still, when a design and prototype are realized, this does not lead an entrepreneur towards business success alone. A business case has to be built up and enhanced continuously in order to actually make a business that can operate based upon the product. When focusing on a single product or one product range –such as in the case of Splash- it is vital that the product is scalable and provides potential for sustaining a succesful business.

The process of synthesizing a business case, and eventually a well thought-trough business-plan on the long run, starts with formulating a company goal.

This goal differs from the goals of the product development process in the sense that is focused on developing and sustaining a business that has potential of growth.

For Splash, this entails stating an initial Vision, Mission and Ambition as a starting-point. However, to reach at this point, the Vision in Product Design method was used to redesign the product context and rethink a vision for the conception of a design framework for it.

Both the ViP and Vision, Mission, Ambition approach are presented in this section. ViP serves more as a guide and reference for designing, while the Vision, Mission, Ambition creates an outlook and focus for development of a business case around the product.

2.1 VISION

Designing a well thought-trough and authentic design solution cannot go without analyzing the context of the product domain and formulating a –often rather abstract- design vision. Vision in Product Design[12] is a method that facilitates this process to take place in a streamlined manner.

ViP is a 6-step approach that enables the designer to have a structural and efficient working process that is documented in a way that creates an easy-to-use reference for later use.

The first three steps are the following:

1. **Product Deconstruction**

In this phase, the physical characteristics of the current situation is analyzed and described in a way that is descriptive.

2. **Interaction Deconstruction**

The interaction phase focuses on describing in abstract way the interaction between user and product. This phase is all about the perception of the interaction in the user. The interaction part of ViP is often regarded as the pivotal element, defining the value of the product in the way it is perceived by the user. User experience of course is vital to the success of a product in the market since it how a product obtains meaning to the user.

3. **Context Deconstruction**

The final phase of the deconstruction chapter is concluded with the analysis of the context of the product domain. This phase is very much characterized by values and principles and is aimed at describing the context of the interaction between user and product.

Construction phase

In the second part of the method, the construction phase**,** all three of these fields are re-designed, starting from the context and working towards the product. After synthesizing the Context for the new product, a Vision Statement is written that describes the core essence of the vision for the new product.
ViP for Splash

For this project, a design concept was already in place. However, to take the design a step further and to clearly define a personal vision for the development of a marketable product, ViP is a valuable addition to the fuzzy-front end of the design process.

The starting-point for ViP in this case was not very clearly definable due to the relatively unique and radical positioning of the product within the bathroom domain. Splash is not a shower-product, not a bath-tub or washing-tub but something radically different.

Therefore, the decision was made to have a two-fold approach towards the deconstruction phase, analyzing two rather separate bathing practices in the first half of ViP.

Bath-tub bathing and Showering were analyzed both in order to have a more complete and valuable input for the construction phase (which was done in a singular fashion).

RESULT

The vision statement (the most important result from the method) resulting from the ViP chart that was made is:

VISION STATEMENT

"I want people to feel in control of responsibly improving their personal care rituals in a reassuring way"

In short, it makes clear that Splashing should be a pleasant, tranquil activity that gives people a feeling of luxury and comfort while allowing them to re-design their bathing ritual.

Appendix K shows the generated product vision in a summarized manner, indicated by keywords that describe it. Appendix L describes the ViP procedure in more detail.

In general terms, the feeling of well-ness and focus on personal care prevail over the environmental aspects of the product. This makes sense for the practice of Splashing, as it is of course focussed on the actual activity itself rather than the side-effects resulting from the use of it.

Splashing should be a practice that people undertake because they feel that it sooths them and relaxes them.

Context

The context in which the Splash is placed and in which it becomes alive is one that

revolves around comfort and wellness. If fits the bathroom of people that care for natural aesthetics, ecology and care for themselves, but want to create their own image and style. Low-maintenance and integration of functionality is important. The bathroom should become a place where people are able to shape their own rituals in a more aware and responsible way.

Figure 16: ViP; New Context

Interaction

The quality of the interaction with the product needs to be playful and energizing and stimulating to the senses. It should be a rather quick ritual to perform as compared to taking a shower, but it has to be at least as comfortable, but in a way that makes people more immersed into the actual practice of refreshing themselves.

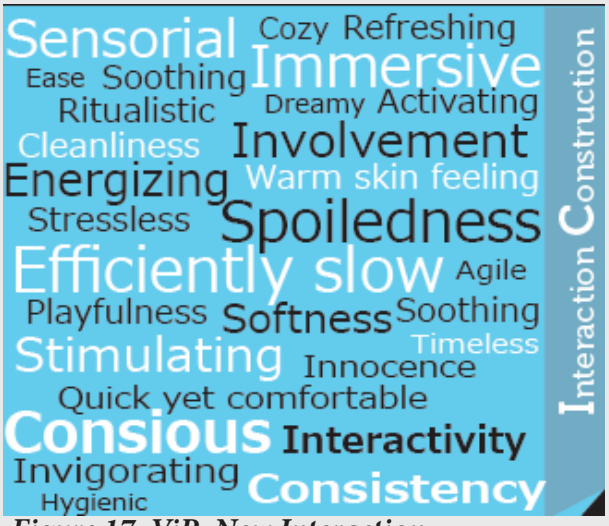


Figure 17: ViP; New Interaction

Product

The product should first and foremost have a hygienic and soft design that suits the interactions described earlier. It is radically different from a shower-cabin but doesn't make the bathroom more restrictive or seem smaller than it is. Rather, it has to be an appliance that gives a sense of spaciousness to the bathroom. Its textures are soft to the touch and create easy to clean hygienic surfaces.

Figure 18: ViP; New Context

2.2 VISION, MISSION, AMBITION

Next to the ViP method, a Vision, Mission and Ambition were formulated. This was done as an additional exercise in order to develop the business-side of the project and create some perspective on how this could look. This is different from the design-vision outlined in the ViP Chart in the sense that it is less abstract and more focused on implementation and placement within the market.

The Vision contains the expected development of a certain context over a period of years to come. This does not yet concern the company goals.

The Mission connects with the vision, defining clearly and concisely what the company goals are based upon the vision.

The Ambition concretizes to what extend

within which boundary conditions the company will operate, and what goals it has for a set period of time.

VISION
"Environmental issues such as water scarcity will change public perception and behavior towards commoditized practices such as bathing"

MISSION
"To empower consumers to take control over their own bathing rituals in a comforting and reassuring way"

AMBITION

2015: *"To market the first product towards a niche that allows [company name] to position itself in the market as a refreshing and notable brand that is authentic and takes responsibility"*

2022: *"To market a differentiated product range and roll-out an enhanced marketing approach that appeals to a sizeable portion of the EU market while maintaining a responsibility-focused approach"*

Not only does it create the opportunity to analyze the current market and envision the future product, it also creates a sense of how it can be positioned and marketed towards the consumer in a sensible and consistent way.

While the vision outlined in the previous section is two-fold, it does seem to indicate a preferred direction for the product development based on it. In order to present a case that will be ready for market introduction at a certain stage, it seems that an ambitious vision needs to be in place that intents to create a start-up company out of the Splash as a product.

This product needs to be fully sustainable since that it what its purpose was from the start. However, the product vision is to focus especially on presenting people with a new and interesting ritual that allows them to rethink the way they care for themselves in the bathroom. On a bigger scale, this concept is envisioned to capture a certain niche in the market by setting itself apart from the current products being offered in the market, being truly unique and recognizable as a brand.

MARKETING STRATEGY

In order to formulate a solid Marketing Strategy around the concept of Splash, I have written a paper called "Identifying opportunities and hurdles for marketing a sustainable bathroom product", which can be found in Appendix D. This paper was written for the elective course "Business Marketing for Engineers". The paper was written with the Splash as a subject.

In the article, I analyze what different approaches can be taken and have traditionally been popularized in business-to-business marketing strategies, focusing especially on how sustainable practice can influences this. Thorough literature research serves as a basis of this.

An attempt was made to present a modern, solid and sustainable case for a business marketing approach for the Splash, taking in mind all considerations that influence commercialization of a product like it. Rather than just focusing on segmentation, I attempted to more fundamentally rethink the way a business could me started with the Splash at its core, taking in mind the entire value chain, focusing on how to create a flexible and agile company that is truly sustainable at its core.

In the analysis portion of the paper, it becomes apparent that for marketing a product like the Splash, which is conceived for being a sustainable solution to a real problem, it is not always so straight-forward to market it in a sensible way.

While, using the right methods, it is possible to identify several market segments, selecting one or several of them and applying a linear approach to implementing a product is not always sensible. Often this results in products

that become too one-sided or that actually generate problems in terms of the image that is portrayed by its marketing.
In practical terms this means that especially for a startup with a green product, focusing on the "greenness" should only be considered if the only customer segment that it can and will be marketed to is really sensitive for products marketed as "green".

This segment is often referred to as Extreme Green. Since this in most countries and markets a relatively small segment of consumers, it may be to bold a statement to market the Splash as a green product too much.

Rather, focus should be shifted towards the more aesthetical and rather intangible aspects of the product such as comfort, luxury and enjoyment. These are aspects already described by the vision outlined earlier in this section, but should be used in the external marketing efforts as the more convincing reasons for consumers to buy the appliance. The water-saving effect could maybe be communicated to indicate a pay-back period or yearly savings achievable when using the product.

Especially for a product that presents a new practice that is disruptive to the existing market, it seems wise to keep an open mind towards the consumer that can be reached. Predefining a too detailed approach for this prior to market introduction might be disruptive to the growth of the company by limiting its marketing opportunities. Focusing on developing effective communication and marketing efforts at an early stage makes it easier to shape an agile company that can actually create demand based on feedback that is gathered from early users.

The internal marketing of the product (how the company culture is shaped and how the preferred way of doing business is communicated internally) can be very much focused on the sustainability or "greenness".

This seems very logical, but actually implies more than just designing a product to save energy or water and then produce it from the right materials. The proposed strategy for the Splash in terms of internal marketing would be to make the Splash a product that is designed so that it can be easily modified, changed or upgraded to fulfill the desires of different kinds of customers. This enables that company to develop the product in a more lean and agile manner, being able to constantly iterate on the design even after market introduction, tailoring it to new insights.

This allows the product to be made as near to perfect as can be while the company constantly gains new insights. A modular design is essential for making this a viable strategy.

Another consideration could be to have a build-to-order process, meaning that the customer can for instance choose between various colours or between various optional features of the product, such as integrated lighting for instance. This approach eliminates the requirement for producing a surplus of products and saves not only money but also materials.

Using recycled materials as much as possible and using only materials that can be recycled in the product itself could make it a truly sustainable company.

An important aspect that has not been focused on is who to partner with in the value chain. This is essential for setting up the business and helps define the marketing approach further. In this scope of this project however, this is not relevant to discuss.

To conclude this section, let's sum up the essentials of the marketing approach set out in this section and the paper:

SUSTAINABILITY AS AN INTERNAL DRIVER

The sustainable aspect should be what drives the company internally. All aspects of how the business is shaped should have this at the core of it. The business culture, materials used, design methods, but also the financial sustainability

of the company should match up with a sustainable vision.

SPLASHING AS A PRACTICE AS EXTERNAL MARKETING FOCUS

The practice of Splashing should be what makes the product unique and the appeal of the product to people should come from this aspect rather than the environmental benefits it presents. While there is a chance that a portion of people will buy the product purely on sustainable motives, marketing it as such risks limiting the possibility of reaching a bigger potion of the potential audience. The change in bathing ritual can be perceived as a boundary for adoption, but certainly does make the product stand out. It will draw attention and redefine the bathroom context in the mind of the consumer.

FOCUS ON THE AESTHETIC APPEAL OF THE PRODUCT

In line with the previous point, the aesthetic and intangible aspects of the product design (material choice, tactility of the product, lighting, available colours, etc.), are a very powerful tool to promote the product and make it stand out. Reflecting the vision outlined for the product, it should be clear from the presentation of the product that it presents a soothing and calming way of changing your bathroom-routine into one that is more practical and flexible.

LEAN PRODUCT DEVELOPMENT

For startups that disrupt existing markets with product that are unlike what is on offer today, it is a high-risk approach to fully develop a product before putting it onto the market. A more agile and flexible method that is often used and gaining attention in the last few years is the Lean approach.

By launching the initial series of products as a framework that serves for developing the product further and optimizing it based on consumer response, the company allows itself to let the exact design issues of the final product to be defined by users themselves.

A modular product architecture allows for easy implementation of this strategy. However, it is essential that all technical issues and a basic product architecture are in place beforehand. And exactly that should be the result of this thesis, a design framework and prototype of it that comprise the basic elements to have a workable product for further development. One strategy for actually implementing this lean development path could be to start out the business with a build-to-order mode of operations, offering a basic product with several optional features that can be changed or defined by the user.

Using one basic product at its core, this allows users to easily change their products to their need and to for instance add features after already having purchased a more basic version of it. For the company this presents a relatively easy and low-cost method of finding out what customers actually want from the product and where a version 2.0 should be focused on. This strategy prevents a business from overcomplicating a product before launch without properly understanding how the market will respond to it, which seems to be applicable to a new practice like Splashing.

2.4 TARGET USER PROFILE

Despite the considerations outlined in the previous section, in a design process it usually helps to have a certain persona or customer profile in mind. Not only does it induce a more creative design context for the designer, facilitating the design process, but it also helps generate more inspired shape-language. It needs to be taken in mind however, that the aim of this project is, like mentioned in the previous section, to come up with a product that can be marketed in a sensible way. This means that whatever results from the use of the user profile sketched here, should not limit the applicability of the product as a whole.

For the Splash product, it seems sensible to market it to various different user groups, using the same basic product configuration. Especially when founding a company that intends to sell this product as their core business, it is wise to diversify the marketing approach.

The modular design of the product itself allows it to be shaped differently for different user groups.

For the scope of this graduation project however, it is not feasible to design a multitude of design variations. Selecting the most suitable initial consumer for introducing the concept will thus determine the design characteristics of the product.

Defining a target user-group involves making assumptions based on observations of the current marketplace and the demographic specifications of this distinct group of consumers that is determined.

These assumptions are almost always generalizations and can be of limited value in reality, but they do provide a starting point for realization of a product. Evaluation of the product among the target user group will allow for verification of the design decisions that were made.

The target users that the first line of the "Splash" product will be targeted to are young families. A brief description of the profile below:

Age:	25-40
Income:	Medium (Modal)
Family Composition:	Married (with children)
Interests:	Holidays, family trips, decoration
Attitudes:	Playful, hard-working, trendy, practical, considerate

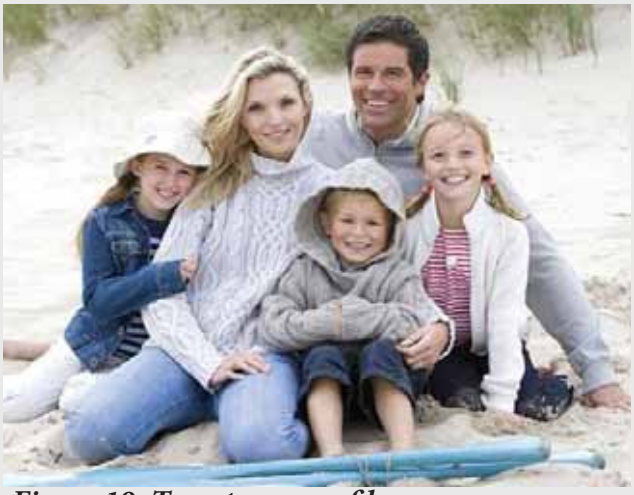


Figure 19: Target user profile

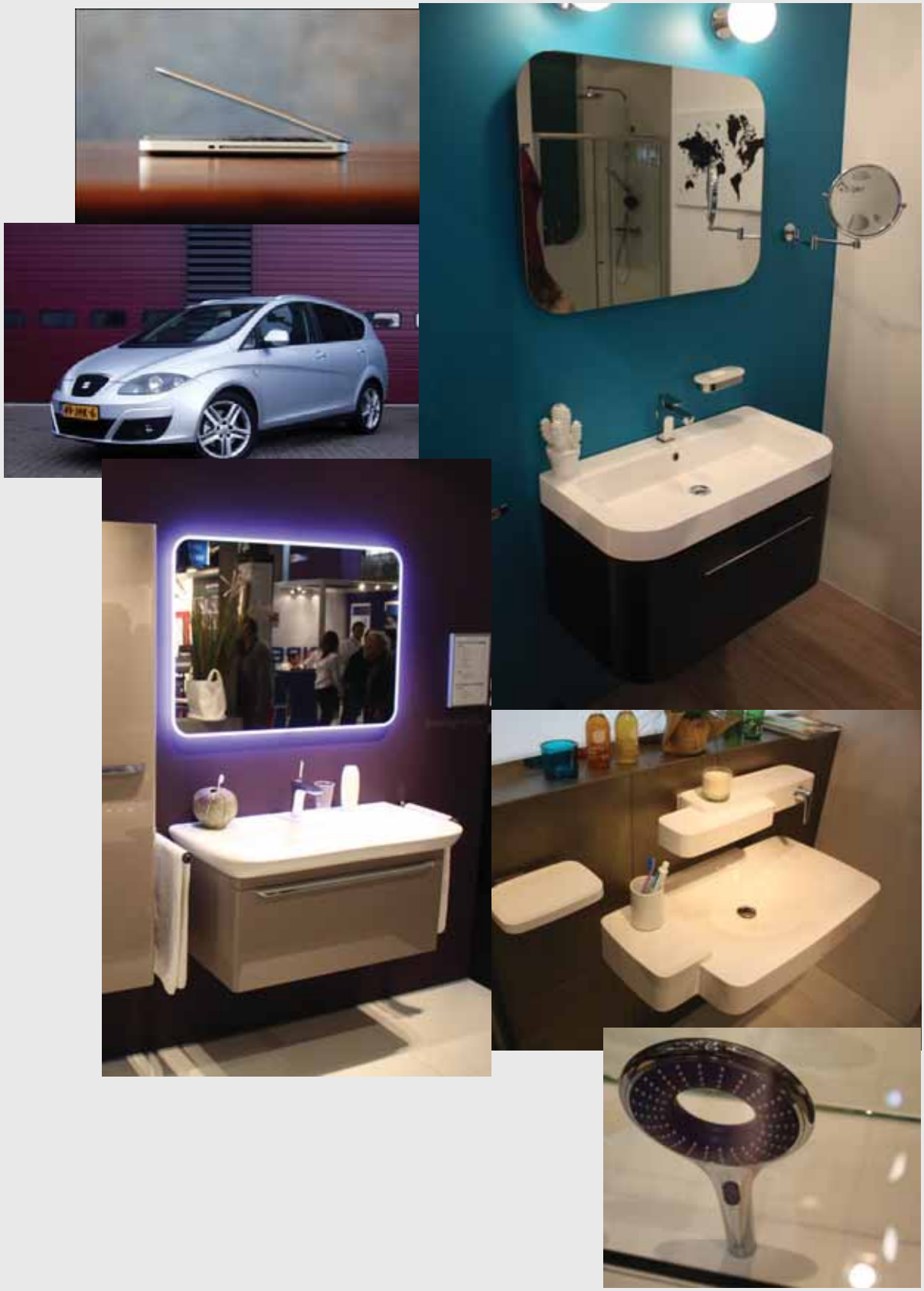
This group of consumers is a suitable group of consumers to target for market introduction for a number of reasons. First of all, younger people are usually more flexible in adjusting to new practices or concepts and implementing them in their daily lives. This is especially true for young children of course.

Young families also have a focus on care for their children, which the product facilitates in a manner that is currently not presented to them by alternative products.

Also, although this will not be a main topic for marketing the product, awareness of and care for the environment is a subject that lives more under younger generations.

DESIGN TRENDS

The collage on this page visualizes this target user in an abstract manner.



Materials

The collage on this page represents the suitable materials that correspond to the target user profile described in this section

Matte Porcelain
Glass (Mirror)
Wood
Aluminium

Use of materials will be determined by functional properties that are required for most of the parts, but accentuation of certain abstract values by using specific materials or technique can greatly enhance the atmosphere that a product creates. Since Splash is a product based around water, ceramic materials spring to mind immediately. Ceramics are recognizable to the user as belonging to the domain of sanitation and are almost compulsory in such a context.
Especially for a radically different product, it is important that the user can instantaneously recognize the product functionality by its looks.

Something very defining in any bathroom is the mirror. It is a feature in the space that determines where the user will be positioned. As such it also influences all other products within the space in terms of usability. For Splash especially, the incorporation of a mirror will define the location of product features such as the washing basin and hand-shower.

Structural elements of the product will be mostly hidden from view due to the fact that they need to be protected from moisture. These parts will make up the basic functional structure of the product and will be made mostly from plastics and aluminium.

For decorative materials, woods seem to be an appropriate choice. They have a natural and calming effect and nowadays can be coated to a waterproof finish that is cleanable as if it was a ceramic surface.

2.5 CONCLUSION

The product vision that has been developed for the design of the product using the Vision in Product-design approach describes a product that makes people feel comfortable in their bathroom and facilitates people to reshape their bathing rituals in a more natural and self-aware manner. Being responsible for the environment is a secondary thing and should only result from seducing the user to use the product in a way that does achieve beneficial effects for the environment, but in a way at least as comfortable as showering or bathing.

The marketing vision that this section describes is aimed at putting forward a product that is radically different and is able to position itself in the market so that it can appeal to a broad audience.

To achieve both of the above visions, it seems smart not to design a product that is to defined in the sense that it is hard to flexibly alter its' aesthetics or secondary features.

It seems logical that there has to be a basic product architecture in place for the product to be ready for marketing, but by striving for a modular product that can be built-to-order, it is possible to gain valuable insights into the true market-demands.

Customers never react as anticipated, and by adhering to a lean manufacturing and development approach, it is possible to anticipate on this in the early phases of market introduction, perfecting the product while already making sales.

Also, while sustainability is an indispensable aspect of the Splash, the external marketing should not focus on this in an explicit manner as this would risk limiting the market potential. Instead, focussing on the intangible and aesthetic aspects of the product as outlined in the vision, will be a more powerful way of enticing people to purchase the product.

All internal efforts of the company should be set up in a fully sustainable manner from the start.
While a target user segment is selected in order make it possible to define a certain shapelanguage and refinement in the design, this doesn't mean that marketing efforts should be limited to this target segment.

Only close evaluation of buying behaviour at the time of market introduction would make it possible to define this with more confidence and specificity.

3 // Synthesis

This chapter of the report comprises the process of ideation and conceptualization. This is usually a quite extensive phase of a design-project and often presented as two separate phases. In the light of this project however, the ideation phase was more aimed at generating new ideas and letting go of the concept as it already existed prior to the start of this project, in order to allow me as a designer to come up with more creative insights and to develop a project that is my own.

Usually, there is quite a clear-cut separation between the ideation and conceptualization phases, the ideation ending with the presentation of various design sketches that can form the basis of concepts. In the conceptualization-phase, these are then detailed into three or more concepts, all of which are suitable growing into a mature design.

In this project, the ideation phase ends at the finalization of the morphological chart. This then serves (along with ideas developed in parallel to it) as a solid foundation for the development of several concepts. The development of these concepts is presented in the Concept Development section of this chapter. While at the start of the Concept development, four drawings are presented that represent four different development paths for individual concepts, development of some of these directions was explored in more detail while others were written off at an earlier stage of concept development. The section ends with a proposed concept design that serves as a basis for the development of a prototype.

3.1 DESIGN CHALLENGES

Heating

To facilitate heating in the washing area a solution suitable for wet spaces (Electrical Zone 1 or 2 / IPX5 or higher) is required[11]. At the moment, FIR (Far Infrared) has proven as one potential solution, but might be challenging in terms of implementation and electrical safety. Also its' effectiveness in terms of providing a comfortable means of heating a wet person in a cold surrounding needs to be verified.

An alternative that is has been considered is a solution using hot-air ducts that can be fed into the washing cabin. These air-ducts facilitate the transportation of hot air towards the person, while the electrical apparatus (air-heater) can be located in an electrically safe location.

Benefit of this sort of system seems to be that it is able to provide instantaneous heating, whereas Infrared usually takes a longer time to heat up. The challenge for this solution is to develop it so that its physical presence in the space is one that makes sense and does not appear misplaced or awkward in it.

Although potentially difficult to achieve in terms of conflicting interests of stakeholders that will then be involved, it would be interesting to evaluate both systems using the prototype. Therefore, at least when it concerns the prototype, the aim will be to allow for both systems to be incorporated in the product.

Sitting
A seat of some sort needs to be incorporated into the design. While it seemed unlikely at the moment that this would be an integral part of the wall-mounted module, the aim was to match the seat and the wall mounted console with the worktop in terms of adjustability and height.

Scoop
The scoop is an essential part in the practice of "Splashing". Its shape and size are essential to its functioning, so it seems. A simple cup is not practical for 'throwing water' on your body. Preferably, several models would have been made, exploring not only shape and size but also matching the shape language to that of the wall-console.

Height Adjustment
Adjustability of the wall-console is required in order to facilitate all members of a family that can then use the product either sitting down or standing up. A base structure for the prototype and for the evolving design of the end-product needs to be tested and optimized.

Modularity of structure
The entire structure needs to be not only adjustable, but modular as well, in order to allow for different an evolving product designs to be applied to the same base structure. Embodiment of this part of the design (which is the very core) is needed before commencing with designing the prototype. This will enable optimization of the design by evaluation of the appropriate prototype.

Clothing Storage
While seemingly easy to incorporate, storing clothing in the washing area itself will involve designing a solution that is not only compact and water-sealed but also easy to use. Within the small context of a shower-cabin this is a challenge that might be hard to achieve. The search will be for a compact solution that caters to the needs of the user, while considering the limitations in terms of practicality.

Lighting
Involving all the senses in the use of a product will immerse people in the practice of bathing while using the new product. Light can be a powerful enhancement of any product design, especially when it concerns personal care. A friendly and calming environment needs to be designed (in line with the product vision) and carefully designed lighting will greatly enhance these aspects of the design.

Functional part placement
The configuration of all functional parts required for interaction with the device need to be defined based on evaluation of the available product topology and usability considerations. Small-scale mockups can assist in guiding this process.

Plumbing
Water is essential to the product. Fresh water needs to enter the unit and is released again. Since the product is adjustable in height, there are issues related to the flexible connections that need to be incorporated. Their durability and effectiveness need to be evaluated and a suitable design needs to be developed.

3.2 REQUIREMENTS
The ideation phase of this project is not so much focussed on actually synthesising a new product but rather on rethinking how the practice of Splashing can be reshaped to fit the context described in the Vision outlined in the previous section. The importance of this part of the design process lies in developing as many idea's as possible and especially in structuring them in a sensible manner for later reference. This ensures that all aspects of the product are properly identified and mapped and that sufficient ideas are generated on all of them.
The process of this ideation phase was primarily shaped and facilitated by

employing a morphological chart (Appendix E).

While initially, several brainstorming sessions were conducted prior to its conception, the morphological chart allows for a structured approach towards ideation. For this reason it was set-up as soon as it became apparent what features of the Splash were essential to its product architecture in any way it would be designed. A list of requirements serves as a basis of this.

List of requirements

1. *Saves energy (rather than water) during use when compared to showering*
2. *Provides a comfortable thermal experience while washing*
3. *Can be used either while sitting down or standing up*
4. *Has a waterbasin at the core of the product*
5. *Has a non-fixable handshower for rinsing*
6. *Facilitates storage of clothing and washing utensils/accessories*
7. *Modular product architecture*

The morphological chart lists the most important aspects of the product and is primarily aimed at maximizing not only the amount of ideas on all of these aspects but also on inducing more creative insights during the ideation phase. Even though some of the loose ideas here can be far-fetched, some of those can sometimes significantly improve the concept that results from the process.

It needs to be considered throughout the design of this product that modularity should be a key feature of the product. Not only does this facilitate a leaner development-path for the prototyping and early production of the product, but it also enhances the potential for marketing the final product to different market segments that have been identified earlier.

The result of the ideation-phase is the conception of various sets of selected product features, selected from the Morphological Chart. These most preferable combinations of features are then used as the input for the Conceptualization phase of the design process, which will be presented in the next section.

3.3 MORPHOLOGICAL CHART

The different aspects listed in the Morphological Chart (Appendix E) were deduced from the list of requirements. All of the aspects represented in the Morphological Chart, will be briefly visited in this section of the report. For each aspect, the main design challenges are clarified and some of the ideas resulting from the idea generation process are presented.

Watersupply to basin

Challenges

The design of a water-basin is an essential part of the product architecture. The practice of Splashing has been designed with this part of the product at the core of it. While the shape of the basin can be explored, it seemed more interesting to focus on the more functional and technically defining aspects of the product in this phase of the project.

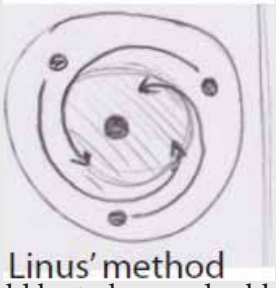
The main challenge for this aspect was to come up with a manner of filling the basin in a way that most appropriately facilitates the use of the product in the way that the practice of Splashing has been thought trough in earlier phases of the Splash project.

While technically this is not the most challenging issue, the ergonomic factors and especially the amount of freedom of use of the product as a whole is defined by this functional part and the way it is to be controlled. Secondary to this, it seems that the aesthetic functionality of the way the water flows is an important factor,

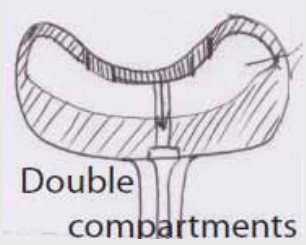
especially taking in mind the vision outlaid earlier in this report.

Ideas

In his prototype, Linus Knupfer used a water supply integrated into the basin. On three points on the sides of the basin, water was lead into the basin. This creates a rotational movement of the water and fills the bowl without any splashing. Also the benefit of this system is that there is no requirement for a faucet and that as a result, the product will have less parts and a cleaner workspace.



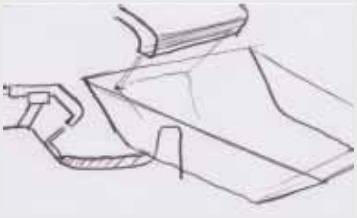
Another way of supplying water could be to have a double-walled basin that fills a compartment on the inside with warm water. Upon lowering the plug of the basin (which moves down upon pushing a button), the basin automatically fills with the warm water that has been filling up the inner compartment.



Integrated into the plug should be a drainage-hole that can be opened to drain the water away without passing trough the internal compartment. The benefit of this system is that again no faucet is required and that upon turning on the appliance, water will run until it reaches the set temperature using a temperature-activated valve.

The complexity of this design however makes it a more complicated one than most others.

The waterfall faucet is quite an ordinary faucet other than the fact that it creates a waterfall-effect caused by laminar flow. By having a tight clearance where the water



exits the faucet, it creates this aesthetically pleasing effect. Funtionally, it is the most similar of all options to a regular faucet and as such will be easily recognizable for its function.

The Laguna presents a worktop with two indents, one for a bigger basin and one for a smaller-sized one that lies higher and to the back of the worktop. Water is lead into the smaller sized basin and overflows into the bigger basin. This creates two separate bodies of water, making sure that there is always a source of clean water that isn't muddled by soap, shampoo or the like. This was indicated in earlier tests sessions as a nuisance in users when washing themselves at a washing-basin.

