In the Candlelight:

Candles in User Interfaces for Emotional Communication

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Abstract

With todays' technology we are more connected than ever. Despite this the main focus of the communication still lacks the usage of emotional communication when it is not happening face to face. The most used communicational device is a smart phone and its apps, which we check several times a day. This masters' thesis aims to study the aspects of emotional communication by using ambient communication device for it.

The process started with an idea of using a real flame in form of a candle as part of an emotional communication device for emotional long distance relationships. From the idea formed the Candle UI, which is a pair of identical candle stands, equipped with one real candle, a small tealight, and an electric tealight. The two candle stands are connected together via wireless network. The concept was developed by conducting user studies including focus group interviews of the Candle UI prototypes. The final prototype was developed using the feedback from the first focus group interview.

It was concluded that while the Candle UI was perceived as pleasant for the eye, the usage of it for ambient emotional communication would be affected by how the users' culture perceives the candle. Other major aspect having impact on the user interface was the length of the distance and time zones between the users and how it will impact on the users' daily schedules. However despite these previously mentioned aspects, the user interface managed to do the work it was designed, to deliver an ambient emotional message of somebody thinking of you.

Due to the user studies being conducted on small groups only, it gives only a small glance over how users in emotional long distance relationships would perceive the usage of Candle UI in their everyday lives. The future research should cover subjects such as customisation of the UI and one more focus group evaluation over it.

Keywords:

Interaction design, User experience (UX), Tangible user interface (TUI), Ephemeral user interface (EUI), Aesthetic user interface, Ambient communication, Concept design, User studies, Ubiquitous communication

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Tiivistelmä

Nykypäivän teknologian ansiosta olemme enemmän yhteydessä toisiimme kuin aikaisemmin. Tästä huolimatta kommunikaatiomuodot eivät silti sisällä sen emotionaalisia puolia. Nykypäivän käytetyin kommunikaation väline on älypuhelin ja sen sovellukset, joita katsastamme useamman kerran päivässä. Tämän opinnäytetyön tavoite on tutkia emotionaalista kommunikaatiota ympärillä tapahtuvan viestinnän kautta.

Tutkimus alkoi hahmottamalla konsepti idea käyttöliittymästä, jossa käytettiin kynttilää kommunikaation välineenä emotionaalisiin etäsuhteisiin. Tämän idean myötä kehittyi kynttiläkäyttöliittymä Candle UI, joka koostuu kahdesta identtisestä kynttiläjalustasta. Molemmat jalustat pitävät sisällään yhden oikean ja yhden sähköisen tuikun. Nämä jalustat ovat yhteydessä toisiinsa langattoman internetin välityksellä. Käyttöliittymää kehiteltiin käyttäjätutkimusten kautta. Viimeinen prototyyppi syntyi fokusryhmä-haastattelun vastausten perusteella.

Kerätyt tulokset osoittavat, että vaikka kynttiläkäyttöliittymän muotoilu miellytti silmää, oli käyttäjän kynttilään kohdistuvien kulttuurillisten konnotaatioilla vaikutus käyttäjäkokemukseen. Toinen suuri vaikuttaja kokemukseen oli se, kuinka suuri välimatka ja aikavyöhykkeellinen ero käyttäjien välillä on, ja niiden vaikutus käyttäjien päivärytmiin. Tästä kaikesta huolimatta kynttiläkäyttöliittymä toimi juuri niin kuin se oli suunniteltu, välittämään emotionaalinen, ympärillä tapahtuva viesti siitä, että joku ajattelee sinua.

Koska tätä tutkimusta varten tehdyt käyttäjätutkimukset toteutettiin niin pienellä ryhmällä, on niiden tulos varsin pieni vilkaisu siihen, miten kynttiläkäyttöliittymä toimisi etäsuhteissa viestintävälineenä. Mahdolliseen jatkotutkimukseen voisi sisällyttää käyttöliittymän kustomointi ja siihen sitten oma fokusryhmähaastattelu.

Avainsanat

Vuorovaikutussuunnittelu, Käyttäjäkokemus, Fyysiset käyttöliittymät, Hetkelliset käyttöliittymät, Tunnelmallinen kommunikaatio, Konseptisuunnittelu, Käyttäjätutkimus, Kaikkialla läsnä oleva teknologia

Muita tietoja:
Suostun tutkielman luovuttamiseen kirjastossa käytettäväksi X
Suostun tutkielman luovuttamiseen Lapin maakuntakirjastossa käytettäväksi (vain Lappia koskevat) X

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1. Introduction

This chapter covers the topic of what this thesis and research are all about. In addition to this, it covers how it was made, who it was made for and to whom I own thanks for their help and efforts towards making the thesis and the prototype of the evaluated product prototype.

1.1 Topic of the Thesis

In the world we live today, social media has gained a large footing in everyday communication and smartphones and other smart devices play an important role as communicational devices through multiple social media applications. In the streets and other public places you can see a lot of people fondling their smartphones, more than ever due to new model releases of different brands. Thus the idea to create a completely different and unique kind of communicational form was born.

The other prompt to this thesis was to explore new kinds of user interfaces mainly aimed for emotional and ambient communication without using the so-called traditional methods such as screens. In addition to this, it should be something tangible, beautiful and with a real, living flame the user could light while using the interface.

The aim was to create user interface for communication without the messages or communication prompts taking too much attention, and that was aimed for ambient communication. In addition, the technology used for the interface should not be considered as traditional technical gimmick or a display but as unique and beautiful as an everyday object. Therefore, alternative options were considered during the design process and how much the traditional user interfaces were needed to make the tangible user interface to work as intended.

The aesthetics of everyday, tangible objects was one design driver. The beauty of not just the object but also the beauty of using the object, and its motion, was in focus of this thesis too. Other design drivers for the design would come from the focus group interview later. Another main purpose of this study is to determine whether the chosen user interface type is suitable for emotional communication or not. Third aspect is to find out how the design of an object can have an effect on user's emotions while being used, and how communication through emotions works through objects.

The chosen user interface is called the Candle User Interface, or Candle UI in short. It is a tangible, emotional and ambient communicational device controlled by real candles.

Research questions are as follows:

Q1 Are candles usable as emotional communication interface?

Q2 How was the designed candle user interface perceived as a tool for emotional communication?

1.2 The Research Process

The design and research went from throwing ideas, to several different kinds of prototypes with different functions to focus group interview and finally finishing the final prototype. The achieved prototype can be used later in future projects, for example if a crowdfunding project is held to get the product into the market or to produce a one of a kind, limited edition of this product. The timeline bellow, figure 1, shows the timespan in which the Candle UI project was created.

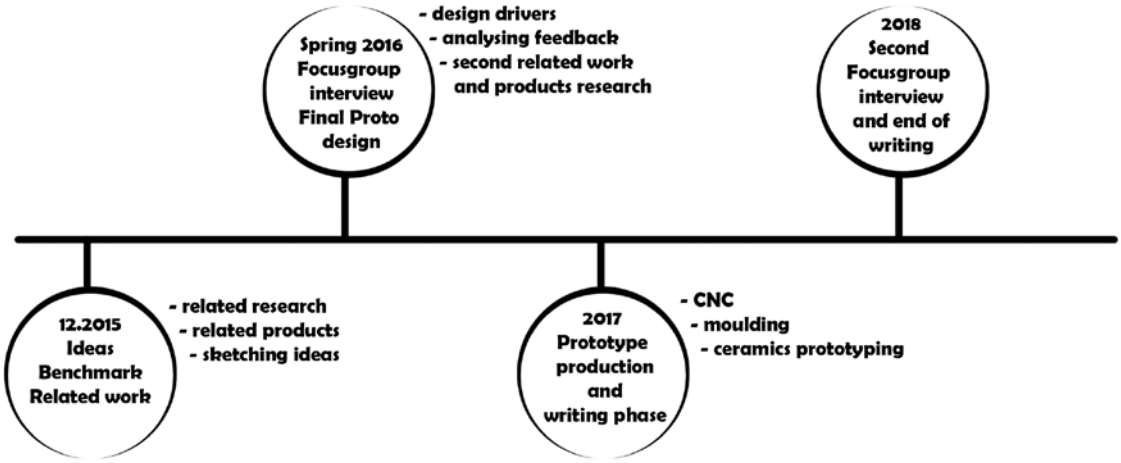

Figure 1 Timeline

The first focus group interview was used to submit a paper into Proceedings of the 5th ACM International Symposium on Pervasive Displays, a conference in Oulu June 2016. I will be referring to that article in this research later in the focus group and the design driver parts.

The second focus group evaluation was led by Hong Li and assisted by Mari Suoheimo. The results were used to write a research paper *Connected Candles as Peripheral Emotional User Interface.* I will refer to the research later in the chapter 7, The Evaluation.

The main functions of the Candle UI is when the real candle is lit in the other half of the set, the fake counterpart, an electric candle, is turned on in the other set. When the other user, who is being thought of, sees the electric candle turned on, they can light their real candle and it causes the fake, electric candle to turn on in the first set. When all the candles burn it confirms that the connection has been established.

Another function that can be added on later prototypes could be that before the real candle is lit, the user tilts the Candle UI flower a bit towards certain emote or symbol and after that the user lights the real flame. It sends a signal to the fake candle which turns the focus of the fake candle like a flash light towards a certain emote or symbol and illuminates it, sending an emotional message to the other user, who is being thought of. This feature was dropped while making the prototype.

I was not the only one working with the prototyping process of the Candle UI. I had help in various tasks, such as 3D modelling and milling the Candle UI prototype from which the mould was made of. In the following, I would like to acknowledge the people who contributed in the work.

With the 3D design, I had huge help from Kirsi Mikkonen. She corrected the mistakes I made during the 3D modelling progress and gave me some tips how to handle the 3D modelling better.

I have Tuomas Lappalainen to thank for setting the CNC carver up and milling the Candle UI flower. In addition to this, he made the first prototype used in the focus group interview.

I myself made the plaster mould from the two different type of Candle UI flowers with all the parts the Candle UI itself needed; the two base leaves and the flower cups. On top of that I designed the Candle UI with little consultation from Kirsi Mikkonen. Later I cast the Candle UI parts into two types of porcelain, normal snow white Mont Blanc and bone porcelain to determinate which type of porcelain clay would be most suitable this type of a product.

After making the outer parts myself, I had another assistant, Aki Leinonen and Ashley Colley to help me with the electronic parts and software implementation. After this, the prototype was ready for the second focus group evaluation.

1.3 The Naked Approach Research Project

The Naked Approach research project is a main purpose is seeking and developing alternative, human centric ways of producing and consuming digital services. The path is leading towards a significant paradigm shift in the relationship between us the humans, the citizens, the users and the digital world: a digital paradise where the user can live “naked” without any carry-on gadgets. The core research of Naked Approach is focused on user-centric design aspects and user experience, the technologies for distributed physical interaction layer and the ICT enablers and solutions in the digital environment.

The big picture of the research project aims to create a hyperconnected society with a Nordic flavour of values, such as values in beauty in efficiency, human rights, trust and silent respective co-living. The aim is to have a trillion connected sensors and actuators in our world, which are built and networked in a sustainable and manageable way. The aim is at high added value for our citizens, societies and companies via hyper-scalable business enablers and emerging business ecosystems (Häkkilä, Colley, Rantakari, Aikio & Pentikäinen, 2016).

The Naked Approach research project has multiple partners and researchers from variety of Finnish research institutes: VTT, Tampere University of Technology, Aalto University, the University of Lapland, and the University of Oulu, complemented with Demos Helsinki, an agile partner for the emerging businesses and future needs research.

The University of Lapland is in charge of creating the design and the user studies, and of turning the research into future demos, which demonstrates the future visions. The project is coordinated and funded by Tekes, a publicly

funded expert organization for financing research, development and innovation in Finland. http://nakedapproach.fi/about/28.2.2017

The Candle user Interface was a project given to me by the Naked Approach research project during my brief time as research assistant with them. My work consisted of helping out in user testing and writing parts of research papers. I worked in the research group of Jonna Häkkilä, who handed me this research topic for this thesis to work on near the end of my employment to work on as my Masters' thesis project.

From the period of time I worked as research assistant I received the first design drivers for the Candle UI to work with and brainstorm on in my own time. There was another research demo created without me, but I was able to use the outcome in my thesis research. This research demo was used with the focus group interview later on and results were used to create the final design for the product and for its functions.

In addition to this the data and information extracted from the focus group interview was used to write an article. The article was published in International Symposium on Pervasive Displays (PerDis) in 2016.

2. User Interfaces

This chapter covers user interfaces (UIs) and what their basic features and functions are. In addition to this, the chapter lists the pros, cons and examples of each interface after their description. Later the chapter goes more in depth with chosen interface types for this research and prototype.

2.1. What is User Interface?

The Collins English Dictionary defines *user interfaces* as, "the software and input devices by means of which computer and its user communicate" (https://www.collinsdictionary.com/dictionary/english/user-interface, 8.5.2018).

The user interface is a part of computer. It is a software the users can see, touch, hear, talk to, or otherwise communicate with understandably. It also defines how the user is able to interact with the product. There are two essential components in the user interface. They are input and output. Input is, when the user inputs their commands, such as needs or desires, to the computer. Most commonly used means to communicate with the computer are the keyboard, mouse, a trackball, users' finger when a touchscreen is present, and the users' voice. Output is the reaction to the input. This happens when the computers conveys the results of its computations to the user. Today's most commonly used output device is the computers display screen. Visual elements can also be paired with speakers for the sound. (Galitz, 2002).

We use them in our everyday life, even without noticing them being any type of user interfaces. Whether it is our smartphone in the morning when we snooze the alarm or when we warm up our breakfast in the microwave. Throughout the day we stroll, and the user interfaces just keep popping up.

The acronym of U stands for User Interface and it is part of products such as machine or software. It is the space where the user interacts with the product in hand. For example the user interface is in use when you use your computer, smartphone and even when you are brushing your teeth (Baston & Griffin, 2007).

User interface is one of the most important parts of the product. There are multiple types of user interfaces in use in a vast variety of products and they have come a long way from their early steps from decades ago. In most of the products it is the part that makes it work as it has been designed to, in examples what you see in the screen of a smartphone, or how you use the stove in your kitchen.

User interface takes shape during the design process, but the mainframe can be decided in beforehand. The other elements, such as the graphical and/or physical elements and parts, are usually designed after the mainframe has been decided. Development of a user interface includes both of the design of the interactive component and the development of the technical implementation, including the interface software. Then developing the user interface is a matter of design iterations, and testing how well the coding works with the UI components (Hix & Hartson, 1993).

The designing of user interface varies on what type of the user interface is. User interface design is a field of study called human-computer interaction (HCI), which is aimed towards studying, planning and designing interaction between the users, humans, and the computer in a way, that the needs of the user are satisfied. There are factors in the design process the designers must consider. Such as what people expect and want, the physical limitations and abilities the users possess, how their processing of information process works, and what the users find attractive and enjoyable. The limitations of the technical parts and

characteristics the computers software and hardware must be kept in mind (Galitz, 2002).

Design guidelines can be used in various ways, since they are useful collection of Human-Computer Interaction knowledge and can provide the human factors professionals an authoritative source of information and advices. They can also be used in education or training. However, the most important role the design guidelines have is to be a source for references and guidance for the designers to use during the design process (de Souza & Bevan, 1990).

Proper user interface design will provide a satisfying experience for the user. The combination of well-designed input and followed output will cater to the users' needs, limitations and capabilities the most efficient way possible. The best user interface is one that permits the user to focus on the information and the task in hand without being noticed. The mechanism used in the user interface should not be a distraction (Galitz, 2002)

A well-designed system must support the behaviour of users with different levels of expertise from Novice to Expert. The challenge of the design process is to provide equal challenge for the different level users without introducing unnecessary complexity for lower level users (Galatz, 2002).

Command Line User Interface

Once upon a time, the computers were controlled by commands as the language of interaction between the computer and its user. The user would type the command and respective arguments on the line followed by a blinking cursor (Norman, 2007).

Even though the services such as Google and Yahoo are called search engines, they are in fact just answer machines controlled through their command line interfaces. The old command line interface is dead. However, there is new, much improved version of it in use. The new command lines are more flexible and sturdy than their progenitor. The word order the command typed is no longer as crucial, and even the synonyms will suffice. In addition, the spelling accuracy is no longer even required since the system can correct the spelling errors, or at least try to suggest the nearest variant. There is a long way ahead for the command line user interfaces, but the developers are offering options close to the command line. These are input like adding appointments into Microsoft's Outlook calendar. So now, the command line user interface is coming back, disguised as search engines. They will get better and better with time (Norman, 2007).

The command usually consisted of a row of letters and symbols that would make the machinery execute the desired function. Another way of distributing commands to the usable machinery is through pressing certain combinations of keys. These combinations vary between operating systems even when the end result is the same, like the differences between Windows OS and Apple iOS (Rogers, Sharp & Preece, 2011).

Pros and cons:

Pros: Cheaper due to the fact that it needs less from its parts, does not need much from the computer, i.e. RAM or the screen, to input the commands, thus it is faster to function and needs less processing time. Can function in any type of operating system.

Cons: confusing to people who have no experience of using it, because a lot of commands need to be learned to operate it properly. Only one spelling mistake or a wrong symbol can lead to undesired results.

A good example of a command line user interface is the old operating systems on computers, the Microsoft DOS, Disk Operating System. Other is the text based games, where the player would type in the command they wanted the playable character to do in the game on the screen.

Graphical User Interface

In brief, graphical user interface (GUI) can be defined as follows; a user interface, as most users describe it, is a collection of mechanisms and techniques which primary function is to provide interaction space for the user and the used device. A graphical user interface has a primary function of is to be a pointing device of some kind. This devices' functions can be compared to a human hand. The items the user interacts are called a collection of objects. The user can interact with these objects with sight, hearing, and touch. They can also be otherwise observed, too. The objects are always visible and usable for the user to perform tasks and operations with, which are called operations. These operations can be, for example, modifying the objects by pointing and selecting them. These objects have standard and predictable results in behaviour (Galitz, 2002).

The graphic user interface revolutionized user interfaces and design. The old, text based interface provided a one-dimensional interface when the graphical user interface gave it three-dimensional look. Screen navigation got a lot easier with the graphical elements on screen and the actions were selected trough using a pointing mechanism using a mouse or a joystick instead of command-based prompts. Information's' graphical presentation is much more efficient for the users information-processing for it loads the users' memory less than just text based information. The charm of the graphics is much more appealing to the eye and corporations can create their own, recognisable style (Galitz, 2002).

The graphical user interfaces appeared to replace the command line user interfaces. By replacing the need to memorize the instructions with easy-to-use, visible objects on the screen, they have served us well. However, the graphical user interface works well only if the number of the objects or actions on the screen is small. When the number of them is larger, the graphical user interface

would not scale well. For example, large amount of photographs or other files is tedious work to scroll through. (Norman, 2007).

The GUI has come a long way from the original design of just interactions between a combination of windows, scroll bars, checkboxes, panels, palettes and dialogue boxes. The basic building blocks are still a part of the modern GUI but have evolved into multiple different forms and types (Helander, Landauer & Prabhu, 2012).