Finally, there is the idea of integrating the faucet and handshower, for instance in a way that it sits flushed into the surface of the worktop, but can be pulled out when desired, in order to rinse the body for example. This is a more complex design that requires quite a lot of engineering to get right, but might be one of the more elegant solutions if done right.

Rinsing with handshower

Challenges

Like the basin, the handshower is an important product feature. It has to be designed so that it can be used to rinse the body but is not used as the main mode of supplying water during the washing process. Up until now, a button-activated handshower has been the most preferred solution for this. However, more elaborate and specially engineered showerheads or other rinsing tools might add value to the design of the product as a whole.

Ideas

The first solution features a laminar waterfall, but this time in a handheld module. In this configuration it could serve as an alternative to a showerhead and would also create a different user experience that may be more geared towards the enjoyable washing practice of Splashing. Additionally, incorporating a steel centrepiece in the showerhead allows it to me magnetically fixed to a mount in the worktop, making it into a removable faucet / handshower.

A pushbutton showerhead may be the most easily achievable, yet least innovative solution for the handshower. It definitely does serve a purpose and makes sure water is conserved. However, it may also be considered restrictive for the washing ritual, since having to keep the button pushed does restrict freedom of movement.

A more tailored design is the handshower ring. Basically, it is a handheld showerhead with a squeeze trigger. The actual spray head is located on the opposite side from the grip. Rotating a cover on the sprayhead changes the spray from a regular to a laminar flow for different skin sensation.

Warming up washing area

Challenges

Results from earlier tests with previous concepts of the Splash, such as the prototype Knupfer made, show that there is a clear requirement for some heating appliance. Knupfer hypothesised that Far Infrared Radiation (FIR) Panels would be a preferred technology. It would use electricity and could be powered on only when needed, the radiation effectively heating the body to prevent cold sensations.

During an evaluation of a 1000W FIR panel provided by Maxxinno (a company specializing in FIR panel implementation), the technology seemed to be hard to integrate into the Splash for several reasons. The most prominent being that at a range greater than about 30cm, there is no sensible radiation effect on the body.

A major complicating factor is the integration of an electric system into the product, which would dramatically increase the complexity of integrating the product in an existing bathroom As a result, the requirement to provide heating has become one of the most prominent and determining challenges (if not the most prominent) for successfully designing the Splash so that it fulfils all its required functions.

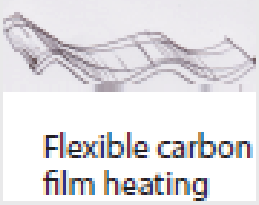
Integrating this functionality into the product in a way that still allows it to be relatively easy to implement and with a limited cost-price and part-count is a major challenge.

Ideas

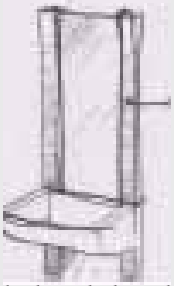
Implementing a hollow waterbasin would make it possible to have an integrated ceramic heating coil in the sides of the basin. The shape can be made so that it heats the user most effectively. For instance, if the basin is part of the worktop surface, the heating coil could be integrated in it as well.
Controlling the surface temperature so that it

doesn't become too hot for touch would be required. Also it is hard to make so that it sufficiently heats the user.

FIR (Far Infrared) heating panels are powered by flexible carbon-fibre based composite heating films. These flexible films usually require about 1500W/ m2 of power. For a bathroom, about 0,3 m2 should be sufficient.



These films can be integrated into the product and are often placed behind matted glass surfaces and can be used to heat mirrors. One example of how it could be used in the design of the Splash, is by making the front surface out of a glass panel, of which the sides are matted and the centre is a mirror.



Heating can then be placed behind the glass panel. Providing the electricity to power the device is the main complication of this method.

Also, the heating-up time of the panels need to be optimized so that it will reach a proper temperature within 5 minutes instead of in 20.

Another alternative is hot-air heating, which seems to be quite an effective method of heating that works instantly. The main drawback here is again that it needs to have quite a lot of power to work. This may require locating the heating device at a distance to the actual washing basin or to engineer a thoroughly waterproofed hot-air system.

A more far-fetched idea, a heated seat, is heated by the hot-water coming from the hot-water line. Engineering this solution would be complicated, but could provide an effective heating method. Heating other surfaces in this manner could also be interesting.

Scooping & water splashing

Challenges

The scoop is a washing utensil that is especially shaped to facilitate the splashing of water from the basin onto the body. While there are no real technical challenges to it, making the scoop a fit utensil for the practice of Splashing while also making it aesthetically appealing and one that makes it pleasant to splash water onto the body is the challenge.

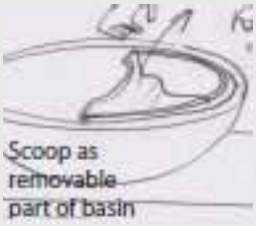
Ideas

Assuming that the core of the whole product would be more shaped like a fixed, wall-mounted console (for instance in the shape of a cylinder) that integrates all functional parts, creates new opportunities. For instance, this unit could have several sockets, on which scoops or containers can be connected. Upon connecting, they fill with water that can be used to wash. Having different ports at different levels makes it a more playful concept as a whole.

A flexible rubber or thermoplastic container can be used by squeezing to squirt water or by releasing it to fill with water. Water can be properly dosed and the "scoop" can be put on the side without water leaking out.

Shaped to comfortably fit the hand and have an organic look and feel, this ceramic or hard-plastic shell can be used to pour or splash water onto the body. The simplicity of the product makes it intuitive to use and doesn't alter the Splashing practice as it has been thought trough.

Alternatively, the scoop could also be made to fit into the basin itself. Filling it would be easy, and storing it inside the basin itself saves space.



Height adjustment

Challenges

Being able to use the product either while standing up or sitting down creates the requirement for adjusting the height of the product or some of its parts. Considering the basic product structure that serves as the basis of this concept, it seems that adjusting the height of the basin and worktop would be the most sensible.

This presents the technical challenge of integrating an easy-to-use means of adjustment that is reliable and can be integrated into the product in a way that doesn't obstruct the aesthetic appeal of the product, the usability of it or the aspect of modularity.

Ideas

As seen in for instance dentist-chairs, a foot operated height adjustment mechanism could be a suitable solution. Usually, this works by a gas-spring mechanism that increases the height in adjustment steps of a few centimetres for every pump. Lowering is done by keeping the footpedal pressed. As a safety, there should either be a way to lock the system so that children cannot operate it, or it should be so heavy to operate that this is impossible.

Using a ballscrew and nut makes it possible to electronically and accurately adjust the height. This makes it comfortable to use and intuitive. Also, electronically operated solenoids could be an alternative solution having the same effect.

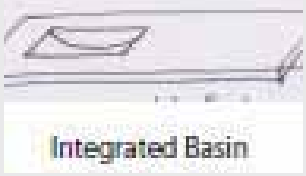
The easiest solution and perhaps the cheapest would be a gas-spring operation as it is often seen in desk-chairs. Remote operation using a button or handle is also possible for this technique. Integration and optimization of the springs allows for smooth operation without requiring much force to lift or drop the product.

Bathroom tray (storage space)

Challenges

Storing accessories required for washing is quite essential for successfully fulfilling a washing session. The way in which these bathroom accessories and utensils can be stored in or on the product is open to various practical considerations. While important to the use of the product and to the total context of the bathroom domain, it seems that this feature is secondary in nature to many of the features mentioned above. Shape and practicality will most likely dictate how this feature can be implemented in the most suitable manner and that is mainly where the challenge of this aspect lies.

Ideas



The most integrated method for this part of the product would be to make the basin an integrated component of the worktop or bathroom-tray. This saves space and makes it an easier product to design.

A more modern approach that is often seen in recent bathroom designs is to have a basin positioned on an elevated level or on the worktop itself. This would shift the focus of the design of the product to make the basin more prominent, but might make production more complicated.

Integrating a compartment in the wall-mounted console would make it possible to store items in the console itself. If height-adjustment is important, this compartment would

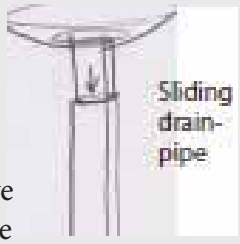
either move with the basin or the console as a whole would be adjustable.

Water drainage

Challenges

Working with flowing water requires the drainage of used water in a way that doesn't disturb the user and that ensures that no water is left in the product in between uses. The adjustability of the height of the basin would implicate the implementation of a drainage assembly has to be adjustable as well. The challenge will mainly be the way in which this feature is integrated into the product in a safe and sensible manner without disturbing the aesthetic appeal of the product.

Ideas



Next to having a regular shower-drain in which the water drains, it would be more desirable to have an integrated drainage in the product. A telescopic drainpipe that leads the water into either the shower-drain or an intergrated wallmounted drainport (if it is present), would probably be an elegant and low-tech solution that is easy to implement anywhere.

Alternatively, a glass plate could be mated to the back-wall. This would then be used as a surface on which a drainpipe that is fixed to the basin empties and flows down towards the shower-drain.

Storing clothing

Challenges

Like storing bathroom accessories, being able to store clothing inside or near the product without them getting wet requires some facilitation. It is unclear whether or not this should mean that there should be an integrated part or an accessory to it to facilitate this.
The challenge will be to design a solution that is sensible and actually makes it easier for the user to fulfil their bathroom-rituals.

Ideas

As an integrated part of the wall-console, an integrated drawer or basket would be a suitable solution for storing clothing. The space available for storing the clothes would be limited, or the compartment would have to be rather big. It would however be the solution that is most elegantly integrated into the product.

Alternatively, a drawer in the basin could also be appropriate.

Conclusion

The ideation phase serves as an input for the conceptualization phase. Usually, a number of different configurations or morphologies of a product are selected. This is done by selecting 3-5 product configurations that are conceived from the morphological chart (Appendix E), selecting one solution from each design aspect mapped in the chart. These selected concepts are further detailed and materialized during the Concept Development phase to transform them into viable products.
Other than following just this structured method, a next design iteration was completed, resulting in four sketched-out ideas to use as an input for concept development. These are not strictly limited to the ideas generated from the morphological chart but are inspired on ideas that result directly from the product morphologies selected earlier.

3.4 CONCEPT DEVELOPMENT

The ideation phase leads into the concept development phase, in which several concepts were developed. The different directions that were explored are described in this section.

Direction 1

The first concept direction developed from the ideas documented during ideating is concept direction 1.
What is interesting about this idea is that it presents a fairly compact design that integrates every aspect the product needs to have.
The height of the product can be manually adjusted using a lever attached to a gas-spring, just like on a desk-chair. The wallmounted consule can be made out of a thermoformed plastic shell with an alumninium frame to support it.
What is special about the functional detailing of the product is that the faucet and controls are an integrated part of the height-adjustable worktop. As can be seen in figure Y, the faucet is a laminar flow waterfall-faucet, its water being delivered through the tubes that form the frame of the worktop or basin frame, hot water coming from one side, cold from the other side of the faucet.

Integrating the controls of the faucet into this as well creates a product that is very functional and should be easy enough to manufacture. Integrating a seat into the product itself was something that is not strived for in all concepts, but an attempt has been made in this sketch. In practice, realizing this seemed like something of a dead end and frankly too much design work to implement into the product in a sensible way.

For this reason, this is the only concept that integrates the seat into the product itself. Furthermore, the product has an integrated storage compartment, too small for clothing, but large enough for shampoo and other bathing products. Heating is provided by means of a low-temperature radiator being integrated into the front of the product. Hot water for this would have to be supplied by leading the hot water through the radiator before dispensing, an idea that will be discussed further later in this report.

While this direction seemed interesting enough the take into the concept development stage, no real ideas were developed that were able to set this design apart from any of the others. Elements of it were taken as inspirations for other designs, but no real concept was developed as a result.

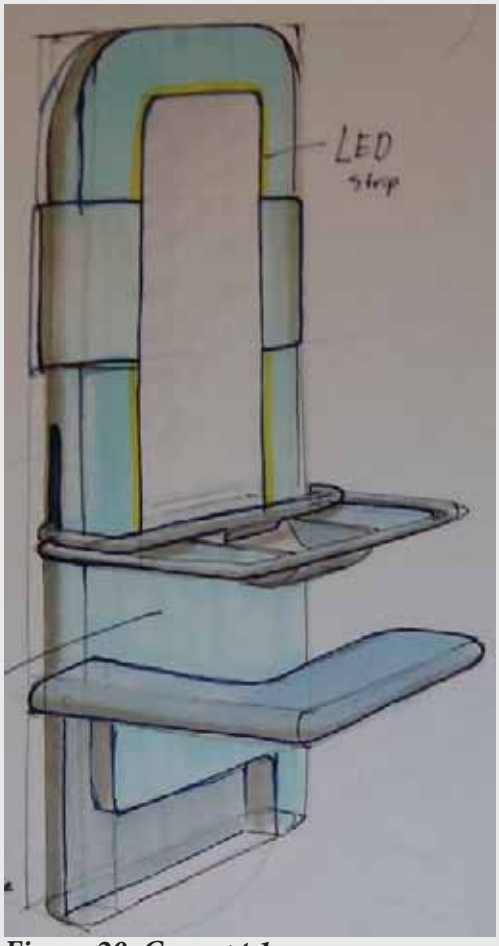


Figure 20: Concept 1

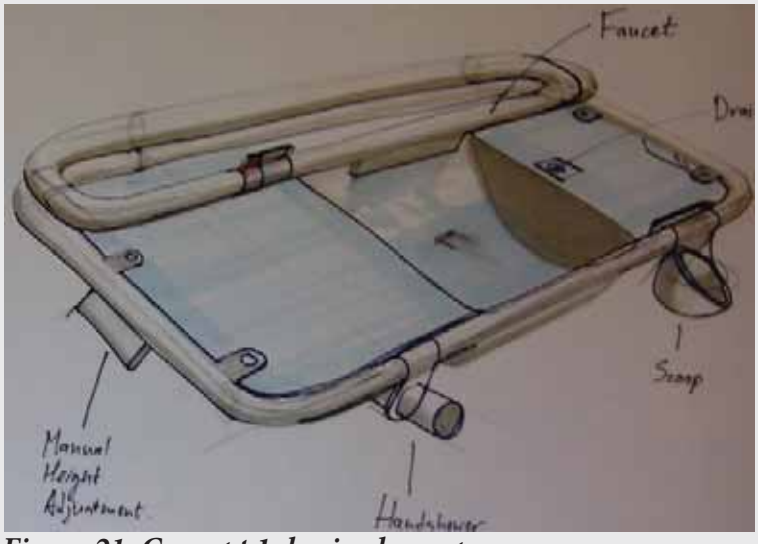


Figure 21: Concept 1; basin close-up

Direction 2

The second concept being considered for further development was one that integrates hot-air heating into a wall mounted unit. What sets this design apart from all the others is the fact that it integrates the height-adjustable basin into the allmounted unit that creates a niche into the wall mounted unit.

This provides the opportunity of making this niche into a special place in which all sorts of aesthetic features can be integrated. The back wall of the niche is a mirror, the side panels of it being lit by colourchanging LED lighting (the armatures of which are integrated in a way that they are not seen by the user. This creates a mysterious and immersive context.

The basin itself, best seen in image 23, is inspired on the laguna idea described in the morphological chart. It is a basin with two compartments, one overflowing into the other. This makes sure there is always one compartment with clean water (without soap). The front face of the wall mounted unit is a glass one, various colors could be applied to it.

While originally, the idea was to have a similar seat integrated into the product as is shown in the earlier idea, it would be hard to integrate this into the product in a nice way. A specially designed seat that is delivered with the product would be a better option. Height adjustment is done by gas spring operation. The hand-shower is fitted into the basin. An accessory compartment is also present.

Since this product is more focused on creating a certain luxurious and ambient atmosphere, a lighting panel is integrated at the top of the unit, creating a soft light to enhance this. It is a product that would be especially suitable for people that are very consciously occupied with caring for themselves and their families. Most likely this is the most feminine of all the idea directions.

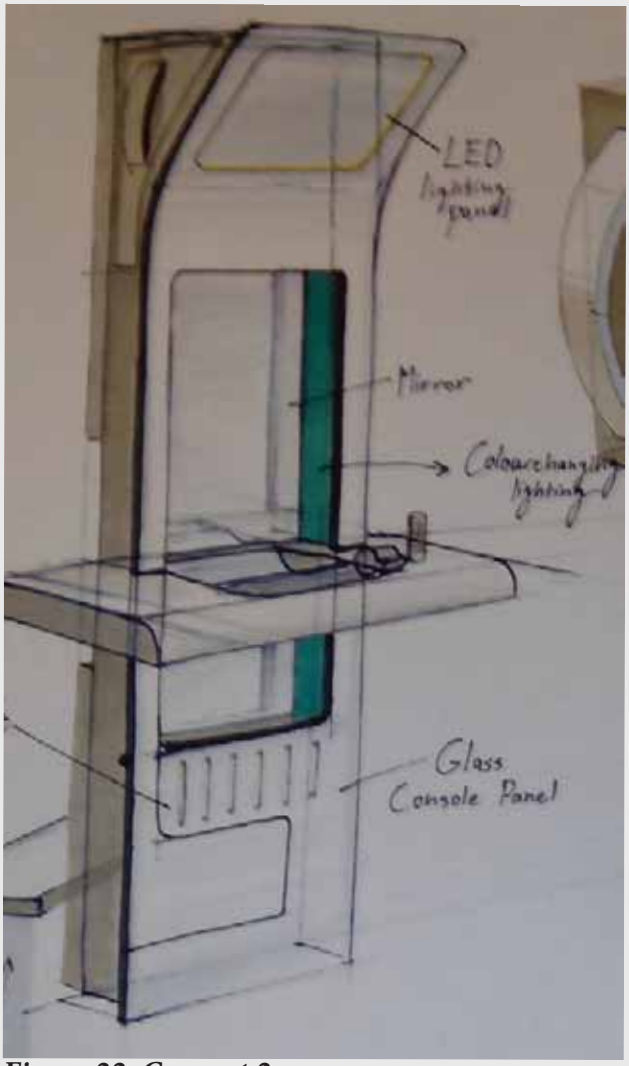


Figure 22: Concept 2

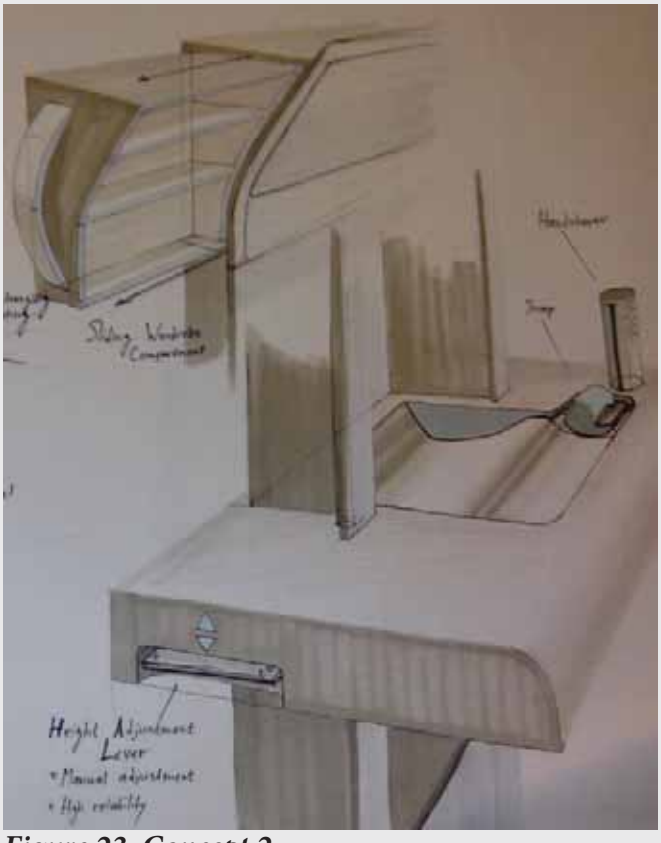


Figure 23: Concept 2

In attempt to further develop the design in this direction, several 3D CAD models were developed, allowing for more detailing and visualization of the design. Shown in figures 24 and 25 is a next version of this concept. The niche in which the washing basin is integrated is seen lit by RGB LED lighting which can change the lighting color. It is a rather minimalistic design which doesn't take up too much space. The hot-air heating is provided by an exhaust at the bottom of the console.

Figure 24: Concept 2 version 2

However, when detailing the design of this concept, it was very challenging to make the system height-adjustable. It would mean for this design that the entire wall-mounted unit should be adjustable and fixed to a wall-mounted back plate. Doing this in a concealed way while still being structurally sound proved to be challenging, especially for manually operated height adjustment.

The result of a structural solution for this concept that does allow for the integration of all those features is shown in figure 26. It is a structurally detained design that integrates manual height-adjustment, lighting, hot air heating and a modular product architecture.

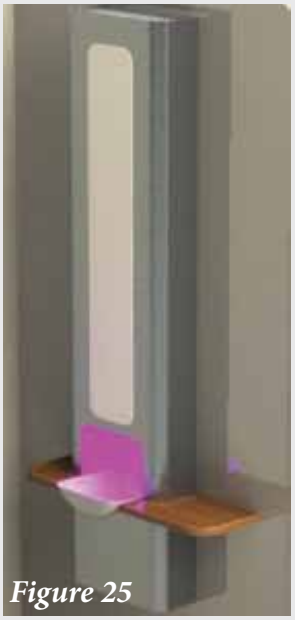


Figure 25

In order to power the hot-air heating however, a strip is mounted to the wall that integrates the power-supply to the equipment. It is designed to also serve as a functional part, for instance for hanging accessories or baskets for storing towels, etc.

It is a design that is technically feasible to build and would adhere to all the set requirements.

It is however quite a large installation that would require more costly means of fabrication and would be a bit harder to modify or upgrade at a later stage in its life, which is one of the visions outlined for the product.

Figure 26: Concept 2 version 3

Direction 3

This direction is probably the most focused on functionality out of all of them. It integrates all of the aspects required and has been designed to be ergonomically sound and practical to use. It uses a drainport that is both a drain and the outlet for the faucet.

Faucet controls would be integrated into the surface of the product. The handshower is one that is especially designed for the Splash concept and has multiple settings. It has a squeeze-trigger that is easy to operate while limiting the amount of water used.

Heating is provided by integrated FIR heating film into the side panels. Height adjustment is done electronically by means of a ballbearing and a ballscrew that can be rotated by an actuator. Different height settings could be preset into the system.

For further developing this design, a good user interface needs to be designed that allows for optimized control of the various integrated functions of the product. A drawback of this design is that is rather big and bulky and that it is more costly product to engineer and produce. Also it is a console that rests on the floor and is anchored to the wall, rather than being suspended on the wall.

The value of this concept is mainly in the ergonomy and comfort of it. The integrated features make it easy to operate and almost fully automated in terms of adjusting and water supply. The unique handshower would be a product in itself however and could have a big influence on how Splashing as a practice is accepted and shaped by the user.

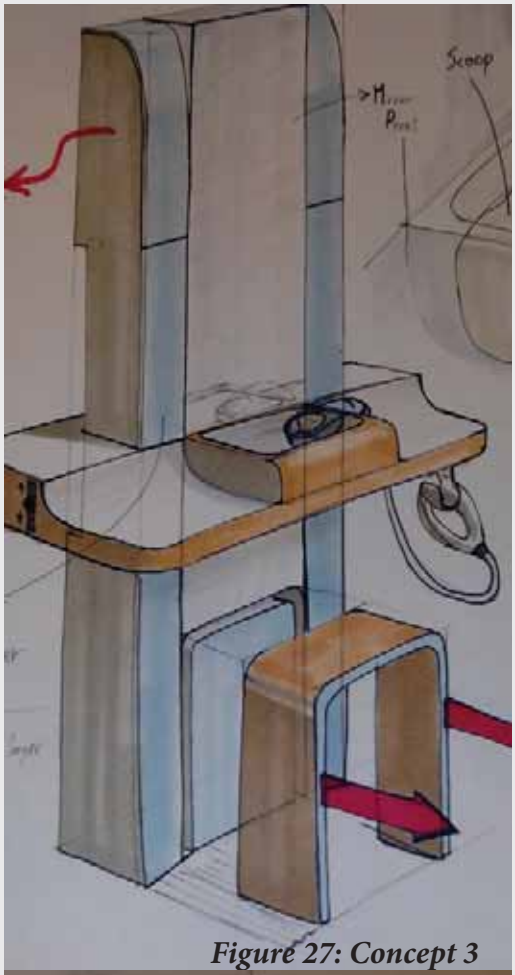


Figure 27: Concept 3

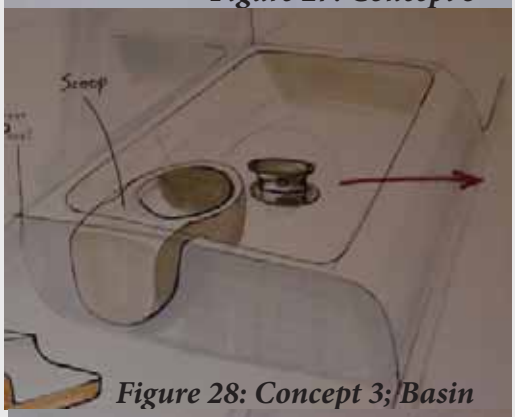


Figure 28: Concept 3; Basin

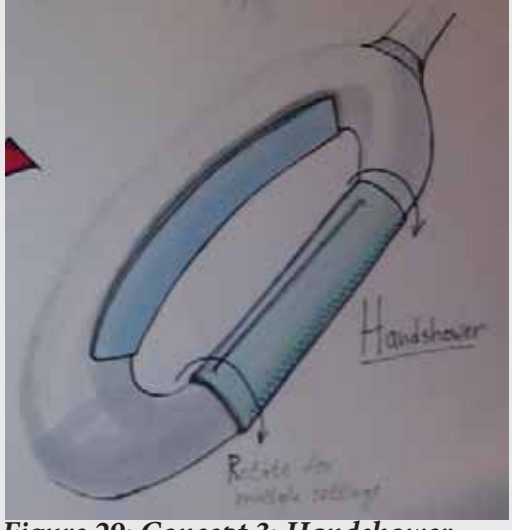


Figure 29: Concept 3; Handshower

Direction 4

While being developed only in a later stage of the concept development phase, this concept presents an interesting product framework that is more slimmed down and stripped to the bare essentials.

What is shown in figure 30 is a modular product architecture in which a wallmounted console provides the basic mounting frame for a height-adjustable worktop.

In this sketch, the focus is on the heating, which is provided in this case by a custom radiator that is connected to the height-adjustable worktop module. As such, the radiator becomes an integrated part of the adjustable module itself, the main console being nothing but a mounting frame for the essential parts of the product.

This design was designed more from an aesthetic point of view and certainly has practical limitations, mainly from the point of usability. For instance, there is very limited space available for placing items. How exactly to integrate the heating in this concept is another problem in itself.

This idea seemed like one of the more interesting ones to develop further, and so a series of 3D models was made to investigate the possible configurations of this product and to try and design a variation that is practical and good-looking.

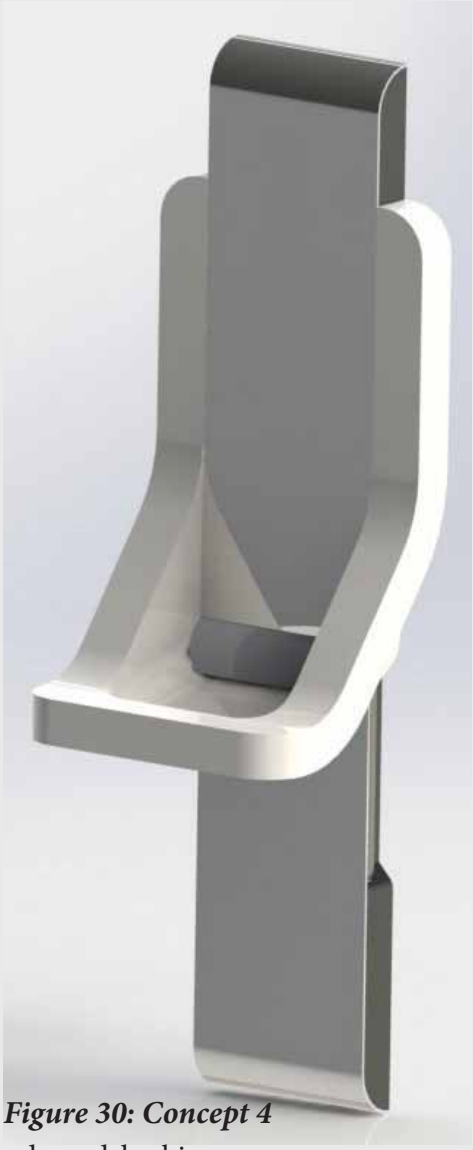


Figure 30: Concept 4

Figure 31 shows the different designs made for this concept. Variation A is the most simplified version, having a basin made from ceramic. It is elegant and slimmed down but maybe not radically different in appeal to a regular washstand. Variation B is much more refined and does provide a uniqueness that is not

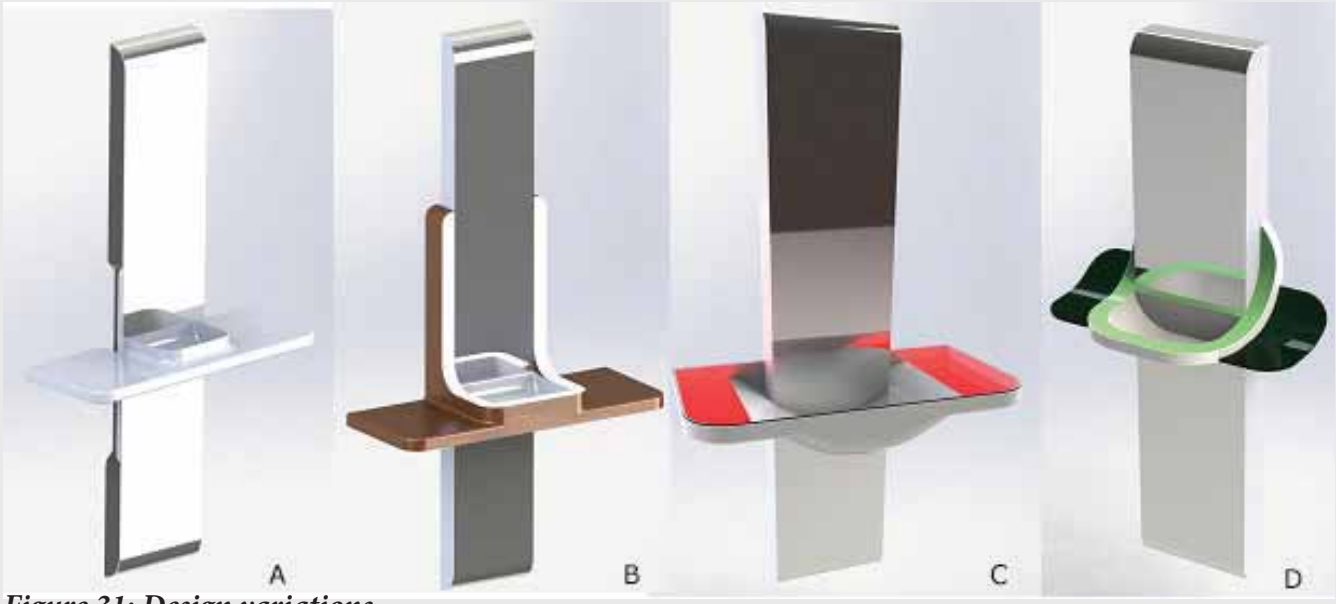


Figure 31: Design variations

present in variation A.
It is however still quite static. Variation C is interesting because it integrates lighting into the unit again.

A larger basin is provided and it is in general a more open and inviting design, however it is quite large. Variation D is an attempt to integrate variations B and C, striving for the elegance of variation C, but the practicality of variation B.

The major benefit of the vertical sides that variation B and D have is that it allows for more easy integration of mechanical parts such as gas-springs that are required for adjustment.

Variation D seemed the most interesting to iterate further, which resulted in the design shown in figure 32.

Figure 32: Concept 4; Version 2

It is elegant and functional and has an inviting and open architecture. Mechanical parts are not visible and even the integration of the showerhead is nicely hidden away.
A major step in this iteration was the development of a newly designed heating-system. Figure 33 shows the modular design of the concept and also the new heating system.

The heating concept developed in figure 33 is powered by an electrical heating element submerged in a closed-circuit radiator. This still requires electicity and is quite a complicated product feature in itself.
The elegance and simplicity of having a wall-mounted console that has a mirrored frontplate allows for a lot of design freedom in the washbasin, which is the essence of the product.

The basin and worktop of the product are the only compartments that move, the radiator being a stationary part. The shape

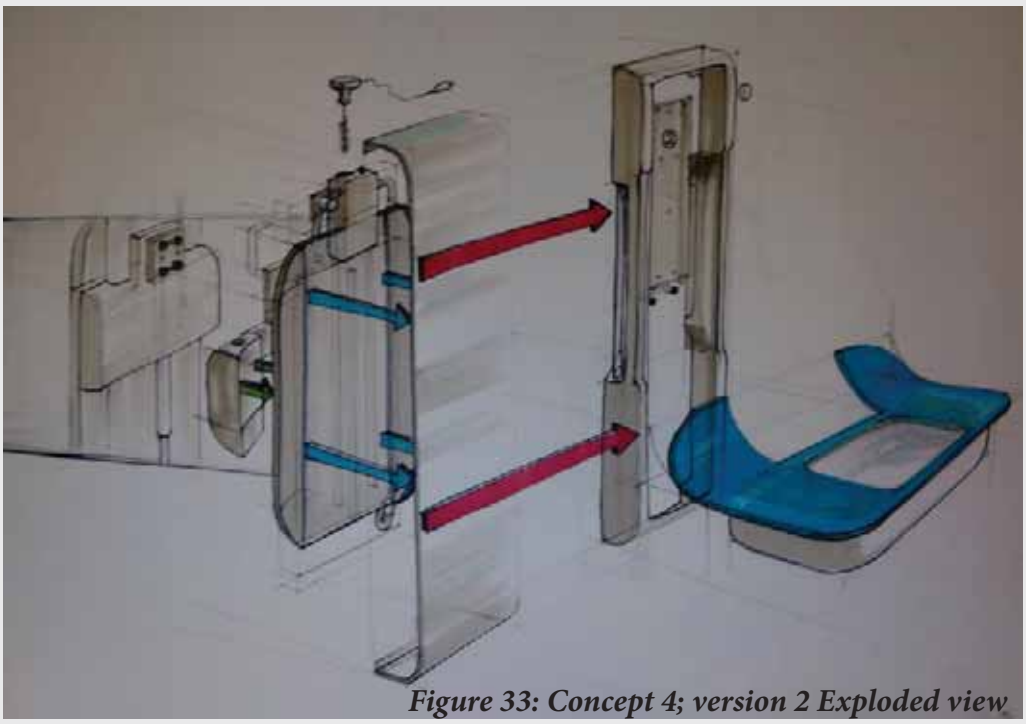


Figure 33: Concept 4; version 2 Exploded view

of the radiator as depicted is arbitrary in functionality and allows for design variations.

As a concept, this one was definitely a personal favorite, and also the result of the last stage of concept development.
Since not all concepts were developed in parallel and this concept being the last one developed, it is the most complete version of all. Still there are some issues that need to be resolved. For instance, the manufacturing of certain parts of the worktop and basin needs to be further investigated. In the current design, it has a colored glass top, but this might be hard to produce as such due to the cuts and bends needed to form the glass plane.

3.5 CONCLUSION

To conclude the Synthesis chapter, an assessment of the ideas presented is required. An excelsheet was made, as shown in figure 34, in order to evaluate the prototypes alongside the most important requirement that should form the basis of the decision. A weight-factor was assigned to all of the criteria, shown in the blue column.
It is quite apparent that, when judging by this chart alone, concept four should be the winner, to be developed further.

While the race between the different concepts was not totally "fair" due to the timing of the development of the concepts, which was not a linear process in which all of the concepts were developed simultaneously. Concepts 1 and 3 are not that detailed and were abandoned quite early during the conceptualization phase in favour of the development of more promising concepts. For concept 1, the main reason for this was the complexity of its architecture that would be quite hard to realize. The integrated faucet for instance, is hard to develop and the added value of it is limited.

The requirement for integrating the seat into the design of the product itself was abandoned early during the conceptualisation phase due to its complexity and the limited value to the design. Making the seat an integrated part of the product would make the product into one that needs to withstand a lot of forces, compromising the both the design freedom and the aesthetics of the product.

But also, it would result in a very technical product that would be very much focussed just on functionality, compromising ease of installation, adjustability and modularity.

As a result, the value of concept 3 also became very limited. Its bulky appearance and complicated systems required for the mechanisms driving the adjustment made this product into one that would compromise the simplicity. The cost of producing an electronically adjustable system would result in a high cost price and a system that needs regular maintenance to keep it functioning properly.

Concept two is quite detailed and has enough nice features that make it stand out. The LED-lid niche would not only look nice, but can also be used to create a mood that suits the user, or the time of day. It is a rather sleek product that is

Criteria	Weight-factor	Concept 1	Weighted	Concept 2	Weighted	Concept 3	Weighted	Concept 4	Weighted
1. Modularity	1	7	7	8	8	6	6	8	8
2. Adjustability	0.9	6	5.4	7	6.3	7	6.3	7	6.3
3. Heating	0.8	5	4	8	6.4	8	6.4	8	6.4
4. Ease of installation	0.7	8	5.6	6	4.2	4	2.8	7	4.9
5. Design freedom	0.6	5	3	5	3	6	3.6	8	4.8
6. Energy-consumption	0.5	7	3.5	5	2.5	5	2.5	5	2.5
7. Water drainage	0.4	4	1.6	4	1.6	7	2.8	4	1.6
8. Storage space	0.3	3	0.9	5	1.5	8	2.4	3	0.9
	5.2		6		6.4		6.3		6.8

Figure 34: Evaluation chart

modular. The drawback is that almost the entire console needs to be adjustable to make this product architecture function. Additionally, the hot-air heating would still require the addition of a wall-strip that complicates matters further.

Concept 4 is the most explored concept that has been developed with the most insight and understanding of the problems at hand. While the heating system is quite a complex system to develop and does require electricity if it uses a closed-loop system, it does provide new possibilities.

For the embodiment of the product, the idea already existed to design an alternative version of the product that has a similar heating system that gets its hot water by integrating it into the water-delivery to the faucet. While this poses challenges in itself, it was one of the main reasons for choosing this concept.

Also, this concept is modular and has the most simplified product architecture. Adjustability is ideal, done with a gas-spring that can be operated by a pushbutton integrated into the worktop. The choice for concept one seemed to be the most sensible one to make.

4 // Embodiment Design

The prototyping phase was one of the vital elements of the project. In order to evaluate the product architecture and the developed integrated heating system, which is now a pivotal element of the product, a high definition prototype was needed as a test-platform.

While previous to building the prototype, a materialized design was developed that should have presented a proper basis for prototyping, new insights taken from the actual design and construction of the prototype had quite a dramatic effect on the actual design of the end-product, and this is exactly the purpose of prototyping; to test and make tangible the issues that cannot be resolved on paper or in a 3D representation of a product, allowing for a fundamentally important design iteration to take place, transforming the design into one that is viable and has value.

This section describes the prototype development stage, highlighting the materials used, technology developed and problem areas that were uncovered. Also, a set of recommendations is presented that serves as input for the detail design phase. These recommendations follow directly from the prototype development and not from the evaluation of the prototype, which follows in the subsequent section.

4.1 EMBODIMENT

Shortly after choosing a concept-design, it was time to start preparing for the building of a prototype. This went hand-in-hand with detailing the design so that a final embodiment of the general product architecture was developed. In this section, I will explain how this process lead from the concept to a product structure and a functional model of the product.

Figure 35 shows an initial version of an embodied design. It differs quite significantly in terms of shape and materialization, especially when looking at the basin and worktop. This has been done to take in mind ease of manufacturing the prototype, which has to be done using basic prototyping techniques such as bending, cutting, milling, etc.
The major challenge was to design a heating system that was viable to prototype and be reproducible in a production series of the product.

Based on the idea of the closed-circle radiator designed for Concept 4, a new heating system was developed that is based on it. A radiator containing water is integrated into the wall-mounted console

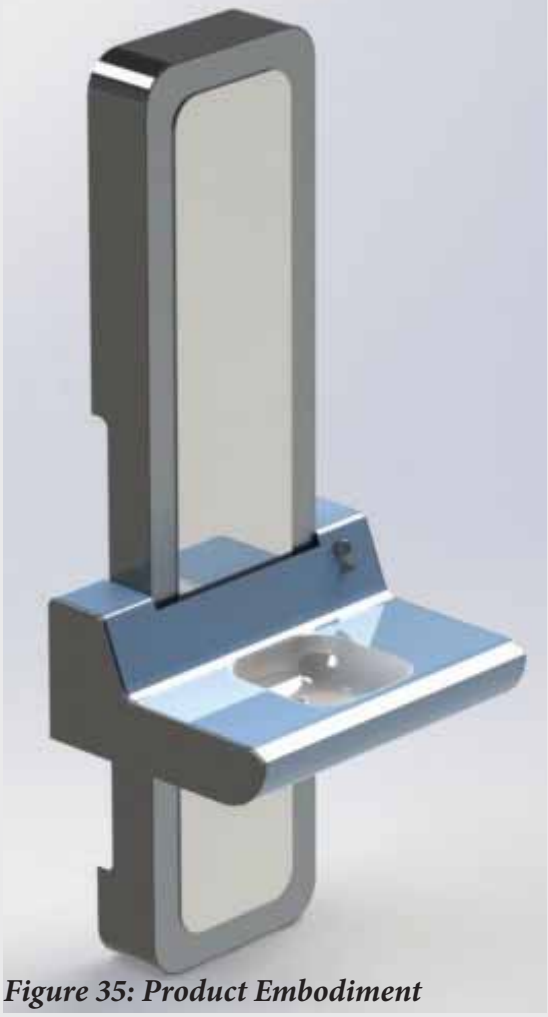


Figure 35: Product Embodiment

like in the concept, however this time it is not electrically powered and heated up but the hot water that heats it comes from the hot-water tap.

As shown in figure 36, a brass or copper tube is to be soldered to the front-plate of the wall mounted console, which then essentially become a radiator. In this manner, the hot water that is used up and usually discarded down the drain immediately after use, is first used to heat up the radiator.

This will cool down the water a bit, but since water will continuously be used troughout a washing session, this only implicates that less coldwater needs to be mixed in order to reach a comfortable washing temperature (usually about 38 degrees Celcius). A major drawback of this system in its current design however is that the tubes soldered to the radiator (the radiator container) have to be made from either brass or copper to be suitable for drinking-water. While this is a very expensive and rather unsustainable metal to use, it does allow for testing and design of an optimized version.

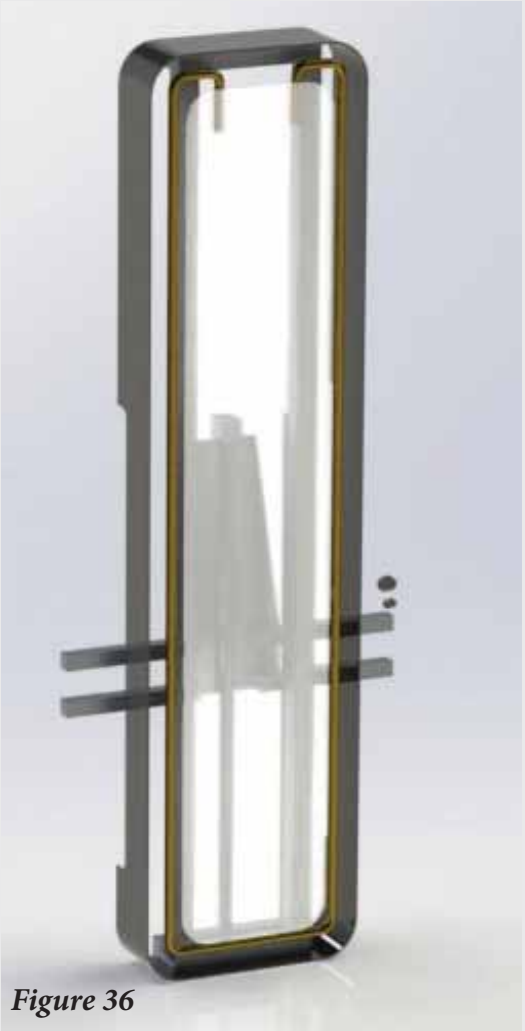


Figure 36

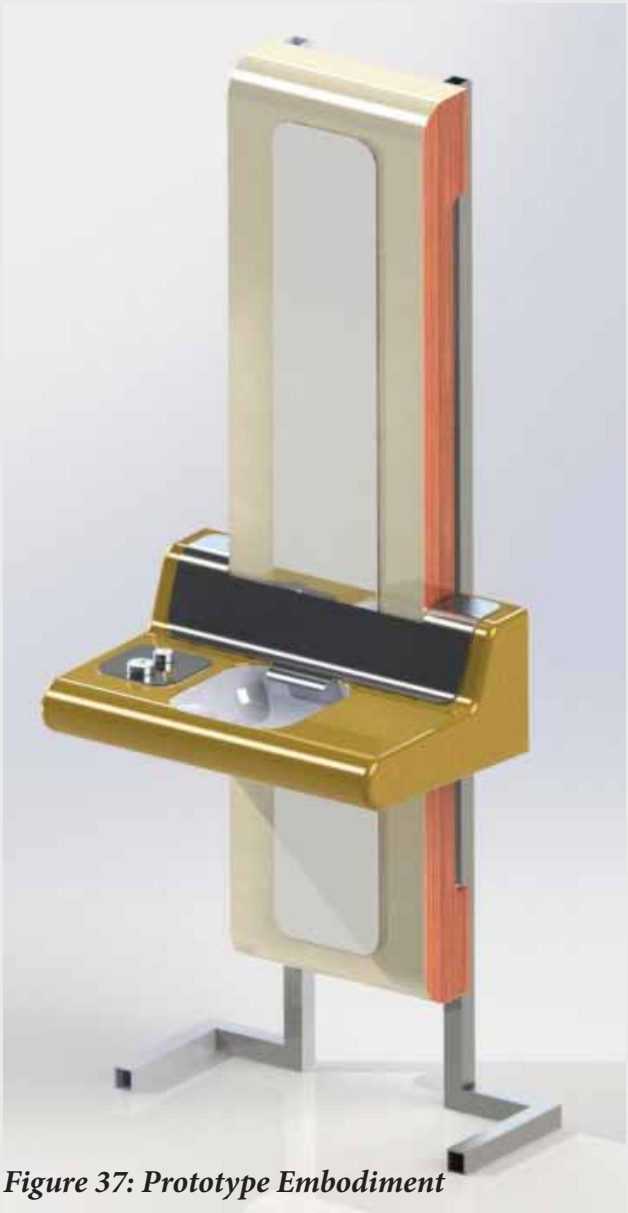


Figure 37: Prototype Embodiment

The front-plate would also have to be made out of the same material in order to make it possible to solder the two components.

Since the structural framework, especially the wall-frame and worktop framework were not yet fully developed in this version of the embodiment, an improved version was made, which is shown in figure 37 and explained in detail in the following subsection.

Figure 38: Prototype Frame

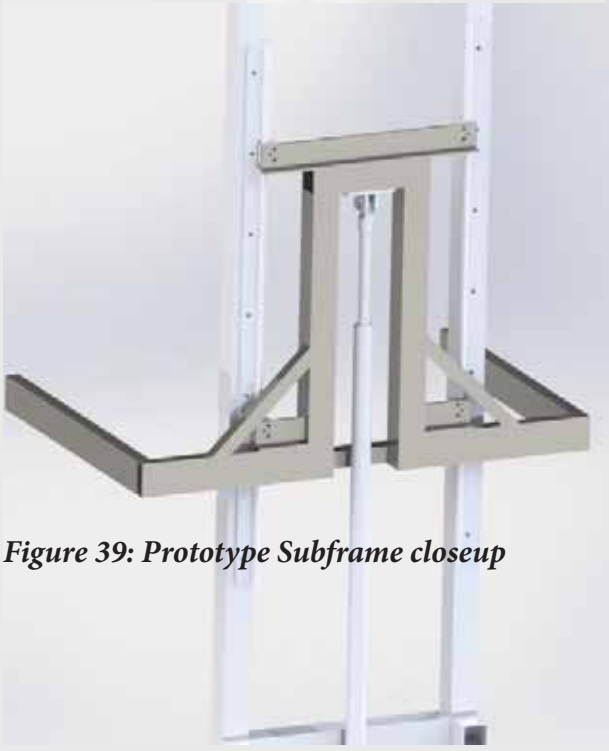


Figure 39: Prototype Subframe closeup

4.2 EMBODIED PROTOTYPE DESIGN

The exact design as shown in figures 37 and 38 was materialized in the PMP-IO workshop. It incorporates all the functionality and parts required and is a simplified version of the design that the end-product will be. Aesthetically it is suboptimal and rather bulky still, but this was the only feasible manner to build the prototype with limited time, resources and manpower.

The prototype is constructed out of a basic framework constructed of aluminium. The frame of the wall-mounted console is in this case mounted on two stands made out of steel.

The console frame is a rather simple structure that serves as the backbone of the entire product. The bottom horizontal beam also supports one end of the gasspring.

As can be seen in figure 39, the other end of this gas-spring is then connected to a subframe that acts as the structural support of the washbasin. This subframe is also constructed out of aluminium. On either side of the subframe, it connects at top and bottom to the console frame by means of linear slides that act as bearings. This ensures smooth operation, but also requires the frames to be produced with accuracy in order to prevent the bearings from skidding, blocking any movement.

The side panels of the product were constructed out of wood and coated with boat-lacquer to protect it. Both the radiator tubes and the front plate were made out of brass and soldered together.
The worktop surface was constructed out of a single plate of aluminium, cut and bended into the right shape.

A standard, off-the-shelve concealed mixing faucet with control unit was built into the worktop surface. This faucet has two outputs, one for a faucet and the other for a shower.

The inputs are obviously hot and cold-water. For the cold-water supply, a flexible sanitary hose will be connected between the wall-outlet and the mixing faucet. For the hot water supply, things are a bit more

complicated in the current design. The hot-water wall-output connects to the radiator tube using a flexible hose.

The other end of the radiator is then connected to the mixing faucet in the same way. Essentially, this means that the hot-waterline is extended in the embodiment of the product. As depicted in the functional diagram in figure 40, the integrated heating system is described by the red area.

A faucet was constructed so that a laminar waterfall effect is created. This faucet was integrated between the worktop and the basin and covered with an aluminium plate that is bent into the same shape as the worktop. This is a purely decorative item in the design, but makes integrating the faucet less complicated also.

Altogether, this design seemed detailed and workable enough to start construction of the prototype. Critical points of the construction of the prototype were primarily the soldering and construction of the radiator itself and proper planning of when which parts needed to be constructed and in which order they had to be assembled.

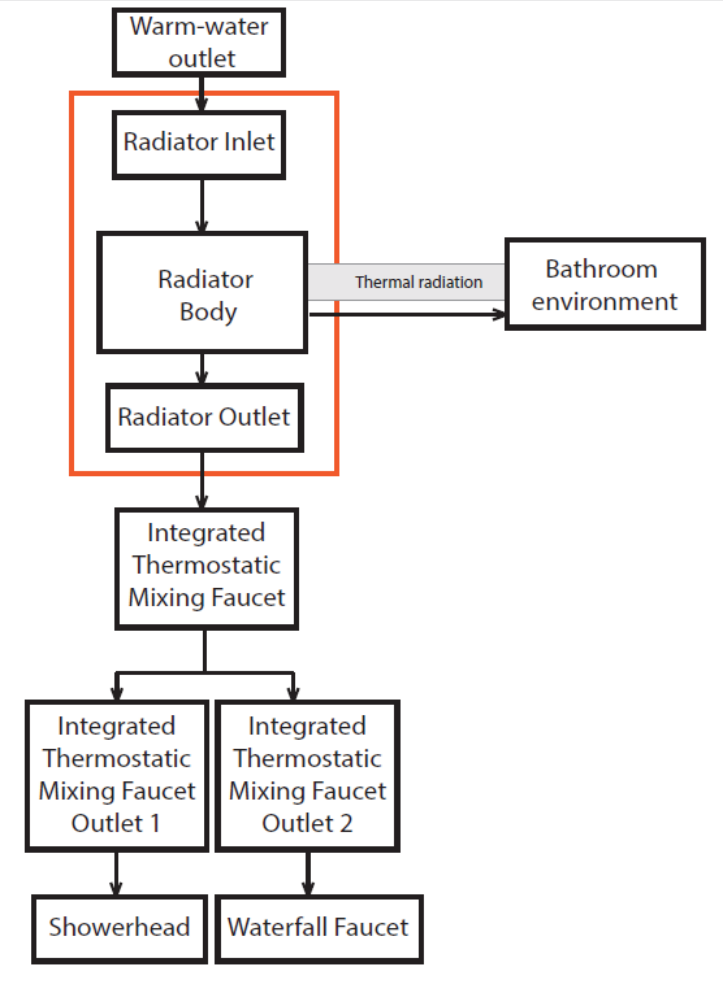


Figure 40: Functional diagram of prototype

4.3 PROTOTYPE BUILDING

The actual building and assembly of the prototype were perhaps the most instructive of the entire project. Also it was the most time-consuming activity. The scale of the product itself posed some major challenges in itself. This subsection will describe the process of the fabrication of the prototype and the considerations taken from the process that allow optimization of the final design.

The first activity to undertake was the construction of the console baseframe, which forms the backbone of the product.
For this, a wooden mould had to be made to size in order to support the beams in perfect alignment, in order to prevent bending or warping of the frame during welding or when cooling down.

The construction of the main and subframe was pretty straightforward, but alignment was essential for proper functioning of the gas-spring and linear slides later on.

After this, the waterbasin and wooden frame for the worktop had to be constructed. This subframe didn't have to look nice, it would be covered up later anyway.

After CNC-milling a 3D model of a mould for the basin, it was vacuumformed and cut to the proper size (figure 42).

The size of the basin was designed to contain about 2,5 liters of water in order to stimulate people to be aware of their use of it.

After cutting a hole for the drainport of the basin and installing the drainport, the basin was glued into place to fit onto the wooden subframe (figure 43).

Figure 41 shows the subframe ready to be welded, fixed to the finished wooden basin-frame bolted together for mockup. In assembly, the wooden frame is one of the last things to be assembled.

However, since the construction of many parts of the product relied on dimensions of other parts, the frames and most of the prototype had to be constantly constructed and deconstructed in order to make everything fit properly.

This was actually one of the more time-consuming and demanding factors of fabrication, but also the one thing that revealed the importance of optimizing the design for assembly and disassembly.

Figure 45 shows the assembled wall-console with shaped brass coverplates. The two plates to the sides of the mirror were later to become the radiator panels.

The mirror was ordered to size at a glasscutter and supported by a series of screws mounted to a wooden truss between the sidepanels. The sidepanels were made out of a plate of

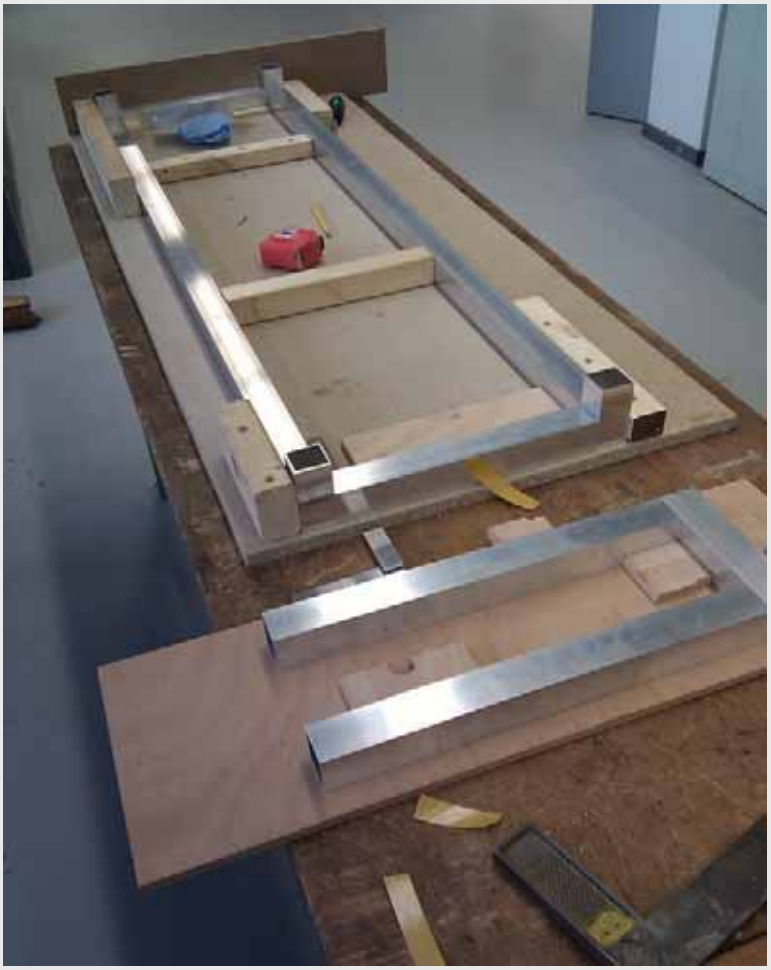


Figure 41: Prototype frame before welding

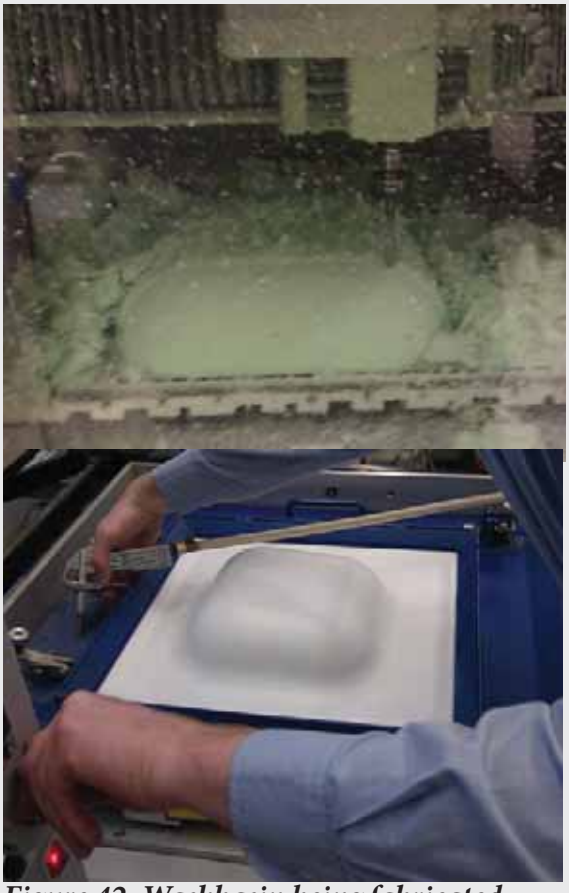


Figure 42: Washbasin being fabricated

Figure 43: Subassembly mockup

Figure 44: Mockup of frames

Figure 45: Main assembly mockup

Figure 46: Worktop panel fabrication

beechwood furniture-plate and lacquered for protection and colouring.
Figure 46 shows the unfinished worktop panel bent to shape and mocked-up to fit the wooden subframe

In figure 44, the subframe is connected to the console frame and the linear slides have been configured and set to work without too much friction. This was a task tedious requiring accuracy of within a millimeter, revealing that it is probably wisest to select a bearing system that is easier to adjust and install, for instance by using unsupported tubes and Delrin sliders as an alternative. Tubes have the benefit that they allow for some bending while installed, while supported linear bearings do not.

In this mockup, the brass radiator pipes were made to size so that they exactly fit into the frame while still allowing the subframe to move.

Sadly enough, at this point I realized that the subframe for the basin had been constructed wrongly, forcing me to take it apart and have it welded again. In the the way it is shown in the photo, the distance between the vertical framemembers would not allow mounting the system onto the wall since the water outlets would not fit in between them. While the design was made properly, during construction an error was made.

After having corrected the frame construction, the radiator panels were soldered to the tubes. This proved to be a difficult process. The material to the sides of the panel warped

because of the heat of soldering and this could not really be repaired afterwards. However, the connection was very solid and upon testing did seem to transfer the heat of the water to the panel properly.

Figure 49 shows a mockup of the prototype at the final stage of production, just before applying coatings. The control-button for the height-adjustment has already been installed and the faucet assembly has also been prepared.

The final part to be constructed was the mounting frame, which exists of two mirror-image steel frames that were welded together and bolted to the console frame (figure 50). This allows the prototype to be fixed and placed as a free-standing product without requiring fixing into a wall, which appeared to complicate the process of installation and getting permission to do so.

Next to mounting the product on the frame, it has to be anchored to the wall with a few screws.

Although the initial plan was to test the prototype in the Concept House in Heijplaat, this appeared to be logistically impossible to realize.

Luckily, after some persistence, a location on the TU Delft campus was found in a temporarily abandoned building.
Figure 52 shows the installation of the prototype in progress. The bathroom provided was quite similar in dimensions to the one outlined in the Analysis section as a target context, with about 4m2 of surface-area.
The prototype was anchored to the wall using a wooden plate that was fixed onto existing drill-holes in the wall.

Figure 48: Soldering radiator panels and tubes

Figure 47: Brass piping mockup

Figure 49: Final mockup

4.4 CONCLUSION

While the construction of the prototype was quite an intensive activity that consumed the better part of about 9 weeks, the result is a fully functional prototype that exactly mimics the embodiment design presented earlier. Several elemental things became apparent during the building process. For one, even though the design did not seem to be very complicated, further integration of parts and simplification of the parts that need to be assembled during installation is a definite requirement.

For instance, the way in which the basin, mixing faucet, drain and flexible tubes all are separate parts that require configuration and adjustments makes it a difficult product to assemble, even if the parts were to be standardized.