Pros and cons:

Pros: symbols are more recognisable than text. They also can be universally understood. Graphical elements such as their colour or shape are used to quickly classify objects. For example the button for information, which is simply a smaller case “i” inside a circle. The graphical symbols are also faster to learn since graphical symbols aid the learning process. The graphic interface is also faster to use for problem solving, since the visual representation of the information has been found easier to process and follow. In addition, because they are easier to learn, they are easier to remember. Graphic interfaces are more natural to use, since they are closer to innate human capabilities. The user interface exploits visual and spatial cues. There is no need to decompose the task into smaller, more complex commands (Galitz, 2002).

Graphical user interface provides context with visible objects. The possibility of an error is lesser when there are options that are more concrete. The user interface will also provide immediate feedback and thus it will make the learning faster. The user has more control over the user interface, in ways such as the typing is needed less since the commands can be done with point and click-motions (Galitz, 2002).

Cons: The design has greater complexity due to the numerous graphical elements on the screen. Proper usage of right types of graphic elements is also recommended because poor design can undermine acceptance. Even though the user interface is easier to learn, it still needs the learning. The user interface might not be as intuitive to use for others since it is not always familiar. The symbols representation might be different from their textual counterparts. In addition, the human comprehension has its limits, too. The number of display variations can confuse even an experienced user. (Galitz, 2002).

The design process of the user interface still has no widely available design guidelines, since the designers have been concentrated on how the user interface works and not how the user interface looks. Moreover, since the field is competitive, why tell the competitors how it was made? And then there are production limitations, since the capability to produce clear symbols using today's technology is still limited (Galitz, 2002).

A good example of Graphical user interface is the modern day operation system on computers. By interacting with the graphical element, it would prompt a reaction, such as launch the wanted program installed on the hard drive.

Menu Driven Interface

The menu interfaces were designed to meet the demand on cost-effective user interfaces for computers. It was necessary for the computer to serve the needs of the user and not vice versa. This required changes in the design process priorities. This meant also ideally that the system designers would be experts in human factors, too. However, this was not achieved, for the individuals who have such various skills are rare to find. There were not enough trained experts in human-computer interaction to participate in the design teams (de Souza, Bevan, 1990).

When using a menu-selection system the user has a list of items to read and select the most appropriate one for the task in hand and then observe the effect of this input. The tasks user completes can be greatly simplified, for the direct manipulation of the object is impossible. The user can complete the task with only few actions and the need to memorize actions is not so great. (Schneiderman & Plaisant, 2005)

Menu-driven interfaces are primarily used for their user-friendly and simplistic properties. It can be compared to the *Choose Your Adventure* books. The user interface lets the user choose one step at the time until the user has chosen the right path to the end results. This way, for example, the user can operate the ATM and draw out cash funds from their bank account, use the information kiosk or connect the smart device to the available via available Wi-Fi *(*Beth Hendricks, Study.com, read at 15th January, 2018).

Pros and cons:

Pros: greatest beneficial feature may be that the structure of the interface is very clear. The user does not have to learn any commands. Easy to use because it is step-by-step, choose the best option type string of choices. This interaction style is appropriate for low-level users, such as novices. The menu itself does not have to be too fancy nor would the lack of graphical elements be a problem. Simple text based options will suffice (Schneiderman & Plaisant, 2005)

Cons: if it is poorly designed it may slow the user and even irritate or bore them. Lack of visual elements can be numbing experience for the user. If there is a long string of menu screens, it may cause a negative experience if the user has to go through options they find unnecessary.

A good example of menu driven interfaces is the menu on an MP3 player such as SanDisk or an iPod. Other is the Automated Teller Machine or ATM where user can withdraw funds from their bank account.

Multimodal User Interface

Multimodal user interfaces are interfaces, which can process two or multiple combinations of user input feed in coordinated manner with multimedia system output. Such input feeds could be pen, touch, speech, manual gestures, gaze, and head and body movements. Multimodal user interface uses also different human senses. This new class of interfaces aims towards the recognition of naturally occurring forms of human behaviour and language (Helander, Landauer & Prabhu, 2012).

Multimodal user interfaces have gained growing interest in the field of research. This has inspired more flexible, transparent, efficient and powerful versions of human-computer interactions. Multimodal interfaces are expected to be easy to learn and use. This made them preferred by the users. IN the future multimodal user interfaces have potential to support new functions to improve their performance and achieve unparalleled robustness. Also to perform flexibility as multifunctional and personalized system (Helander, Landauer & Prabhu, 2012).

It is important not to be immoderately influenced by a predefined interface type when the conceptual model of a product is being thought of. The variety of interface types available prompts to use different perspectives towards the design of the product that is being under development and this way there will be variety of possible outcomes. Therefore keeping the variety of different kind of user interfaces in mind during the early phases of product design can help to create alternative variations for the product (Rogers, Sharp & Preece, 2011).

Pros and cons:

Pros: they help the user prevent and correct errors and if error occurs, it helps the user to recover from it. Using multiple modes is better suited to entering and delivering different kinds of information. They bring robustness to the

interface, bring more bandwidth to the communication and add alternatives to communication methods to suit different situations and environments.

Cons: since they use multiple different input sources, the computer needs more hard disc space, memory and processing power. Since the input comes from multiple different sources, it is necessary to keep them simple due to the massive amount of information and because of that, make sure that the processing computer can handle it and would not mess up the results.

Tangible user interface

Tangible user interface is an interface that the user can touch more intensively than just the interaction between the user and for example, the keyboard or the surface of a smartphone. They provide a physical form to digital information and computing. This also makes facilitating the direct manipulation of bits possible (Ishii, 2008).

I will explain the user interface in-depth in the next subchapter, since the Candle UI is one of them.

Ephemeral User Interface

Ephemeral User Interfaces are interfaces that have part of it not designed to last long. The ephemeral materials can be various things, such as water, soap bubbles, sand, rocks and even food. This aspect of the user interface will help to create more immersive user experience (Döring, Sylvester & Schmidt 2013).

The user interface is explained in-depth in a later subchapter. They were included to this thesis and research since the Candle UI has expirable part, the burning flame, in it.

2.2 Tangible User Interface

Tangible User Interfaces have been emerging more and more in the field of research for richer multi-sensory experience for the user. In addition to this, they have become more popular since they give more in experience as multisensory way to the user than ordinary Graphical or other traditional user interfaces. The new technology however, comes with its own challenges.

The Tangible user interface has been defined by other researchers in their papers and researches as follows:

> A tangible user interface is a user interface that interlinks together the digital and physical worlds. For a long time, it seemed as if the human–computer interface was to be limited to working on a desktop computer, using a mouse and a keyboard to interact with windows, icons, menus, and pointers (WIMP). (O. Shaer & E. Hornecker, 2009).

> Tangible interfaces use sensor- based interaction where physical objects e.g. bricks, balls, and cubes. The objects are coupled with their digital presentations (Ishii & Ulmer, 1997).

An early research paper from 1997 *Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms* mentions the tangible user interfaces tangible parts as tangible bits. It was written by Hiroshi Ishii and Brygg Umer. Their aim in the thesis was to “make computing truly ubiquitous and invisible” by taking advantage of the physical affordances. This would achieve the seamlessness interaction between the users and information (Edge, 2008).

Tangible User Interfaces are considered difficult to design and built since the interaction with them is not limited just on the aural and visual senses. In addition to this, they rely on the sense of touch. Tangible User Interfaces are also not just two-dimensional images on the screen of the used device and therefore the interaction can be three-dimensional. And because Tangible UIs are still just emerging in the field of research on user interfaces, their design space is constantly evolving (O. Shaer & E. Hornecker, 2009).

When designing a tangible user interface, material qualities are integral part of the holistic experience. The quality of the physical objects materials have been considered thoroughly in other areas, such as the industrial design and mechanics. However, there is very little research on materials role in interactive systems, especially research on usage of natural materials. The research on material qualities should be in interest since tangible user interfaces can enrich the user experience with different material qualities which are associated and perceived with different physical materials (Häkkilä, He & Colley, 2015).

By using different natural materials as part of tangible user interface the user experience will be more intense, since the different materials cause reactions which strength can vary depending on the chosen material. Some materials were favoured over other for their qualities, such as the water was perceived over fire since it was calming and inspiring when the fire was perceived hot and untouchable. Based on the Product Reaction Chart, or PRC in short, light and lucid materials were perceived more playful than others. Solid materials such as stones, ice and sand were perceived mostly pleasant and more controllable than the lucid materials and thus were more easily associated as controls with the task in hand (Häkkilä, He & Colley, 2015).

The design process of the Tangible User Interface follows the three stage process of motivate-prototype-analyse. First the motivate part is that the design can be opportunity-driven, where the opportunity determinates the nature of the following design process. The opportunities can rise from the usable technology and from the identification of what the users' problem. These two are usually mutually beneficial, where the technology provides the basis for the solutions. Previously mentioned opportunities can also be an offering to enhance our interaction experiences by breaking the limits of physical reality. This is achieved via designing physical objects and structures which are digitally augmented for this purpose (Edge, 2008).

Second stage is prototype. Great and valuable tool for prototyping Tangible User Interfaces is low-fidelity prototyping, such as sketching the design concept. This is contains also the 3D sketching materials which help to explore the three-dimensional design space. These materials include foam boards, pipe cleaners, and wooden spatulas, variety of modelling clays, stickers, glue and paints among other things. These sketching tools are called solid diagram manipulators. In contrast to this, there is also lightweight version for prototyping tangible user interfaces. This is based on traditional pencil-on-paper-sketching. This is to explore the communication capacity for interaction components. This is achieved by choosing a minimal number of interaction mechanisms and then explore the combined expressiveness of these mechanisms (Edge, 2008).

Thirdly is the analysing phase after the low fidelity prototype is done. Prototyping is recommended for it gives a better understanding how it compares to the existing Tangible User Interfaces and how the users interpreted its meaningfulness. The two main related ways to describe a tangible user interface is to refer its structural form and its style of mapping (Ullmer & Ishii, 2001). First the structural form of a tangible user interface defines the meaningfulness of the created physical structures. This shows how well the tangible bits are in sync with their digital counterparts. These are called tangible tokens or TAC

paradigm. The TAC paradigm have five key points which the tangible user interface should follow; Couple, Relative definition, Association, Computational interpretation and Manipulation. The primary purpose of the TAC paradigm is to be a descriptive tool, which is aimed to identify tangible user interface patterns (Edge, 2008).

Tangible User Interface is an interface that the user can use more creatively and thus have more immersive experience than just the interaction between the user and for example, the keyboard or the surface of a smartphone. The user interface usually has tangible parts the user can interact with. When the user interacts with the said part or two, they produce an input for the user interface. This in turn causes a reaction to the interaction, an output.

To prevent the overload of data from these sensors the programming is usually made to react to only when the input surpasses certain threshold to create the desired reaction to the input. Then the data collected from the sensor is processed and then distributed to what have been programmed to output devices, such as in the speakers, lights, screens or even animatronic robotic parts.

Tangible parts and bits of the user interface are usually electronic for the input to transfer from the sensor to the processing computer. The sensor possibilities vary depending on what the data is needed to collect from. Usually the sensors are microphones, gyroscopes, light and flame detectors, touchpads or touchscreens, or sensors that detect distance or angle, temperature and pressure.

However, the research of Tangible UI is still in its early stages. To fully understand what Tangible UIs are and how they work, extensive research is

required. This includes developing new techniques and technologies to connect the digital world with the physical world, thus work towards making more immersive and tangible user experience with better knowledge of user interfaces (O. Shaer & E. Hornecker, 2009).

Tangible user interfaces can be used as a learning tool, too. There are numerous properties of Tangible UIs which can be used in pedagogical context. First, the tangible interface adds physical actions to the repetitive learning activities based on computer based learning. This is more natural or familiar for young children for it adds the value of sensori-motor experience. Second, when the tangible user interface is paired with augmented reality, it helps users with problem solving by reducing the cognitive effort required to the problem solving. They can also together encourage learners to try harder and try more than one strategy to solve the problem. And thirdly, Tangible user interfaces support face-to-face collaborative activities by allowing multiple users to interact with the system while collaborating with each other (Schneider, Jermann, Zufferey & Dillenbourg, 2011).

Tangible UIs have been suggested for applications, which target for emotional communication. Research has introduced several systems, where the emotional connection between distant partners is mediated through a touch (Li, Häkkilä & Väänänen, 2018).

Advantages of tangible user interface are for example, a more immersive user experience with a rich, multi-sensory. The interface supports collaboration of different technical parts and the user interface can be used by multiple users simultaneously while they are interacting with each other. And when it is paired up with augmented reality they will support the functions of each other.

Disadvantages of tangible user interface are that like previously mentioned, they are more challenging to design and create a working model. And since they have usually multiple sources of data input and in addition to this, the programming is much more complicated.

A good example of a tangible user interface is the Musical Bottles made by Hiroshi Ishii, Ali Mazalek and Jay Lee. It is a minimal user interface which main purpose is to access digital information while using glass bottles as containers and controls. The project illustrates their attempt to explore the interfaces transparency that intertwines itself into the everyday life. The emotional aspects of a glass bottle are used to enhance the user experience of the user interface. These aspects are both tangible and visual (Ishii, Mazalek & Lee 2001).

They used multiple bottles of information to explore more artistic contents such as music. Music also had more wide range of cultural significance and emotional expressions. By manipulating one or more bottles the user would cause a reaction. In this case, it would start to play or mute a musical track. These bottles have their own stage, where are indicator for where the wireless sensors for the bottles are (Ishii, Mazalek & Lee 2001).

The Musical Bottles were demonstrated in major public exhibitions twice. Even without a properly controlled experiments, they were able to observe the users reactions. The users understood quickly how to use the user interface, even with minimal instructions. The overall reactions of the users were emotional. The aesthetics of the design was pointed out multiple times. The magical and poetic nature of the bottle interaction was part of the enjoyment and caused the users to return to the installation, often with friends or family in tow (Ishii, Mazalek & Lee 2001).

2.3 Ephemeral User Interfaces

Ephemeral User Interfaces are rather new variety in the selection of user interfaces. Ephemeral user interfaces give the user more immersive experience of using the interface since the ephemeral user interface emphasises the importance of users own senses, like touch, smell and hearing, making it a multisensory experience.

The word Ephemeral origins in the Greek word *ephēmeros,* which translates into ”lasting only one day”. It is often also used to describe temporary qualities, it is still an useful umbrella term to classify the user interfaces into a larger class. Ephemerality is an important part of human life, whether it is on the larger scale, i.e. our lifespan, or in the smaller scale, the fleeting special moments and events in our daily lives (Döring, Sylvester & Schmidt 2013).

Ephemeral user interfaces are a category of user interfaces where one or more parts are expirable and last only for a limited amount of time. In addition to this, there are other factors like the environment the user interface and how they are combined with the materials properties of the used determinates how durable the user interface is (Döring, Sylvester & Schmidt 2013).

This might be due to the fact User Interface elements are needed only for a short period. Or it causes the user to be more engaged to destroying and creating new ones. The disappearance of User Interface elements might also raise the attention to the user interface or limit the users’ mental load by presenting information subtly in the background for a limited period. The temporality comes a part of the meaning of the interaction in Ephemeral User Interfaces (Döring, Sylvester & Schmidt 2013).

Most notable feature of the ephemeral user interfaces is the fact that it is time-based which means that the parts of the interface would not last for a longer period of time. The time window the user interface is usable varies depending on the chosen material or set of materials and how much the usage of the interface will wear the material or materials out. In addition to this, the properties of the material or materials itself can determine how long the user interface will be usable. For example ice will melt and the user interface will no longer be usable.

There are few main points to keep in mind while designing an ephemeral user interface. These pointers will be a great help to get a deeper understanding of the design space for ephemeral user interfaces (Döring, Sylvester & Schmidt, 2013).

Firstly are the materials, which can vary a lot depending on the needs of the user interface itself. The materials can range from water, ice and fog, soap bubbles, fire and smoke, light and shadows, plants, rocks, dirt, smells like perfume, or even food like jelly. The chosen material or set of materials have a great impact on the user experience since every material have their characteristic haptic, visual and acoustic properties (Döring, Sylvester & Schmidt, 2013).

Ephemeral materials as display media are harder to control and thus they offer less bandwidth for the displayed information. Because of this the data would not be displayed in its purest form, but the data will be blended with environmental influences. This approach might contribute an additional dimension to the display if the influences are kept in mind during the design process and they are compatible with the purpose of the representation (Offenhuber, 2014).

Second focus of the materials is on the aesthetics of the user interface. More precisely, the aesthetics of the material used to create the ephemeral parts of the user interface. The quality of the chosen materials have a significant impact on the aesthetics of the user inter face too. The better the quality of the chosen material is, the longer the user interface is usable as it has been designed.

Using natural materials as part of the user interface have their own aesthetic qualities and they can enhance the user experience with their associated backgrounds such as in culture or the users' previous experience with the said material (Häkkilä, He & Colley).

Thinking about the qualities natural materials have and their interactive qualities leads to the question how the materials could be designed to be used in a user interface. Current studies with nano- and material science focus already on the invention of materials with new features and in the future, the next design tasks may focus on creating a new material over selecting an existing one. Ephemeral natural materials could provide new, valuable starting point for new point of view for user experience. This includes the features and the interaction techniques. For example, the focus could be on the aspects of ephemerality of certain materials durability span and how it could be controlled in the design space (Döring, Sylvester & Schmidt, 2013).

The analyse of integration of natural and ephemeral physical elements for user interface design can help to improve design of digital systems. This is uniform with the framework has a reality-based interaction as a starting point. The challenge for the designer is in balancing reality and computational power, but usually taking the nature only as a model. Insights would be then transferred back to the digital domain. The potentials have not been fully utilized, but few examples of nature-inspired user interfaces have been designed. One big issue is how could hard- and software elements mimic what nature do, such as grow, get

older, degrade or even decay? In this sense, ephemerality could be used as a concept for software design (Döring, Sylvester & Schmidt, 2013).

The meaningfulness of the chosen material can amplify the aesthetic aspects of the user interface. After analysing the set of user interfaces and their descriptions and design choices was found that the one end of the continuous spectrum was the properties of a certain material, such as its physical, thermal, mechanical, optical, electrical, or acoustical properties. The other end of the spectrum was the materials semantic properties. This includes the materials cultural context since they may carry a special embedded meanings from other contexts and they are often comes with a deeper meaning for the user depending on their cultural backgrounds. (Döring, Sylvester & Schmidt 2013).

Next important pointer in designing an ephemeral user interface is the interaction between the user and the interface. There are three types of ephemeral user interfaces; those that are used as for output only, those that use the ephemeral material for input only, and those that use one material for both purposes. Mostly used is the type which uses ephemeral materials as output only, such as ambient displays. The input is received for these interfaces either from a computer or from a user. When the input comes from a computer, it can either involve no interaction by the users – for example for displaying digital information – or the user can provide input, such as if the user interface tracks human behaviour. IT can happen quite often without the user realizing it, too. A further category is that uses the ephemeral materials for input only, such as tangible musical instruments, which use jelly, clay or water for input. The next category is where ephemeral user interfaces are an output when the user provides an input. The input and output spaces are separate thus making it indirect interaction. These kinds of user interfaces use ephemeral materials for both input and output ideally unify the input and output design spaces use more often lucid and light materials as an output, such as ice, fog or soap bubbles (Döring, Sylvester & Schmidt 2013).

Lastly is the ephemerality. One of the greatest characteristics of the ephemeral user interface is that parts of the interface are not intended to last long. This comes to two major leading design parameters. First is how the degradation or disappearance of ephemeral user interface elements is determined. Second is the class of durability of ephemeral user interface elements. Different mechanisms can be used to determine the degradation or disappearance of the ephemeral user interface elements based on the material (Döring, Sylvester & Schmidt, 2010).

There are three different mechanisms to control the ephemerality of the user interface elements. First is the natural phenomena, such as gravity, gravitation, disappearing sunlight, phase transformation and naturally bursting bubbles. Second is user interaction such as bursting said bubbles or eating the food used as user interface elements. Third is system trigger such as interfaces that use ferrofluids as part of the user interface. Different ephemeral materials offer different durations. Natural materials used as part of ephemeral user interface can be classified into six different durability classes ranging from ultrashort durability to long lasting durability. Ultrashort durability elements, such as water drops, last only mere seconds. Long lasting durability elements can last long periods of time, even up to months or even years. These are elements such as plants or food. Additionally there is one class for materials which do not have a self- determined durability. They rather rely on other conditions, such as temperature or their amount, flexible durability. AS an example, ice can last forever if the environmental aspects are right, such as the temperature is low enough. The ice can also melt quite quickly from one moment to another (Döring, Sylvester & Schmidt 2013).

It is advisable to keep in mind how easily the used material of the user interface is changeable. Would it require normal or special made tool to change material or materials? The replacing the materials should happen either between the uses, or when the user interface is being used next by somebody else entirely.

The exchange of bacterial or viruses is more present with expirable materials like dirt and food.

Advantages of Ephemeral User Interface are such as that the used materials enhance the user experience of the user interface. They make the user interface pop from the other types of user interfaces by being unique and enchanting. Used ephemeral materials also provoke multi-sensory experience when the used material can use multiple human senses such as touch, sight and smell, and even the sense of taste can be used in ephemeral user interfaces. With usage of multiple senses the user will be more immersed to the user experience.

Disadvantages of ephemeral user interface are that firstly, the used material or materials will expire. Sometimes the used material expires faster or slower than expected and thus will change the desired user experience. Another is that they are harder to link with the digital user interface than for example tangible user interface. Programming the digital user interface to react to the input from the ephemeral materials usually requires a link between them to decipher the input data. Then the used ephemeral materials can be perceived negatively based on the users' culture and history with the material.

A good example of Ephemeral User Interface is the Soap Bubble User Interface. The ephemeral material is soap bubbles and by moving the bubbles around user can change the light ambience of the room. The bigger and more recognisable the bubble is, the brighter the room is. Hue is set according to the position of the bubble varying from bright blue to red tones. In the installation, soap bubbles were used as fragile, tangible handles for input (Döring, Sylvester & Schmidt 2010).

The setup for the soap bubbles consisted a round transparent table top surface with a diameter of around 20 inch with a thin layer of dark liquid on top. The soap bubbles can be blown around the surface or gently with a moistened finger. The bubbles stay intact up to several minutes. The bubble movements are tracked with a camera, which is positioned under the table, where it has a clear view of the bubbles and their movements. The surface tension causes clear, visible rings in the dark liquid (Döring, Sylvester & Schmidt, 2010).

3 Emotional Design and Design for Emotion

Emotions are important part of our everyday communication. Whether the emotions are delivered via our body language, words or the tone of our voice, they are there. One major communication device is the smartphones and other smart devices we use in our everyday life. The smart devices are often in the hands of the user longer and more often than we may realize in more and more situations in our daily lives. And quite often the used application is one or multiple social media applications.

Seventy-nine percent of smartphone owners will check their devices every morning within fifteen minutes of waking up. And quite baffling is, that one-third of Americans would give up on sex than lose their cell phones. A university study made in 2011 suggests that people check their phones dozens of times a day. Though the industries believe the number to be closer to 150 times a day (Eyal, 2014).

Emotional design is a design method, which strives to create products that brings up appropriate emotions. This is to create positive user experience. To achieve this, the designers consider the connections that can form between the users and the object in use, from the emotions can rise. The emotions brought up by the product have strong influence on how the user will perceive it (Norman, 2004).

Besides the design of the object, there is a personal component as well. This component cannot be provided by the designer or the manufacturer. The objects in our daily lives are more than just mere material wealth. There is pride we put in them, for not just showing our wealth or status. In addition to this they have special meaning in our lives. The most treasured items are usually inexpensive items, things like trinkets, old furniture, books or photographs. They are often

dirty, faded or otherwise worn out during the time they have been in use (Norman, 2004).

Emotions are inseparable part of our cognition. Everything we do or think has a shade or flavour of an emotion or two. Much of this is not even conscious. This in turn has effect on the way we think and behave. They steer us in a way, away from bad and towards the good (Norman, 2004).

In addition to this, the emotions are a great part of how we use the devices and products in our daily lives, whether it is conscious or unconscious. This can be noticed when you look certain products and memories waft over you. The effect is more notable in products that have been in use for long time and or has been passed down from user to user, like from mother to daughter or from father to son.

User's emotional response has great impact on whether the used product becomes something more than part of the day to day life or not. There have been extremely successful products that have been embraced for their ability to satisfy more than one need, emotional needs being the greatest ones, the emotional needs during the usage of the product (Van Gorp & Adams, 2012).

One big part of the design process is to keep design for emotion in mind. It is because the emotions have a great influence over our day to day lives and emotions determinate multiple affairs and matters, such as they dominate decision making, commands attention and enhance some memories, while minimizing others (Reeves & Nass, 1998).

The meaning of the product can be different for different users and thus transferring emotions can be difficult. For example the user who receives the product might cherish it because the giver has given a meaning for it or the giver has used the product themselves and the receiver had seen the product in use. In other words the said product brings back memories of the user, not the used product itself. In addition, these memories can be triggered if the receiver sees the same product in shops or used by other people. Would buying a new copy of the product cause same kind of reaction?

Emotional bonds are formed between other humans and the products and things based in part of the personality they perceive. Personality traits should be kept in mind as they are powerful influencers in design and they contribute to many things. They may affect what what we choose in terms of media, such as the television and radio, and have a say on what products we choose to purchase and what we choose to embrace or ignore in brands (Govers & Schoormans, 2005).

Don Norman proposes in his book *Emotional Design: Why whe love (or hate) everyday things* distinguishes three levels or aspects in emotional design. They all have their own ways to influence our experience of the world. These three levels are visceral, behavioural and reflective (Norman, 2004).

The first, visceral, is responsible for our ingrained and automatic qualities of human emotion. They can even be described as animalistic since it is fast and makes rapid judgements of what is good or bad. These emotions are usually out of our control. Second, the behavioural level refers to controlled aspects of human behaviour and actions. In this level we analyse the situation unconsciously to develop a goal where the amount of actions needed to take are few as possible. And thirdly the reflective level, is where home of reflection is.

It consists of conscious thought, learning of new concepts and generalisations about the world (Norman, 2004).

Visceral design concerns itself with the appearances. This refers to how the qualities of a product will make the user feel. A good example is two different types of clocks, such as the grandfather clock and a mantelpiece. Both have the same functions of displaying time, but the owner still values one product over the other. The distinguishing one product over the other is also called branding. Not because one product has better qualities or benefits than the other, visceral design uses the users' beliefs, feelings and attitude towards the product and the usage of it. The marketing might use different elements to provoke appropriate emotions in the consumers by using various objects or themes. To enhance the feel of youthfulness can be achieved by using pictures of animals, small children or cartoon characters. The right choice of colour can enhance certain appearances, such as red is associated with sexy or black wit scary. Using well-chosen shapes or styles will make the product to look like from certain, well distinguished eras from the past styles. Visceral design aims to enhance the user experience via emotional bonds to certain things or themes and thus encourage the consumer to become user by purchasing the business products (Komninos, 2018).

Behavioural design has to do with the user experience, such as pleasure and effectiveness of the usage of the product. This is often referred as usability, but these two terms are quite different from each other. Behavioural design is more concentrated on, for example, how users carry out their activities, the accuracy and time used on to achieve the goal of the task in hand and how many errors the users make during the task in hand. It also measures how well the used product will accommodate users with different levels of expertise. Perhaps the easiest way to test behavioural design is to test the performance levels of the physical parts such as buttons, levers, switches, keys et cetera. Or how well the usable parts are changed or manipulated in some way. For example, how long it

would take a user to complete a task involving two buttons with different functions? And as an example for behavioural level include the pleasure received from finding the right contact from the contact list and calling them, the ease of typing on a computer keyboard, the hardships of using too small touchscreen or when the design of a gaming system is spot on and a pleasure to use. The behavioural level reflects our emotions what we feel as a result of either accomplishment or a failure. When a product or object enables or restricts us the followed emotions usually reflects it. When enabled the emotions tends to be positive. In contrast, when we are restricted in a way, we feel negative emotions due to the user experience we perceive in negative way (Komninos, 2018).

Reflective design weights the rationalization and intellectualization of a product. Is there a story to be told? What it does to my self- image and self-worth? Reflective design is also called the highest level of emotional design. It represents our conscious layer, where we have a conscious approach towards a design. We weight the pros and cons, judge it various ways and determine what it means to us as an individual. This includes how much we enjoy the chosen product and what the impact of it is on our self-esteem and how it boosts our self-expression. This reflection of our consumer behaviour allows us to take environmental influences into the behavioural level. For example, products perceived as luxury items, such as smart watches. On one hand, the watches are perceived as technical innovations by their usefulness and how easy they are to use. On the other hand they are perceived as luxury fashion products related to self-expression. How much the user would enjoy using the device has also a say in the user experience. Both self-expression and enjoyment are influenced by previously mentioned visceral level. What my friends will think when they see me using this product? Does the product look beautiful? The reflective level is linked to the behavioural level by how well the product is usable and what are the reactions of our peers when we use the said product. Branding has a large influence on this, for example the first Apple Watch. It was riddled with

usability issues and functional problems, but consumer still bought it with all its flaws (Komninos, 2018).

3.1 How these are shown in the Candle User Interface?

The first option would be to design the product to be used together with another user, to create memories together tied to the product and to show to each other how the Candle UI works. Therefore users can bond with the product and insert both good and bad memories into it. Inserting memories will determine whether the product is cherished or not.

This is one reason the Candle UI has two sets of candles, the one with a real flame and the one with an electrical flame, instead of just texting to the candle the emotion or response. It engages both of the users to commit actions and in addition to this, it can be left to the background as ambient enhancer, what candles usually are used as.

In addition the one way connection from the previous prototype did not feel right since no communication is usually one way only. And, instead of just adding a button for response function like in the LoveBox, the designed function leaned a bit towards the LovLit Candle. Instead of having both of the candles electrical and in one object, a real one was chosen to be the other functional part in it. And the candles were in separate holders too.

Other Features

The Candle UI has a built in slot for a small item from the other user, like a memento. It can be places in between the candles, on the small dent of the larger leaf. It has also another purpose as a hinge where the bigger leaf overlaps on the smaller leaf.

3.2 Ambient Communication and Displays

Ambient communication is a communication form that happens in the background, at the corner of your eye. It is not a constant and interactive like other forms of communication, in example, a conversation with another person via either speaking or texting.

Ambient communication is defined as a complex form of communication, where the elements of environment such as the physical surfaces, are in use. This has been claimed to elicit the consumer's engagement towards the corporations and brands (Gambetti, 2010).

The word ambient (ˈambɪənt) is an adjective and it has several meanings:

1. Of the surrounding area or environment.

2. Completely surrounding.

3. Creating a certain reaction or mood, often a subconscious one, by being wherever people tend to be.

4. Pertaining to or noting sounds that create a peaceful and relaxed atmosphere.

5. Pertaining to or noting close and constant social contact and communication fostered by the Internet or the use of digital devices.

Ambient is also a noun:

6. Ambient music (definition 1).

Source: http://www.dictionary.com/browse/ambient 5.9.2017

People are surrounded with lots of physical media objects in the age of ambient media. These objects render digital world into natural environment and they should interact with the user without disturbing them (Serral, Gil & Valderas, Pelechano, 2014).

Nature is filled with subtle, expressive and beautiful ambient displays that engage our senses. For example, the sound of rain and the feeling when the warm wind caresses our check helps us understand and enjoy the weather. This happens even when we are engaged in other activities. Current personal computing interfaces sadly ignore these rich ambient spaces. They instead focus on vast amounts of digital information on small windows. This information is usually just "painted bits" on a flat screen and requires the users full concentration. The interaction between the user and digital world are now almost entirely mundane Graphical User Interface based, which consists of monitor, keyboard and a mouse (Wisneski, Ishii, Dahley, Gorbet, Brave, Ullmer & Yarin, 1998).

Ambient media are embedded to the users' natural environment through physical objects that surrounds the user. These objects are, for example, the users own smart devices, the TV at home, and they stimulate their human senses. These objects are called media objects, which to promote the natural interaction between the environment and the user must behave unnoticeable and unobtrusively. Volume and medium of them should also be negotiable (Serral, Gil, Valderas & Pelechano, 2014).

Ambient displays are pictured as being all around us and thus suitable for the environment in home and overall everyday life. The ambient displays can aid when we need to feel connected to other people, loved ones especially. Other suitable environments include spaces such as highly specialized environments for monitoring multiple streams of information. This information is not necessary

just digital, but good example is a cockpit of an airplane, the control room of an atomic power plant or the driver seat of a car (Wisneski, Ishii, Dahley, Gorbet, Brave, Ullmer & Yarin, 1998).

When designing ambient communication and media, there are few design pointers to keep in mind in the design process. Ambient media relies on mechanism often called Cocktail Part Effect to gain the users' attention. In the noisy ambience of a cocktail party where multiple voices talk simultaneously we still manage to immediately recognize when someone mentions our name, even when the conversation is otherwise not fully followed (Offenhuber, 2014).

For the designer, ambient media and communication poses a number of challenges. The traditional principles and practices cannot be really be applied during the design process. There are multiple ways to hide the ambient media and display since the ambient display is required to be hidden. One solution is animism. It is the idea that all objects and things are husks for living spirits. This concept can be seen in multiple places, such as in cartoons where everyday products and items come to life. Alternative to moving and talking appliances is the abstract and static and unanimated. Though, when animated in a proper way, they will produce more intense effect (Offenhuber, 2014).

Another way is invisibility through mimicry. This example has been seen in the nature for long time already, since mimicry is a strategy of species to survive. This is by mimicking another species which is more powerfull and dangerous than the creature itself is. In conclusion, ambient media device can be disguised as another, more common and familiar object in the household or in the public space and thus will slip the attention of the already occupied mind (Offenhuber, 2014).

Then there is blending the object and its representation to hide the ambient device in plain sight. This can be demonstrated with a display showing environmental information in a public place. For example, installation Garden of Eden has salad plants planted under glass domes. These glass domes are then filled with air from different cities in the world. They also shows the air pollution from each city and generates the right amount of air pollutions according the data the display receives. The data, or air pollutions impact on the salad plants, is the only information given to the viewer. Other is urban-scale project Nuage vert, where the emissions coming from a power plant chimney could be displayed on the said chimney. This information comes from the near neighbourhood and displays their energy consumption. By overlapping digital information with visual elements the ambient device can be hidden in plain sight. And the user experience will be richer when including a natural phenomenal. (Offenhuber, 2014).

Another way to make ambient media device is to embrace the instability of the display media. The traditional display aims to control all the variables around it, such as the influence from the environment. The display should appear the same in every time it is being used. The changing of the environment, such as the lighting, should be used as part of the experience than just try to minimize it. This may be achieved by using ephemeral materials as part of the ambient display. However, since the environment influences the ephemeral materials, the data would not be displayed on its purest form. If these influences are kept in mind during the design process, they might work and add a layer to the user experience (Offenhuber, 2014).

Keeping the environmental influence in mind, the design could be done with physical wear. Despite the negative connotation the decay and wearing of material has, they could offer a lot of interesting opportunities and features to the design. For example, the wearing of marble staircase shows the preferences of the ones who has been using it. In that sense the wearing of materials is an

ambient information display itself. By quoting Walther Benjamin, patina and wear are major elemental information we can call the objects aura. This includes also aspects and features of the object that cannot be described fully with only words (Offenhuber, 2014).

Digitally the wearing and tearing can be seen for example, when a Youtube video or .jpg image is downloaded and re-uploaded several times. Parts of the information gets lost during every download and upload and in time the digital information will decay.

Comparing the metaphorical and physical wearing, the latter seems more interesting for environments, such as the urban environment. In the outdoors, unprotected, physical wear is a permanent issue and needs constant or occasional maintenance. By choosing ephemeral materials over static, unchanging user interface materials can provide a subtle messages about the objects history. It can offer additional cues to the user about the age and previous interactions when the users' ability to assess materials is taken advantaged of (Offenhuber, 2014).

Lastly is the deliberate exclusion of the user to hide the ambient device. When the invisibility is understood as a sense of opacity, it is deliberately hard to understand what is presented. This paradox seems like nonsensical, but only few examples of public interfaces come into mind. Curiosity is a powerful engine and can strive us to learn the right ways to use the interface (Offenhuber, 2014).

There are several modes of visual communication in public. This includes signals like fashion, which is universally understood, and street art and graffiti, which are more personal and self-referential system. These can be applied to augmented reality games or alternate reality games. Invisibility plays a central

role when applied this-is-not-a-game- aesthetics. This is achieved mainly when the game elements such as puzzles are deeply integrated with the real world elements in the urban context. This is to make the participants more curious by holding back some information. The information can be brought up for example, via the camera application on the smart phone, which will recognize the digital game elements and add them to the reality via the screen of a smart phone (Offenhuber, 2014).

These six previously mentioned methods illustrates how the ambient device can be hidden from the user and blended to their surroundings by establishing a relationship with the context of the user interface. They focus especially on the transition between foreground and background of the users' attention and can be divided into two groups depending on the transition. The first group covers the transition from foreground to background by mimicking and embracing the usable display media. This tightens the coupling between the foreground and background and accomplishes this by using the tendency to blend out the elements that are familiar. These include both the usable media and physical wear by enhancing the influence the users and environment have on the interface elements. The second group is focused on the opposite direction, where the ambient device emerge from background to foreground. This includes animism, which is ambiguity of object and its representation. This in some extent includes also the exclusion of the user. All these strategies are meant to increase users' awareness within a specific context (Offenhuber, 2014).

As in conclusion it can be said, that the presented strategies highlights the importance of situation. They are an invitation to designers who work on ambient interfaces to breach the limits of their current expertise and to explore strategies that seem off and use art and architecture as a source for inspiration. These new points of vew may help us see our environment from different perspective (Offenhuber, 2014).

Ambient communication and media can be used as a learning tools, too. Just like when learning to drive a car, the user will learn from the ambient prompts when to switch from the gas pedal to brake while for example, changing the radio station while driving. It is expected that the person in ambient environment will learn how and where to look for information. Time used in the learning environment will have an influence on the users' capabilities to use the said ambient environment (Wisneski, Ishii, Dahley, Gorbet, Brave, Ullmer & Yarin, 1998).

How are candels an ambient display?

Since candles are usually left into the background as an ambient enhancer and they are not constantly under our watchful eye. This is why they fit for the emotional and ambient communication perfectly. It is important to keep in mind never to leave the candle burning unsupervised.

4. Research Methods

This chapter covers different kinds of research methods in the design process of the Candle UI. I also include how they were used during the design process.