It has to be said that in the final prototype, the draining away of used water was kind of an open end.

While the design outlines an integrated drain with a telescopic tube, this is complicated to implement and appeared to be near-to-impossible to realize in this prototype. A complicating factor is also that in a standard shower-compartment, there is no drain-inlet integrated in the wall. This means that water needs to be diverted to the drain in the shower-floor.

Figure 50: Frame mockup

Figure 51: Prototype worktop closeup

Figure 52: Prototype on test location

As mentioned before, it might be a consideration to implement a different kind of bearing system in order to ease assembly and eliminate the need for accurate adjustment of parts.

Also, while height-adjustment using the gasspring and remote operation of it seemed to work perfectly fine before installing, when the prototype was installed, operation of the height-adjustment was quite heavy. In a final version, an optimized gas-spring needs to be designed and built especially for the product. This might best be outsourced to a company that specializes in this and might also be able to solve the bearing issue mentioned before.
In the section detail design, a design is presented that takes all these considerations and those taken from other parts of the project and research into mind.

5 // Prototype Evaluation

The purpose of the evaluation of the Splash prototype are to evaluate first and foremost its primary function and user perception of the improved version of the Splash concept.

1. **User Experience:**
Since the concept itself originates from co-design and practice-oriented design research, it seems logical to evaluate the user experience. This will be a more abstract piece of research that will be very helpful in analyzing the user perception in terms of thermal comfort, perception and the practice of Splashing.
2. **Technical functionality:**
Does the prototype deliver what it should in terms of technical features; heating, adjustability, etc.
3. **Human factors:**
The ergonomic properties of the design have to be designed in such a way that they cater to the needs of the user. Evaluating these properties is essential for validating whether or not the preconceived ideas behind the design are reflected by actual use of the product.

One obvious aspect that does need to be monitored also during participant testing is water use. Furthermore, it is necessary to evaluate as much as possible all technical aspects of the product, although this is not necessarily incorporated in participant tests. While the ergonomic and technical evaluation will be best evaluated with a bigger group of subjects, the setting of the concept house also presents the possibility of long term testing with a smaller group of people that (temporarily) inhabit the concept-house. Although the prototype was not installed here, plans to use the prototype for testing in the concepthouse do exist. This provides a unique opportunity to research and analyze the more abstract aspects of the product interaction such as the forming of rituals and of usage patterns after a certain amount of time.

5.1 METHODS & MATERIALS

Participants Selection

Participants are preferably be gathered from a list of people that have participated in earlier usage test with the previous prototype. This ensures that users will already be familiar with the concept and will therefore not judge the product without prior knowledge of the practice of Splashing. This makes sure that the qualities of the new design can be evaluated against that of the old design.

Research Approach

Participants are be instructed prior to testing the prototype.

Participants must be aware of the fact that technical details, as far as they are disclosed, are confidential and that the system as it exists is still under development.
Participants have to agree to let the test session be audio-recorded.
Basic functionality of the prototype is shown and instructions for operation are handed out.

An illustrated 10-step (Appendix I) scenario for a washing session is shown as an example, the participant being asked to re-enact the scenario.

A plasticised copy of the sketched scenario was provided in the shower cabin.

The scenario is simple and follows this script (depicted in figure 52):

Set thermostat to a comfortable temperature between 38-40 degrees.
Open faucet until water turns warm.
Fill the basin with water
Wash hair
Rinse hair
Wet the body with the scoop/ showerhead
Apply soap as seen fit
Wash body as seen fit
Rinse using showerhead
Finalize washing session

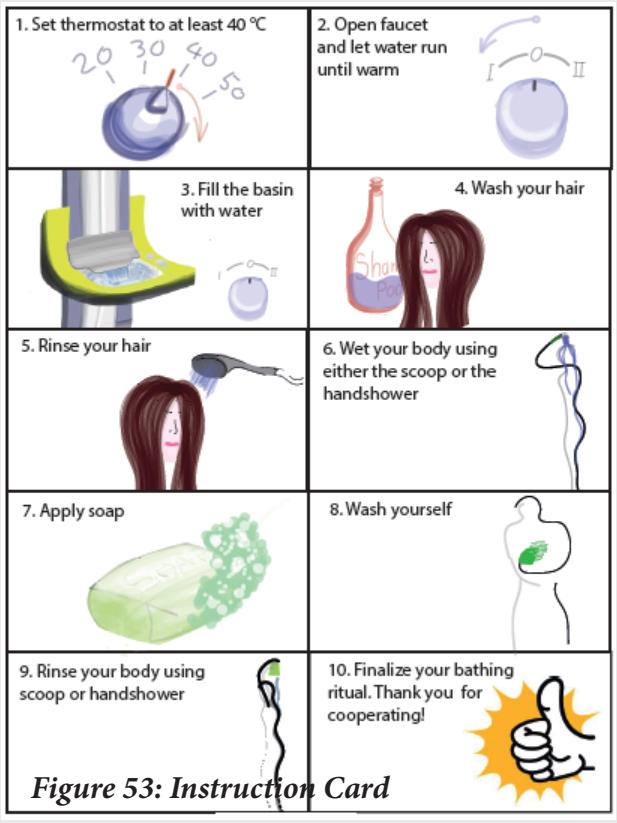


Figure 53: Instruction Card

During all of the steps, the participant is asked to self-report by speaking out loud in order to capture the steps of the session on audio.

Directly after finishing the session, participants are asked to evaluate the session together with the researcher. The audio-tape can serve as a guidance in clarifying non-verbal and less explicit clues relevant to the research. To this end, permission to video-record this evaluation session is requested at this time.

Data Collection

Water and energy conservation are the reason d'etre of the Splash concept, evaluation of these factors is essential. For this reason, water-usage is constantly measured and logged using a datalogger and waterflow-sensors. Water usage is measured at the two outlets (the faucet and the showerhead) so that different modes of use can be assessed and compared. Since implementing a means of measuring water temperature independent of the outlet being used would over-complicate the test setup and limit the functionality of the thermostatic faucet by limiting the flow velocity, estimations of the actual use of hot and cold water are made by deduction from the measured variables.

Evaluation of the quality of heating from the integrated radiator is one of the main factors to evaluate, infrared thermo-imaging is used to evaluate the heat radiation from the radiator and the loss of thermal energy in the hot-water that runs through the radiator.

This is important since it determines the heating efficiency of the radiator and the temperature of the water that flows from the radiator into the thermostatic mixing faucet, which in term influences the use of both hot and cold water and thus the thermal efficiency of the entire system. In order to capture audible cues from the participants, an audio-recording are made during the participant tests.

5.2 RESULTS & INTERPRETATION

General Impression

In general, most people were initially positive about their experience using the Splash prototype. Many noted that they liked the fact that they were forced to think differently about the way in which they washed themselves, transforming their washing ritual into a more active and conscious one than they normally had.

It was especially interesting to see that two people mentioned that it was sort of a step back to less prosperous times and more primitive forms of washing, while three saw it as a more luxurious form of showering.

An often heard remark was that it was an efficient and more comforting way of washing also in terms of how much time it took to complete the routine. Several people also had trouble adjusting their routine to the scenario and deviated from it.

Thermal Comfort

One of the most important aspects of the usage tests was to validate whether indeed the radiator had a noticeable effect on the thermal comfort levels experienced by the users of the prototype. While in early test setups and measurements, a notable –albeit arguably small- heating effect seemed to occur, in the participant tests, a majority of users did not notice any heating effect whatsoever while some even reported to be notably cold at times.

Of course, none of the participants that were previously unaware of the heating were informed about the active heating that was integrated in the Splash prototype. Of those uninformed people, only one claimed to sense some warmth, especially on the upper part of the body.

Of the four people that did have prior knowledge about the heating, only two noted a comfortable warm sensation. One noting a changing room temperature, the other a comfortable radiation effect. Only one uninformed person noted a comfortable temperature during the session.

Overall, four out of the 11 participants indicated to have a cold sensation at one or several times and also indicated. One of them even found it strange that no heating was included since this was one of the most prominent recommendations made after testing the previous prototype. Other negative connotations concerned the unpleasant temperature of the seat and the need for a form of heating from the back-side, which two users noted to get especially cold.

Although this is obviously not included in the data, upon testing the appliance myself, I also sensed a clear effect of the heating and even managed to measure this, more on this later.

Four others neither felt notable cold or warm or only felt cold at the start of the session.
When also taking into account the technical evaluation of the integrated radiator, it seems that the perceived thermal comfort that has been reported by users doesn't match the measured numbers, both pieces of the research even indicate quite the opposite; while the measurements indicate a clear and measurable heating effect that has a comparable effect to that of proven technology (FIR panels), perception of users indicates a lack of heating.

This can be attributed to many things, and given the complexity of actually measuring and determining thermal comfort in a clear and quantifiable manner, it seems that no satisfying conclusion can be drawn from this section of the research other than to point to potential specific matters calling for further investigation.

One of such subjects is that of the cooling effect that radiated heat can have on the temperature of wet skin. Just like when drying your body to the sun after a swim, any heat radiating surface makes water evaporate and so dries the skin.

One effect of such evaporation is the dissipation of heat from the skin into the vaporized water. This effect was not considered prior to setting up

the tests, but might have a significant effect on the perceived temperature.

Upon hypothesizing that this effect had any influence of perception, I performed a small and insignificant test in which I wetted one half of my body while leaving the other half dry. I then sat in front of the heated radiator and took thermal images at several intervals over the course of three minutes.
On the images, the wetted part of the body was up to 6°C colder than the dry part of the body after 1.5 minutes. While this is in no means a conclusive evaluation of the subject, it indicates that this effect does indeed have a significant effect. An interesting question would be whether or not an increased heating intensity would either increase or decrease this effect and the perception of it occurring.

Overall, the user perception of the thermal comfort levels while using the prototype do not seem to validate a clear positive effect of the heating appliance. It seems that for this type of heating appliance being integrated into a bathing product, a more complete and conclusive research needs to be conducted especially aimed at this part of the product architecture.

Ergonomics
A major aspect of the prototype was the adjustability of the height of the product. Therefore, it was important to try and get people to try both sitting up and standing down while using the product.
For 6 the participants, the height was set to a comfortable sitting height, for the other 5 the height was set to a higher setting more appropriate for standing.
Trying to get people to try both settings, I stressed that they could change the height. However, only two out of the eleven participants actually adjusted the height from standing height to sitting height.
In total, 7 people stood up while using the product, only two completed the whole routine while sitting down.

Three people noted that the basin was too small for them, for two of them this seemed to be a pressing issue. However, this might have been because it forced them out of their usual routine.

Four people noted that the faucet was maybe not so effectively integrated into the product since it was hard to put your hands underneath to fill them with water. While this was intentionally designed to be a more soothing and elegant way of filling the basin, this might indicate that the lack of space forces people into a restrictive mode of use in this sense, which is an interesting remark.

Water use
As expected, far less water was used by the participants when compared to regular showering, which on averages consumes 67

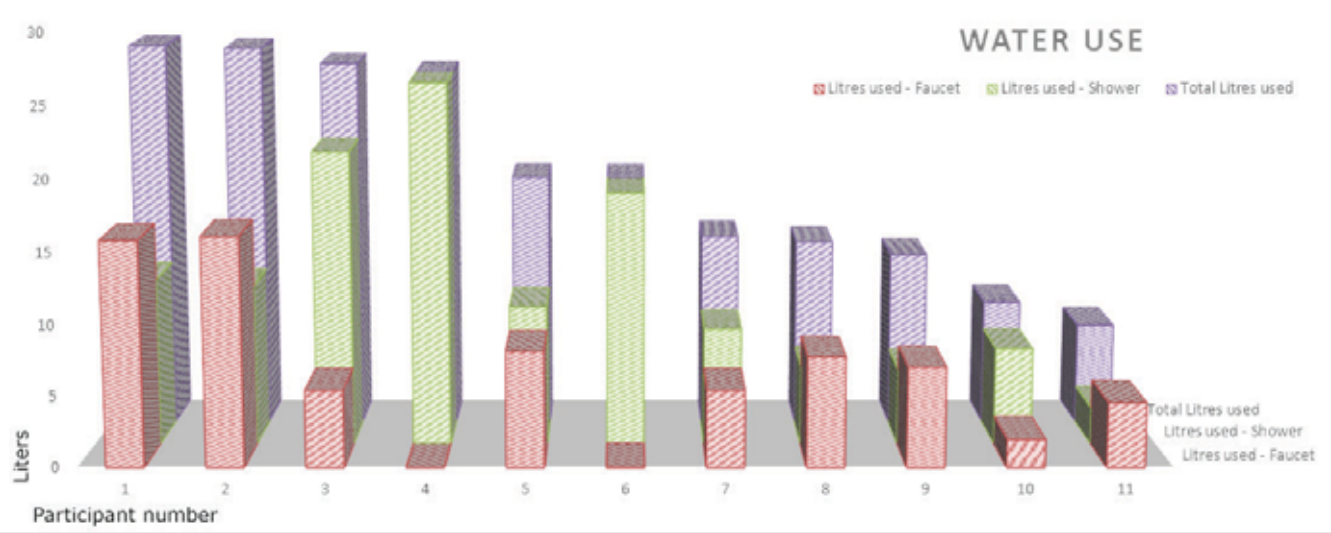


Figure 54: Water use measurements visualization

Participant #	Participant Name	Litres used - Faucet	Litres used - Shower	Total Litres used	Total Session
10		15.85	11.82	27.67	00:05:28
6		16.14	11.33	27.47	00:07:28
9		5.45	20.93	26.38	00:07:12
3		0	25.79	25.79	00:06:07
1		8.18	9.91	18.09	00:12:21
7		0.03	18.04	18.07	00:04:45
8		5.45	8.301	13.751	00:08:01
2		7.79	5.55	13.34	00:02:53
4		7.07	5.34	12.41	00:07:01
5		1.99	6.88	8.87	00:03:04
11		4.589	2.581	7.17	00:03:43
Percentage of total		6.6	11.5	18.1	
		36%	64%		
				Average Bathing time	00:06:11
				Average water use in L/min	2.924

Figure 54: Water use measurements per participant

liters. On average, 18.1 liters was used per participant, which is a very similar result to that observed in the previous Splash prototype by Linus Knupfer, in which the average use was 20.6 liters. On average between all users, about a third of the water was dispersed through the faucet, the other two-thirds from the hand-shower.

What should be noted is that prior to each participant beginning their sessions, the water was pre-heated so that it already was warm. This ensures that the radiator was pre-heated and that the amount of water spilled by the user to pre-heat the water is not measured since this is not of any value for the evaluation. The measured amount needed for heating up the Splash when cold is 4,2L of hot water.

Some participants showed odd usage patterns when compared to others, for instance by letting the water basin fill up with water and overflow, which was done by two participants. Interestingly, this also happened when Linus Knupfer tested his prototype. Since the total amount of water used was high, but not dramatically different in relation to other users, the results were not omitted from the analysis.

When adding up the water required for heating to the average use, 22,3 liters of water were consumer on average (a 65% reduction as compared to a regular shower), the average session lasting just over six minutes. This means that, excluding the 4,2 liters required to pre-heat the appliance, 2,9 liter/minute is consumed at a temperature of about 40°C. This means that about 1,4 liter/minute of hot water passes through the radiator, which is more than enough to keep the heat output of the radiator at a maximum level (above 930W/m2), according to measurements.

It is rather easily concluded that a 65% reduction in use of warm water in comparison to a regular shower also causes a 65% reduction in energy needed for heating this water. This means that instead of about 8,3MJ for a 64 liter shower, Splashing uses up only 2,9MJ of power at a cost of €0,19. While this is slightly more than the 2,3 MJ used up by Linus' prototype, the new version does have integrated heating that uses up power. Without this, the energy consumption would have been similar.

Splashing as a practice

The practice of splashing, when compared to showering, is quite different. It has been designed to be at least as comfortable as showering, while allowing users to focus more on their personal routines.
The practice itself was not the main focus of this prototype or the tests performed. However, some interesting remarks were made about the practice, also in relation to the design of the appliance.

The most often heard comment made about the actual practice was that people felt that the appliance made them more focussed on the actual washing activity and were more aware of what they had to do and in what order.

As one person put it "It is more active and makes you more focussed on the tasks you have to perform". For most this was seen as positive, giving them more time and attention to focus on washing and to enjoy the warmth of the water, experiencing this aspect as comfortable and more relaxing.

For some others it was experienced as something that forced them out of their regular comfortable routines and was seen as less comfortable.

While the use of the water-basin was indicated to be part of the practice and the scenario, 3 people did not use it at all and most people switched to using the shower halfway through the session.

One participant claimed that "I actually didn't even think about using the basin. If I had known that was the intention I would have used it. But also I have the feeling the basin would be dirty somehow". Strangely enough this person did use the most water using the faucet, but just let the basin overflow, thinking this should be part of the test.
When asked afterwards how people experienced the practice of Splashing regardless of the way the prototype looked or felt, a big majority was rather positive about the practice of Splashing.

Perception and marketing
Over sixty percent of participant would consider purchasing a Splash under certain conditions. Heating was only mentioned twice as a requirement here, slimming down of the product and the requirement of a bigger basin were seen as more important. Another condition mentioned a few times was that having a fixed showerhead would make transitioning to Splash more likely for them. An interesting remark of one participant was that "without experiencing the Splashing before considering purchasing it, I think it would be difficult to understand what benefits it can actually deliver". Prior to using the prototype, he was rather sceptic towards the concept, but now does see a benefit for it.
The average purchasing-price participants were willing to pay for the Splash as a finished product was €1250. Although the range of prices mentions ranges between €250 and €2500, the number might be used as an indicated price to strive for.
While 60% saw the Splash as a useful appliance for families, some saw more use for it either for public bathrooms, the elderly or for use in hotels.

Considerations
One of the main reasons for testing the new prototype was to evaluate the thermal comfort that users of the product experience while "Splashing". While most people were relatively naïve towards the actual technical details of the product and seven out of the ten were totally unaware of the fact that any type of heating was integrated into the product, temperature was mentioned during 8 out of the 10 sessions.

No clear relation between awareness of a means of heating being present and levels of thermal comfort reported could be established. While about half of the participants noted one or several times that they were chilly or, in two particular cases, noticeably cold during certain moments of the washing session, the other half felt rather comfortable or even claimed to experience a comfortably warm sensation in two cases. One of those was a person with prior knowledge of the integrated heating being present and might have been especially focussed on it.

While there is a clear, measurable rise in room-temperature in the shower cabin upon heating-up of the integrated radiator in the prototype, it seems that further development and optimization of the heating system is required before it presents a truly valuable addition to the product as a whole.

Despite the fact that the type of heating integrated in the prototype and final design being the most desirable in terms of legislation and regulations and the least intrusive in terms of implementation in existing bathrooms, the sheer complexity of the heating system in itself requires a clearly noticeable thermal effect for the consumer for the product to have a purpose. Since currently, despite promising measurements, this doesn't seem to be the case, the heating aspect of the concept remains a troublesome issue.

5.3 TECHNICAL EVALUATION

The Integrated Radiator that was designed especially for the Splash prototype in order to evaluate whether or not it would be a suitable alternative for electrically powered heating devices such as the previously considered Infrared lamps or Far Infrared Panel heaters.

While most modern-day household radiator heaters fulfil their heating function only up to a slight portion by actually radiating it rather than by convection –only about 30-40% is radiation heat-, the Integrated Radiator in the Splash is designed to function purely on the radiation heating principle.

While of course, it cannot be prevented and is likely that as a by-product of the induced radiation, some amount of convection is produced, the focus of the investigation during testing was purely on assessing the actual efficiency and effectiveness of the radiator in radiating heat.

Materials & Methods

In order to be able to clearly measure any radiation and the effect of it on the ambient temperature and on the level of comfort in the user, measurements had to be done in various different ways using various means of measuring.

Using a thermal imaging device as shown in figure 55(SP Thermoview 8300+), various series of measurements were taken to clearly visualize and actually measure in time, the temperature of the radiator as a function of the amount of hot water being lead through it.

Figure 55: Thermal Imaging camera

Three consecutive measurements were taken using the following scenario:

1. Water-temperature set to hottest setting
2. Let water run until warm

a. Determine amount of water needed

3. Let radiator cool down while
   a. –taking photos on regular intervals
   b. –noting down ambient temperature measured using a stand-alone digital thermometer

This scenario was repeated in total four times, the first series of measurements not being successful due to wrongfully recording of data using the thermal camera. As a result, this first series had to be omitted from the evaluation. After having recorded all the required data, a set of measurements could be made using the software IR Analyser.

Figure 56 shows an example of how the camera records an image. From this image, a series of data-sets can be distilled, such as minimum- and maximum temperatures

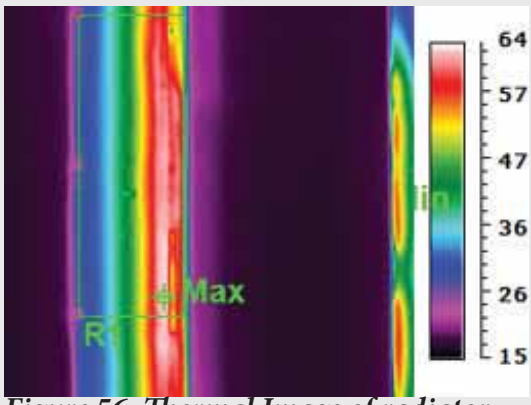


Figure 56: Thermal Image of radiator

measured in the image or in a selected portion of the image. This data was generated from the recorded thermal images using the IR Analyser software and then manually transcribed into the datasets found in Appendix P.

Selecting just the radiator section of the picture, the minimal, maximum and average radiator temperature can be determined through time. This data can later be transferred into graphical and mathematical representations that allow the determination of the heat output of the radiator over time (in Watts), so that its effect can be measured and compared to that of other heating equipment.

This data can then be used to evaluate the effectiveness of the heating apparatus and possibly point to recommended improvements.

Additionally, measurements using a digital thermometer were taken in three occasions in order to evaluate the change in room-temperature in the shower-cabin. These measurements were taken during the thermal imaging sessions.

Results

The thermal imaging sessions resulted in the datasets that can be found in Appendix P. From these datasets, graphical representations of the decrease in temperature of the radiator elements could be made, which are shown in the graph below, which is made with the software package Graph.
The datapoints displayed with dots represent the measured maximum temperature in each consecutive photo. The squares represents the average temperature measured in the selected area, which is limited to just the area of the radiator itself as shown in figure 57 on the previous page.
In figure 57, all acquired datasets are represented The x-axis represents the time in seconds, the y-axis representing the temperature in degrees Celcius.

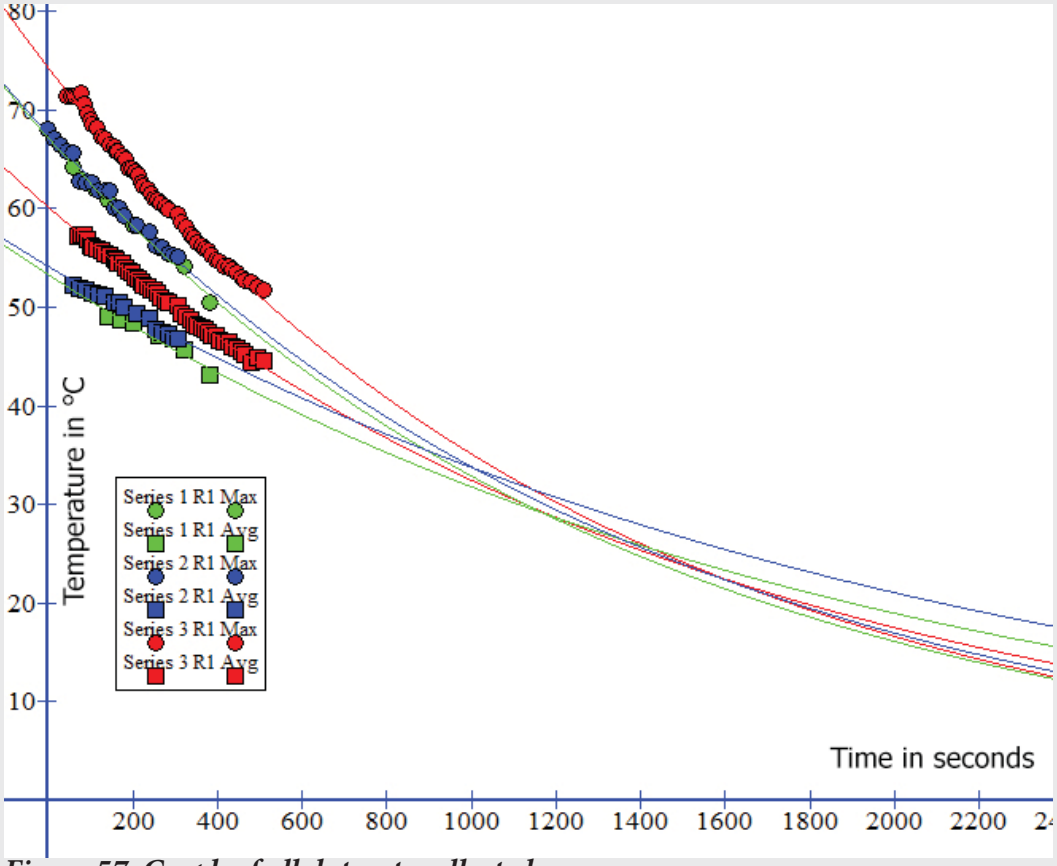


Figure 57: Graph of all datasets collected

As can be seen, Series three contains the most detailed data and seems to be the most coherent to a definable function.

All three series show similar results and since the curves of all three series can be represented by highly similar functions.

Data and interpretation
For details on calculations and methods used to derive the data presented in this section, please refer to Appendix F.

Represented in figure 58 are the measurements of Series 3. This is the series that is used for all further calculations in this section since it is most detailed and a good representation of heating characteristics during normal use.

The top graph (dots) represents the maximum measured temperature in the thermal image, the bottom graph shows the average temperature measured in a selected portion of the image, in this case the radiator itself.

The yellow graph in figure 59 shows the Wattage this translates to for the radiator (both sides combined) and the blue graph is a translation of this value to the output power per square meter.
When evaluating the power output the average power output is determined to be 292W over the course of the measurements (8 minutes 45 seconds).

As can be seen from figure two, the power output of the radiator starts of at 340W, decreasing to 300 Watts within about 3:45 minutes (225 seconds).

Since during use, users will continually turn the warm water on, we can assume that a power output of between 300W and 340W can be assumed. This translates to anywhere between 850W/m2 and 977W/m2.

When comparing this to the power output of for instance (FIR) Far Infrared Radiator panels, which generally output 1480W/m2, the integrated radiator of the Splash prototype delivers up to 66% of that capacity.

Furthermore, it should be noted that the rate of heat dispersion, and thus the power output, is limited in the prototype due to the construction of the radiator itself.

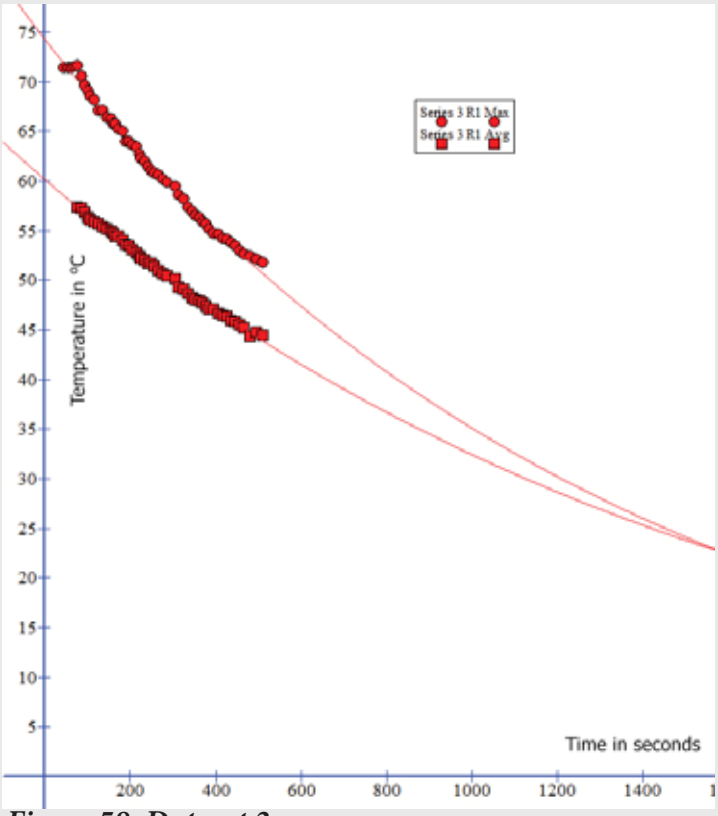


Figure 58: Dataset 3

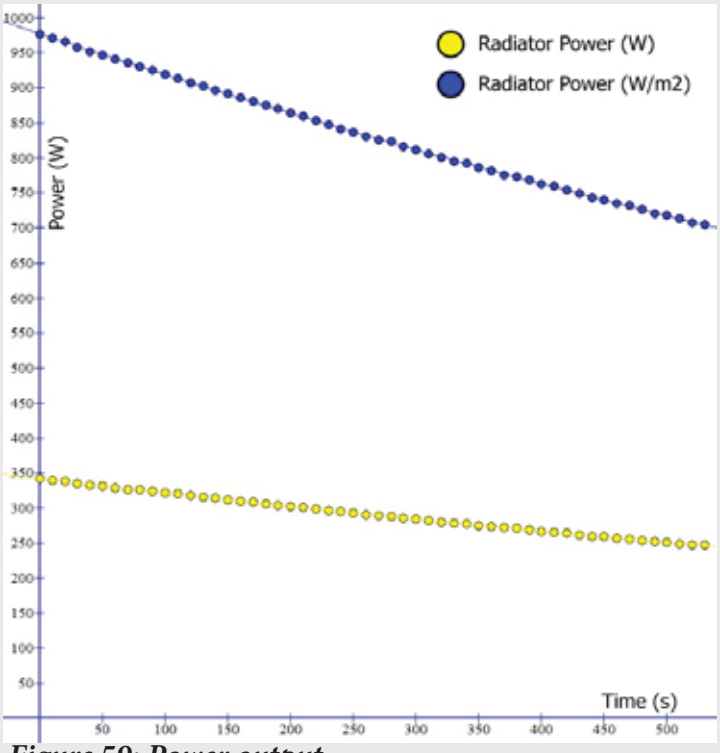


Figure 59: Power output

As can be seen in figure 61, the radiator is constructed by silver-soldering a brass tube to a brass plate. The total contact surface of this bond can be safely estimated to be no more than 0.06m2 in total. As seen in figure 60, this

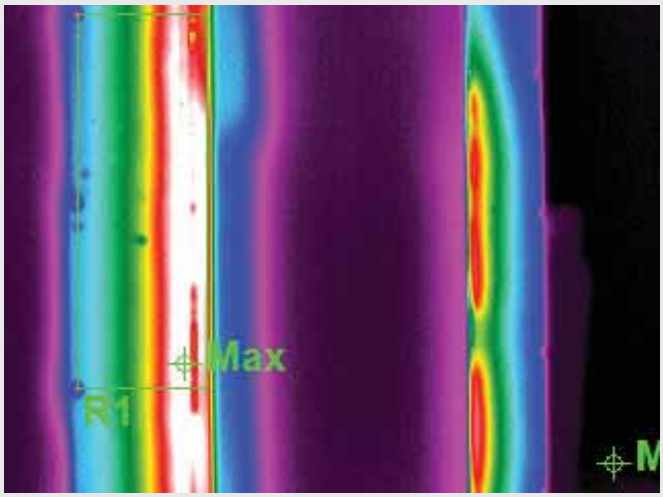


Figure 60: Thermal Image of radiator

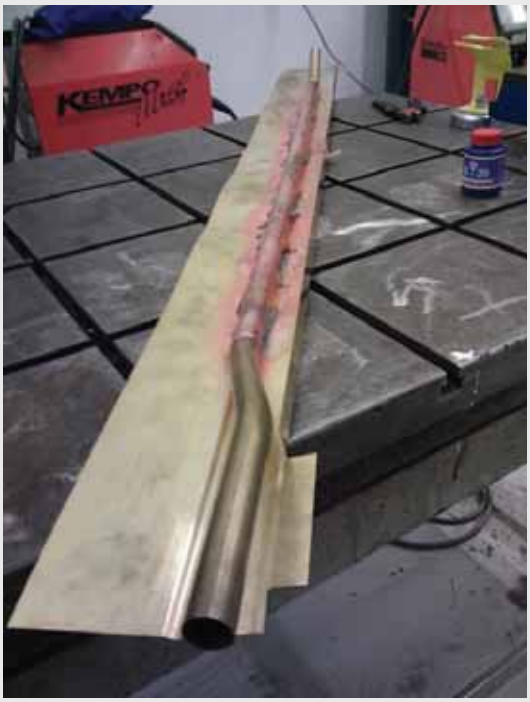


Figure 61: Soldering the radiator

results in all the heat from the water being transferred trough a small cross-section of the potential contact surface that could be created in a specially designed radiator.