4.1 User-centric design

Like the name suggests, user centric design method puts the user into the design process. It is a broad philosophy and covers variety of different methods. There is also a broad spectrum of ways how the users are involved with the design process. This helps to maximise products suitability before it is released to the market. This minimises the risks of the product backfiring after the release, too.

User-centric design (UCD) is a broad term to describe design processes in which end-users influence how a design takes shape. It is both a broad philosophy and variety of methods. There is a spectrum of ways in which users are involved in UCD but the important concept is that users are involved one way or another (Rogers, Sharp & Preece, 2011).

In other words, user-centric design is design method where the user has large influence on the design of the product. Since there are so many different kind of users with different preferences and needs, most of the design is still made in "one size fits most" style to cut the costs, usually in places like production or materials.

The term user-centered design originates from research laboratory led by Donald Norman at the University of California in San Diego (UCSD) in the 1980s. It has become widely used after Norman and Dappers published a book in 1986 titled *User-Centered System Design: New Perspectives on Human-Computer*

Interaction. The concept was later built more in a book by Norman, titled as *The Psychology of Everyday Things (POET)* (Abras, Maloney-Krichmar & Preece, 2004).

In recent years, user- centric design practices, training and research have been applied and developed specifically for approaches to design thinking and activities. Focus of these studies have been in endorsing the empathy of the designers, tie together knowledge and inspiration, ease or back up teamwork, idea generating, communication and decision making (Mattelmäki, 2006).

Variety of users included to the research and design process ensures the suitability of the product to a larger consumer base. But this one size fits all philosophy has lost its monopoly position in the market and in product design for the consumers prefer products that they can take part in customising it themselves in various ways.

Four basic suggestions were made how a design should be. Firstly it should be easy to determine the actions that are available at any given moment. Secondly, things should be visible, including the conceptual model of the system. This includes also the alternative actions and the results of those actions. Thirdly, it should be easy to evaluate the current state of the system. And, fourthly, the design should follow natural mappings between the required actions and intentions; and show the results between the performed actions. The information should also be visible how to interpret the system state (Norman, 2004).

These recommendations place the user in the centre of the design. Designer role in this is to conduct the task for the user. This includes making sure that the product is being used as intended with minimum effort from the user to learn

how to use it. Norman took note of that user manuals that were long and contained jargon were not user-centered. The old fashioned user manuals could be replaced with short, easy and quick to read pamphlets that use the users' knowledge of the world (Norman, 2004).

Some design principles are needed to guide the design process since just telling the designers to design intuitive products is not enough to make it happen. Norman suggested in 1988 the following seven steps or principles of design that are essential for guiding the design process towards more user friendly products (Abras, Maloney-Krichmar & Preece, 2004).

First is to use both knowledge in the head and the knowledge in the world. Write manuals that are written before the design is implemented to make them easily understood. This can be achieved by building conceptual models first. Second is to simplify the tasks' structure. Make sure that neither the short term memory nor long term memory of the user is not being overloaded. The user is able to remember five things at a time in average. The task in hand should be consistent and include mental aids, which are easily fetched from long-term memory. The user should have control over the task in hand. Thirdly is making things visible. Make a bridge between execution and evaluation. The device should be intuitive to use just by looking at the devices buttons and figure out how to use it by pressing the right buttons or other device parts. Fourthly is to get the mapping right. This can be done by using the right kinds of visual graphics. Fifthly is to exploit the power constraints. These includes both natural and artificial. They will give the user the feeling of there is one thing to do. Sixth is the design for error. While designing the product it is important to keep the possible errors in mind and thus have an option to recover when the user makes an error. Seventh is that when all else fails, standardize. Design an international standard for said design when or if something cannot be designed without arbitrary mapping (Norman, 1988).

How to Involve Users in Design?

There are many kinds of users and it is necessary to think carefully who they are and how they can be involved in design process. There are users who are using the final product to execute certain tasks or goals. But they are not the only types of users. There are users who have individual needs and expectations and they demand more from the used product. Eason wrote in 1987 that there are three different types of users: primary, secondary and tertiary. Primary users are the ones who actually uses the product. Secondary users are those who occasionally use the product. In the secondary user category are also those who use the product through an intermediary. And the third category are the users who are affected by others who use the product or make the decision to purchase it or not (*Encyclopedia of Human-Computer Interaction*).

The succession of the design will depend on the stakeholders of the artefact, but not everyone who is a stakeholder needs to be represented in the design team. Only the effect of the artefact needs to be kept in mind. The designers can develop the design solution once these stakeholders have been identified and their needs investigated. At the beginning of the design process these solutions can be simple as pencil sketches on paper. The users discussion of the alternative designs can help the designers to understand the intended purpose product. Listening the users may provide information that did not came up while interviewing the user. The next step is to produce small amount of prototypes to be tested by the potential users. This step is crucial and the designers should pay close attention to the users' evaluations of the said prototype in hand. This information can be measured by certain criteria and thus if will help the designers' work (Abras, Maloney-Krichmar & Preece, 2013).

This measurable information contains criteria of how usable the product is, how efficient it is while being used to complete a certain task, how safe it is to use, utility, how learnable and memorable the product is to use while performing the

most common task, and how satisfied the user is after the task is completed. All the previous points shows that it is near impossible to the designer to imagine all the important usability criteria. The refining of the product can only be accomplished through the users feedback and involvement (Abras, Maloney-Krichmar & Preece, 2013).

The user testing is important part of user-centered design process. The user testing, according to Dumas and Redish in 1993, aims to achieve the following five goals. First is that the testing will improve the product's usability. Secondly it will involve real users in the testing. Thirdly is that the testing will give the users real tasks they can accomplish. Fourthly the testing will enable the observation and recording options of the test participants to the ones who supervise the test. And fifthly, the testing will enable more accurate analyse of the collected data. (Abras, Maloney-Krichmar & Preece, 2013).

The usability testing will focus on the needs of the users. The testing can be compared to rehearsals of a play before the opening night. Historically the user testing were performed inside usability laboratories with experts in user interface design and testing. This is still widely used in larger companies, such as IBM and Microsoft. By using these laboratories the tests can be conducted without environmental distractions. The testers can observe the users during the test unnoticed. But since the costs of upholding such testing facilities, mobile usability testing environment kits have been more popular environments to conduct user testing. The costs of the user testing have also prompt new, alternative ways to test usability. One is website guided by high-level-heuristics to reduce the loan on short term memory. It is also aimed to target the user population they identify problems with the design. This sounds appealing with the low cost of testing but also makes a dent in their efficacy (Abras, Maloney-Krichmar & Preece, 2013).

There are variations in the user testing, but it has its limitations, too. The testing would not cover all the interface features since it will last only for few hours in laboratory environment. This would not show how the product will behave in real environment over time. Also the small number of participants would not cover all of the population and their different kinds of needs and preferences. It is suggested that the user testing should be approached from a different perspective and the testing should have three phases of iterative testing. First level is evaluation, where the conceptual level of the design is being evaluated. The level is designed to give feedback of the design before any code has been developed. The testing should be done in the workplace to see if the design is usable with minimum to no instructions. Second level should be executed when there is a usable, coded prototype. The feedback comes from the usability of the product. Same principles as in the first level. The third level is testing phase that comes after the first testing, but the tested prototype includes the user interface. The purpose is to evaluate the final products usability and weather it meets the goals set in the first level (Abras, Maloney-Krichmar & Preece, 2013).

Lastly is the participatory user-centered design, where the users are in essence, co-designers. This approach emerged in Scandinavia, born from the labour unions push to improve the workers work environment and increase their control over it. Because of the cultural differences and walls, the users have hard time to understand the designers' intentions. This is why it is advised for the design team to use prototypes, or mockups. These can be three dimensional paper based models or just paper based outline of the product. These prototyping methods also includes the low-fidelity prototyping with items such as papers, sticky notes and pens. This is also videotaped. Other method is storyboarding. Recent years participatory design approach has gained better footing among other design approaches (Abras, Maloney-Krichmar & Preece, 2013).

There are few advantages and disadvantages in using user-centered design. The biggest advantage of user-centered design is that it will help the designers gain deeper understanding of the organizational, psychological, and social and ergonomic factors that has effect on the every stage of the design process and eventually the evaluation of the product. By involving the users assures the products' suitability for the intended consumer audience and the product is suitable for their intended use-environment (Abras, Maloney-Krichmar & Preece, 2013).

The user-centered design method will also help the designers to manage the expectations about the new product. The knowledge from an early stage will help with the expectations and how the users will feel about their ideas and suggestions have been taken into the design process. This will also lead to higher customer satisfaction because the users will feel a sense of ownership of the final product. It will also lead to smoother integration of the product and its desired user environment (Abras, Maloney-Krichmar & Preece, 2013).

But as a disadvantage, if the design is not user-centered, it might lead to ill-thought out designs. When the expectations of the user are not met, it may cause feelings of frustration and even anger. Other major disadvantage is that the testing might turn out to be quite costly. It takes time to ganther data about the users and then to process it. This is especially present when data is collected from the understanding of the user environment. The processing will require resources in both human and financial. The design team generally benefits from multiple different disciplines, but the downside of it is that the team needs to learn communicate the findings to the development team and respect others in the process. They might even have to validate their works worth to the management and other higher-ups (Abras, Maloney-Krichmar & Preece, 2013).

4.2 Focus Group Method

Focus Group method is an interviewing method where, like the name suggests, a group of potential users are gathered into same space and interviewed together. They all answer the same questions and based on that, have a conversation of the topic in hand. The conversation is led by trained interviewer.

Focus groups have been well documented through the history as a method of collecting data. Both private and public sectors have been using the method. However, the research method has gained more interest in the field of academic research. Research method has gained popularity especially amongst social science since their perceived cost effectiveness is better than traditional methods. The research method is also easily adapted to different approaches and designs. But despite the growing interest on the research method, there has been very little critical discussion of the problematic parts of the focus group method. This includes the conduction of the groups and how the relevant data is extracted from the group (Parker & Tritter, 2006).

A focus group usually consists of up to ten individuals, who are volunteering for the discussion. The discussion is led by a trained facilitator, and the topics are usually about reviewing a product prototype, such as a film or a pilot episode of a new TV show they have just seen. This method is also often used in political campaigning, marketing and in social sciences (Rogers, Sharp & Preece, 2011).

How to choose the participants to the focus group interview? The participants may not always want to engage to interaction with each other. They may feel too much of a strangers, or they might know each other previously, and thus are not too keen to participate. This is why it is important to keep in mind who is taking part in which group to keep the group dynamics in balance. There are requirements for the participants to fulfil. The participants past experience,

opinions, beliefs and attitudes play a crucial role in this selection. There are few ways to encourage the focus group members to participate. They are either monetary or non-monetary incentives, but there is no guarantee that either of those rewards will work (Rogers, Sharp & Preece, 2011).

The data is being collected from the participants in various ways. But mainly, it is an in-depth discussion of the topic or product in hand. The questions used in the interview are usually logical and open-ended. The questions are designed to encourage the universal participation of the focus group members. If the group dynamics, often called as synergy, is right, the participants will have easier time to contribute to the conversation. In turn the opinnions, actions and individuals feelings, attitudes and beliefs emerges from the conversation. Thus the collected data will be much more than just the discussion about the topic in hand (Parker & Tritter, 2006).

The analysis of the focus group data can be done based by what the form of the data is. The questions asked by the interview leader are not asked individually, but they are asked from the whole group. The analysis of the answers of the said questions are usually either most commonly, content or thematic analysis. There are many ways to analyse focus group data. For example biographical, content, discourse or conversation analysis, ethnographical, experiential, narrative, phenomenological or thematic way to analyse the collected data (Silverman, 2013).

Analysing the focus group data is basically the same as analysing any other data from qualitative self-report. The basics are that the researcher draws together and discusses the comparison of similar themes. The researcher also compares the group data to the variables of a sample population. It is more important to try to separate the individual thoughts from the group consensus. In all qualitative analysis the attention must be given to the minority opinions and

examples which are against the larger consensus. The only distinct feature that separates focus group analysis the researcher must take full advantage from the group dynamics and interactions between the group members, and thus analyse the session from that point of view. While preparing the questions for the group interview and the discussion, it is worth using specific categories for certain types of narrative. Jokes and anecdotes are good examples of interaction which brings out the personality of the individual. The collected data should also include graphical elements such as illustrations of the recorded discussion, for it will be more presentable than just taking single questions and answers that feel they are taken out of context (Kitzinger, 1995).

Advantages of Focus Group Method is that there are usually multiple different personalities and views on the topic present so the topic can be observed from multiple points of view. Another advantage is that in the focus group more diverse or sensitive topics can be discussed properly. It is assumed that the individuals develop opinions within the context via the discussion, which amplifies the community point of view more than just individual ideas or experiences.

There are few disadvantages in the Focus Group Method. First, it is not as in depth as individual interviews. Some opinions can be overrun if the person is shy or there is a more dominating personality in the group. Another disadvantage is if the interviewer has strong opinions themselves and tends to curve the discussion towards their ideal goal. There is also the fact that is that the focus group interviews are more expensive to do since the participants usually should be compensated in one way or other for their contribution.

4.3 Industrial design Prototyping Methods

There are multiple different ways of prototyping methods and materials to choose from depending on what product you are making or testing. The following is a list of several different methods which were considered for making the prototype. I also explain in more detail why the certain methods were chosen over other.

3D Printing

Unlike traditional manufacturing involving material injections into a pre-made mould or removing material from a base object, shaped usually like a block, 3D printing is a form of additive manufacturing that starts from a virtual model and transforms into a physical object one layer at a time. These layers are built individually on top of the previous one thus creating a solid object representing the virtual three-dimensional object, which includes all the details without requiring additional work from different machines or treatments involved with traditional forms of manufacturing (Hausman, Horne, 2014*).*

3D printing has been compared and contrasted with mass customizations of products. Advocates of 3D printing argues that this technology would enable firms to build limited quantity products ecologically. Mass customization and 3D printing are both profitable processes for making limited quantity items and other benefits, however they are very different in terms of the manufacturing and logistical technology (Berman, 2012).

These days you can print almost anything with a 3D printer, china included. However, usually when printing clay the layers are quite thick and extremely visible. The finished print would require some work after the printing phase is done. This might distort the object. Smoothing out the surface after it has been in the kiln would require lot more work since the material is hardened and it is

hard as stone. With walls thin as the Candle UI has, they even might shatter in the hands of the maker.

Printed ceramic has the same smooth surface and material properties as its hand-made and kilned counterpart. 3D printed bone implants are one of the most promising products to apply 3D printed ceramic. The digital model is gathered from the patients CT scans. The bone implants made of ceramic can be custom-made and since they are less spongy material than conventional materials, the outcome can be three to five times stronger. This will also reduce the amount of micro-debris and post operation inflammation (Lipson & Kurman, 2013).

In addition to this, you can print out the object with various kinds of plastic and make a mould from it. Depending on the selected printing method the quality of the surface will vary and the amount of work needed to be done for the object to be mouldable since the printers will leave some streaks of material during the printing process.

The time the printer takes to print one object also varies by how fine the layers are. Therefore 3D printing can sometimes be a slower method to prototype a product than using other methods, such as sculpting by hand or carving it with a machine. But the results are usually better and more like the modelled object.

3D printing was not used to create the Candle UI but it was considered during the decision of what materials could be used in the prototype. It could have been created with a 3D printed plastic, but since there is fire involved, I chose not to use this prototyping method to create a prototype of Candle UI.

CNC Milling

As the name suggests, you can use a computer aided machine to rapidly make functional prototypes of the product. It is the opposite of 3D printing machine, which adds material to the object which is being made into physical object from the digital model in the computer.

The cost of producing small batches of parts has been driven by how much the process of engineering the parts is. The cost of one or two-of-a-kind machined parts has been dominated by the cost of the planning the part, even the traditional computer-aided process planning has gotten faster. These costs to create small batch of items also covers the special tooling and machine setups (Frank, Wysk & Joshi, 2004).

Simulating the carving in virtual environment first prevents the errors in the carving process. Users can rapidly model the machines, tool paths, and the used fixtures by exploiting the material library built within the software package. Most used programs for virtual milling ale called CAD programs (Ong, Jiang & Nee, 2002).

Methods of CNC milling have been developed in a way It will cover all the aspects of the process planning for rapid machining. This includes the toolpath planning, tools geometrical aspects, calculating setup orientations, and a concept for universal approach for the fixture. The general idea is to carve the visible surfaces of the part in the making. This can be done from plurality of orientations. Only the external, visible surfaces can be machined with this technology. (Frank, Wysk & Joshi, 2004).

There are different kinds of carvers, but the main differences are the size of the carving area and the number of directions it is capable of carving. Usually there are two (x and Y) and three (x, y and z) axis carving machines available. If only two axis are available, it is possible to flip the carved object to another side and carve the other dimensions. This requires some precision and has a high possibility of failure.

You can carve either the prototype itself with the machine or the usable mould. Usually the mould suitable for casting the prototype depends on what material the prototype will be made of. In this case, it was better to machine the object the mould would be made of, since carving plaster is too hard. The plaster would just fill the drill bit and thus prevent it from carving the material.

This method also requires further work because the surface would not be smooth enough and if you have to combine parts to make the object, smoothing out the seams is additionally recommended.

Sculpting by hand

It is possible to sculpt or cut the piece by hand and then make a mould from it from various materials using a vast variety of tools. Used sculpting materials should be chosen based on the piece that is being made, but mainly clay, polymer or other plastic or oil based clays are favoured by many sculptors and prototype makers. For example designers use a special wax to create models of cars they are currently designing. The clay can be softened and hardened according to the designers' desires.

For this prototype I chose not to sculpt the Candle UI flower piece by hand because the piece was too complicated to make symmetrical with my current crafting skills. Therefore it was better to sculpt the outer petals of the design by hand over the computer carved base, since they were difficult to model in the 3D sculpture.

The Candle UI base, the overlapping leaves, was much easier to make by freehand. It was basically just a flat leaf with few holes and a dent on it. I made it thick enough to hide the necessary electronic parts inside of them. On the part where the leaves overlap, there is a small, shallow bowl-like part where users can place a small item or items from the person who has the other half of Candle UI.

5. Background Research, Design Drivers and Related Products

This chapter covers the topics of focus group interview and the analysis of the results gathered from the interview. The chapter also covers the background research such as related work search and the benchmarking of the products.

5.1 Conducting a Focus Group

As the first user study related to the thesis, a focus group based user study was conducted to gain knowledge about the design drivers for the Candle UI. In the focus group, an earlier prototype utilizing a candle and text messaging, was used for this purpose as a design probe (figure 2 &3). The prototype that was being evaluated was only one candle holder, made from paper and different kinds of electronic parts (figure 2 and 3). Inside the prototype was a smaller lampshade like carton to focus the light on desired spot. The user would send a text message to it, which caused small motor to turn the candle inside the prototype to illuminate emote or symbol the user had texted to it. Around the candle was a reflective cone with a hole in it that focused the light from the candle into a specific area and therefore illuminated only one specific emote or symbol at a time (Häkkilä, Lappalainen & Koskinen,2016).

Figure 2 & 3, the First Prototype

This prototype was meant for one way communication only as the candle reacted to the send text message and did not send anything back to the sender. What if the candle motor does not have any power left in the battery? Or if the text would not go through because there is no service? Or what if there are other unforeseen things like there is no candle in the device at all? These are the main reasons among other minor ones why I needed to redesign the Candle UI basically from the start.

The first task was to evaluate the idea of the flame changing its colour while a text message was sent to the Candle UI (figure 4). It was quickly found as unnatural, but still the thought interested some of the group members. When the flame changes its colour, it usually means that there is something wrong with the burning process, such as the flame might be producing carbon monoxide, which is a deadly gas. In addition to this, the coloured flame brought up the red lantern district and classic, coloured Christmas lights, fireworks set off in the oven and the traffic lights. It was also felt that the changing of the colour might also go unnoticed by the other user.

Figure 4, coloured flames

The second task was to evaluate the combination of colour and emotes or symbols. How would the user remember what colour meant what? In addition to this, the meaning of the message would also automatically change if the user chose a different colour for different emote or symbol. And the interpretation of the message would still vary between what the sender meant and how the receiver understood it. Chances of being misunderstood are high. In addition, one danger is that the candle is not even lit when the message is sent and the communication is lost (figure 5).

Another option was that the colours meant one specific sender. The user should be able to set the colours themselves, but it still requires a lot from the user to remember which colour was for which sender. Other option is to use a specific symbol for each sender (figure 6).

One idea the group came up with was to combine the flame and a certain scent. "The user would not even have to notice it, just smell it." The smell has really strong effect on remembering memories linked to a certain scent, but what would certain scent meant for the sender and the receiver? How long would one scent last? Would there be a pause before changing to the next scent? A cacophony of scents would really be an unwanted situation.

The Candle UI prototype had only 5 emotions and it was felt insufficient for emotional communication. In addition to this, the group pondered whether this was useful for only specific range of emotions. As an example, longing user could use the same amount of effort and energy to just call or text the receiver.

Also because this is only one way and possibly one candle for one sender, would the receiver have to purchase multiple candles for different senders? One solution for this would that the Candle UI would decode hidden messages such as

how many times certain emote was sent in a conversation or what kind of a tone the messages had. Occurring to those results the candle would display the right kind of emotion and the situation would be much more readable and the hidden messages seen better.

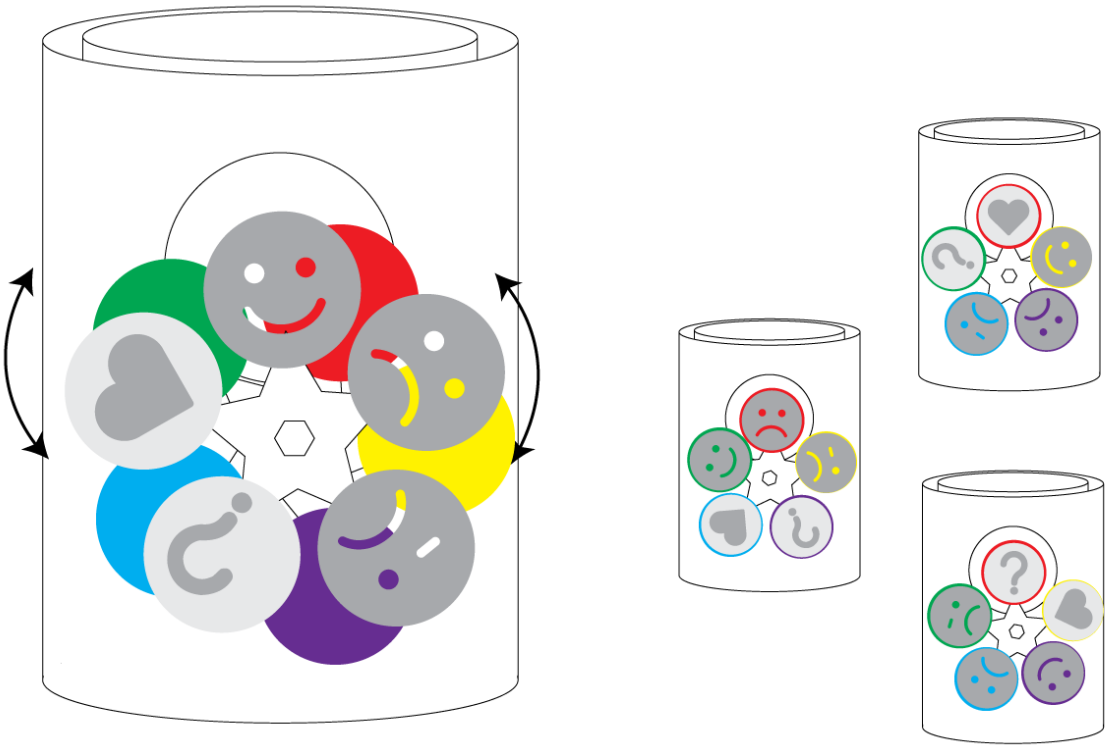

Figure 5, colour wheel with emotion wheel

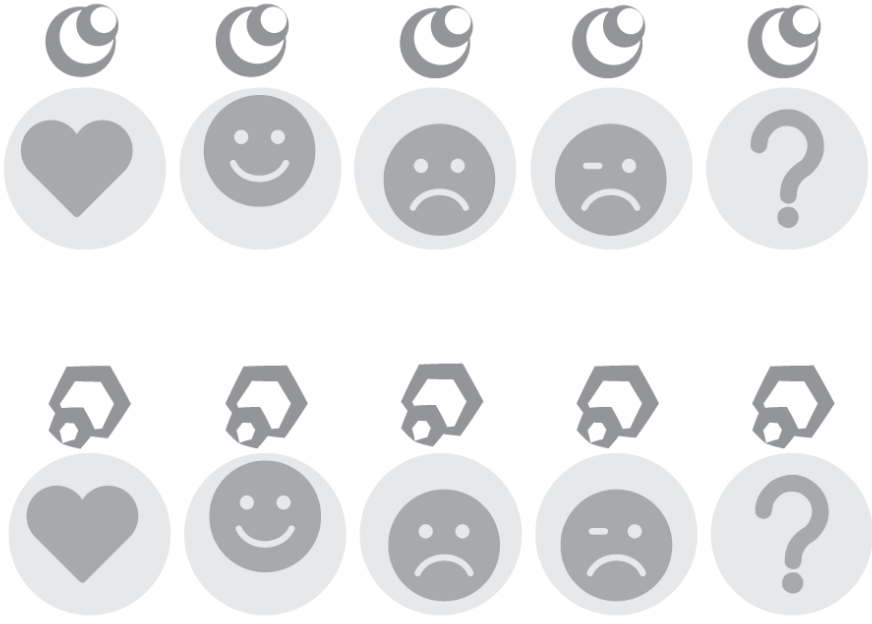

Figure 6, emotes and users

The third task was to evaluate the proper way to light a candle. Each one of the group members took their turn to light the candle either with a lighter or with matches. Majority of the group thought that the proper way was to use the matches. The candle was also depicted as a city campfire and the flame awoke something from the inside, something primitive from the caveman era of human history (figure 7).

While lighting up a candle the group members felt they were doing some sort of a ritual. Fire was also perceived as the symbol of life. Fire creates life, but also while playing with a candle you might forget really fast how dangerous thing fire actually is.

Figure 7, discussion about the candle

The fourth task was to evaluate augmented reality. The idea was that you could as an example; find a specific grave from the graveyard. Mostly it was viewed negatively as it was felt to disrupt the peace at the graveyard. In addition to this, it was felt that with augmented reality, the graveyard would turn into a digital circus.

The fifth task was to evaluate the prototype itself. When the concepts were described to the focus group, there were a few comments about the Candle UI being useless gimmick which would be forgotten within days after it has been taken into use. After actually trying out the Candle UI, the perception changed and the reception was much more positive.

The prototype was a simple machine with a Bluetooth receiver and a tiny motor. Group member liked the little sound the motor made while turning to the right side. Another notable thing was that the members liked the sleek, seamless design. The lack of visible seams, visible cords and other technical parts was praised (look back at figure 2 and 3, page 66).

The most selected Product Reaction Cards terms that came up from the questionnaire, which was handed at the end of the Focus Group Interview, were as follows (Häkkilä, Lappalainen & Koskinen, 2016):

> creative (5), empowering (4), playful (4), novel (3), unfamiliar+ (3), useless (3) and visually pleasant (3)

5.2 Design Drivers for the Candle UI

When speaking of design drivers, it usually means the drivers that are the forward driving force that guides the design. Such drivers are acquired from multiple sources, such as the sources the designer gets their inspiration from, or outside forces such as the task giver or focus group interview.

Design drivers are types of probes that are used to gather data about the inspected phenomenon. The collected data, or signals, are then used to aid the design process. The design thinking and design practises are under changes. This means that the products which are being designed, are starting to have new purposes (Mattelmäki, 2006).

The industrial designer's role has been traditionally keeping the different perspectives in mind during the design process. In addition to this, the designer should be prepared to defend them during the process. The used probes previously mentioned are being used in other projects as well. Mainly in places such as experimental research and corporation projects (Mattelmäki, 2006).

The focus group partially gave the design drivers for the Candle UI, and they are as follows:

- the design should be seamless, no visible seams in the product
- the electronic parts should be hidden from the user
- more emotions / feelings into the user experience
- real candle as part of the user interface, lighting a candle is a ritual

Like previously mentioned, biggest points that rose from the focus group interview data were, that the device should be seamless and that the electronic and technical parts should not be seen. The second big issue was if the flame changed colour, it would look unnatural and indicate that there is something wrong with the burning process and the flame would seem to be impure.

Because I wrote my Bachelors thesis about arctic design, I wanted to partially integrate those thoughts from the thesis I wrote into the design of the Candle UI. Mostly it was about honouring the materials qualities and keeping the Nature in the design by having shapes and influences from the nature and the weather. Therefore the shape the Candle User Interface got was a combination of arctic design and the focus group results so it came out as a simple, seamless flower with two layers of petals. The base of the candles would hide the electronics used in the Candle UI, such as flame sensors and network adapters.

The base itself is designed to look like two overlapping leaves. On the cross section there is a dent for inserting a small item from the other user as a memento of sort, so that the user can remember who has the other half of the Candle UI set if the user has multiple halves of the Candle UI set. The Candle UI flower will be at the tip of the leaf, sort of like a morning dew drop on the leaf.

The inspiration for the design also came from natural shapes which have six sides. Just like a honeycomb or a six sided flower from the arctic woods, the arctic starflower (*Trientalis europaea*). The number six was also chosen because it doubles the number three. Candle UI also has two layers of petals. The Candle UI also have been said to look like a lotus flower. This was unintentional.

Another main part from my Bachelors thesis was how arctic design creates a feeling around it, sort of ambient communication. Whether it is survival against

the cold, cruel nature it can also be creating warmth indoors with softness and light. And the Candle UI does just that, it creates warmth for the user, both physical and emotional when the user knows they are being thought of by someone who they hold nearest and dearest.

I chose to include the materials into the design drivers based on the conclusions on my Bachelors thesis. Taking materials into the design process has a large impact on how the products functions, such as how it would look like when it is made and how users will receive it. The materials ethnic and semantic values have also an impact on the user how they will perceive it.

The wish to make things is a human characteristic feature and materials are the starting point. Chosen materials are then shaped into parts, which then are attached together and when finished, the assembly will be defined as a product. From the Ford Model T to Apple's iPhone, the design is intended to provide a meaningful and delightful user experience, not only offer the basic functions of the used product (Ahby & Johnsson, 2002).

Materials have a central role in the user experience. The selected materials should and must satisfy multiple technical performance limitations. This has been studied thoroughly and there are vast tools available in software and methods. It is harder to analyse or codify the aesthetical, perceived and emotional attributes of the product. These are still an essential part of the design and its functionality (Ahby & Johnsson, 2002).

First material choices were bone china that was partially made of cremated reindeer bones. However, it was not possible to use this due to the fact that the most used bones come from other animals such as cows and pigs. As such, I had to change the base material. There were some experiments with reindeer bone

china but they would have been really hard to obtain and possibly way too expensive for the prototyping uses.

Rice porcelain would have been too distractive with the lighter dots, the rice in the clay, shining too much light through the porcelain. Therefore the chosen material was ordinary china porcelain clay. In addition to this, I made a couple copies with bone china, in which the bone came from cows and pigs. The bones are by-product, just like wool and leather.

Since the mechanical parts would not be visible in the product, they were present in the design process only via how much room they would take in the parts of the Candle UI. To make it work like it was designed, there had to be room for the mechanical parts to sit and function in.

5.3 Analysing Related Products

I started the design process as always, with benchmarking products that already were being made or were in the process of gathering the needed funding. The location did not matter, since these days you can order products from all over the world. Later I took a look of studies made in other research facilities and compared them to this research.

This method is called benchmarking. It is a research method to find out if there are products, research or even business with the same or close idea or design. This is to prevent creating something that has already been done, one way or another. In addition to this, benchmarking helps finding resources to utilize in your own research and design process.

The main focus of the products in search was in different kinds of lighting, whether it being ambient or active in their functions. Another main focus was on products that were meant for long distance users. For example lovers, friends or family, who live far apart from each other. That does not mean that the product could not be used for short distances too, for example in the same city. Most common ways to connect two different products that were far apart from each other were mostly using wireless network. If the objects or products were close enough, a Bluetooth connection would suffice.

In addition to this, the product should contain two copies of the same item, to have the two way connection established. If not, there should be a way to contact the product, for example via a smartphone application.

The crowdfunding sites were quite fertile grounds for finding products with the previously mentioned qualities. There were few products that were gathering funds for the production of the product; some were more successful than others.

Lovlit Candle

First what came up with the search was the LovLit Candle. Lovelit Candle is an interactive, electronic candle. It was created for emotional communication for relationships far and near (figure 8).

Figure 8, Lovlit candle on a bookshelf

> Lovlit Candle: A New Way to Connect with The Ones You Love
>
> An internet-connected, flameless candle that connects you with your loved-ones anywhere in the world. With just a gentle, prolonged hold, the Lovlit Candle illuminates like magic. It is so simple and easy, people of all ages can use the Lovlit Candle.

> And if you are away from home, you can light a loved-one's candle using the Lovlit Candle's application (From Lovlit Candle Kickstarter page).

It has two electric candle cups which can be set just by holding the device. The same candle can be lit from different candles and you can check via smartphone application who has lit it and when (figure 9).

Similarities are that both have two-way connection. When the Lovelit has been seen, the other user can "reply to it" by holding the candle in hand. This will light the lower lights on it and when both are lighten, the connection has been made. Another difference between Lovlit and the Candle UI was that the other end can then turn it off without turning the receivers candle off, unlike in the Candle UI, which will turn off the electric candle when the real flame has been put out or it has burned itself out.

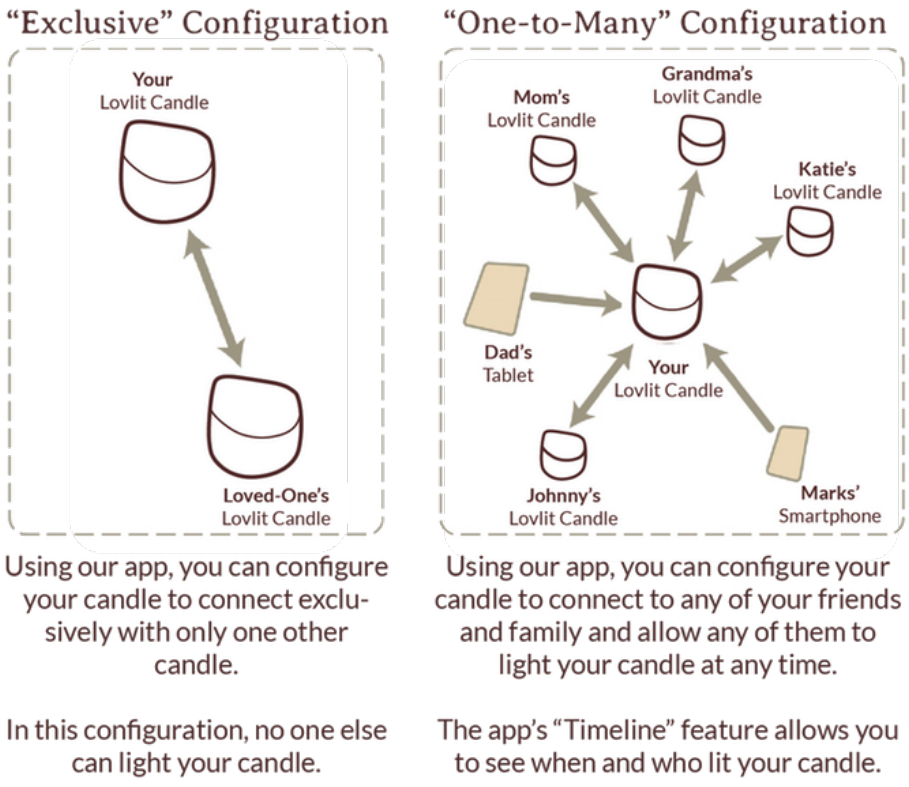

Figure 9, functions of Lovlit

Unlike Lovlit Candle, the Candle UI has more functions and has actual living flames. Lovlit needs an application to functions like checking who has lit the candle, since it can be lit from multiple other candles and from the application itself too, when the Candle UI needs an application to connect and disconnect itself to internet and to the other Candle UI set of flowers. And with Candle UI you always know who lit the candle on the other end without checking any application.

LoveBox

LoveBox is a wooden box with a simple electronic screen to display messages which are sent from a smartphone application. The user can reply to the message by spinning the heart on the side of the box, which will send a "rain of hearts" to the sender to confirm the message has been received (figure 10).

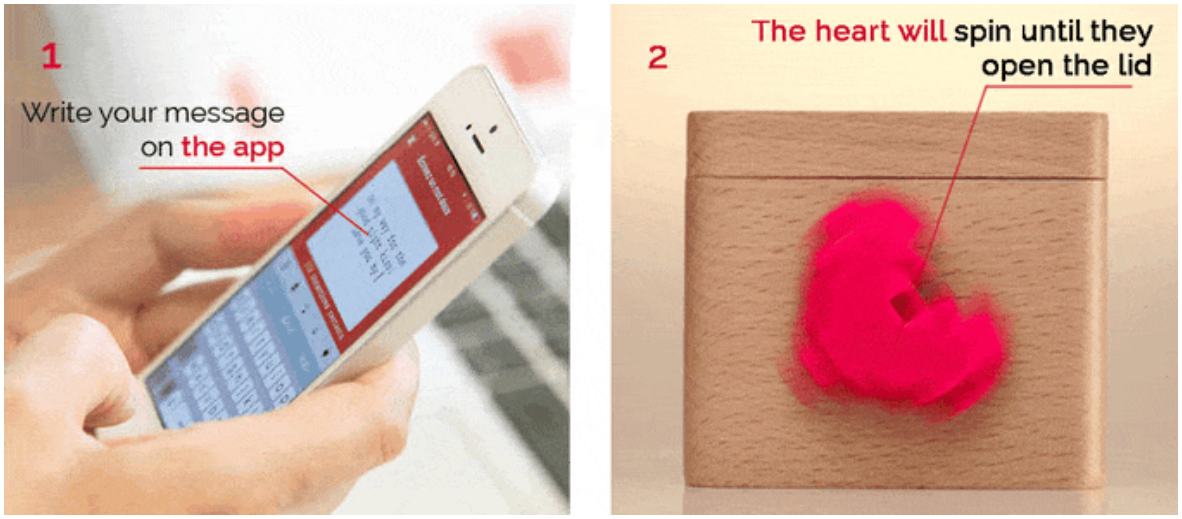

Figure 10, LoveBox parts

LoveBox was designed by Xavier Houy.