Therefore, it seems that it is certainly safe to assume that it should be possible to at least match the power output of a FIR radiator panel, given the fact that the contact surface between the water and the metal that conducts the heat energy towards the radiating surface can be significantly increased in an optimized design.
Furthermore, one of the major reasons to reject the use of FIR panels, despite the difficulty of introducing electrics, was that the heat-up time of the device was about 15 to 20 minutes.

The Spash radiator heats up to its maximum capacity in about 20-25 seconds from turning on the hot-water supply, using merely 4,2L to reach 71°C.

Assuming that the cold-water temperature is 15 °C and that an avage gas-heated HR-boiler has an efficiency of more than 90%, it would require 0.04m3 of gas to reach this temperature, costing about €0.0275 at €0,22 per m3.
When comparing this to a 15 minute warm-up time of a FIR panel of the same size (500W), this would consume 0,125kWh also costing about €0,03 over this period of time.

In terms of heating efficiency considered in kJ/KWh or in monetary terms, we can conclude that the two hardly differ when considering the cost of heating itself.

However, since the water is not only used for heating the radiator, but also for washing (for which would have to be heated up anyhow), we can also reason that the energy consumed for radiation heating is essentially an excess of energy present in the system regardless of the radiator being part of it or not.

Since the hot-water output has a temperature of at least 65°C in order to prevent legionella from developing, and users generally only requiring 38-42°C as a comfortable showering or washing temperature, all of the excess energy can be used without any extra energy being required.

Other than the thermal images taken, on three occasions, the Splash was heated when the

room and the appliance were cooled down and the change in ambient temperature was recorded using a digital thermometer.

On average, the starting temperature was 16,8°C. A slight change in temperature could be measured between 8-12 minutes into the tests, with the average ambient temperature rising to 18,4°C.

In order to prevent the warmed up water vapour influencing the measurements, water was directed into the drain using the showerhead.

5.4 CONCLUSION

If a radiator would be integrated into a washing and/or drinking-water system like the Splash, legionella-prevention should be carefully considered. While this applies to all hot-water equipment, care should be taken that before each use, or after not using the appliance for an extended period of time, the water-lines have to be flushed with water of at least 65°C.
Since in the current design, the hot water only enters the faucet after having gone through the radiator, the same care should be taken as when implementing other bathing appliances.

A practical safeguard solution for the Splash could be the integration of an automatic shut-off valve that is integrated into the faucet that triggers at for instance 40°C. This ensures that at least before each use, no "old warm water" can be left inside the pipes.

Not only does this obviate the legionella issues, it also can make the use of the Splash more care-free, the user simply pushing a button to turn the device on for instance while undressing. The water supply automatically stops when the appliance is ready and the radiator warm, and the faucet can then be used as normal. While it would require a more integrated design of the faucet and probably the design of a specially made faucet for the Splash, it would definitely improve the usability of the product, the ease of operation and the efficiency.

Also, as mentioned in the previous section, an optimized design for the radiator would greatly improve the heat-transfer between the water and the radiator, and thus increase the effective power-output of the radiator.
In order to fully evaluate the actual effectiveness of a next version of the radiator, a more thorough investigation of and more modelled approach towards the design of the radiator would be required. Selecting the right materials and production techniques for producing it would be key in improving its actual design.

One aspect that was not considered in the technical evaluation but which might prove relevant is the percentage of heat that is not dissipated as radiation. While it was not the scope of this research and could not be measured in the given setup, optimization of the design in this respect could further improve efficiency.

One possible example of such an optimization could be the design of a radiator that only has one very thin metal sheet as a radiator while the water is contained in a hard-plastic shell that acts as an insulator. Figure 62 illustrates how this could look, the green section being the plastic water-line, attached to the radiator surface.

Putting a reflective insulation material at the back of the radiator might further reduce unwanted heat-dispersion.

One of the main considerations in further designing the radiator should be to properly select the right materials, since they have to be materials that are approved for use as hot-water lines. For instance, brass, copper and PE are suitable materials.

Since brass and copper are expensive, other metals could be considered for the radiator, as long as the inside is coated with a non-corrosive layer, for instance HDPE (which is an allowed material). In that case, aluminium could be a cheap, light material that doesn't corrode and can easily be applied with a surface treatment that optimizes the emissivity (brushing, polishing, sanding, powder-coating, etc.).

Which treatment is appropriate should then

also be evaluated. Generally, the bigger the effective surface area of a metal (or the finer the microstructure of the surface), the higher the emissivity of its surface.

When only considering the technical analysis, we can say that the heating element designed for the Splash definitely should have the potential to be a highly efficient and an effective way of heating.

When optimizing the design for production, it is clear where the challenges should lie in terms of technology and development. Despite this, it is worth mentioning that the user experience of the heating appliance indicates a need for improvement (described in another section).

Also, there seems to be a clear and promising opportunity to apply for patents on the heating system as described in various sections of this report. While these possibilities need to be further examined and where not part of this graduation thesis, it seems like a novel innovation could result from it, greatly increasing the potential for future valorisation of this concept into an actual product.

Figure 62: Radiator design

6 // Design Proposal

This section describes the design proposal of the Splash in the scope of this thesis project. It presents a detailed overview of the product that has been created, lists the most important parts and explains the basic considerations for production of essential parts.

Materials and methods of production are recommended and a rough estimation for a cost-price of the product is presented. An evaluation of the design is also presented and finally a set of recommendations is outlined for further development of the product design.

Figure 63: Product Proposal

6.1 PRODUCT PRESENTATION

The rendering shown in figure 63 presents a detailed design of the Splash in a form that is optimized for modularity, easy construction and assembly and maintenance-free operation. The working principles behind the appliance are the same as presented in the previous sections, the difference being not only the shape language and refinement of the design, but also the integration of essential parts.

The product will be described in the order in which it has to be assembled and installed. This ensures that all features are presented and a clear overview is given of the modular approach taken towards the design of the appliance.

The first part of the assembly is preparing the console frame for mounting onto the wall. Initially, the wall-brackets are bolted to the wall at the top and bottom position of the console shell.

These brackets (figure 64) are punched out of steel and bent in shape.

The shell of the wall console is a rather large part (figure 67) but has a relatively simple geometry that can easily be thermoformed and textured to have a luxurious exterior.
Next, the linear slides (preferably unsupported tubular slides) are mounted on the backside of the module.

Figure 64: Wall-mounting brackets

Before bolting them, the mounting frame for the worktop (figure 65) is slided onto the bearings, fixing this component into place as well.
A mounting bracket is bolted to the back of the console shell, allowing a custom gasspring that extends from 700mm to 1250mm (550mm adjustability).
The assembly now looks like the rendering shown in figure 67.

Figure 65: Subframe

Figure 66: Console and subframe mounted on the wall

It is now time to mount this part of the assembly onto the wall. Before bolting to the wall, the product is aligned and holes are drilled.

After inserting wall-mounting brackets, the module is screwed in place with 4 screws (figure 66).

After the console is securely mounted onto the wall, a rubber seal is installed on the protruding section of the shell. This protects the mirror that is later installed (figure 68).

Then follow a series of steps that are not included in the 3D model, but are vital to a proper installation. Since after installing the mirror, the backside of the frame cannot be reached, this is the time to install the flexible (stainless steel wound) tubes that connect the water outlet sockets to

Figure 67: Main wall console with linear slides and subframe assembled

the radiator and the faucet.
The cold water is lead directly into the mixing faucet. The hot water is at this stage connected to a socket on the side of the wall console. A fixed polyethylene tube leads the water into the radiator that is fixed at a later stage. From the other side of the radiator, a similar flexible tube is lead into the warm water input of the mixing faucet. Refer to figure 40 on page 49 for the functional diagram that illustrates this assembly.

The mirror is now fixed onto the console (figure 68a). It fits nicely onto the rubber seal and is fixed with two metal clips that are later consealed by the radiator, which is installed as a next step.

Before fixing the radiator however, the output hose of the radiator is connected to it.

The radiator is held in place by four screws that are inserted from the side of the plastic console shell and hidden with plastic covers.

The radiator is made out of aluminium and has an integrated water-compartment through which the hot water passed before going trought the faucet.

The radiator panel is made out of a single panel of aluminium that is cut and bend to shape. In this design, an aluminium profile is welded to the panel, forming the water compartment (figure 69).

It is clear that this aspect of the radiator is still only an onset to a finished design, but it does outline a working principle.

The front of the panel is matted and colour-coated.

Next, the base shell of the worktop is connected (figure 70 & 71). It slides right onto the back bracket and is held in place using a couple of bolts inserted from the inside of the base shell.

The shell itself is probably best producible using rotational moulding. Or, if split into two

Figure 68: Console with mirror installed (a) and with radiator panel installed (b)

Figure 69: Radiator panel back-side

Figure 70: Installation of washingbasin sub-assembly

Figure 71: Washing-basin Shell

parts, thermoforming.
It has to be noted that in this design, the plumbing components of the product are largely absent since their exact positioning and configurations are quite ambiguous.

It is clear that the mixing faucet should be mounted inside the shell as well as a connection for a drain that connects to the lower backside of the shell. The shell itself is shaped so that water leaving the basin flows into the shell itself and flows to the back of the shell, where it can be connected to an integrated drainpipe on the back of the main console.

After the faucet and drain are connected, a coverplate for the module is inserted. This could be made out of powdercoated aluminium for a high-quality finish. Colors can be selected by the costumer from a set of coulor schemes.
As a next step, a coverplate for the faucet is connected.

The final step in installing the product is attaching the knobs for the faucet and for the height adjustment. This completes the product and it will be ready for use.

Figure 72: Assembling the faucet

Figure 73: Close-up of safety faucet control

Figure 74: Assembling control knobs

6.2 PRODUCTION

In order to actually produce the product as described in this proposal, the most prominent parts of the product, such as the console shell, subframe, radiator assembly and brackets, need to be produced especially for the product. This requires several highly expensive machines and the production of at least two vacuumforming moulds. These are investments that are only viable to make for in-house production of these parts when high production orders are required, in the tens of thousands of units.

Before such numbers are viable, the company needs to grow and might need to outsource the production of most of these parts.

About half of the product parts needs to be bought from (specialized) suppliers. Some parts, such as the mirror and the gas-spring will have to be made by speficication and have to be ordered in bulk. This will require upfront investments before starting production.

The cost estimation shown in figure 75 assumes that the mentioned parts are all outsourced either to partnering companies or are bought as standard parts from trusted suppliers.

Assembly will take place in the company workshop and requires about 1,5 - 2 hours per unit.

This would implicate that in order to produce just 3000 units in the first year of production, a crew of 3 is required to assemble and test the products on a full time basis.

The total costprice is just shy of €650,- based on the estimations made. This means that when to product can be sold directly through vendors, the recommended retail-value of the unit needs to be around 300% of that, or just shy of €2000,-. This leaves a margin of above 30% for the reseller.

If we assume that the production company can sell the product for double the productioncost, €650 can be made per unit, resulting in a €1.9 million profit before taxes in the first year of production.

In order to assess whether or not it could be viable to put this product onto the market, a quick evaluation of the financials behind the business-case presented up until now was executed, using the cost-price-evaluation as input.

Assuming that in the first year, €350.000 in salary costs will be incurred, €1.300.000 in investments is required to kickstart production and become operational. This takes into account that €140.000 of annual fixed costs are incurred and that production preparation, IP protection and administration are covered by the mentioned investment.

It is assumed that 20% of profits are payed back as dividend to the investors. In this way, the company could deliver a 50% interest rate over the first few

Part	Amount per product	Material	Weight	Material price €/kg	€	Labour time	Labour cost	Assembly	Logistics
Fabricated / outsourced							15	33%	20%
Main console shell	1	ABS	3.6	€ 30.00	€ 108	0.25	€ 3.75	€ 36.88	22.4
Mounting brackets	2	Steel	2	€ 1.80	€ 4	0.05	€ 0.75	€ 1.44	0.9
Radiator assembly	1	Aluminium	2.4	€ 2.50	€ 6	0.5	€ 7.50	€ 4.46	2.7
Faucet cover	1	Aluminium	0.24	€ 2.50	€ 1	0.2	€ 3.00	€ 1.19	0.7
Washbasin shell	1	ABS	1.4	€ 30.00	€ 42	0.05	€ 0.75	€ 14.11	8.6
Washbasin worktop	1	Aluminium	0.8	€ 2.50	€ 2	0.1	€ 1.50	€ 1.16	0.7
Drainpipe assembly	1	ABS	0.9	€ 30.00	€ 27	0.1	€ 1.50	€ 9.41	5.7
					€ 189		€ 18.75	€ 68.62	€ 42
							Sub total		€ 318
Bought parts (standard)						Purchasing price			
Faucet	1	Brass	€ 2.90	€ 15.00	#####	€ 93.50		€ 30.86	€ 18.70
Flexible hoses	3	Steelwound	€ 4.00			€ 55.00		€ 18.15	€ 11.00
Mirror	1	Glass	€ 1.60			€ 65.00		€ 21.45	€ 13.00
Fasteners	16	Steel	€ 0.20			€ 5.00		€ 1.65	€ 1.00
Faucet controls	3	Mixed	€ 0.30			€ 6.00		€ 1.98	€ 1.20
Gas spring + Controls	1	Mixed	€ 2.70			€ 95.00	Sub total		€ 320
							Grand total		€ 638

Figure 75: Estimated cost-price of one Splash unit

years, making it possible to pay back investors within three years time with a total return on investment of 300%.

The costs will slightly drop over the years as more and more parts of the product will be standardized and produced more cheaply due to economy of scale.

Where in the first year of production, the margin will raise from 40% to about 45%.

However, all of this does assume a sales-price of €1350 (towards vendors) and a retail-value of €2000.

When assuming a price-drop from the side of the production company from €1350 decreasing to €1000 over the first 5 years of sales, profit after taxes will top off at €700.000 per year in the fourth year instead of almost €2.500.000 per year based on the very conservative drop in production-costs of only 5%. This indicates that the minimum salesprice that is viable in this scenario would lie around €1100.

However, for any of this to hold any value, it needs to be said that without protection of intellectual property, it will be very hard to find investments or grants making it possible to get this off the ground. When a patent could be filed on a certain design aspect of the product, there will be much more potential for making it into a business based on the case described here.
Additionaly, tax cuts will increase profitability by almost 30%.

Figure 76: Cash/year projected

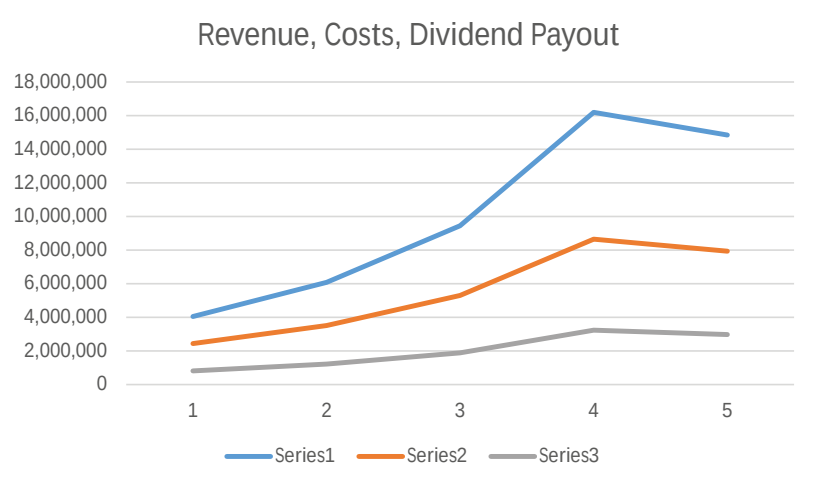


Figure 77: Profit (series 1), Costs (series 2), Dividends (series 3)

Year		Now	2015	2016	2017	2018	2019
Units/Year			3,000	4,500	7,000	12,000	11,000
Price/Unit			1,350	1,350	1,350	1,350	1,350
Revenues			**4,050,000**	**6,075,000**	**9,450,000**	**16,200,000**	**14,850,000**
Costs			**2,440,000**	**3,515,000**	**5,290,000**	**8,640,000**	**7,940,000**
Debt			0	*0*	*0*	*0*	
Debt/Year		*0*	*1,300,000*	*950,000*	*600,000*	*250,000*	*0*
Debt		0	1,300,000	950,000	600,000	250,000	0

Figure 78: Balance

To conclude this short section, it seems likely that a potentially worthwhile company can be founded based on the Splash concept as it is proposed in this report.
However, there is a need for finding a unique element in the design of the apparatus that is patentable or protectable against reproduction in order to make the company investable.
When this innovative step can be clearly described, there should be the potential of a company based on Splash.

6.3 CONCLUSION

It seems clear that this is still a product that requires quite some engineering before it can be put onto the market. However, the design outlined in this thesis report presents a modular framework that is suitable for a next development step. The most logical next step would be the design and fabrication of a first series of products. However, several things need to be considered when designing this first series.

First and foremost, a proper design for the radiator part of the product needs to be made, taking in mind that regulations require drinking water to only pass through certified materials.

There is only a very limited amount of materials suited for this, copper, brass and HDPE being only generally applied materials. While making the radiator out of aluminium seems sensible due to its low weight, recyclability and most importantly, its emissivity of radiation-heat, aluminium cannot be used for drinkingwater.

This would mean that for instance, a HDPE water compartment that can be joined to the panel could be a sensible solution to the problem. By coating the backside of the panel, it might be possible to still use aluminium. Then, the newly designed radiator needs to be tested extensively and optimized so that it provides the proper heating. Selecting the right surface treatment and shape of the panel will probably be vital.

The exact positioning and implementation of small components such as sockets, plugs, bolts and other connections needs to be well thought-trough. The design presented has been developed with production and assembly in mind and all parts are easily adjusted so that they can be fixed by just adding suitable fasteners.

Due to limited time and need for further design of several parts however, this final detailing-step was not possible anymore.

Another part that needs proper engineering and has to be developed in cooperation with a sanitary equipment manufacturer such as Grohe or Sphinx is the faucet. This is a job that is probably best done by larger manufacturers.
It might be necessary to develop a special faucet that integrates all functions of the Splash is a sensible manner.

Another point of attention would be to make sure that the flexible hoses used to connect the plumbing is kept concealed at the back of the unit. Proper dimensioning of these parts and possible adding brackets will prevent them from showing.

As mentioned earlier, the placement of the basin and the custom-made faucet in the worktop-shell requires a proper means of fastening. A series of inserts could be produced to facilitate this. The exact dimensioning of these parts cannot be determined at this stage and is left out intentionally.

Furthermore, there needs to be a thourough investigation of the possibility for creating intellectual property based on this prototype. If this would be possible, it would creatly increase the viability of the product as a marketable one.

7 // Recommendations

Interest has been shown to further the Splash project and since there seems to be a potential for valorisation of the developments made throughout this project. However, before the product could be implemented, it is clear that there are a series of issue that need proper attention.

Most issues have already been touched upon in earlier sections of this report, this is a final recap of all relevant aspects.

The product has been developed with the vision of building a company based on the product. When pushing a new product is put into the market by a start-up company, first and foremost, proper attention is required towards the marketing strategy of the company. It seems valuable to launch the Splash as the radically new product that it is while not emphasizing the sustainable aspect of it. While sustainability is a driving factor behind the product, it should be an internal driver for the company, the sustainable benefits resulting from business strategy but also the use that the product induces in the consumer.

For the customer that is targeted, the product should be invite people to experience Splashing by appealing to their senses and by standing out as the extradorinary product that it is.

In order not to limit the acceptance of the product by various user groups, as far as they can be named groups at all, a lean manufacturing approach is advised in which the product is optimized both in terms of secondary functionality (accesoiries, colour, lighting, etc.) as a result of market insights gained by closely monitoring evaluation of early adopters.

A pilot in which a varied demography of users would get to use the product would be ideal.
User tests with the prototype show that most users positively evaluate the practice of Splashing.

While some saw the difference in washing rituals as a downgrade, the majority noted positive elements of using the product. It is clear however, that certain aspects of the product need further attention, the most important aspect being the heating element.

The heating was suboptimal due to the limitations in the prototype, but could easily be optimized in a next version of the product. Even though a heating effect was very well measurable, reports by users about the temperature tended more to coldness than a comfortable warmth. Technically, the optimization should not be very complicated, but might require the fabrication of one or several prototypes to evaluate the most optimal configuration and materialization. Development of an IP strategy seems vital for furthering the design in a commercially viable manner.

When evaluating the efficiency of the heating system, the proposed design only consumes a marginal amount of energy. It has to be noted that most of this would have been consumed anyway. The drop in temperature of the water not being nearly enough to be colder than required for washing. This means that the only real effect is that less cold water is required for mixing. Essentially, the cost and impact of heating is almost none.

Other than optimizing heating, engineering is required to alter the design to fit custom parts such as a faucet.

Inserts and fasteners to connect parts together have to be integrated into the design. Currently, these features are not included in the design.

Interestingly, only a few people sat down when using the prototype. While this might have to do

with people not feeling comfortable doing so when it is not their own bathroom, it probably is also related to resistance to adopting new rituals.

While there is a reason behind giving the product the capability of being easily adjustable, it might be interesting to evaluate whether or not a non-adjustable version might be viable as a concept commercially, since it would greatly reduce production cost of the unit. However, this would of course dramatically alter a core element of the current design.

It would be interesting to evaluate whether or not people would adopt a ritual in which they do sit down when using the product when using it for a prolonged period of time.

Other than just the aspect of sitting, a prolongued pilot session on a larger scale, preferably with a variety of prototypes, will make it possible to quickly iterate the design in a truly interactive and sensible manner.

As long as a thorough plan for validation of the product as a whole is layed out, producing a series of prototypes (some may be slightly different from others), basic assumptions that were made up until now (such as the requirement for sitting down or the actual perception of heating and the effectiveness thereof, can be validated.

During the course of this optimization, the design could be finalized and prepared for production. Simultaniously the businessmodel can be validated and adjusted for market introduction.

8 // Reflection

When I started working on this project, the intent was to try and develop the product so that it would be ready, or near to ready, for market introduction. I felt a desire to pursue my vision of becoming an entrepreneur, and this graduation project promised a potential lead towards this. Working towards that was also the intent from the start.

However, a few months into the project another opportunity presented itself. One that was more my own and which took off on a flying start and presented an interesting business opportunity. Since there was already a team behind it, this was a more attractive and motivating project to pursue professionally.

This did have quite a dramatic effect on the course of this thesis project. Having had decided to graduate while trying to build a company next to it appeared to be achievable in the beginning, however it became clear as the project progressed that it would cause quite a lot of delays. This has been the main reason for the fact that this project was finished in about 15 instead of 5 months.

Other than the fact that dividing attention between two different projects that both are quite intensive, it also became apparent that the assignment I had set for myself might have been a bit ambitious. I had written the assignment at a point where my perspective on my professional future was different although similarly ambitious.

Reflecting on the contents of the assignment, it seems like it might have been a lot smarter to focus just on the design and engineering of the product and not on the business-side of the project. Even if my attention was focused just on my graduation on a full-time basis, finishing it within the 5 months would not have been realistic given the goals set. Prototyping and testing alone took the better part of three months. Handing that side of the project over to somebody else, for instance as an SPD graduation project, would have allowed for a more focused and structure approach.

Concerning the process and methodologies employed throughout the project, documentation was not updated regularly and rather unstructured. While a lot of reading, analysis and design work was done (a lot more than made it to this report), it was not structured in a single reference.

Not only did this complicate communication but also it resulted in a design approach that was not as structured and focused as I would have liked.

Especially the stage from ideation towards prototyping was a rather fuzzy one. This was partly because of lack of early documentation but also because of the timespan that it took up in the entire project.

As is clearly visible in the concepts, some of them are rather detailed while others never made it much further then sketches. The reason that they were presented as concepts is because they were chosen to be concepts. During the concept development however, several new concepts had been developed that were more interesting and relevant.

When reflecting on the end result of the project, I feel that it does deliver something new to the concept of Splash. While it would have been nice to have a fully detailed design as a result, time wise this would not have been possible. I hope and think this report can form a foundation of a next step for Splash.

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10// Appendix A

Stakeholders

Development of a new product concept often is a path that is non-linear and can take years of work and lots of investments. The end result of such a development trail is however always very much dependent on the stakeholders that are either directly or indirectly involved in the project. Within the scope of this graduation project, not that many stakeholders are involved from the start. This implies that in order to actually grow it into a feasible project for further development, attention is needed in finding and connecting to at least a few of the stakeholders that are listed below. As such, this list of stakeholders is not limited to those involved directly with the graduation project as defined in its scope, but analyses the broader context of the project in the projected future.

1. TU Delft

Since the TU Delft is offering the thesis project and continues to place efforts at developing sustainable behavior changing strategies and products, the Splash being one of them, it is one of the major stakeholders in the project. If the project is ever to enter the marketplace with a product, the TU Delft is likely to be involved in incubating the company that may sprout from it. Legally, the TU Delft will hold rights to any patents that might be filed or brands that are founded as a result of the project. Exact details depend heavily on the way in which this stage is initiated and if indeed intellectual property can be protected in any way shape or form.
What is evident is that the TU Delft can be a valuable partner in developing the product even after this graduation project, possessing the facilities and funding possibilities of growing it into a company that can eventually sustain itself. The role of all the other stakeholders in this is to be defined at a later stage.

2. Lenneke Kuijer

As a PhD student at the faculty of Industrial Design Engineering, Lenneke Kuijer is doing research on practice oriented design approaches and how they can be implemented into design methodology. The Splash concept as it has evolved throughout the years has been an object of study for the research she is conducting. Her research is especially focused on the sociological factors relating design and societal change. Household resource consumption is her main focus for application and evaluation of the practice oriented design approach she develops.
During her PhD work she has mentored the previous graduation students that have been involved in the Splash project and has been involved in the project from the start.
It is obvious that she is a skilled and suitable mentor for this project, especially for bringing this project to the next stage.

3. Daan van Eijk

Prof. Ir. Daan van Eijk has committed to being the chair for this graduation project, despite his very busy schedule. His own experience in the designing of bathroom appliances brings useful insights and guidance for the project. Daan van Eijk is also the supervisor of Lenneke's PhD research work and as such was already familiar with the Splash concept before this thesis.

4. Bathroom resellers

Although at the current stage this seems far-fetched, in the end, bathroom resellers will be major stakeholders if the project ever becomes fruitful. They are the ones that are supposed to be selling the appliance and should see some benefit in it if they would ever commit to sell the product.
If sales will be achieved through other channels, resellers would still be stakeholders in the respect that the Splash project will become a competing brand in the market, presenting an entirely new concept.

5. Concept-house

In order to perform usage tests with the eventual prototype of the product, a suitable location has to be selected and confirmed. Since the start of the project, the Concept-house in Heijplaat has been the location of choice, both due to the nature of the project as being a holistically designed sustainable house and because it is intended for evaluating sustainable domestic and housing solutions. Since the faculty of Architecture is a co-owner of the project, contacts are already in place. The difficulty may be in convincing the owners to allow for renovation of their newly built bathroom. Implementing our system might interfere with the carefully designed utility products that are already in place.

6. Material suppliers

When producing a new product involving a variety of different materials and technologies it is important to select the appropriate suppliers that are willing to provide assistance in making decisions or designing certain features of the product. At the start of this project, no manufacturers or suppliers were involved in the project in any way. It would be interesting to see if and in what form, certain companies would be willing to invest their efforts into the project.

7. Contracted installers

Since the product installment in existing housing will involve a certain level of renovation and plumbing, it seems important to contract a partner that is involved in the project as soon as it is to be marketed. This benefits not only the plumber/installer, but also the company that is to sell the product. Experience and routine in installing a product as different from regular bathroom appliances is an added benefit to the (perceived) quality and reliability of the product and to the comfort and service delivered to the consumer.

8. Investors

At a certain stage, investors are likely to be required in order to initiate production, distribution and marketing efforts. Initially, the TU Delft could be one source of investments or grants. It is very likely however, that more investors are required to maintain a feasible business. Investments could also come from any of the partnering companies or suppliers that at that stage are closest to the project. Another possible direction of development could be in the form of a joint venture with a larger, established firm that can support the initiative in a meaningful way.
Investor relations are of course not within the scope of this graduation project, although it seems important to at least present a somewhat realistic estimation of production costs and provide an overview of what this would implicate for a start-up company.

9. Costumers

Last but certainly not least, the costumer is of vital importance in the development phase of the product and of course when it is launched. Throughout the Splash project, evaluation of users reactions to the concept have been valuable to the development. This will remain to be an important driver during the design, prototyping and optimization of the product.
More obviously, costumers that buy the product will experience an impact in their daily lives because of the rather radical physical changes to their bathrooms. In this sense it is even more important to closely monitor reactions and user experience at every stage.

11// Appendix B

1.1.1. Far Infrared Radiation Heating

In the wellness-segment of the bathroom market, heating and sauna's are a big source of attention and innovation recently. While IR(infrared) heating has been around for quite some time now, especially in sauna-cabins and small-scale applications, the use of regular infrared heating is somewhat controversial. The controversy regards regular, red-hot infrared lamps such as shown in figure X.
With a wide range of applications, infrared has many claimed health benefits such as increasing bloodflow and thus benefitting the cardiovascular system.
However, according to {sources}, the wide spectrum lamps that glow visibly also emit harmful wavelengths that can even cause skincancer when used excessively.
Due to this risk in long-term use of the technology, it seems that applying this technology for heating is not without risk.