> Gift a Lovebox to your loved one. When you send a message, the heart spins until they open the lid and discover your message inside (from LoveBox Kickstarter page).

Unlike the Candle UI, LoveBox does not have a second copy of the product to work as the sender and receiver. Instead, it works with the smartphone as sender and later the receiver of rain of hearts.

> Can anyone send a message to the Lovebox?
>
> It is not the philosophy of the Lovebox at all. A very limited number of people (between 1 and 20 people) can send messages to the Lovebox. You'll decide who are these lucky ones when you set it up (LoveBox Kickstarter FAQ).

However the LoveBox needs the internet connection to function with the smartphone application, just like the Candle UI. Using open internet connection, such as from internet cafe, is not recommended to be used as the connection. LoveBox also does not have a noticeable light source built in it, but it is designed for emotional communication and long distance relationships, thus included for related products search.

Figure 11, Long Distance Touch lamps

Long Distance Touch Lamp

Long Distance Touch Lamp is like the name suggests, a lamp designed for long distance relationships. It is an ambient enhancing light which can be activated with the user touching it (figure 11). Long Distance Touch Lamp was designed by John Harrison and Vanessa Whalen.

> Light up a loved one's life—across town or across the country— with two or more of these in-sync lamps. When you turn one on with a simple touch of your hand, its mate emits the same ambient glow, no matter where it is and who is on the other end: Parent or grandparent, niece or nephew, or long-distance significant other (*product site*).

The product changes colour every time the user touches or taps it, and that indicates the emotional message has been received. They are connected together via wireless internet connection.

Long Distance Touch Lamp is the closest product to Candle UI I had found during my research. The both have illuminating features and they need to be connected via wireless internet. The differences are that with Long Distance Touch Lamp is illuminated wit electrical light only. Other is that the Long Distance Touch Lamp has colour changing light, which was considered as a bad feature with the Candle UIs focus group.

The illumination on Long Distance Touch Lamp can be set on with a tap and the length of the illumination can be set with a timer and it will fade of in 1.5 hours to 8 or 24 hours. The Candle UI is turned on by kindling the candle and it will fade off when the candle(s) have been completely burned.

Related work research

In addition to benchmarking, I made related work research on other researches made on the same and related topic on hand. These covered researches made by other researchers in their research facilities. There were very few researches made close to the topic of this thesis.

LumiTouch

Lumitouch is an emotional, semi-ambient communication device, which consist of pair of interactive picture frames (figure 12). They are designed for long distance relationships. Lumitouch was designed by Angela Chang, Ben Resner, Brad Koerner, XingChen Wang and Hiroshi Ishii.

Figure 12, LumiTouch Frames in use

> While existing technology already enhances the connections between people, most require active focused participation. New communication devices tend to be multimedia, supporting many different types of content (integrating text, audio, video). Over time, users feel the need to augment these existing communication mediums to convey emotional qualities. LumiTouch explores a design that solely supports emotional content (Chang, Resner, Koerner, Wang & Ishii, 2011).

The picture frames work via wireless internet connection. When the user touches their picture frame it causes the other picture frame to light up. The picture frame holds the picture of the loved one, who has the other picture

frame from the pair. It is similar to the Long Distance Touch Lamp by how the emotional communication is exchanged, but instead of tapping the device, user squeezes it. The illumination, the length and the strength of the light, is determined how the user squeezes the picture frame.

Similarities to Candle UI are the lights and that it operates via wireless internet connection regardless the location of the picture frames. Both are more suitable for ambient than active form of communication. But like the previous products from the related search, the LumiTouch also has only electrical light source. And it is a pair picture frames.

Tell-Me Presence

Tell-Me Presence is an exploration into how networked, physical lighting objects can be utilized to facilitate intimacy over long distances (figure 13). This project was the result of the Physical Computing course with Hideaki Matsui, Umesh Janardhanan, Zubin Pastakia, Andrew Nip. I did not find any research papers on this one.

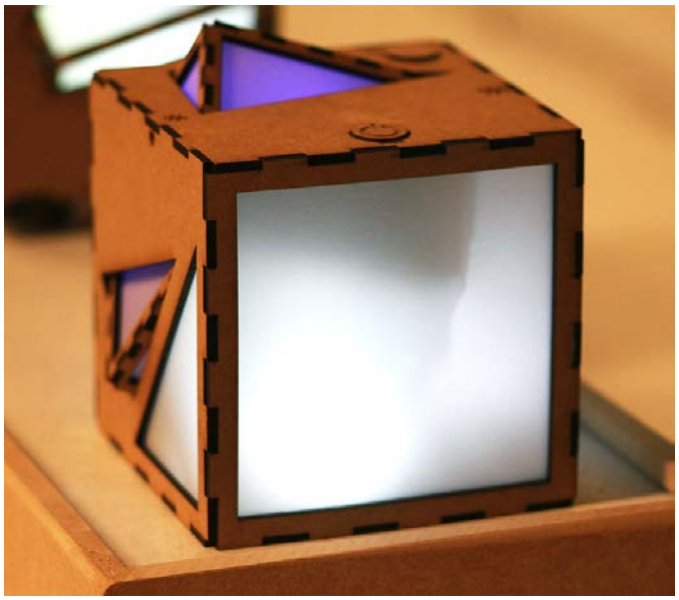

Figure 13, Tell-Me Presence

Designed as twin-objects to be shared between lovers, family members or close friends, the lamps serve as a simple interface to communicate the presence of another non-verbally. The cube-inside-a-cube physical structure allows the larger part of the lamp to continue to function as an ambient light, while the

smaller, nestled cube serves as a presence indicator when a light “message” is sent from one person to the other.

Tell-Me Presence works by placing your hand over the light. The device will then sense the hand hovering over it, and you can send your presence to the other side by changing the light in the other device.

Related Products Benchmark

The other benchmark research I made was about the candleholder itself. The main shape was a flower, which is quite used shape in general. And the same theme in design can be found in multiple cultures.

As for materials, I searched for china and porcelain cups and candleholders to see how the light shines through the material. China and porcelain are also fireproof and with various kinds of glazing the look of the Candle UI could be changed.

The only risk from the design was from the porcelain cups, which might cause the stearin to vaporize and cause the whole insides of the cup to burst into flames. Though that phenomenon is quite rare, the risk is still there and therefore the burning candle should never be left unattended.

6 Design and Prototyping of Candle UI

Here in this chapter I will explain the process of making the prototype for Candle UI from start to finish. I explain the steps in depth of the each step as the process goes on.

6.1 Designing and Prototyping the Candle UI

Sketching Phase

I started the process by sketching a lot of different ideas and shapes how the Candle UI could look like. Usually the sketching is done with pen-on-paper style using black ballpoint pen. But in this case, I felt that black coloured pencil would be a better choice for the task in hand. Later, if the designer wishes, it is possible to add some shading to bring out the shape of the object using markers such as Copic brand markers. I started from basic shapes and added details on them to make the design more interesting. Making paper sculptures and shapes in the real size also helped a bit with the forming of the design.

From the very beginning, I felt strongly drawn towards to “natural shapes” such as different parts of plants and flowers. Thus, the Candle UI is a set of flowers resting on pair of simple leaves instead of shapes like cubes, triangles or spheres, though those geometrical shapes were few of the possibilities as well (figure 14 and 15). The figures 16, shows the other concept shapes and surfaces that were considered for the Candle UI base. Figure 17 shows the possible candle positions for different shaped bases. Figure 18 shows different silhouettes for the flower. The figure 19 shows how the size and shape were taken into consideration. It also shows combinations of shapes and sizes and how they would look like. Figure 20 shows the possible positions of the overlapping leaf bases. Figures 21 and 22 are final shapes of the flowers, and in addition 22 has possible sensor placements included.