A new technology that is only recently gaining ground is Far Infrared Radiation (FIR) heating. This technology uses a glass fiber composite film that can be applied in a wide range of applications. Most widespread are the wallmounted heating panels that have a glass sheet covering and can be used instead of conventional radiators. Figures XX and YY show two examples of applications for FIR heating..

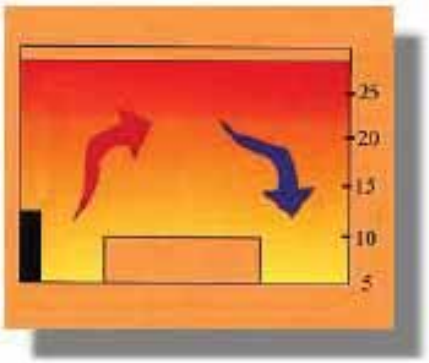


Figure 2xxx: Convection heating

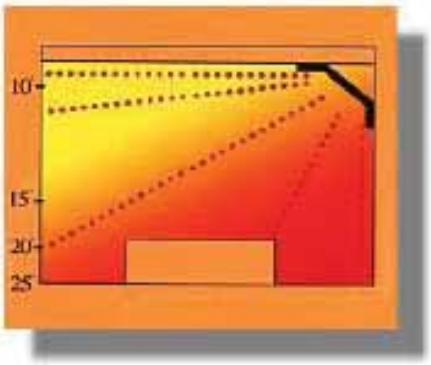


Figure 1xxxx - Radiation heating

The big difference with regular (convection) heating is that infrared heating uses radiation to heat the room. This means that there is no flow of air or heating of air as a direct result of the activation of the heater itself. The infrared wavelengths radiate warmth into the space, but only heat the surfaces that they shine on. As a result, it is claimed that a lot of energy can be saved for heating purposes due to the more efficient heating of a space, not wasting energy on heating the air.

Figure 3xxx: source: KOREA HEATING CO., LTD.

Although it is hard to substantiate due to the secretive nature of the FIR industry, it seems that all FIR heating uses far infrared heating film (or hotfilm), which can be incorporated into various designs for use in all sorts of applications ranging from car seat heating to egg-hatching or regular household heating applications.

During the start if this graduation project, the intend was to apply FIR panel heating to provide a comfortable and energy-efficient heating solution that could be integrated into the Splash concept.

For testing purposes, we contacted a Dutch supplier (undisclosed) that provided us with a 1000W FIR panel. Despite the promising details of the technology, practical use of the product was disappointing.

The dimensions of the screen were {90*90cm}, fitting perfectly above a shower cabin where it was temporarily fixed into position.
Using a laser thermometer and a stopwatch, measurements were logged and plotted in order to evaluate the potential of the product for this specific application.
It has to be noted that the shower itself was turned off and that no person was inside the cabin. The setup is shown in the pictures (????).

The heating up time of the panel was quite significant, taking 4? Minutes to reach 90?. Etc ect.
As far as heating any surface in the shower cabin, no significant changes could be observed. It has to be noted that many of the surfaces were reflective and as such don't absorb much of the energy that

is generated. However, upon testing of the appliance by standing underneath it, no notable heating could be felt lower than about 35 cm from the panel itself.
Sitting directly in front of of the panel did have some effect, but it is not at al clear whether or not this satisfies the needs of the application in mind.

Another challenge is related to safety regulations that apply to bathroom spaces. In the shower cabin itself, it is not permitted to connect appliances with a voltage higher than 12V (NEN-1010) in zone 0 and 1 of the bathroom. More details on these regulations follow in section 8.6.
As a result of these regulations, it was not possible to actually test the product while using the shower at this stage. Further investigation of the potential of FIR heating in the bathroom domain will require consultation with experts.

1.1.2. Kinetic water heating

Although still very much a concept, the vein-shower by Natalie Weinman, Victor Stelmasuk, Sebastian Jansson and Fernanda Pizá uses the kinetic energy of flowing water provided from the mains water supply to heat up shower water. Using piezo-electronic fibers, kinetic energy from the movement of water can be harvested and converted into electricity, which can then be used to heat up showerwater. Insipired by the vascular system, the design is certainly something quite different. From a practical point of view however, it remains to be seen whether or not the system is actually able to heat water enough to comfortably take showers. What it does show is that by using unconventional principles that are sometimes not that new, inventive solutions can be developed.

Figure 4http://inhabitat.com/magnificent-vein-like-shower-harvests-piezoelectricity-to-heat-water/

Figure 5 source: junyasumoto.com

1.1.3. Gray-water systems

Interesting from the point of water-conservation are grey-water systems, which recycle used (bath)water and recycle it so that it becomes drinkable water again.
These systems are generally very expensive and require quite significant modifications in order to implement them.
One design by Jun Yasumoto presents a more natural looking system that uses a combination of natural filtration and filtration technology to recycle used showerwater in a contained unit. In essence, it resembles a natural eco-system that not only presents a soothing atmosphere, but also saves water.
Again, since it is a concept, the actual value it presents is limited, but it presents another angle for reducing water-use.
Also, as I will describe in section 8.7, saving water is not necessarily an effective way of making showering or bathing more sustainable.

1.1.4. Water-saving showerheads

A vast amount of water-saving showerheads are on the market today. Generally, these showerheads use some way of aeration of the waterstream in order to allow for a reduction in water dispersal while still maintaining a pleasant feeling in the user.

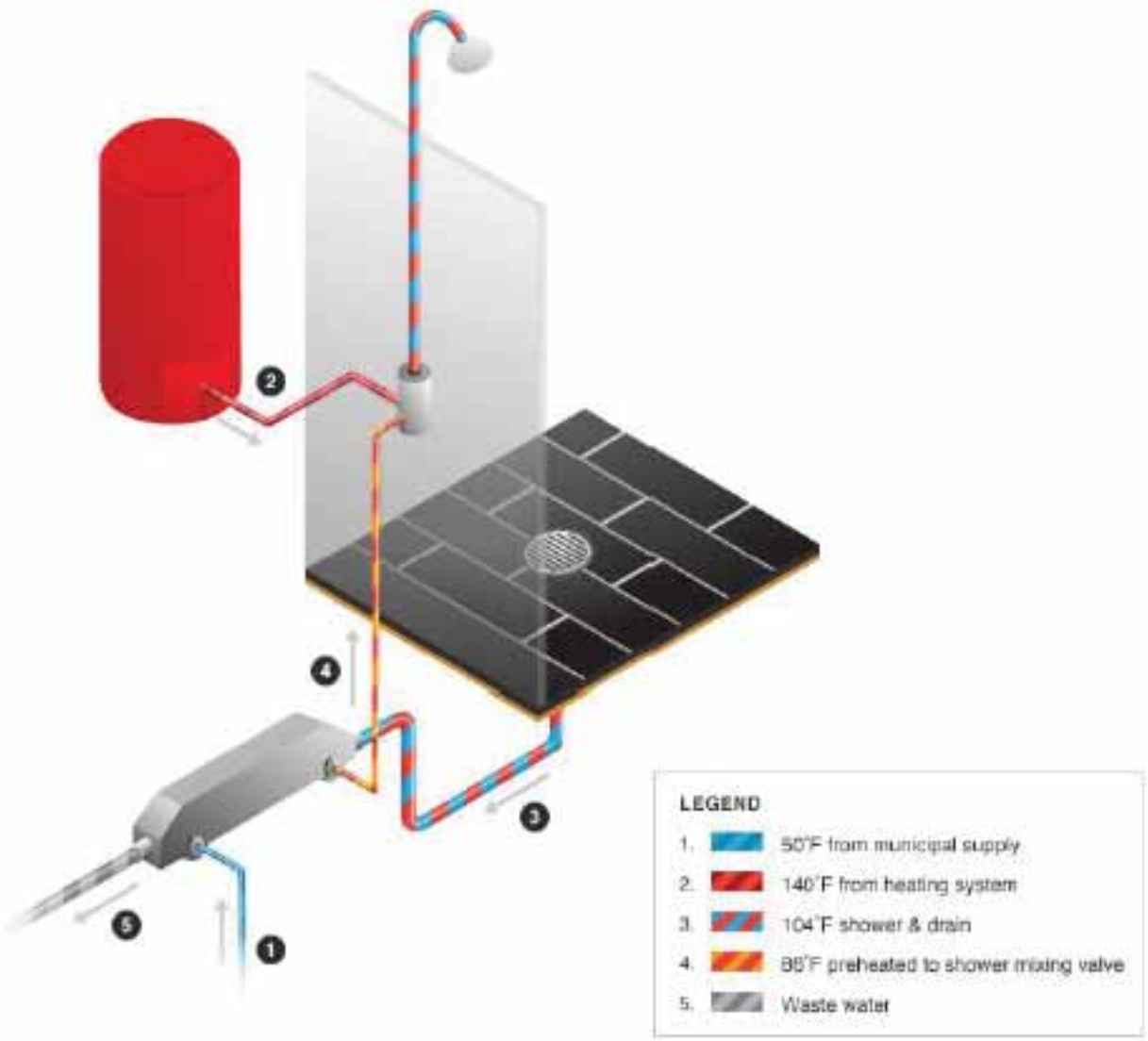
There are basically two types of water-saving showerheads. The most basic ones are those using a flow restrictor, which as the name implies, limits the output flow of the showerhead. In effect, not all pressure available in the lines is used to output water. Water output is diminished by about 4L/min.

Aerated showerheads are more advanced and generally slightly more expensive. They use the pressure in the waterlines to draw air into the spraynozzle. This air makes the water foam a bit, creating an aerated water jet that is ejected out the nozzle. While the reduction in water-use is comparable to that of a restrictor nozzle, the pressure that is created on the skin is similar to that of a non-restricted high-output shower.

As investigated by Phipps et al. (2009), skin pressure is the most defining factor for acceptability of a showerhead as a suitable cleaning utensil. Aerated showerheads do not limit perceived comfort significantly, while restrictor heads limit comfort to the extent that most subjects preferred to switch back to their original showerheads.

There are of course many different design variations and various patents in existence, some combining multiple varieties of water dispensing in one unit. However, the basic principles used remain divided between the abovementioned two.

1.1.5. Heat exchanger systems



Heat exchangers can be installed in bathroom installations in ordered to regain up to 50% of the energy present in wastewater that is otherwise lost. Such a system is usually implemented in grey-water systems that recycle not only water but also energy.
A limitation of using this technology is that the heat that is reclaimed from the water needs to be fed back to the water stream, meaning that it can only be used to pre-heat water up to a certain point. When used in conjunction with a regular heating system. As such, systems like these are usually very costly and require quite substantial renovation work in order to be implemented.
However, savings in hot-water consumption on the long run are expected to be substantial by implementation of such a system.

Alternatively, slightly easier to implement solar water pre-heating panels can be used to preheat the hot-water supply to the bathroom. These roof-mounted systems collect heat from the sun to pre-heat water that is later run through another heating appliance such as a boiler. Again, this is quite a substantial investment, but will pay off significantly in reduction of gas-use required for heating water.

1.1.6. Comfort showers

Comfort-showers exist in different forms, but have all gained in popularity in the past years. The most important incentive for purchasing a comfort shower is for its spa-like qualities. Having such a luxurious system at home appeals especially to younger generations.
In order to achieve this sensation of comfort, excessive amounts of water are involved, often coming from multiple spouts that are mounted in an integrated cabin. Chromotheraphy (using coloured light) is often applied in these products as well to enhance the experience.
The main shower-head, that is oversized and often integrated into a ceiling panel. Usually this main showerhead has a rain-shower setting, in which large droplets of water fall on the user. Since droplets of water don't provide the same level of pressure on the skin, which is for most people associated with the sensation of cleanliness, an additional hand-held showerhead is usually present. In more luxurious units, waterjets and steam-nozzles are also present to further increase the bathing experience and the water-use.

[Plaatjes]

1.1.7. Shower Stopwatch

In an attempt to make shower-users more aware of their consumption patterns, shower stopwatches are available that indicate how long the shower has been turned on for.
Products like these are available in many different forms and configurations, either digitally or as a simple hour-glass.

1.1.8. Integrated shower consoles

An often seen configuration on the shower market is an integrated shower console that comprises all different appliances usually found in the shower. Other than a regular shower, they all include a fixed overhead showerhead as well as a hand-held shower that is fixed to the console body.
Some models have digital controls or even integrated radio's and the like, while others are nothing more than the sum of their parts.

http://www.ecofriend.com/entry/eco-gadgets-eden-mist-shower-saves-water-each-time-you-cleanse-yourself/

1.1.10.Faucet turbines

Do not ignore any possibility of using water

Mini Hydro Turbine

Hair Dryer
Electric Shaver
Mixer
Electric Toothbrush
Lighting
Water Boiler

and available for all of gadgets beside tap

There are multiple companies such as {}{} that produce in-flow micro hydro-turbines in order to power small electronic devices such as radio's or lighting. These turbines can be connected to any standard faucet or water outlet and are generally used either on a faucet or in between the water outlet and a showerhead. A patent for a turbine inside a showerhead itself also exist.
Of course this presents an interesting way of supplying energy for low-powered devices.
This kind of solution could be useful for the Splash concept since it seems to be suitable for powering low-voltage electronics such as LED lighting or LCD-displays. As such, ambient lighting and low-powered electronic circuits can be integrated without the need for drawing power from a wall-socket (which complicates matters, especially in bathrooms).

12 // Appendix C

When looking at the current bathroom market, there are some clear trends that can be observed, as already pinpointed in section 8.3. These trends do not only regard technology-driven trends and general product architecture, but also aesthetics. It is quite clear that there is a diverse market for bathroom renovations and the manufacturers focus their attention on markets that they can cater to. This means that in most cases, it is rather clear that a product range or even an entire brand image is focused on a certain "kind" of costumer.

While it is always ambiguous and thus never an accurate prediction method of product acceptability among the actual user, it seems very reasonable from an aesthetic as well as from a usability point of view to analyze and identify various distinct market segments. It allows for the conception of a clear and targeted marketing and product development stage that might otherwise lack direction from an early stage on.

It has to be noted however, that it can be a risk for a start-up company, especially when introducing a radically new concept, to limit the marketing to just one segment. For this section however, just identifying and describing (in this case six) the various market segments will facilitate later processes that take all of the above into account.

Every segment is described in the form of a persona profile, along with one section of text that describes the daily lives of the persona and their demands within the bathroom. Images help provide a visual way of presenting the segment. Keep in mind, this is ambiguous and abstract information, but can provide valuable insights.

Later in this report (where), a marketing strategy will be formulated that can make use of the identified target segments. Appendix I contains a paper written by the author aimed at investigating the opportunities and challenges for marketing a new, sustainable concept into the bathing market. Relevant to this section, what can be concluded from this paper is that it might not be wise to focus attention merely on a selected market segment. This holds true especially for radically new products, let alone environmentally oriented products.

However, a segment can give direction for an aesthetic appeal and a starting point for formulating a design vision for the product. Keeping all of the above in mind, it might be best to strive for a product architecture that is flexible enough to allow for various design variations to be produced using the same structure. This benefits the flexibility of the marketing effort that is needed to market the product and might be an economic way to differentiate the products on offer while minimizing maintenance costs.

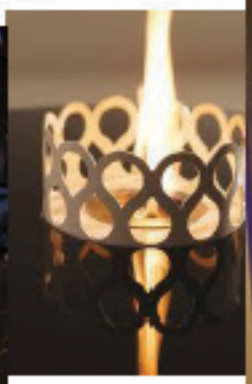
Segment 1: Hospitality

Age	:	45-65
Income	:	High
Family Composition	:	Married, grown up children
Interests	:	Comfort, reading, enjoying a good wine, sight-seeing
Attitudes	:	Conservative, Economically minded, individualistic
Favorite Car-brand	:	Audi

The hospitality segment is especially focused on comfort and luxury, but appropriate luxury that serves a purpose. This target group often goes on short trips and stays in hotels, also for business. They tend to drive German cars of decent size and are people that like enjoying time together, either just with the two of them or together with their family. Colours that are typical for this group are earthly colours such as brown, but also granite-grey.

Segment 2 - Wellness:

Age	:	30-50
Income	:	Medium
Family Composition	:	Single
Interests	:	Spirituality, reading, cooking
Attitudes	:	Health-conscious, understanding, social
Favorite Car-brand	:	Renault



The wellness segment is one that is very much gravitates towards not only physical, but also mental or even spiritual wellbeing. The bathroom for them is a place that is like a temple for personal care. Anything that sooths and calms is appropriate. Preferred shapes are more organic than geometric, but not necessarily of natural materials. Often, quite a lot of money is spend on personal care items such as soaps and lotions. Conservation is less important than comfort and care.

Segment 3 - Eco-Aware:

Age	:	20-35
Income	:	Medium
Family Composition	:	Living together
Interests	:	Volunteering, DIY, animal welfare,
politics		
Attitudes	:	Enthusiastic, critical, radical
Favorite Car-brand	:	
Drives a bike		

The Eco-aware segment is typically younger and more skeptical towards many mainstream products. Natural materials are preferred and details that resemble nature are a recurring theme in their homes. In the bathroom, this segment is likely to use little or no soap or shampoo's and search for ecologically safe products. It is not unlikely that the eco-aware consumer is a little less focused on personal hygiene, accepting the idea that the body is capable of managing its own maintenance to a big extend. This doesn't imply that they are dirty or careless, but generally try to shape their daily routines in a more conscious manner.

Segment 4 - Care (elderly):

Age : 55-85
Income : Medium
Family Composition : Married
Interests : Gardening, card-games, family visits, swimming
Attitudes : Careful with money, melancholic, structured (rituals, time)
Favorite Car-brand : Fiat Dolbo

The care segment is signified by their desire for comfort, mainly due to physical limitations. As a result, aesthetic values are a less significant factor when compared to all other segments. Much more important is practicality and structure. Conventional practices and products are more likely to be accepted whereas more novel concepts can be hard to adjust to. Daily routines are very important and should not be interfered with. Reachability and accessibility are important keywords.

Segment 5 - Young Families

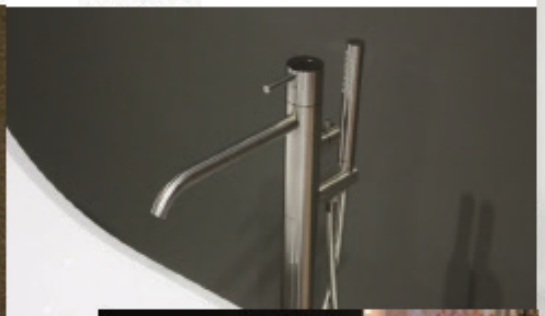
Age : 25-35

Income : Medium

Family Composition	:	Married / Children
Interests	:	Holidays, family trips, decoration
Attitudes	:	Playful, hard-working, trendy
Favorite Car-brand	:	Seat

Young families value their time together. Not only do they share the bathroom more than the other segments, they also are likely to use a lot of water. Efficiency is important, but attention for each other prevails. Safety and accessibility are very important to this segment, but aesthetics should definitely be appealing. Generally, they are homeowners that like to give their homes a personal identity and search products that fit this. Colourful products with playful shapes or patterns dominate their taste.

Age	:	35-55
Income	:	High
Family Composition	:	Without children, single
Interests	:	Real Estate, Renovation, Design, Appearance
Attitudes	:	Serious, career-minded, vain, individualistic
Favorite Car-brand	:	Mercedes



This segment is one that is characterized by the career-minded people that populate it. They tend to be financially more prosperous and have a distinct taste that is resembled in almost any item they purchase. Geometric shapes and unconventional use of materials and texture in products draws their attention. Hygiene is very important and grooming takes up a sizable portion of their personal rituals. Orderly and smooth surfaces and minimalistic design are more important
than environmental concerns, which are viewed with skepticism.

13 // Appendix D

26-4-2012

Identifying opportunities and hurdles for marketing a sustainable bathroom product

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Faculty of Industrial Design Engineering

Abstract

In order to gain insight into the possibilities for marketing a new and radically positioned bathroom product, this paper investigates potential opportunities and pitfalls that can be encountered when marketing such a product. Literature research is used to give an overview of the current views and approaches that are employed. Strategies such as psychographic segmentation analysis and build-to-order practices are described and analyzed. Finally, a framework is presented which outlines the relevance of the presented research to the specific case, giving suggestions on how to approach marketing planning activities for this sustainable product and company.

Keywords:
sustainable, green marketing, eco-labels, segmentation, strategy, logistics, value chain

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1. Introduction

This article describes what challenges are to be faced when marketing a sustainable bathroom product. Business-to-business marketing strategies greatly influence all aspects of the commercialization of a product. Traditionally, approaches towards marketing sustainable products have often focused on using them as segmentations tools, neglecting potential for thoroughly implementing sustainable and responsible practices throughout the business and up to the value chain. By reviewing literature on these issues, an attempt is made to present a framework for drawing up a sustainable marketing plan for a future business by identifying opportunities and potential pitfalls that come up when putting a sustainable product onto the market. This potential new business is based on water saving bathroom products currently under development.

2. Method

While since the 1980's considerable attention has been given to environmental concerns and companies have become increasingly aware of the implications of these concerns and the value of sustainable practices, the way to approach these matters is not as straightforward as might be expected. To provide a solid basis for hypothesizing a suitable method for implementation of sustainable products by means of green marketing methods, insight is required into current practices employed in the field of green marketing. Literature on both internal marketing and issues such as market segmentation and positioning have been researched by different disciplines, but consensus over certain issues has never been reached.

In order to give insights into the current literature available on these matters, a literature review is conducted. The literature is all related to marketing and is selected to be from different angles and disciplines, serving to of giving insights into green marketing approaches and area's thereof that have not been researched extensively.

After having reviewed literature, a hypothetical framework that provides structure for generating a marketing plan for the product described earlier is proposed. This framework of course will present suggestions for additional research in certain areas. The purpose of this approach is to have a solid basis on which to found the generation of a realistic and well-considered marketing plan, aligned with development of said product.

3. Research Goals

While no specific market for the product has been selected yet, it seems vital to the successful marketing of a sustainable product in any market that the incentives for purchasing the product are shaped and communicated in a way that makes the product as a whole attractive without people perceiving it as sub-optimal or misinterpreting its functionality or features. Therefore, in this paper I would like to focus on identifying potential opportunities and pitfalls for marketing sustainable products and on strategies aimed at preventing them from occurring. The results will allow me to synthesize a feasible and well-founded marketing-plan.

3.1. Research Questions

- Identify the most evident opportunities for marketing sustainable bathroom innovations?
- What are the most prominent hurdles to overcome in this specific market and what possible strategies can be investigated further to overcome them?

4. Literature Review

4.1. Overview

Within the past decades, green marketing has gained increasing attention from companies, but the way in which marketers have made use of the potential that sustainable practices present to companies has not generally resulted in successful green marketing approaches.

While general marketing principles should lie at the foundation of any green marketing approach[1], currently accepted approaches involve practices that might not have the desired result.

Eco-labels are mentioned by Rex & Bauman (2006) as one aspect that requires special attention due to various factors. Furthermore, in the last few decades, green products have often been marketed as such were targeted merely at a hypothetical fraction of consumers that has up until now not been understood sufficiently[2] and has been approached as a more or less homogenous customer segment.
This is regarded by some authors[2,3] as shortsighted and limiting to the potential market penetration that sustainable product might achieve when considering the actual user needs and wants more accurately.

Focusing on how to alternatively map and visualize these aspects, Mostafa[2] presents an alternative method of analyzing and characterizing certain groups of consumers based on cultural, social and psychological attributes.

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While external marketing aspects are often regarded as the most important aspect of a green strategy, Sharma et al. (2010) also describe the importance of various aspects of internal marketing efforts and their possible implications on a business-to-business marketing strategy and the competitive edge it may provide to a company. The following sections will explore the abovementioned aspects in detail.

4.2.1 Eco-labeling

Sustainable product categories have been developing over the past decades, some categories capturing bigger portions of their target market than others. While it is hard to attribute their success to one or a few factors, Rex and Bauman (2006) try to analyze the aspects involved in how green marketing approaches influence the success of products in the market along the lines of traditional marketing approaches such as described by Kotler et al (2003).

Kotler describes the activities involved in the marketing process along the lines of four main aspects:
(1) analyzing market opportunities; (2) selecting target markets; (3) developing the marketing mix; and (4) managing the marketing efforts. These aspects provide structure for evaluating aspects of the traditional marketing method that require attention when applied in the domain of marketing sustainable products.

In the 1980's and 1990's, when green marketing was gaining ground, most attention was geared towards identifying and profiling the 'green consumer'. Most of the work done in this field was based on surveys that were setup to evaluate the likeliness to purchase green products by certain segments. However, as for instance Mostafa (2009) and Rex and Bauman (2006) emphasize, this one-sided approach is limiting to the success of a sustainable marketing plan because it is restrictive in the way the product and its communication towards the market is shaped. It also limits the integration of a holistically detailed sustainable strategy within the business itself (Sharma et al [4]), which in turn is a very powerful factor in successfully implementing a green marketing strategy. More elaboration on this follows in section 4.2.3.

Ecolabels have been gaining ground especially since the '90s, governments endorsing the use of them and regulating certification in order to maintain a fair and transparent system. While labels can be useful tools in helping promote sustainable products instead of less sustainable ones, there are certain aspects and considerations that need to be taken into account in order to enhance the brand image and still maintain credibility among a large customer base.

A 2008 OECD publication[7] focused on promotion of sustainable consumption describes the history of government efforts such as food and energy levels and their effectiveness for marketing purposes.

Two types of food labels can be distinguished; mandatory labels and voluntary ones. Mandatory labels are increasingly being used to labels products based on energy efficiency or for instance in order in order to signal health issues. Food nutrition labels are a good example of this. It is stated in this report that food labeling is in general more effective in changing consumer behavior as compared to energy labels because they communicate a message that the consumer relates to and is directly affected by. Awareness and clear incentives seem to be key.

According to Rex & Bauman, eco labels are only suitable for convincing people that already have a tendency towards ecologically responsible products. Therefore, the awareness about the underlying issues needs to be articulated and promoted in order for labels to have any meaning to other consumer groups. Another negative aspect of mandatory labels that is often mentioned[1,7] is that they actually limit the innovation of sustainable products because the criteria used for labeling are based on current practices and are therefore not a stimulus for industry to strive for improving performance significantly.

Voluntary labels are another option for companies to employ, but their use risks falling victim to skepticism from consumers if accurate representation of the data and the consequences to the consumer are not made explicit and credible to the prospective buyer. Voluntary labels are regarded[7] as most suitable for communicating complex information in simplified ways. The design of the label then of course greatly defines its potential.

In recent years, voluntary labels have shown a clear shift towards not only ecological, but also social and economic issues, aimed at a more holistic sustainability approach. This seems to reflect Rex & Baumans observation that in order for green products to be appealing as such, more than just ecological concerns need to be addressed. A more complete message that puts things in better perspective could be an approach that appeals to a larger segment.

Either way, labels alone are not a solution for marketing a green product. In order to be credible as a company, independent verification of claims and public awareness about the specific issues at hand seem vital to the success of a marketing approach.

4.2.2 Market segmentation and green consumers

Surveys conducted by numerous authors show widely diverse statistics about consumer awareness and willingness to involve sustainability issues in their purchasing decision-making. Generally, only a relatively small portion of consumers are regarded as actually consciously looking for information on these issues and base their choices on this information. Different researches show any percentage between 15-60% of consumers claiming to be willing to spend more money on green products, differences being very fragmented geographically. Research on actual buying behavior of consumers in correlation to their proclaimed sustainable purchasing behavior is virtually non-existent. However, some sort of consensus exists over generalized segments that can be distinguished among consumers related to their 'greenness'.

For instance, Ogilvy and Mather (1992) divide the market into five segments. 'Activists' make up 16% of the market, being likely to have a focus on sustainability and having concerns about the environment. 34% are realists and are worried but skeptical about the term sustainability and al that comes along with it. 28% is seen as complacent and don't feel it is their responsibility to do something about environmental issues. 22% lacks interest for sustainability issues altogether. Segmentation layouts like these are representative of EU and UK markets and seem to have variability among different sources, but a 12-16% segment of truly green consumers seems a plausible assumption based on different sources[1,2,3,7] This is the segment that is willing to spend up to 20% extra on sustainable grounds, making a conscious green decision[1,7].

A U.S. survey (Roper, 2002), also distinguishes five segments: (1) True blue greens (9%), take responsibility and have a strong tendency towards green consumption; (2) Greenback greens (6%), more willing than average to make green decisions but are not activists; (3) Sprouts (31%), are unlikely to spend more on a green product but are aware of environmental issues. They can be persuaded to go either way and as such are maybe the most interesting segment to research. (4) Grousers (19%), generally uneducated about environmental issues and cynical about the quality and cost related to green products. (5) Basic browns (33%), do not care about social or environmental issues and are more concerned with day-to-day concerns.

As can be concluded from the examples above, current segmentation approaches do define separate groups but base this segmentation on highly subjective and poorly understood generalizations of groups of consumers. Based on discussions by different authors,[1,3,7] it can be concluded that a different approach to measuring and profiling market segments could assist in truly understanding consumer behavior concerning green products in the modern market.

Psychographic analysis presents a way of analyzing personal lifestyle preferences and is based on survey research conducted in psychological analysis. While this method has proved to have limitations, this can be overcome by relating the kind of questions more closely to product- or market specific aspects that can be evaluated (Solomon et al, 2006). Solomon describes[8] how such analysis methods can be used to either generate lifestyle profiles and segmentation, and product-specific profiling or segmentation. As such, psychographic analysis can be a very powerful tool to employ to produce a foundation for a sound marketing strategy. Mostafa proposes a method of psychographic analysis using Self Organizing Maps[2] (SOM), using an algorithm to analyze survey data collected from large randomized groups of consumers. The reasons for applying this different approach towards segmenting markets and conducting consumer research were that according to Mostafa, reasoned action and planned behavior, which lie at the heart of consumer behavior, are influenced by psychological rather than external forces. Mostafa's view is that reasons for choosing a sustainable lifestyle are threefold: concern for the self (egoistic), concern for others (altruism) and concern for the biosphere (biospheric).The gravitation of a person towards any of these three factors depend on socio-cultural aspects and therefore need to be considered as separate factors within each context.

The author claims that traditional segmentation tools don't take these factors into account and are applied and being researched mostly in western countries, the validity of the tools themselves in non-western countries being limited or poorly understood. Mostafa's research was conducted in Kuwait.

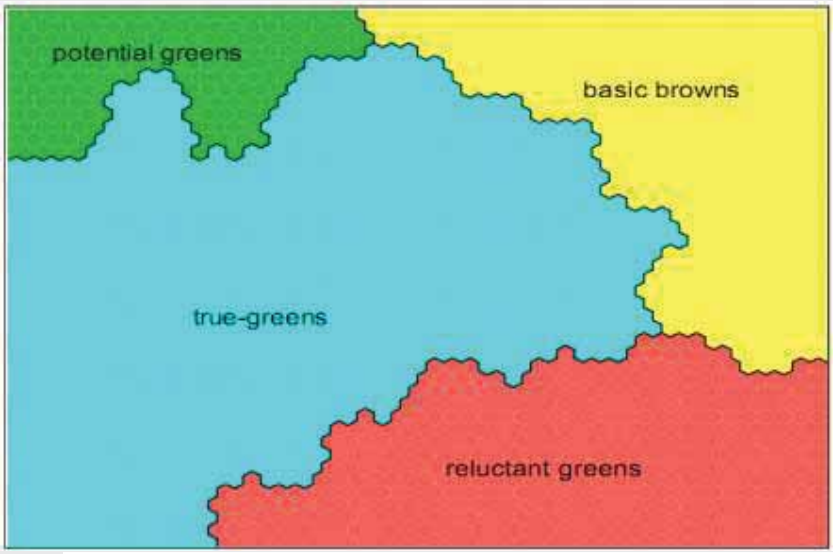

Figure 1: Feature maps of input attributes

The output of this SOM analysis is a two-dimensional representation of the market, showing in contrasting colors the correlation between various consumer behavior characteristics concerning green consumption. The four segments in figure 1 show clearly distinguishable groups of consumers, figure 2 showing the correlation of specific attributes such as environmental concern, altruism, intention and skepticism. From this figure it bomes clear that for instance the true-

green segment shows a significantly higher level of concern, intention, attitude and knowledge compared to other segments.

While this tool seems applicable and useful in investigating and understand market segmentation even for markets that are poorly understood, the basis on which the data is gathered (self-reporting by consumers) might still limit somewhat the actual predicting value that such a tool might have.

Other aspects not directly related to culture can also be of big influence dependent on the product category that is the subject. For instance, females have much more influence in buying decisions of categories of products such as household items and personal care and health items, while males are more dominant in categories such as cars and electronics. While this is again a generalization, the specific manner in which a segmentation strategy is defined could be influenced by this in the light of the target audience.

According to the OECD 2008 report[7], females make over 80% of buying decisions while males may spend over 80% of household funds (of course differing greatly among cultures / social conditions). Females make more decisions about basic essentials and health and hygiene products, while males are more dominant in larger and more expensive decisions. For bathroom products, it would be very interesting to investigate this aspect further.

One thing that seems to be true according to most literature is that abstract knowledge concerning sustainability, which is knowledge about ecological problems and issues and potential solutions for them, has a strong correlation with green consumer behavior patterns[1,2,7]. This means that making the public more aware is presumably one of the most effective ways to motivate the consumption of green products. More on this in section 4.2.3.

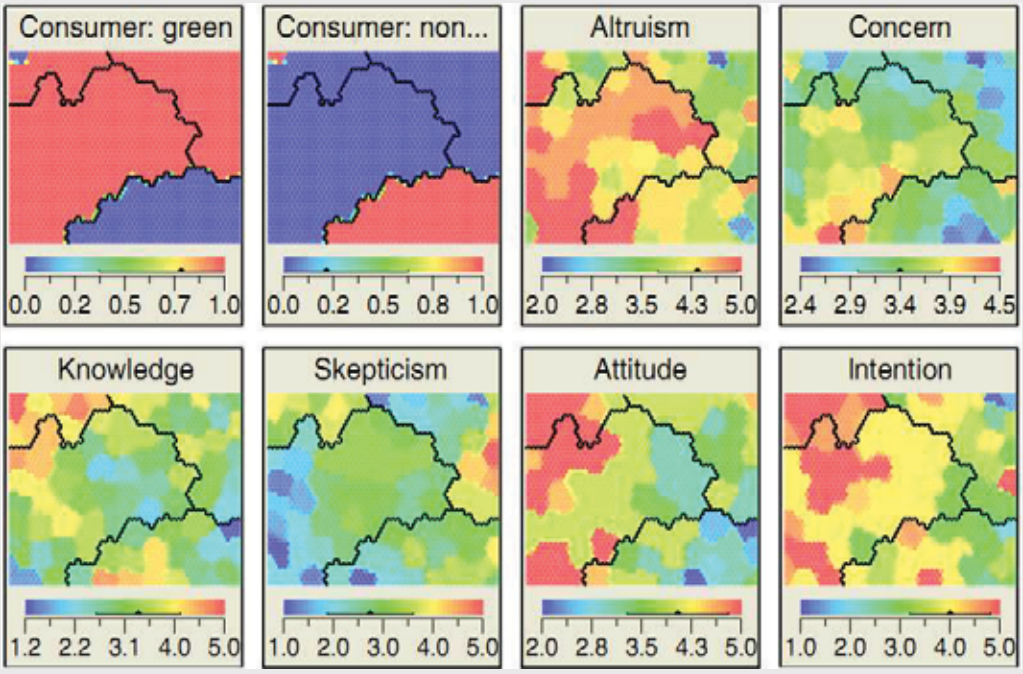

Figure 2: SOM-Ward cluster (Mostafa p.5)

4.2.3 Choosing a green marketing strategy

As a company, it is important to have not only insight into the market potential and possible segmentation strategies as described above, but to put the results of this analytical framework to good use. When marketing green products, historically companies have employed diverse strategies that allow this to take place, some more overt while others are very covert.

Ginsberg and Bloom [3] provide an insightful overview of currently employed strategies and considerations for applying them in more effective ways. One of the biggest hurdles they identify for companies to actually present themselves as green is consumer skepticism towards green products. While green products might eventually end up benefiting the consumer even economically rather than just on in an emotional or ideological way, Ginsberg and Bloom [2; p. 4] claim it is unlikely that consumers will want to compromise traditional product attributes such as convenience, price and quality.

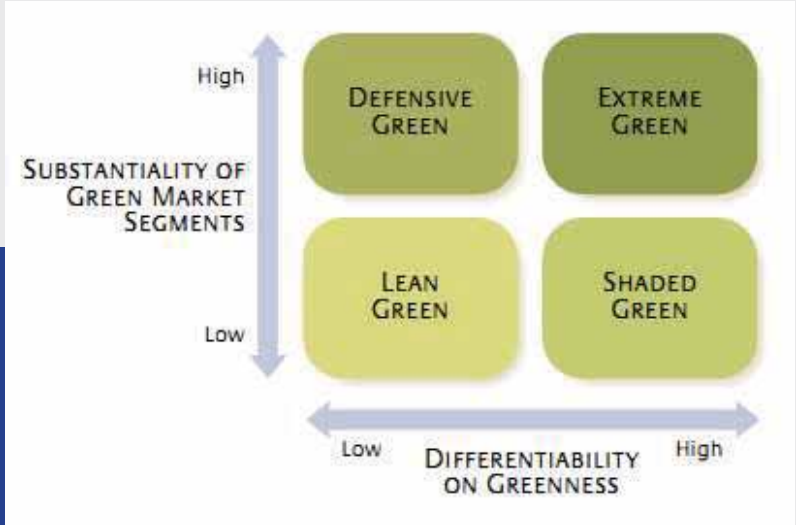

Figure 3: Green Marketing Strategy Matrix (Ginsberg and Bloom, p.5)

This means that in order to successfully market a product, it seems evident that it has to be able to compete within the existing market on the basis of all aspects other than sustainability as well. It is even suggested that for many companies, the sustainability argument is best avoided in order not to scare away the skeptical part of the market. On the other hand, it seems evident that even "sprouts" or basic browns might be convinced of going green when it benefits them financially by saving on energy consumption for instance. Since in that category of consumers, this has more to do with awareness of rising energy prices rather than environmental concerns, established companies might do best adopting a traditional marketing approach while highlighting some positive aspects that result from increasing the ecological improvements made in the product. As represented in figure 3, Ginsberg and Bloom recognize four different categories of marketing strategies that companies adopt. Two main factors are presented that differentiate between these approaches, the first being the potential of marketing towards a green consumer segment. Is the segment large enough and is it willing to accept or looking for sustainable solutions. The second one is whether or not the company has the knowledge, resources and internal willingness to `go green´ and truly adopt a sustainable approach. If competition is better equipped to fulfill this role within the market, it is probably hard to compete with them. The four strategies will be discussed below.

Lean Green

Lean Green companies try to do what is good for the environment and society but do not focus attention on publicizing

or marketing their sustainable ideals. Their incentives for ´going green´ are cutting overhead costs, improving efficiency and thereby gaining a competitive edge over non-sustainable competitors. Another motivation not to be openly green is to avoid unwanted attention and scrutiny of company practices which might reveal non-ideal situations that the company is responsible for, which would not have been uncovered by not making ambitious sustainability claims.

Defensive Green

Defensive Greens do communicate their sustainable efforts to the market, but generally do so only as a response to either a crisis or because competition forces them to. Resources and efforts going towards sustainable practices are not substantial enough to present the company as truly green and the green marketing efforts are therefore generally limited. Unless the greenness of the company can outperform that of competition, large campaigns are not implemented.

Shaded Green

Shaded Greens are focused on long term investments is sustainable practices and see sustainability as an "opportunity to develop innovative needs-satisfying products and technologies that result in a competitive advantage"[10]. While technologically and financially they have the capabilities to share their environmental vision with the market, they are somewhat conservative in their marketing approach due to the fact that they see more potential in stressing the additional benefits that this strategy can deliver to the consumer. The Toyota Prius is used as an example of a shaded green product because the energy-saving characteristics of the vehicle are seen as more capable of convincing the consumer as compared to purely environmental claims. The approach is deemed especially useful for products that have energy-saving capabilities that reduce recurring expenses for the consumer.

Extreme Green

The most holistically oriented of all strategies is the Extreme Green strategy, companies adhering to this kind of approach being green in all aspects of their internal processes and external communication. Extreme greens are generally focused on capturing a specific niche market that can be defined by an ecologically-oriented consumer segment (true-blue-greens). The entire value-chain is optimized and Life-cycle analysis is employed to fully integrate sustainable practices throughout the company.

Implementation

In order to consider any of the above strategies, managers must be aware of the consequences that green marketing can have on their company. Proper analysis and profiling of potential consumers has to be conducted in order to define which market is to be focused on. Psychographic analysis can form a basis for this. Next, considerations can be made about to what extend the company can gain anything by emphasizing their greenness to a certain extend.
While from an internal point of view, sustainability can be seen as beneficial to the business processes, shaded- or extreme green strategies should only be applied when a certain niche that can be understood and analyzed properly can be identified.

4.3.3 Internal marketing considerations

Internal processes are elemental to any green strategy, no matter how it is communicated to the outside world. Different aspects of the value chain require special attention when converting to or setting up a sustainable business. While up until now in this article (and in literature) there has been little focus on the business-to-business aspects related to green marketing, Sharma et al. provide a sensible framework that presents sustainable challenges and opportunities within the value chain itself.

The basis of Sharma's conviction that sustainable business marketing provides significant financial opportunities comes from two streams of research on which the authors base their framework. On the one hand, resource-based theory suggests that a competitive advantage can be gained by increasing efficient resource management efforts, eventually increasing profitability. On the other hand, Sharma points to empirical evidence[11] indicating a correlation to ecologically oriented business practices and an increase in customer retention, which also increases performance.

Sharma proposes a framework in which firms adhere to sustainable internal business practices by integrating the forward supplychain with the reverse supplychain, taking full responsibility of the products they produce over the entire lifecycle. This of course has implications on the way a business should be managed and marketed internally.

The foundation of the framework that Sharma proposes is twofold:

(1) Reducing surplus supply: *By minimizing overproduction and surplus product streams internally and externally, both the efficiency of the manufacturing unit can be increased while slimming down the value chain so that both environment and economy benefit.*
(2) Reducing reverse supply: *By making sure that less products have to be recycled at the end-of-life phase, design for disassembly and producing repairable or refurbish able assemblies or components, valuable materials and thus waste streams can be managed more sustainably, reducing environmental impact produced by landfills while providing the company with an efficient way to manage materials.*

In order to properly integrate such an approach within a company, especially an already established company, internal marketing is vital to the successful integration of such an approach[12]. Internal marketing is described as all processes related to the changes that need to be made inside the company, especially relating to communication efforts.

Reducing surplus supply

Reducing surplus supply being one of the pillars of the Sharma framework, focus is primarily on Build-to-order (BTO) principles. The reasoning is that when not producing any product prior to closing a sale, there is no excess production, no wasted logistical efforts and no products that have to be recycled without ever being sold. Also, it bypasses the implementation of a discount system on hard-to-sell products, which usually results in a big portion of the products being bought by consumers that barely use them or recycle them early in the lifecycle.

Dell is often used as a shining example of

a company that incorporates a BTO process into their business activities. Actually, it is one of the few companies that have successfully implemented it. This is because a major limitation of BTO is that consumers have to order and wait for their product, rather than taking it home immediately. For products for which customization or personalization is required or possible however, it can be regarded as a powerful practice that people are willing to participate in since BTO facilitates customized production orders due to the fact that at the time the order is made, production still has to start. This can create a strong bond between client and supplier.

However, in order to successfully implement a strategy as complicated as BTO (especially for larger firms) many changes have to be made internally. Product design has to be more modular to allow for customization. Product information has to be shared with suppliers so that they can anticipate, potentially risking leaking valuable information. Also the quality of the product might suddenly depend on a small factor within the supply-chain.

However, for a startup company having a close partnership with only one or a few suppliers, the potential for implementing a BTO strategy might be an interesting one depending on the market that is catered to. For luxury products that can be customized for example, it could be a valuable approach.

Reducing reverse supply — recycling

Equally important is how to limit the amount of useless waste that is created by a company. Valuable materials are put out in the market, a big portion never being properly reclaimed.

This should be another focus of attention according to Sharma. Modular product design will facilitate not only customizable marketing strategies, but also facilitate improved recyclability and refurbishment of products already distributed into the market.

Increasingly, the responsibility to manage waste-streams is shifted towards industry, forcing companies to put effort and thought into how to recycle their products. Design for disassembly has been a major focus within industrial design research over the past decades, but again, the marketing side of the story still requires much attention in order to propel truly sustainable initiatives within corporations.
Not only internally the importance of material responsibility will have to be stressed, also externally, the consumer has to be provided with incentives to be aware and feel responsible for recycling and reclaiming materials. When this is realized, the potential for successfully using recycled materials in production and marketing them as such has the potential to further increase this relationship between company and consumer[11].

5. Framework

The goal of this paper is to provide insight into the current state of academic research into to domain of green marketing practices in order to create a potential framework for implementing this theory to a real case that is currently under development in the scope of a graduation assignment with the intention of actually marketing the product at a later stage. While the framework presented here is still open to improvements, it can be used as an onset

to the development of a marketing plan. The case is described briefly in the following sub-section. Please refer to Appendix I for a thorough description of this case.

Case Description

The case can be characterized by certain aspects that define the scope of the framework that is presented in this section. It is focused on furthering the development of a sustainable bathroom product that positions itself quite radically within the context of the bathroom. The product itself is characterized primarily by the interaction the user has with the product and the water-saving (using 66% less water compared to using a regular shower) potential that the product has.
The challenge is to develop a marketing strategy that is suitable for the product and that allows for a solid foundation for creating a business that is scalable. A concept design that currently forms the basis of the product is shown in figure 4.

Figure 4: Product concept

Considerations

Marketing approaches

While it seems evident that sustainable practices are become increasingly more mainstream and acceptable for consumers, it remains challenging to directly target the green consumer in a way that is credible and convincing. Eco-labeling is acceptable in the domain of many product categories, but the actual value it provides to a company in terms of marketing is often limited by the perception people have of the issue at hand and the manner in which the label itself conveys the often complex message that is to be communicated. For a bathroom product like the one in this case, it seems evident that communication of the thoughts behind the product will have to be either catered to an especially green consumer segment that is well-informed or focus needs to be shifted towards stressing the other qualities that the product has. Saving water and thus reducing recurring expenses could be one important way to convey users to invest in a product such as this. One option to achieve this is by using an eco-label that clearly shows the benefit of the product over traditional alternatives. Since no recognizable and widely-used label seems to be in place, stressing the economic benefits may be the most straightforward method.

Segmentation

Awareness of sustainable issues differs greatly among cultures, countries, sub-cultures and even gender. While research shows that only a relatively small portion of consumers actually consciously search for sustainable product offerings (9-16%), up to 60% are willing to consider green products when this provides a

clear benefit and is not suboptimal compared to traditional products.
It is hard to clearly define consumer segments and their sizes, especially since research has not focused much on actual buying behavior but rather on survey based self-reports by subjects, making it hard to get a clear image of what the typical green consumer is like. It seems most sensible to assume there is no typical green consumer and to focus marketing efforts towards tailoring a product and communication to the market so that a demand for the product is created rather than producing as a reaction to existing demand. Considering the uniqueness of the concept that is presented in this specific case, this is even a very logical approach to assume, also in respect to its design aspects.

Adhering to such an approach still requires the company to consider all relevant aspects that go into marketing a product (and company). By focusing on creating demand for a product, one still needs to develop and plan for catering to the needs of a certain target user segment. But rather than segmenting the market in four or five segments and focusing on just one, it might be useful employ tools such as psychographic analysis[2]. This allows for more insight into what actually motivates people to make consumption decisions. However, this approach shares some of the limitations that more traditional tools suffer from, such as the limited value of self-reported data. More elaboration on selecting a suitable tool for this case might therefore be required.

Another potentially important factor in the case of bathroom products is analyzing the gender issues related with decision-making on consumption behavior. It seems relevant that women have a tendency to have more power over decision-making processes relating to hygiene and sanitary products. While this is expected to be culturally complex as well, it is a factor that should not be overlooked.

Furthermore, research into the extent to which consumers are aware of and consciously dedicated towards choosing water-saving products is an interesting factor. Certainly in countries where water-use is heavily restricted, this might be a very important factor and therefore might point towards the most interesting location for initially marketing such a product.

Marketing Strategy

Deciding upon a company marketing strategy involves selecting the most appropriate approach for the specific case at hand. Aspects such as consumer perception of green products in the selected target segment and potential for differentiating within the market are fundamental to detailing a marketing strategy. Considering the four basic marketing strategies that can be employed as described by Ginsberg and Bloom, selecting one depends on all aspects mentioned earlier in this section. For the bathroom product, it seems that the most appropriate strategy might be a either Shaded Green or Extreme green, depending on the identified target segment.

Internal marketing considerations

In order to become a truly sustainable business, internal processes need to be aligned in a way that is sensible and streamlines the value chain. This will not only increase efficiency of the use of resources, but the ecological practices

that the company employs will eventually have an impact on the products and the perception of the consumer.

The main design challenge will be to design and manufacture a modular system that is capable of providing a suitable platform for the bathroom product. This platform is preferably designed such that sub-assemblies or components do not have to be wasted at the end-of life or in case of failure, but remanufacturing or recycling of basic elements and materials can take place. Design-for-disassembly and a cradle-to-cradle oriented approach could be valuable methodologies that can aid the product development in this respect.

From a logistical point of view, a build-to-order structure in which there is no overproduction and subsequent unnecessary distribution and recycling of the products make senses. Especially for bathroom-products, which are usually showcased in a showroom and are often installed by specialized personnel, not being able to buy the product off-the-shelve will not be too unexpected in the consumer. This approach could be applied to enhance the relationship between the company and the end-consumer or intermediate channels in the supplychain. While for established companies it is hard to convert to a BTO process, a startup may not face as much difficulty and will in this way even be able to minimize initial investment costs.

Services such as distribution and maintenance would be more challenging for a startup like this, the potentially most suitable option being to engage in a partnership with a distributor and plumbers for instance.

By making use of recycled materials, the impact of the products can be reduced, potentially enhancing the message that is conveyed by the company. But more importantly, the product needs to be developed in such a way that it can easily be recycled. Applying a true cradle-to-cradle methodology here can be of much value to the company. This also means that attention is required for how easily materials can be reclaimed from the product (design for disassembly) and to making sure that channels are developed or exploited through which products can be recollected at the end-of-life phase. This is a factor that is often overlooked, but can be very beneficial to the environmental impact and value chain efficiency when done in a proper way.

In order to truly start with marketing planning, the approach outlined in this section can be guiding. However, attention to aspects such as labeling, which channels to integrate and which external channels to contract and the selection of the most appropriate segment identification methods is still required.

6. Conclusion

It seems that although research in areas of green marketing such as consumer behavior and segment profiling are scarce and inconclusive, the selection and implementation of appropriate methods of both internal and external marketing aspects could be guided by the literature that is presented in this paper.

The specific case for which this paper was meant to present a useful framework has pointed to several interesting areas of research that could be implemented fairl. Design for disassembly and modularity are the most obvious strategies the employ for the design of the product itself. Raising awareness of water scarcity issues might be required depending on the location of implementation. In any case, it seems necessary to stress the benefits that the product towards the user more strongly than the green message, such as water savings and thus a reduction in recurring expenses. The use of some form of eco-labeling could be instrumental for this.

For actually detailing the marketing plan in terms of communication and promotion, further investigation and identification of the target segments using psychographic analysis approaches seem to be the first step. This will enable the creation of a clear vision towards how the product itself needs to be designed and what attention is needed in specific areas in order to generate a demand for the product. Investigation of socio-cultural factors such as gender can further guide and shape this part of the strategy. From what has been described in the literature review, it seems most plausible to go for an approach that generates the demand for the new product by means of what the product itself has to offer instead of designing it towards the demand that already exists. This is aligns with the positioning of the product within the context of the bathroom in which the way in which the user interacts with the product is radically different. This aspect needs to be exploited so that the sustainability aspects can enhance the total image of the product.

Consecutively, this segmentation and marketing approach will guide the decision-making process concering an appropriate positioning strategy of the company itself within the market. Currently, a shaded-green or extreme-green strategy seems to be the most suitable to the case. However, this depends largely on the identified segments and the scalability of the concept within those segments.
The company itself has not yet been founded, presenting the possibility of shaping its internal processes very green manner considering there is not yet a business culture that needs to be changed. In existing companies, adopting such a strategy requires considerably more investments, resources and efforts.

It seems clear that the company would have to gravitate to minimizing the waste it produces by employing strategies such as BTO, which could benefit the company in other ways as well, as was mentioned in the framework section as well. Striving for modularity and recyclability will align with implementation of such as strategy while further enhancing the sustainable advantage of the company over competition.

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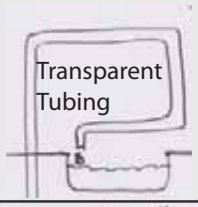
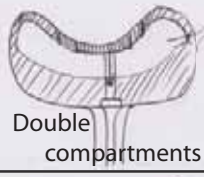
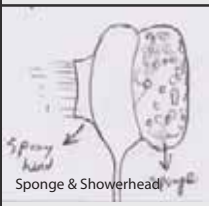
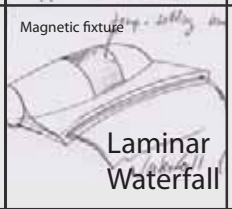
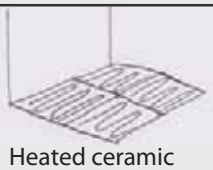
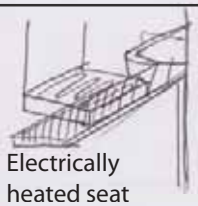
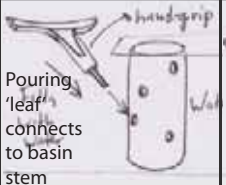
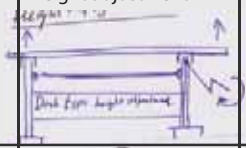
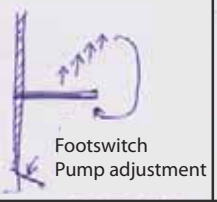
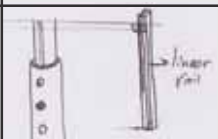
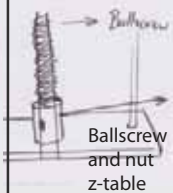
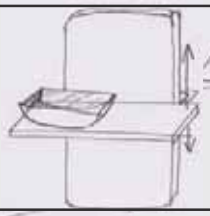
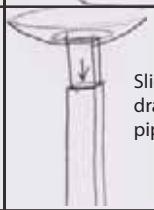
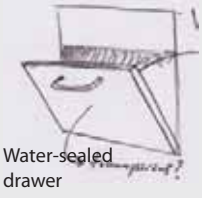
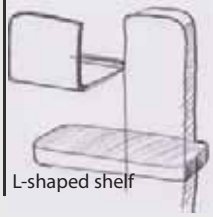
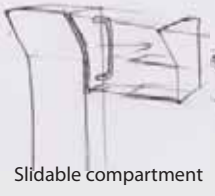
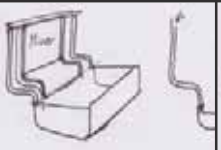
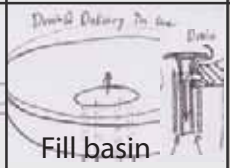
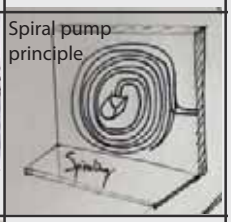
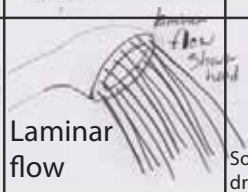
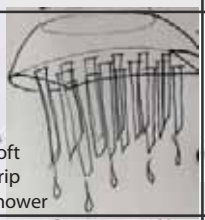
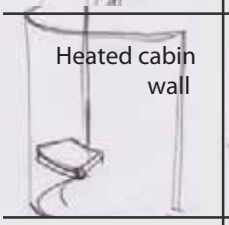
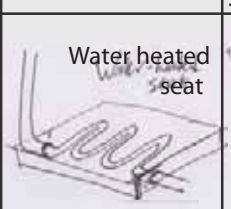
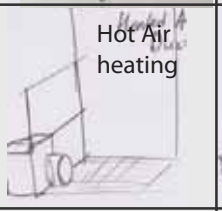
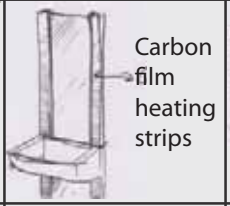
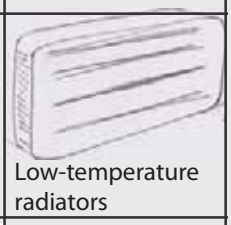
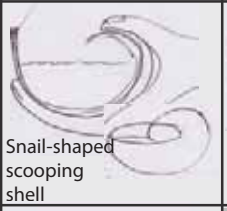
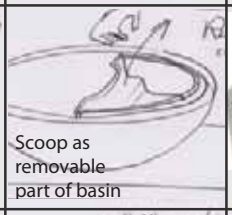
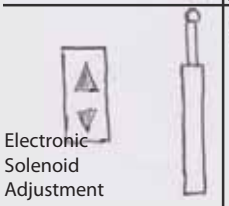
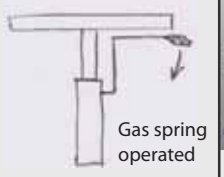
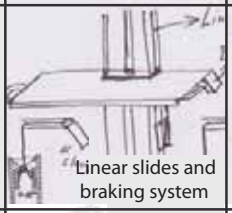
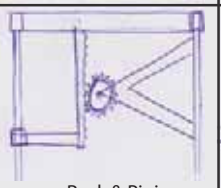
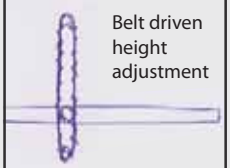
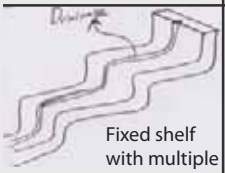
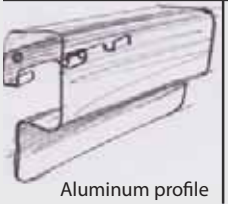
14 // Appendix E - Morphological Chart

		A	B	C	D
1	Watersupply to basin	 Linus' method	 Transparent Tubing	 Double compartments	 Tranquil Waterfall
2	Rinsing (handshower)	 Sponge & Showerhead	 Magnetic fixture Laminar Waterfall	 Regular handshower fixture	 Squeeze activated hand-shower
3	Warming up washing area	 Heated ceramic basin	 Heated ceramic tiles	 Electrically heated seat	 Shortwave IR
4	'Scooping' Water splashing	 Pouring 'leaf' connects to basin stem	 Scoop with handle	 Scoop connects to basin	 Squeeze Rubber balloon with syphon
5	Height Adjustment	 Desk type height adjustment	 Footswitch Pump adjustment	 Vacuumhose-style	 Ballscrew and nut z-table
6	Bathroom tray			 Integrated Basin	 Divided shelf
7	Water drainage	 Regular Shower Drain	 Sliding drain-pipe	 Open drain waterfall	 Perforated floor plate
8	Storing clothing	 Water-sealed drawer	 L-shaped shelf	 Slidable compartment	 Drawer integrated in bathroom tray

4-12

E	F	G	H	I	J
 Laguna Overflowing basin	 Mirror Waterfall	 drainpipe & watersupply in one Handshower & Faucet 2-in-1	 Laminar Flow Faucet	 Fill basin trough drain	 Spiral pump principle
 Pushbutton shower	 With Brush	 Laminar flow showerhead	 Soft drip shower	 Easy grip handshower	
 Heated cabin wall	 Water heated seat	 Flexible carbon film heating	 Hot Air heating	 Carbon film heating strips	 Low-temperature radiators
Flexible hand scoop 	 Snail-shaped scooping shell	 Scooping pan	 Scoop as removable part of basin		
 Electronic Solenoid Adjustment	 Gas spring operated	 Rotating handle Locking mechanism	 Linear slides and braking system	 Rack & Pinion	 Belt driven height adjustment
 Fixed shelf with multiple heights	 Manually adjustable hanging shelf parts	 Slidable tray on Basin	 Compartment in console	 Rotatable basked/tray	 Multiple sliding trays
 Split bamboo draining floor	 Spiral floor drain	 Angled floor with quickdrain	 High grip floor with drainage		
 Aluminum profile	 Behind mirror	Behind curtain			

15 // Appendix F - Calculations

Figure 1 shows the combined measurements taken over three series. Only series three serves as a basis for all other calculations in this appendix.