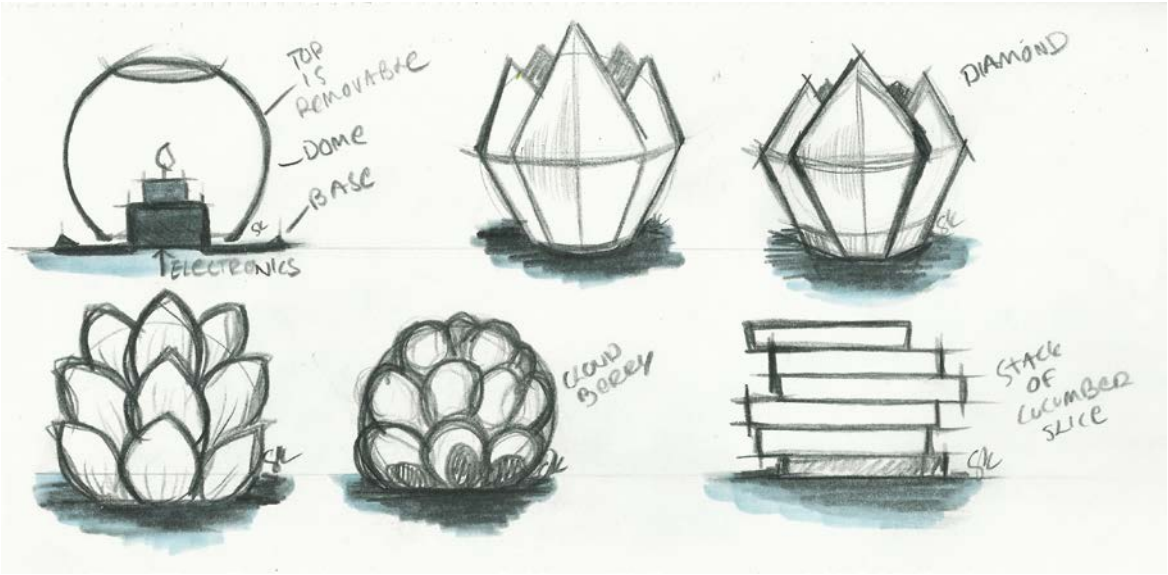

Figure 14, shapes

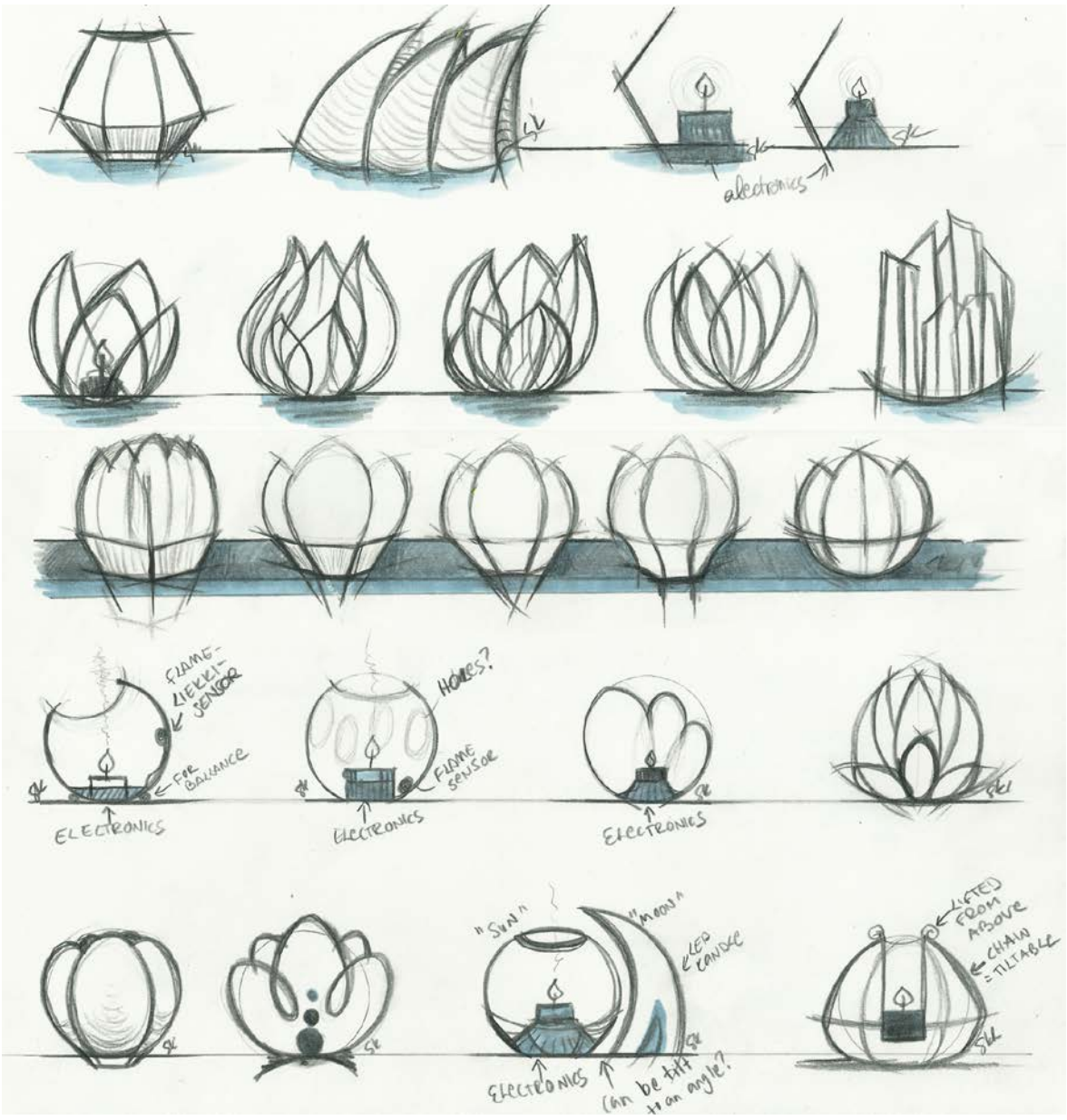

Figure 15, possible shapes of the user interface

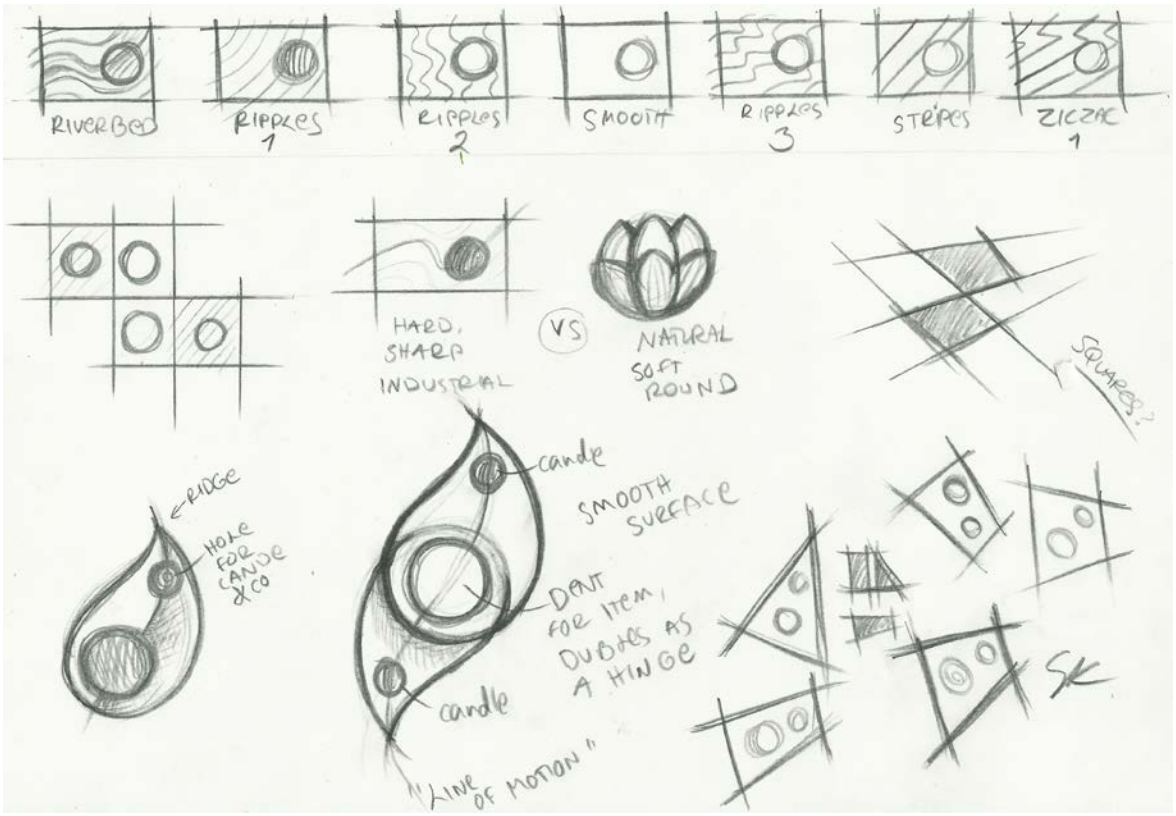

Figure 16, other base options

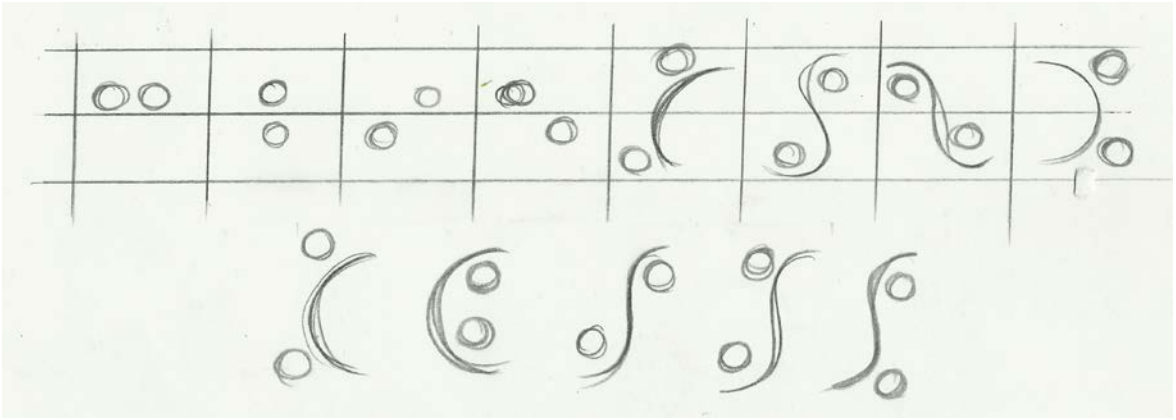

Figure 17, possible positions

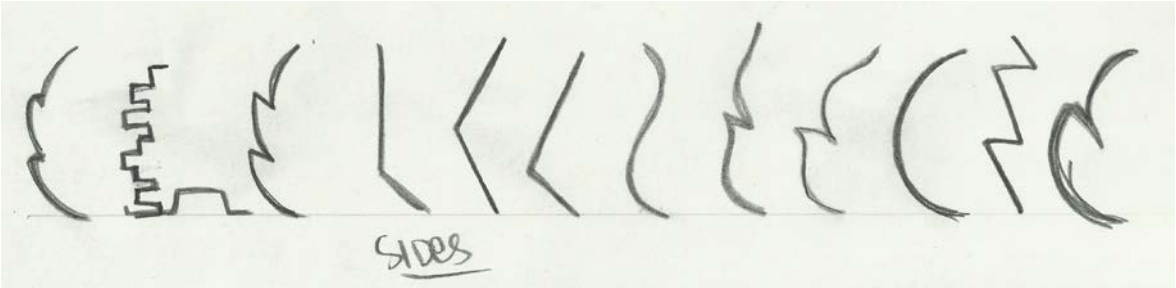

Figure 18, possible silhouettes for the candle stand

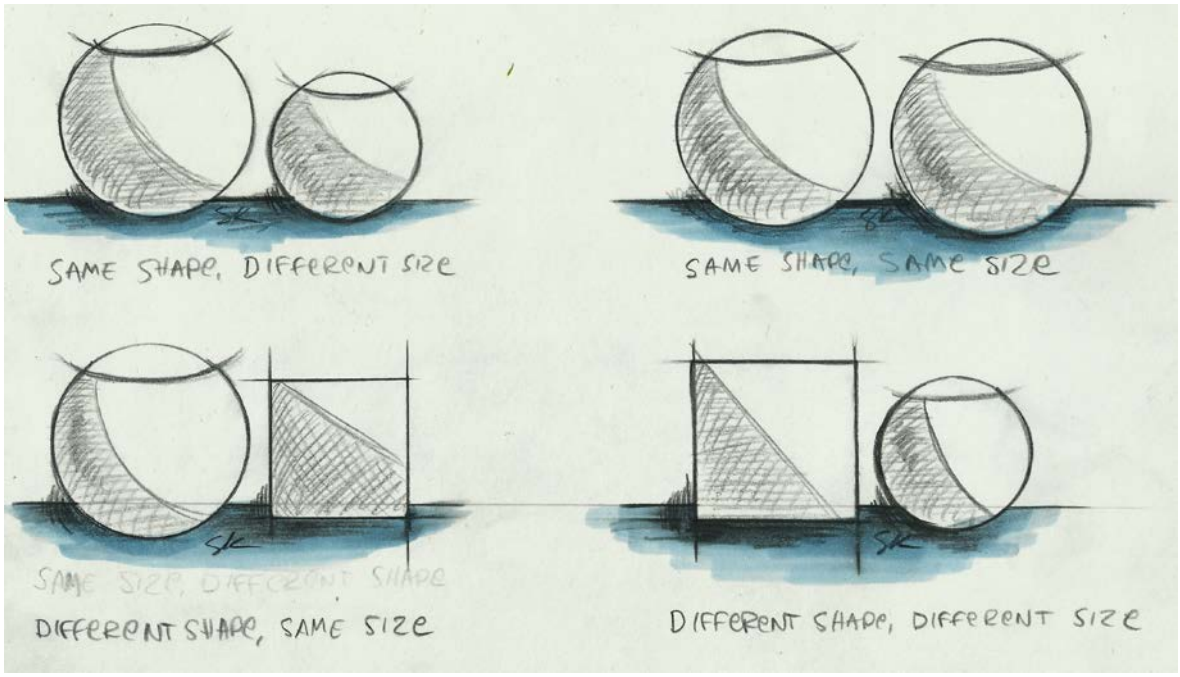

Figure 19, shape and size options

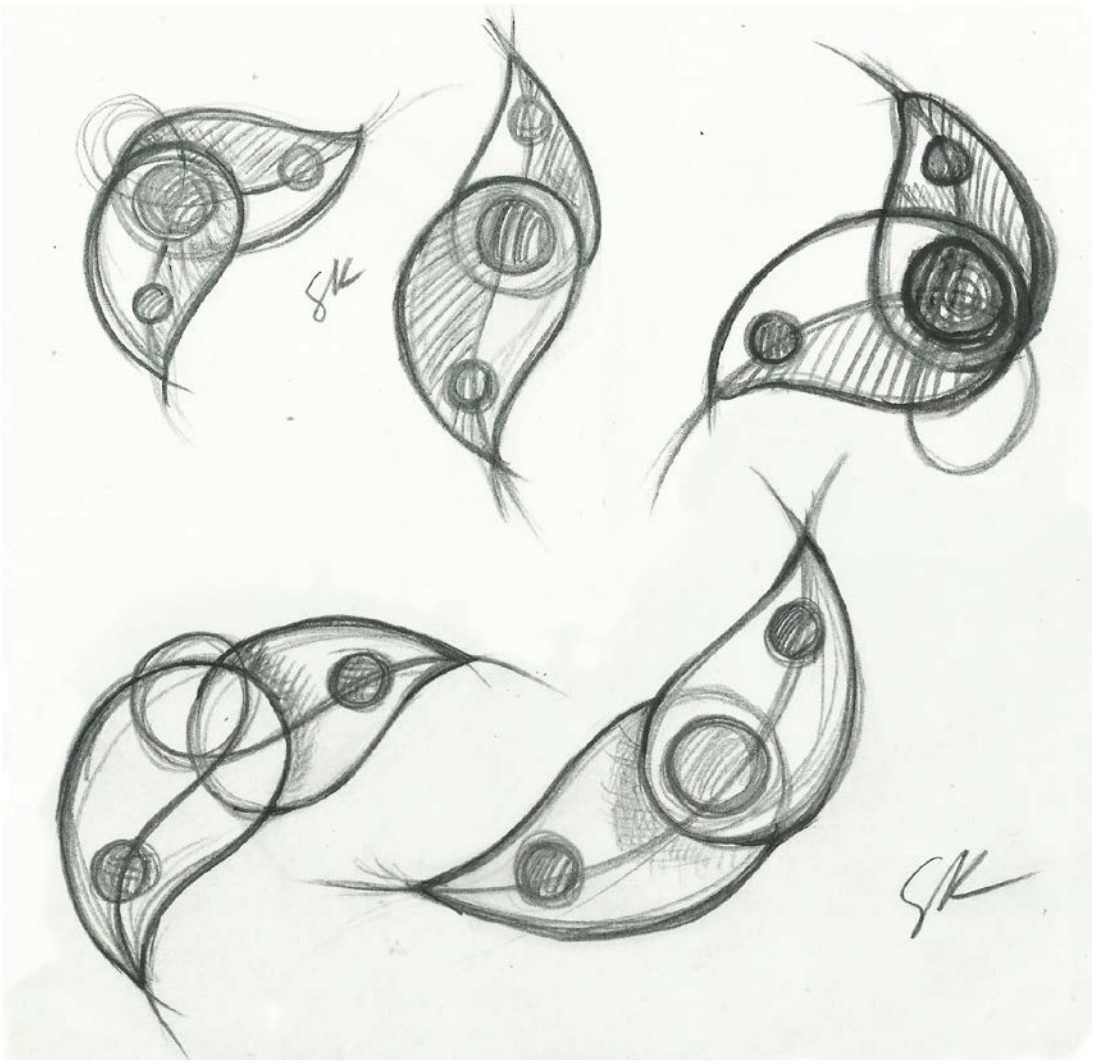

Figure 20, positions of the leaf shaped base

Figure 21, final shapes

Figure 22, possible placement of electronic parts

3D Modelling

After sketching it was time to make the 3D model for the Candle UI cup (figure 23). The modelling took some time since it was a bit of a challenge to make the 3D model look like the sketches I made. I decided here not to add the outer, smaller layer of petals to the 3D model, since it would be easier just to add the outer, smaller petals to the CNC machined object and then make the multi-part plaster mould of it. The leaf shaped base was not virtually modelled since the shape was simple enough to be sculpted by hand.

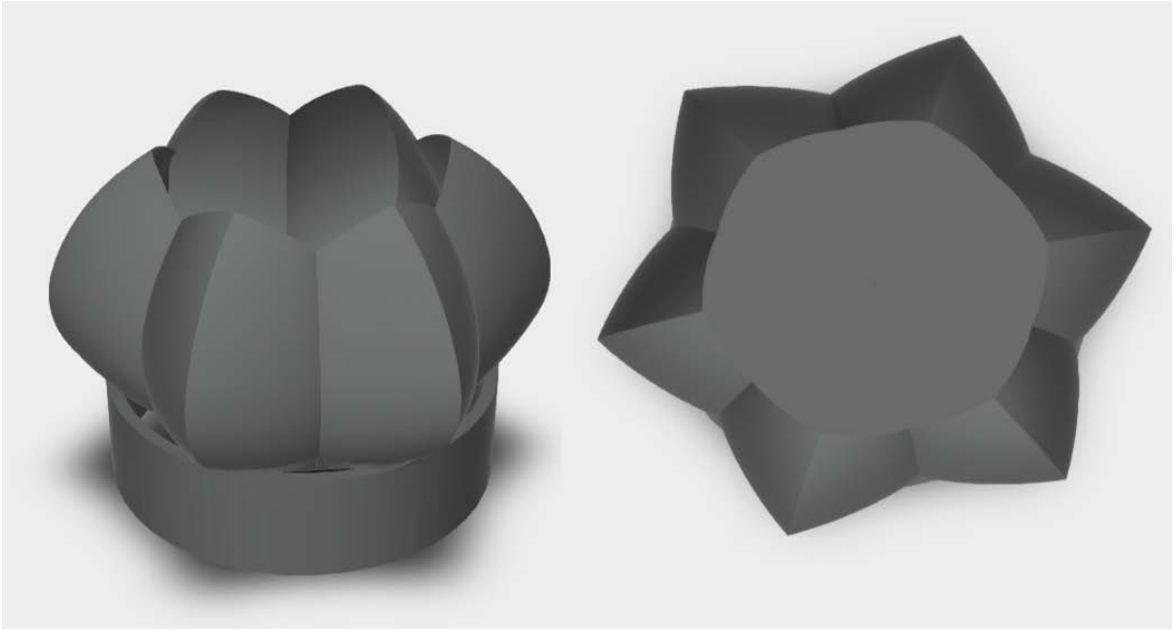

Figure 23, Candle UI flower on a placeholder base

CNC Milling

After the 3D modelling was done, the Candle UI pieces were transferred into CNC machine, a computer aided drilling and cutting machine, for making an object to be later cast in plaster (figure 24). The milling process was slow since I did not want to have unnecessary after machinery work in smoothing the surface. And since the CNC machine at the university workshop has only two axis milling option, the Candle UI cup was split into two halves and machined in two identical halves. They were later glued together. I only machined the Candle UI flower part since the leaf bases were much easier to sculpt by hand.

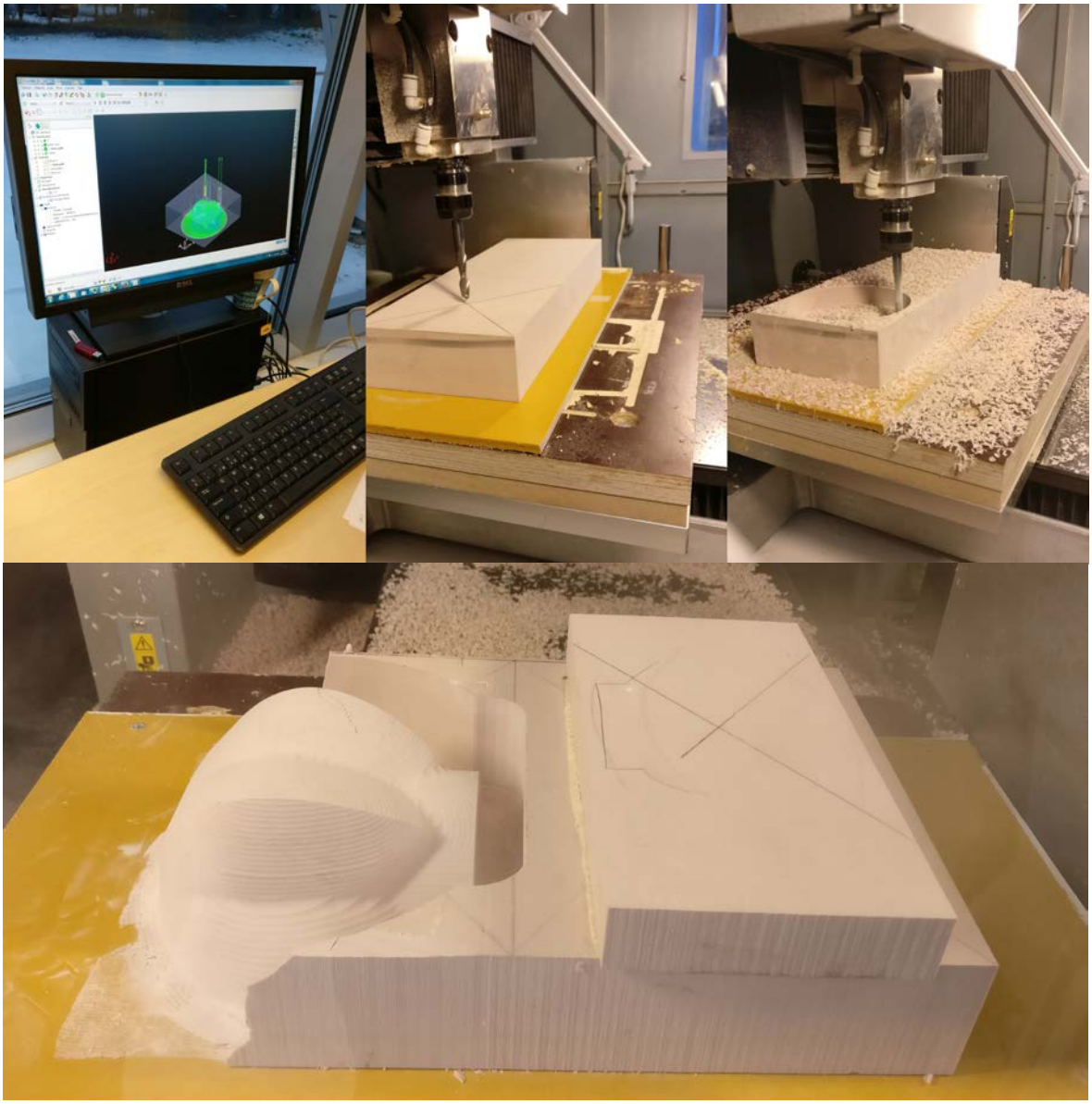

Figure 24, CNC milling

Finishing the Mouldable Objects

The cutting process took a while and in the end I had to smooth the surface with different kinds of putty. For the second layer of petals I used a sheet of soft craft foam since it is easier to cut and glue on the surface than creating an even layer of putty (figure 25). It was also pretty easy to harden with a thin layer of spray putty and glue. After fixing the surface it was time for the finishing coat of spray putty and spray lacquer.

The leaf bases, like mentioned previously, were carved out of flat sheet of clay (figures 28 and 29). The base leaves did not have any other features than holes to put the Candle UI flower cups and the dent on the larger leaf to place the mementos on. The surface was left smooth on purpose so the Candle UI cups could be on the centre of the attention.

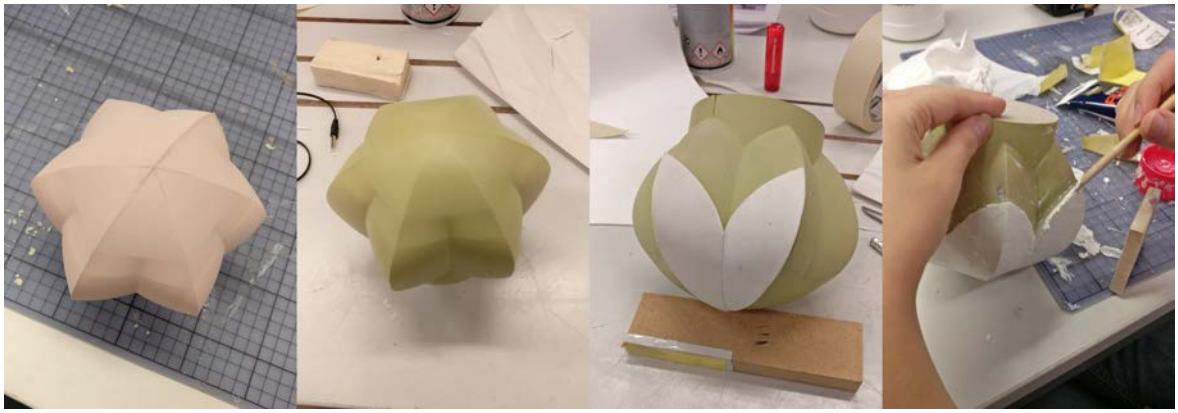

Figure 25, phases of prepping the surface textures of the flower cups

About the Variations between the Two Candle UI Flowers

Because I wanted to have a variety on the external surface texture, I first made a rough surface and cast it on plaster (figure 26). Because of the shape of the Candle UI the plaster mould was made in six parts. If it had been made of fewer parts the Candle UI might not come out from the mould in one piece or it might even get warped. After moulding it (figure 27) the rough surface was easy to peel off from the soft foam sheet and then smooth out again for the smooth mould.

The idea behind the different textures was to create a bit of tension between the cups and that it would be easier to recognize which cup was for which candle. The leaves would also have size difference between them for this same reason too.

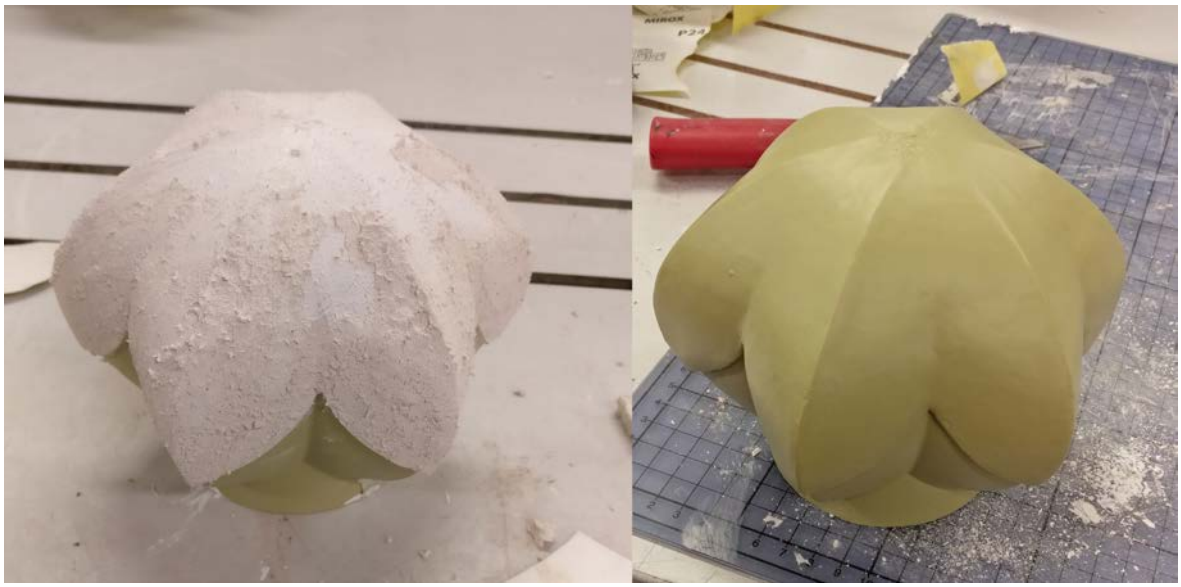

Figure 26, the surface tension in the mouldable object

Figure 27, making the flower cup mould

Figure 28, sculpting the bigger leaf base

Figure 29, moulding the smaller leaf base

About the Materials

Because the porcelain clay, especially the bone porcelain, is almost impossible to roll out as thin sheet of clay, I diluted the clay with water into soft, silky goo like substance, which I used like regular casting clay (figure 30). The difference was that the soft goo did not have one of the main ingredients of the casting clay. But when the porcelain clay has been fired in the kiln, the materials qualities come more visible and it can be seen why it was chosen for the material. For example, the thickness of the clay can be thinner with porcelain and the light shines through the clay better and can be perceived as more beautiful than clay candle stand made with ordinary clay.