Radiative surface area

2*0.125m*1.4m =**0.35m²**

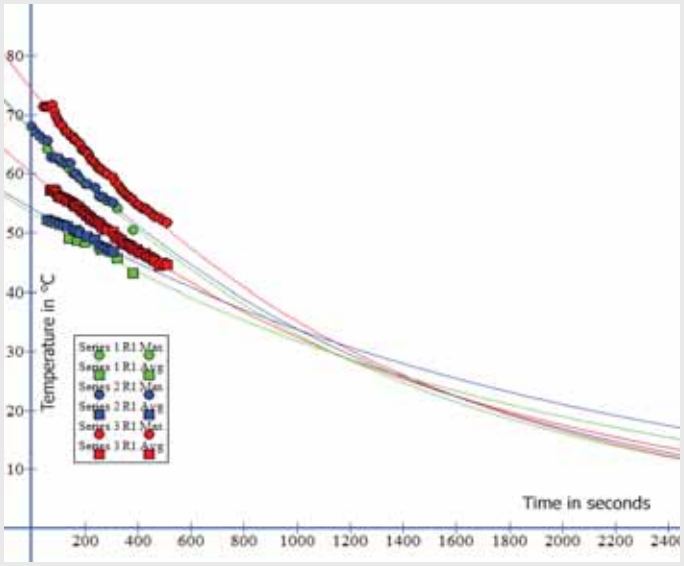


Figure 1: Combined measurement series

Equation: y = 60.107x^-0.1 f(x)=60.1632.9994^x R2=.9967*

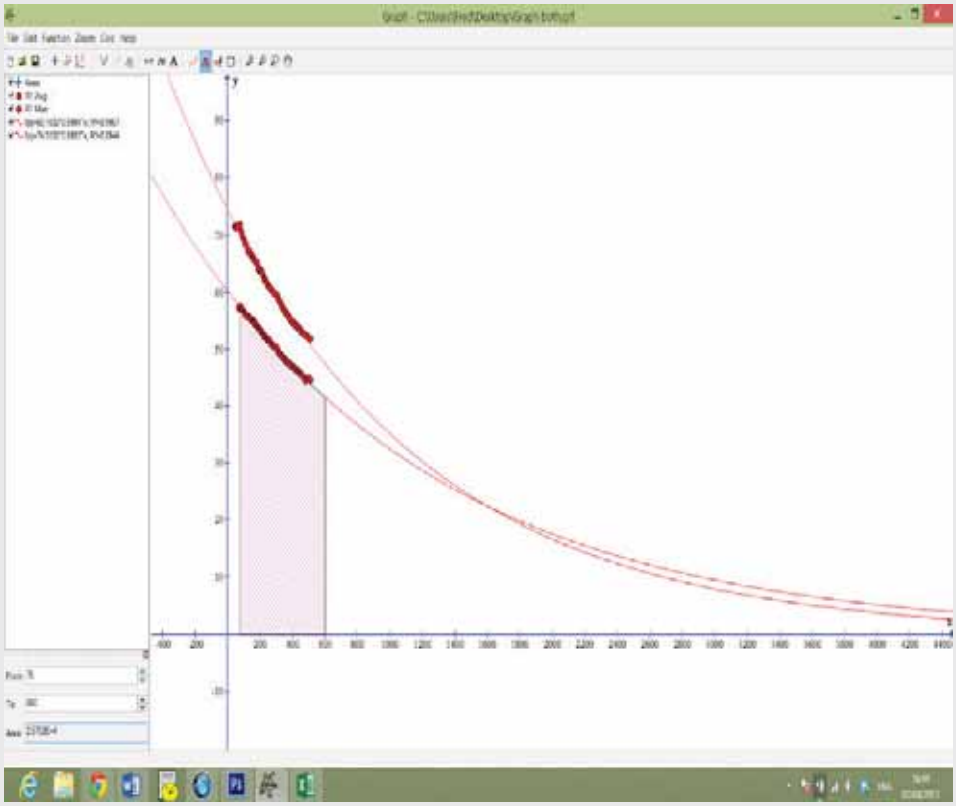
Volume of radiator (two sides)**0.000245m³** = 2*0.125m*1.4m*0.000^7m

Heat capacity of radiator

Heat capacity of Brass: $\mathbf{C_{brass} = 0{,}38kJ/kg*K}$
Density of Brass: $\mathbf{\rho_{brass} = 8500kg/m^3}$
Mass of radiator: $\mathbf{m_{radiator} = 2.0825\ kg}$ = 0.000245m^3 * 8500kg/m^3
Emissivity of brass: $\mathbf{\varepsilon_{brass} = 0.6}$

Mass of radiator water

Water volume: $\mathbf{l_{water} = 4{,}2\ L}$ (measured using water-use sensor upon 3 seperated measurements)
Specific weight / m^3 at 20°C: $\mathbf{\rho_{water} = 998.2kg/m^3}$
Heat capacity of water: $\mathbf{C_{water} = 2.11kJ/kg*K}$
Mass of water in radiator: $\mathbf{m_{water} = 4.19kg}$ = 0.0042*998.2



Thermal measurements

Integral from x=75s to x=600s:
25752°C*s over 525 seconds

f(75)=57.4°C
f(600)=41.5°C
ΔT=15.9°C
ΔT/s = 0.0303 °C/s

Determining radiator power

Formula

P_{avg}= kJ/kg*K (°C * kg)/s + kJ/kg*K (°C * kg)/s

P_{avg}= kJ/kg*K (°C * kg)/s

P_{avg}= (kJ/kg*K) * (°C * kg / s)

P_{avg}= (kJ/~~kg*K~~) * (~~°C * kg~~ / s)

P_{avg}= kJ/s

P_{avg}= kW

Filling in

$P_{avg} = C_{brass}(\Delta T * m_{radiator})/\Delta t + C_{water}(\Delta T * m_{water})/\Delta t$

P_{avg}= 0.38 (15.9* 2.0825)/525 + 2.11(15.9* 4.19)/525

P_{avg}= 0.38 (33.15)/525 + 2.11(66.621)/525

P_{avg}= 0.38 (33.15)/525 + 2.11(66.621)/525

P_{avg}= 0.02399 + 0.26775

P_{avg}= 0.2917kJ/s

P_{avg}= 292W

Radiator power per m^2

Calculated from the average values:

P_{avg} / m^2 = 292W / 0.35m^2
P_{avg} / m^2 = 830 W/ m^2

Table 1 represents:

- The actual measured temperature over time
- f'(x) shows the actual temperature-change per second as a function of x (time in seconds from t=0),
- P(t) describes the calculated power output of the radiator as a result of **$P(t)= C_{brass} (f'(x)* m_{radiator}) + C_{water}(f'(x)* m_{water})$**
- The power output of the radiator per square meter of surface area
- The last column shows the The yellow graph shows the Wattage this translates to for the radiator (both sides combined) and the blue graph is a translation of this value to the output power per square meter.

Figure 2 plots the output power and the output power per square meter of surface area over time.

t(x)	T(°C)	f'(x)	P(t) (W)	W/m2
0	57.4	-0.0355	342	977
25	56.5	-0.035	337	963
50	55.6	-0.0344	331	947
75	54.8	-0.0339	327	933
100	53.9	-0.0334	322	919
125	53.1	-0.0329	317	905
150	52.3	-0.0324	312	892
175	51.5	-0.0319	307	878
200	50.7	-0.0314	302	864
225	49.9	-0.0309	298	850
250	49.2	-0.0304	293	837
275	48.4	-0.03	289	826
300	47.7	-0.0295	284	812
325	46.9	-0.029	279	798
350	46.2	-0.0286	275	787
375	45.5	-0.0282	272	776
400	44.8	-0.0277	267	762
425	44.1	-0.0273	263	751
450	43.4	-0.0269	259	740
475	42.8	-0.0265	255	729
500	42.1	-0.0261	251	718
525	41.5	-0.0257	248	707

Table 1: Power output

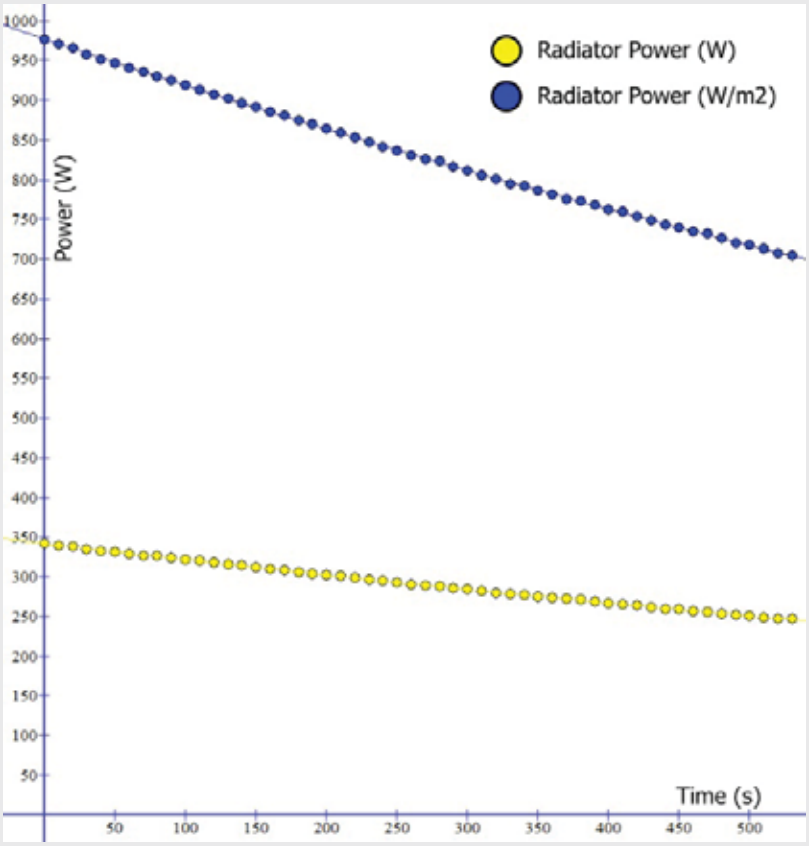


Figure 2: Power output

16 // Appendix G -Thermal Measurements

Summary

In order to assess the effectiveness of the integrated heating system of the new Splash prototype, measuring the temperature-change in the shower-cabin as a result of activation of the system (heating up of the warm-water lines that create the heating effect) is essential. The list below is a scenario that has to be repeated at least three times. The output of these three tests should be a clear and objective indicator of the heating system's effectiveness.

Required data for testing:
Average amount of litres used in participant testing, (L_a) =
Time needed to reach this level (T_a) (a little less than two buckets) =

Sequence 1

1) Measure ambient temperature in bathroom prior to activation
2) Set up thermal camera
    a) Take photo's every 15 seconds
3) Initialize water metering device
4) Set water temperature to hot
5) Activate faucet
6) De-activate when water is hot
    a) Note exact time required for heating up
7) Measure ambient temperature every 15 seconds
8) Determine optimal ambient temperature reached with one initial heating batch
9) Let ambient temperature drop back to initial value
    a) Keep taking pictures every 15 seconds

Repeat sequence 1 at least three times

Data processing:
Determine water used to warm up
Determine time to warm up – T_1
Generate video from photo's – Marked with timestamps and data

Sequence 2

10) Measure ambient temperature in bathroom prior to activation
11) Set up thermal camera
    a) Take photo every 15 seconds
12) Initialize water metering device
13) Set water temperature to 40 degrees marker
14) Activate faucet until warm
    a) Note time used
15) Leave room heat to optimum value
16) Let cool back to $T_{optimal}$

17) Activate faucet until 1/4 L_a

18) Let cool back to $T_{optimal}$

19) Activate faucet until 1/2 L_a

20) Let cool back to $T_{optimal}$

21) Activate faucet until 3/4 L_a

22) Let cool back to $T_{optimal}$

23) Activate faucet until L_a is reached

Repeat sequence 2 at least three times

Data processing:
Log total amount of water used
Generate video from photo's – Marked with timestamps and data
Log maximum temperature at fixed positions
Note litres used at step 14

17 // Appendix H - Evaluation Form

Prototype Evaluation

Participant name:

1. What was your general experience while using the Splash?

2. What are the most noteworthy differences compared to regular showering or bathing?

3. In terms of temperature, how comfortable was your washing experience?

4. Ergonomically, how comfortable was it to wash using the Splash? Where there any particularly comfortable or uncomfortable aspects?

5. If you used the scoop, what did you use it for?

6. How did you experience washing your hair using Splash?

7. How much water do you think you used compared to showering?

8. Compared to showering, did you find Splashing more or less comfortable and why? Do you experience a same level of cleanliness?

9. If you have experience with previous versions of Splash, how do the experiences compare?

10. Would you consider replacing your shower with a Splash? Why, or why not?

11. What grade would you give Splashing as a bathing ritual?

12. In what applications do you think the Splash would be most valuable or suitable for market introduction? Choose up to 3.
    - o Hotels, Bungalows, etc.
    - o Apartment buildings
    - o Young families
    - o Student dorms
    - o Public bathrooms
    - o Elderly
    - o Other, namely:……..

13. Do you have any final remarks or observations?

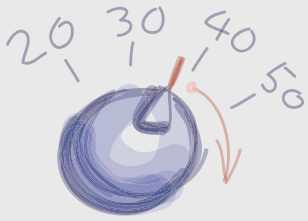
Thank you!

18 // Appendix I - Instruction Card

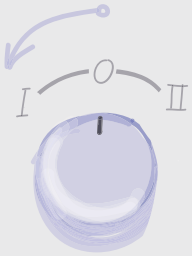
Splash Instructions

This short list of instructions will guide you on how to perform a washing ritual using Splash. Please feel free to shape your own ritual as you see fit! And please speak out loud and explain anything you think, feel or have problems with during the session.

1. Set thermostat to at least 40 °C



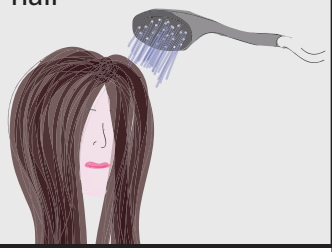
2. Open faucet and let water run until warm



3. Fill the basin with water

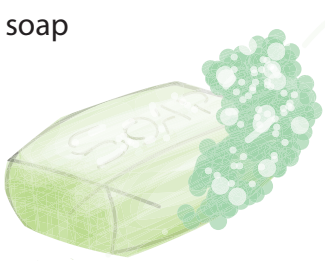
4. Wash your hair

5. Rinse your hair



6. Wet your body using either the scoop or the handshower

7. Apply soap



8. Wash yourself

9. Rinse your body using scoop or handshower

10. Finalize your bathing ritual. Thank you for cooperating!

19 // Appendix J - Research Setup

Appendix I

Research Proposal

Fred Henny

The purpose of the usage-tests of the Splash prototype are to evaluate first and foremost its primary function and user perception of the improved version of the Splash concept.

Research Goals

1. *User Experience:* Since the concept itself originates from co-design and practice-oriented design research, it seems logical to evaluate the user experience. This will be a more abstract piece of research that will be very helpful in analyzing the non-tangible aspects of the design and for optimizing the visual design aspects. A final design will be presented to the participants in a printed questionnaire.
2. *Technical functionality:* Does the prototype deliver what it should in terms of technical features; heating, adjustability, etc.
3. *Human factors:* The ergonomic properties of the design have to be designed in such a way that they cater to the needs of the user. Evaluating these properties is essential for validating whether or not the preconceived ideas behind the design are reflected by actual use of the product.

One obvious aspect that does need to be monitored also during participant testing is water use. Furthermore, it will of course be necessary to evaluate as much as possible all technical aspects of the product, although this is not necessarily incorporated in participant tests.
While the ergonomic and technical evaluation will be best evaluated with a bigger group of subjects, the setting of the concept house also presents the possibility of long term testing with a smaller group of people that (temporarily) inhabit the concept-house. This provides a unique opportunity to research and analyze the more abstract aspects of the product interaction such as the forming of rituals and of usage patterns after a certain amount of time.

Methods

Participants Selection

Participants will preferably be gathered from a list of people that have participated in earlier usage test with the previous prototype. This ensures that users will already be familiar with the concept and will therefore not judge the product without prior knowledge of the practice of Splashing. This makes sure that the qualities of the new design can be evaluated against that of the old design.

Research Approach

Participants will be instructed prior to testing the prototype. Instructions will follow the following script:

- Participants must be aware of the fact that technical details, as far as they are disclosed, are confidential and that the system as it exists is still under development.
- Participants have to agree to let the test session be audio-recorded.

- Basic functionality of the prototype will be shown and instructions for operation will be given.
- An illustrated 10-step scenario for a washing session will be shown as an example, the participant being asked to re-enact the scenario. A plasticised copy of the sketched scenario will be provided in the shower cabin. The scenario will be simple and follow this script:

    1. Set thermostat to a comfortable temperature between 38-40 degrees.
    2. Open faucet until water turns warm.
    3. Fill the basin with water
    4. Wash hair
    5. Rinse hair
    6. Wet the body with the scoop/showerhead
    7. Apply soap as seen fit
    8. Wash body as seen fit
    9. Rinse using showerhead
    10. Finalize washing session

- During all of the steps, the participant is asked to self-report by speaking out loud in order to capture the steps of the session on audio.
- Directly after finishing the session, participants will be asked to evaluate the session together with the researcher. The audio-tape can serve as a guidance in clarifying non-verbal and less explicit clues relevant to the research. To this end, permission to video-record this evaluation session will be requested at this time.

Data Collection

Water and energy conservation are the reason d'etre of the Splash concept, evaluation of these factors is essential. For this reason, water-usage will be constantly measured and logged using a [datalogger and sensors]. Water usage will be measured at the two outlets (the faucet and the showerhead) so that different modes of use can be assessed and compared.

Since implementing a means of measuring water temperature independent of the outlet being used would over-complicate the test setup and limit the functionality of the thermostatic faucet by limiting the flow velocity, estimations of the actual use of hot and cold water will be made by deduction from the measured variables.

Evaluation of the quality of heating from the integrated radiator is one of the main factors to evaluate, infrared thermo-imaging will be used to evaluate the heat radiation from the radiator and the loss of thermal energy in the hot-water that runs through the radiator. This is important since it determines the heating efficiency of the radiator and the temperature of the water that flows from the radiator into the thermostatic mixing faucet, which in term influences the use of both hot and cold water and thus the thermal efficiency of the entire system.

In order to capture audible cues from the participants, an audio-recording will be made during the participant tests.

20 // Appendix K - Vision in Product Design

ViP Chart

27.03.12

Bathing

Product Deconstruction

Time Shiny Sterile Majestic Smooth White **Ceramics** Fixed **Big** Limited manouvring Watery mess Foam **Comfort** Luxury Bubbles Heavy **Spacious** Geometry Hot

Interaction Deconstruction

Indulgence Bulky **Wastefulness** Extensive Multi-task **Immersiveness** Playful Softness **Timeless** Care-free Status **Soaking** Pyjamaness Dreamy Sleepiness **Boredom** Volumeness Carefulness Boundedness **Spoiledness** Relaxation **Lengthy** Cozyness

Context Deconstruction

Status Wealth Self-care **Escapism** Value Aging Population Universal **Wellness** Decadence Dreamy Excitement **Relaxation** Aesthetic **Sensorial** Feminine Romantic

Showering

Product Deconstruction

Chrome **Calcification** Goal-oriented Showerpit Tiles Hair Orderly **Hardness** Linear Spraying Soap **Pressure** Standardization **Commodity** Fixtures Geometry Glass-like

Interaction Deconstruction

Quick **Warmth** Soothing Letargic **Lazyness** Hypnotizing **Ritualistic** Hardness Ease Effectional Personalized Expectedness **Cooling** Watery **Passiveness** Cleanliness Intensive Rinsing **Refreshing** Sequential

Context Deconstruction

Commerce **Cosmetics** **Hygiene** Safety **Affordable** Aging Population **Control** **Scarcity** Culturally bound Individualistic Bourgeois Masculine **Limited space** Fast paced living **Flexibility** **Practicality**

"Swoshing"

Product Construction

Intrinsically Mysterious **reassuring** **Flexible** Novel **Reminiscent of nature** Constant **Aqueous** **Ergonomic** Hygienic Unity **Radical** Calming Opulence Modestly Luxurious Safe Spacious **Adjustable** **Vivid** Transparant Notable **Luminous** **Lasting** Texture Tranquil **Soft** **Authentic** Flowing

Interaction Construction

Sensorial Cozy Refreshing Ease Soothing **Immersive** Ritualistic Dreamy Activating Cleanliness **Involvement** Energizing Warm skin feeling Stressless **Spoiledness** **Efficiently slow** Agile Playfulness **Softness** Soothing **Stimulating** Timeless Innocence Quick yet comfortable **Consious** **Interactivity** Invigorating **Consistency** Hygienic

Vision Statement

I want people to....

...feel in control of responsibly improving their personal care rituals in a reassuring way

Context Construction

Responsibility **Awareness** Empowerment Care **Health** Integration **Transience of current practices** **Hygiene** **Ecology** Ergonomics **Foresight** **Dermatology** Sensorial Unisex Relaxation Self-care Accessible **Control** **Low-maintenance** Personalization Safety **Wellness** Practicality Time-management Biomimicry **Natural** **Comfort** Water scarcity Universality Time for self Novation Aging Population Aesthetics

21 // Appendix L - ViP Procedure

Appendix L– Vision in productdesign

ViP procedure

ViP is divided into two main portions, deconstruction and consecutive construction of the product domain. In the deconstruction phase, the current solution –for which the new design is to be developed- is analyzed based upon keywords that characterize the situation. This is done in three sub-phases:

1. Product Deconstruction
   In this phase, the physical characteristics of the current situation is analyzed and described in a way that is descriptive.

2. Interaction Deconstruction
   The interaction phase focuses on describing in abstract way the interaction between user and product. This phase is all about the perception of the interaction in the user. The interaction part of ViP is often regarded as the pivotal element, defining the value of the product in the way it is perceived by the user. User experience of course is vital to the success of a product in the market since it how a product obtains meaning to the user.

3. Context Deconstruction
   The final phase of the deconstruction chapter is concluded with the analysis of the context of the product domain. This phase is very much characterized by values and principles and is aimed at describing the context of the interaction between user and product.

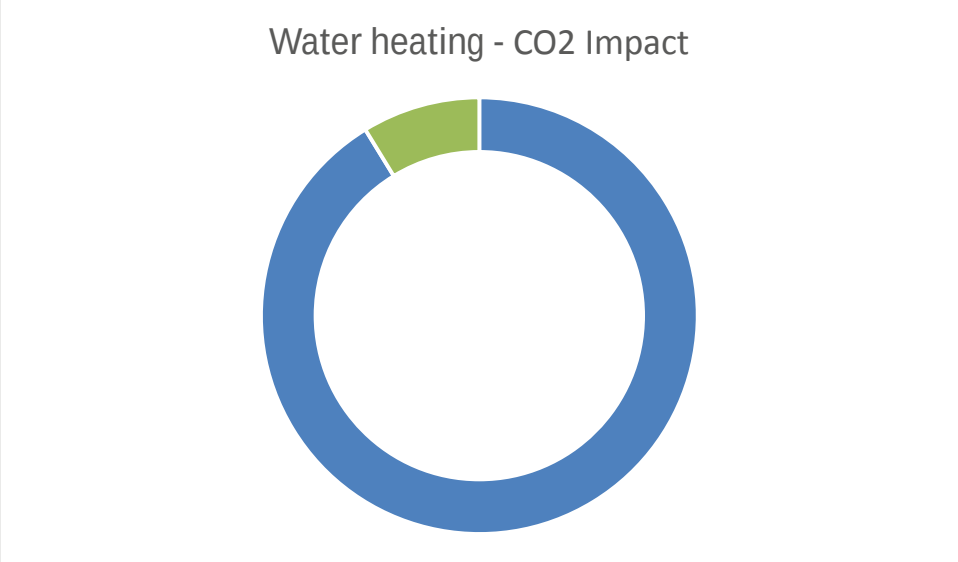
After having completed the deconstruction, the designer has intrinsically formulated a well thought trough perception of the current domain that is to be designed for. The lists of word that summarize this phase serve not only to describe the three described domains, but more importantly, the conception of these words forces a thought process that is the most important result for the true understanding of the situation by the designer and for forming a sensible vision in the construction phase.

The construction phase that follows works in opposite direction, going through the construction of the new context, interaction values and product characteristics. This is where the true vision of the future situation is generated.
After having envisioned the future context of the product domain –making assumptions and preconceptions of the future situation- the designer formulates a so called Vision Statement.
Basically, this statements forces the designer to clearly define his/her vision based upon analysis of the current practices and predictions and desires for a new context. The function of this is to abstractly create a divide between what can be analyzed and envisioned based upon what current practices and products provide to the user and what the designer actually has to create for him/herself.

Making this statement creates an opening for starting to construct the desired interaction values for the new product. The last stage, the product construction, makes the product more concrete and serves to inspire design of a new product based upon more tangible characteristics.

22 // Appendix M - Water use impact

Water use (L)		Gas used (m3)	CO2 per m3 (g)	Grams of CO2 (g)	
65		0.24	1780	427	91%
	kWh/L (water treatment)	Wh required	g CO2 / kWh		
65	0.002	0.098	420	41	9%
				468	



23 // Appendix N - Radiator Measurements IR

#	Time	Ambi-ent	Max	Min	R1 Max	R1 Avg	R1 Min	Timestamp	
2		17.2	21.0	14.5	21.0	19.8	17.7	00:00:00	
3		17.2	21	14.5	21	19.8	17.7	00:00:20	
4		17.2	21	14.5	21	19.8	17.7	00:00:40	
5		17.2	64.9	14.9	64.9	46.8	20.4	00:01:00	
6		17.2	64.3	15.2	64.3	48	21.6	00:01:20	
7		17.2	63	15.2	63	48.6	21.7	00:01:40	
8		17.2	62	15	62	48.8	23.3	00:02:00	
9		17.2	60.9	15.4	60.9	49	23.2	00:02:30	
10		17.2	59.7	15.3	59.7	48.7	23.7	00:03:00	
11		17.2	58.3	15.5	58.3	48.4	25.6	00:03:30	
12		17.2	56	14.9	56	47.1	24.8	00:04:00	
13		17.2	54.2	15.1	54.2	45.7	24.6	00:05:00	
14		17.2	50.4	15	50.4	43.1	23.9	00:06:00	
15		17.2	48.8	15	48.8	42.2	22.5	00:07:00	
16		17.2	68	15.4	68	52.4	24.8	00:09:00	
17		17.2	67.1	15.5	67.1	52.5	25.1	00:09:15	
18		17.2	66.5	15.4	66.5	52.5	23.7	00:09:30	
19		17.2	65.8	15.1	65.8	52.4	24.3	00:09:45	
20		17.2	65.6	15.2	65.6	52.3	24.6	00:10:00	
21		17.2	62.8	15.4	62.8	51.9	25.7	00:10:15	
22		17.2	62.6	15.1	62.8	51.7	24.9	00:10:30	
23		17.2	62.6	15.1	62.8	51.5	24.9	00:10:45	
24		17.2	61.9	15.4	61.9	51.2	24.5	00:11:00	
25		17.2	61.9	15.4	61.9	51.1	24.5	00:11:12	
26		17.2	61.9	15.4	61.9	51.2	24.5	00:11:24	
27		17.2	60.1	15.3	60.1	50.5	24.4	00:11:36	
28		17.2	60.1	15.3	60.1	50.5	24.4	00:11:48	
29		17.2	59.3	15.2	59.3	50	24	00:12:00	
30		17.2	58.3	15.4	58.3	49.3	24.7	00:12:30	
31		17.2	57.7	15.1	57.7	48.8	24.8	00:13:00	
32		17.2	56.2	15.6	56.2	47.7	24	00:13:15	
33		17.2	56	15.6	56	47.4	24.6	00:13:30	
34		17.2	55.5	15.3	55.5	47.2	24.5	00:13:45	
35		17.2	55.2	15.5	55.2	46.8	24.4	00:13:55	

36		17.2	55.1	15.5	55.1	46.8	24.3	00:14:05	
37		17.2	57.5	15.5	57.5	47.6	24.5	00:14:15	
38		17.2	64.5	15.6	64.5	50.8	24.2	00:14:25	
39		17.2	69.9	15.4	69.9	53.8	24.9	00:14:35	
40		17.2	71	15.5	71	54.9	25	00:14:45	
41		17.2	71.2	15.7	71.2	55.5	24.8	00:14:55	
42		17.2	71.4	15.7	71.4	56.1	25	00:14:59	
43		17.2	71.5	15.7	71.5	56.4	24.9	00:15:00	
44		17.2	71.4	15.8	71.4	56.8	24.9	00:15:08	
45		17.2	71.5	15.7	71.5	57	25.5	00:15:16	
46		17.2	71.6	15.7	71.6	57.2	25.5	00:15:24	
47		17.2	71.7	15.7	71.7	57.4	26.4	00:15:32	
48		17.2	70.6	15.8	70.6	57.3	26.3	00:15:40	
49		17.2	69.7	15.8	69.7	56.9	27.5	00:15:48	
50		17.2	69.1	15.6	69.1	56.3	26	00:15:56	
51		17.2	68.6	15.7	68.6	56.1	26.2	00:16:00	
52		17.2	68.2	15.7	68.2	55.9	26.2	00:16:10	
53		17.2	67.2	16	67.2	55.7	26.7	00:16:20	
54		17.2	67.1	15.6	67.1	55.4	26.1	00:16:30	
55		17.2	66.4	15.9	66.4	55.2	25.6	00:16:40	
56		17.2	66.3	15.8	66.3	55	25.9	00:16:50	
57		17.2	65.8	15.9	65.8	54.8	25.9	00:16:55	
58		17.2	65.8	15.8	65.8	54.5	26	00:16:59	
59		17.2	65.3	16	65.3	54.5	25.5	00:17:08	
60		17.2	65.1	16.1	65.1	54	26.5	00:17:16	
61		17.2	64	16	64	53.6	26.7	00:17:24	
62		17.2	64	16	64	53.5	26.7	00:17:32	
63		17.2	63.5	15.9	63.7	53.1	26.6	00:17:40	
64		17.2	63.5	16	63.5	52.8	25.7	00:17:48	
65		17.2	62.7	15.8	62.7	52.5	25.7	00:17:56	
66		17.2	62.3	15.8	62.3	52.2	26	00:18:00	
67		17.2	62	15.8	62	52	25.8	00:18:08	
68		17.2	61.5	15.7	61.5	51.7	25.8	00:18:16	
69		17.2	61.1	15.8	61.1	51.7	25.7	00:18:24	
70		17.2	60.9	16	60.9	51.4	25.8	00:18:32	
71		17.2	60.6	16	60.6	51	26.1	00:18:40	

72		17.2	60.2	15.9	60.2	50.7	25.7	00:18:50	
73		17.2	59.9	15.7	59.9	50.5	26	00:19:00	
74		17.2	59.5	15.9	59.5	50.1	26.4	00:19:20	
75		17.2	58.7	15.8	58.7	49.3	28.6	00:19:27	
76		17.2	58.2	15.8	58.2	49.1	28.7	00:19:40	
77		17.2	57.4	15.6	57.4	48.7	26.9	00:19:50	
78		17.2	57	15.6	57	48.3	28.5	00:20:00	
79		17.2	56.6	15.8	56.6	48	27.8	00:20:08	
80		17.2	56.3	15.9	56.3	47.9	27.1	00:20:16	
81		17.2	55.9	15.8	55.9	47.7	27.8	00:20:24	
82		17.2	55.7	15.6	55.7	47.4	27.8	00:20:32	
83		17.2	55.2	15.6	55.2	47.1	26	00:20:40	
84		17.2	54.8	15.9	54.8	47.1	25.4	00:20:50	
85		17.2	54.7	15.7	54.7	46.7	25.3	00:21:00	
86		17.2	54.3	15.8	54.2	46.5	27.6	00:21:10	
87		17.2	54.1	15.6	54.1	46.4	27.5	00:21:20	
88		17.2	53.7	15.8	53.8	46	24.3	00:21:30	
89		17.2	53.7	15.9	53.5	45.8	24.1	00:21:40	
90		17.2	53	15.6	53	45.5	24.5	00:21:50	
91		17.2	52.8	15.6	52.7	45.2	24	00:22:00	
92		17.2	52.5	15.8	52.5	44.4	25.1	00:22:15	
93		17.2	52.4	15.7	52.1	44.8	24.4	00:22:30	
94		17.2	51.8	14.7	51.8	44.5	29.9	00:22:45	

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