Figure 30, casting process of the flower cups

Though the results were pretty much the same with both types of the porcelain clay, the bone china took a bit longer to set into desired thickness in the mould and to dry enough to be removed from the mould. It was still a far better way to work with it instead of painstakingly slowly moulding the rather runny clay into the mould, one sheet at the time when there was no guarantee if the sheet of clay would stay intact from the rolling table to the mould.

I also lost the other mould I made previously when the room it was stored in was refurnished. This only slightly slowed me down when instead of casting I had to smooth out the rough surface of each flower I wanted to have the smooth surface. In the end, the prototype turned out better than I anticipated, even with these little setbacks during the prototyping process.

Finishing the Prototype Porcelain Parts

After casting the Candle UI parts into a plaster mould it was time to for wait the clay to dry completely and then to fire them in the kiln for the first time (figure 31). The drying of clay is crucial since if there is too much moisture inside the clay, it might evaporate in the kiln and demolish the clay artefact. The drying process should not be too fast. If the object dries too fast, it might warp or even crack the clay and thus the object should be re-casted. Thankfully the clay is re-usable with just re-dissolving it with the same liquid casting clay it came from. Just add some water since the water is absorbed to the plaster mould.

Figure 31, parts drying

The temperature in the kiln in the first firing is not as hot as the final firing, as the purpose of it is to prepare the clay for the glazing. Some artists tend to fire their ceramic products or ceramic art in one firing to save time of in the

electrical bill, but it is safer to do the firing in two rounds. And some materials used for the glazing, such as the underglaze, needs the two firing rounds to work as designed.

After the first firing, I glazed the Candle UI flower cups to prevent the soot, smoke and ash from the candles tarnishing the white porcelain clay inside the Candle UI flower cups. The glazing would also provide a surface the light from the burning candle to bounce and make it easier to the flame sensor to catch on (figure 32). And when the insides do get dirty, with the glaze it is easier to clean by washing it by hand. Using the dishwasher is not researched but like porcelain clay in generally, it is recommended to wash them by hand to prevent them from shattering into pieces.

Figure 32, right after applying the glaze

Adding electronic parts

After the second firing the porcelain parts were done and it was time to add the electronic parts to the prototype. This included the flame sensors and an Arduino with wireless network adaptors. For the electrical candle was an electric tealight used to mimic the flame, since it already had the necessary electrical components to mimic the real flame. This also decreased the workload of coding since the changing of the electrical candles flame colours was not needed in the code.

I also needed to create a pillar-type structure to hold the candles in place and at the right height, and a base for the flame sensor to be placed on. They were made of different shapes block of wood and hot-glued to the base leaf structures. This ensured that the candles and other parts would stay in one place and the prototype would work s it was designed to work.

Application Design process

I made only a mock-up application front page with the function map the app could have for the Candle UI since it was not necessary to get the application to work. I just felt it was necessary to make a mock-up app as part of the design process, for it felt incomplete without it. And this is user interface Master's Thesis project, I felt that there should be the user interface used to control the Candle UI included in the work.

In the beginning the task was benchmark similar applications that connects two objects together, such as a smartwatch or Bluetooth headphones with a smartphone or users computer. I also wanted the Candle UI application to reflect the physical product's design in graphics so the same flower was added to the graphical user interface of the app.

The applications main function is to get the Candle UI to connect with a router at the user's home, so only few buttons and text command lines would be needed in the finished, functional application. Used information is the ID of the Candle UI device itself and the router information, such as the router name and the used wireless network password.

The two Candle UIs should be already connected together so there is no need to find each other through the internet. There should also be a button for disconnecting the Candle UI from the internet. If the connection is lost, they should be easy to connect back together simply by using the Candle UIs individual ID number programmed into the code used to make the Candle UI work. Sketches of the layout and elements, figure 33.

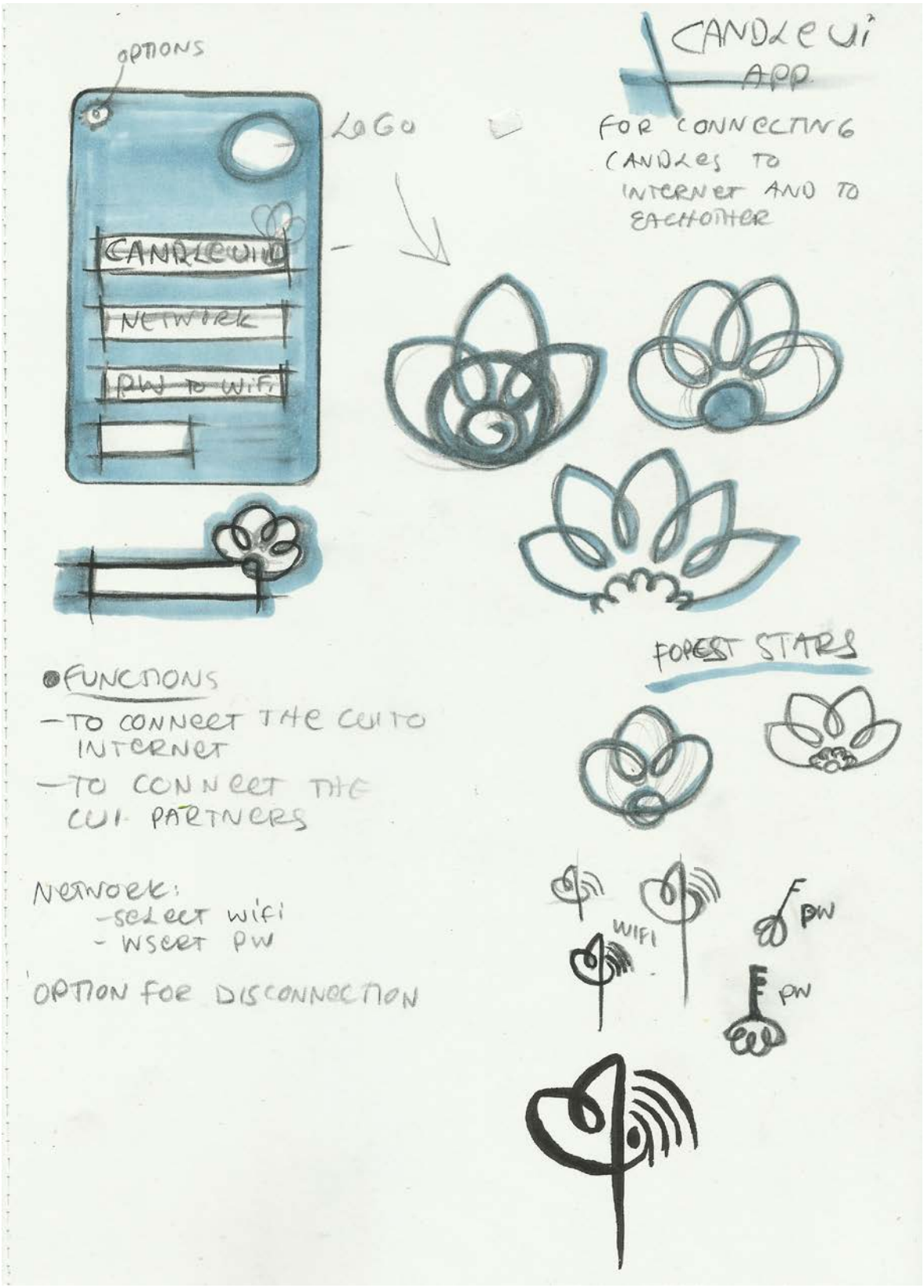

Figure 33, application sketches

Application prototyping

There are many great, free ways to prototype an application for smart device without actually coding it first. Online websites to create mockup applications, paper models, mind maps and service paths are few to mention. For this purpose I chose just a simple mind map to show how the paths of different parts of the application work and, which button has what function (figure 34).

The application in hand is designed for the Candle UI to be connected to a wireless router at home, so a smartphone is the most usable option to connect those two if you don't want to use cables to connect them. And if the two sets lose their connection, there should be a way to manually set them back together.

The most challenging part was to create suitable graphics and choose the right colours. The application itself is really simple in the end and doesn't have many functions. The colours and shapes of the smartphone application have impact on the user experience when the application is in use.

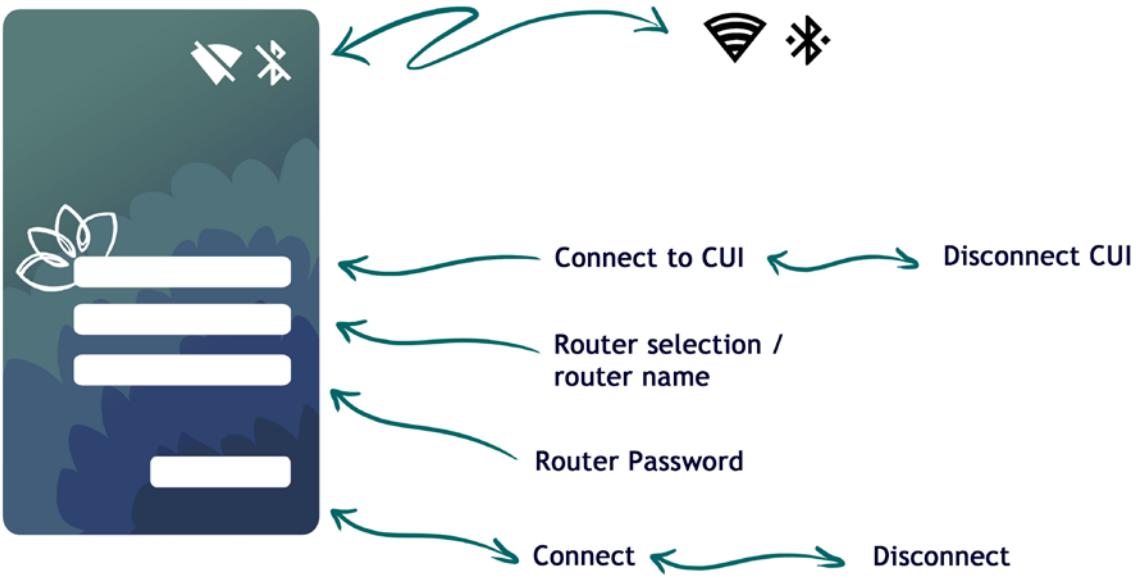

Figure 34, application paths

6.2 Final Prototype and Its Evaluation

The functions of the final prototype are pretty simple and uses two-way-connections. The user interface also requires only a small amount of effort from the user, mainly it is noticing their electrical candles light and then lighting their own candle (figure 35 and 36).

The Candle UI consists of two identical candle stands with one real candle and one tealight. First the user who wants to send an emotional message to their chosen loved one and lights up the real candle from the candle stand with their chosen method. This can be, for example, a matchstick(s) or with a cigarette lighter. This causes the flame sensor to activate in the Candle UI stand and it will send a signal via wireless network to the other, the receivers Candle UI stand. This will light up the electric tealight and it will burn as long as the real flame is burning in the first candle stand. When the candle burns out or is put out, the electric tealight will also turn off in the Candle UI stand. It will only burn when there is a real flame present.

Figure 35, Candle UI set, both candles burning

Figure 36, Candle UI sets

The receiving user needs to notice this light burning in their candle stand and then it is their turn to light up their real candle from their Candle UI stand. And as seen when the first candle is lit, this will also send a signal to the other, first, candle stand and light up their electric tealight. When all the candles are burning, the emotional connection has been created.

To evaluate the final prototype of the Candle UI another focus group study was conducted. The responsible person of the focus group study was Hong Li, who conducts doctoral thesis research on emotional communication, and Candle UI was passed on to her for user study purposes. In the following, the focus group and its key findings are summarized.

We recruited six participants (four female) who were students and staff at the university and had a median age of 32 years, with 4/6 from non-design background. The participants were recruited with the criteria of being involved in a steady long distance relationship (Li, H., Koskinen, S., Colley, A. & Häkkilä, J., 2018).

Participants of the focus group evaluation tired the Candle UI / Connected Candles demo prototype when they were in remote locations. They were given introductory explanation about the aim of the Connected Candles demo, the purpose of the study and what their roles were. The other tasks for the focus group was to evaluate other concepts of emotional candles. They were a commercial candle with a real flame, lit by a smartphone app. Other was digital candle mobile app which would be connected with a picture frame of the loved one. It would then light to signal the loved one is being thought of. And third was the Candle UI / Connected Candles demo (Li, H., Koskinen, S., Colley, A. & Häkkilä, J., 2018).

Participants were asked to evaluate the concepts using the product reaction cards (PRC) and by selecting five terms to describe the concept. They were also asked for their consent and background questionnaire, light the digital candle in the mobile application and evaluate it by using PRC, evaluate the Connected Candle after they tried the demo and later imagine the demo in the daily lives and based on that draw a storyboard scenario.

> The digital candle app was described as simple (3), visually pleasant (2), and inspiring (2). It was also deemed as useless (4) in their long distance relationship. It was also perceived as unclear (2), difficult to use (2) and complex (2) (Li, H., Koskinen, S., Colley, A. & Häkkilä, J., 2018).

> The Candle UI / Connected Candles demo was perceived as visually pleasant (4), innovative (3), easy to use (2), pleasant (2), desirable (2), responsive (2) and useful (2). The design appealed to most of the participants aesthetics (5/6) was described as “spiritual design” (#2), “something that I’d put on my table” (#3), “novel idea” (#4), “lovely decoration” (#5) and “natural unlike fake digital candles” (#6) (Li, H., Koskinen, S., Colley, A. & Häkkilä, J., 2018).

However, there were some concerns towards the use of a real candle. Participant #5 considered the real candle was uncontrollable, as the real candle in the demo was somewhat small and would run out quickly. “It’s fun to expect both candles lighting up at the same time, but with real candles you can’t control how long it will last.” (#5). Participant #1 was not fond of the design and raised a question: “Instead of a fixed shape, why not make it customizable?” (#1). Participant #1 suggested that the shape of the design could be customizable, so that users are be able to personalize different shapes that would fit their aesthetic preferences. Participant #4 also suggested that pleasant scents could be added to the real candle as a subtle clue for users to notice the candle flame. Most of the participants (5/6) were able to picture how the Connected Candle could be used in real-life scenarios. However, participant #1 felt she could not use it in her LDR, due to the time zone differences she had with her remote partner. Interestingly, in the storyboard of participant #5, the shape of the demo was customized to a cat-shaped candle, which could make a ‘mew mew’ sound when the connected candle lit up, to remind users to pay attention to the connected candles (Li, H., Koskinen, S., Colley, A. & Häkkilä, J., 2018).

7 Discussion

This chapter covers the topic of the research questions and the discussion of what came from the results. At the beginning I will involve the research papers done based on this Masters' Thesis project to the discussion. Focus group I is presented in the paper by Häkkilä, Lappalainen and Koskinen (2016), and Focus group II is reported in (Li, Koskinen, Colley & Häkkilä, n.d.).

7.1 User Perceptions

The Focus Group I Candle UI prototype was deemed as a useless, easy to forget gimmick at first, but after the users tried to send a message the apparatus and saw how it actually worked it got better reacceptance and a set of various use scenarios came up from the discussion. The feedback from the prototype gave me design drivers to work on the next and final prototype (Focus Group I).

The final Candle UI proto was well received by the evaluation focus group. The candle stands were perceived as visually pleasant, innovative, easy to use, responsive and useful. They created a warm and comfortable atmosphere. It was even compared to spiritual design. There were differently perceived aspects, such as that the candle could be scented if the electrical candle light goes unnoticed (Focus Group II), when in the first focus group the participants were against the idea (Focus Group I).

The Candle UI prototype was perceived well and the participants could imagine the user interface to be used in long distance relationships, unlike in the Focus Group I evaluation of the first prototype. The concept of the candles was well understood and it was reflected on the scenario storyboards. But when the difference between time zones is too great, the recipient might be asleep or at work and will not see the emotional message sent to them. The real flame of the

candle raised some concerns among the users, as well as the cultural connotations of the candle itself (Focus Group II).

Most of the small group of participants were able to picture how Candle UI would work in real-life situations, but there were concerns about larger differences of time zones between the long-distance relationships and whether or not the emotional message would be missed by the recipient for one reason or another (Focus Group II).

The candle as part of the user interface was received mostly well in both groups, the focus and evaluation groups. The concept was perceived to provide a warm and soothing atmosphere and subtle communication. The naturality of the candlelight was perceived as an important part of the prototype. The real flame of a candle was also perceived as a classy element, such as when in a fancy restaurant the waiter would light up the candle in your table. The candle uses different human senses, such as the sight and smell, to create an ambience to the room. It was also agreed that lighting the candle represented an old ritual from the early steps of humanity when our ancestors learned to wield fire. For some users the candles represented an urban campfire in a smaller scale (Focus Group I).

The candle also carries large cultural weight and meanings since they are linked into many traditions in multiple cultures. However, here was also the connotation to religious aspects of the candle. Lighting up a candle was deemed as a gesture to memorise people who had passed away and thus perceived negatively (Focus Group II). By adding a digital element to the process, it can function as a remote empathy (Focus Group I). The ritual of lighting the candle was also deemed as a moment of calmness and relaxation that needs its own time that cannot be rushed (Focus Group I). There were suggestions that the adding a digital flame to increase the expressiveness of the candle and thus

introduce a larger set of emotions, but also it might attract more visual attention (Focus Group II).

The electrical candle and the artificial colours might change the user experience to negative direction (Focus Group I). Unlike in the first focus group interview, the electrical candle in the Candle UI was perceived more natural than fake digital candle app concept (Focus Group II).

7.2 Answers to Research Questions

Q1: Are candles usable as emotional communication interface?

Candles themselves were perceived mostly as pleasant items. The candles themselves created a warm, soothing ambience when they were lit and were perceived as an invitation to calm down and relax. In a way, by sending emotional message via a candle powered user interface, it is an invitation to relax with the sender.

As how they suit as part of a tangible ephemeral user interface, the choice was right for the task. The ambient properties of the candle as an ambient enhancer do get to shine in the final product. The materials used in candles place in the scale of ephemerality based on their size as in how much fuel, stearin, the candle is packing with. Since the small tealight candle used in the user interface can burn up to several hours, the ephemerality of the user interface is quite fast. The used candle is designed to be easily replaced with another tealight.

The ambience the candles create may, however, be perceived differently based on what kind of emotional and cultural properties the candle has within the culture. Based on this the Candle UI is not meant for everyone to use who are in a long distance emotional relationship, or have close relatives far away. The

Candle UI would have a small marketing niche targeted towards the users, who perceive the Candle UI as it was designed, as an ephemeral ambient communication device.

This is not a bad thing in the end, for to design a product that pleases all its users is still quite an impossible task to achieve. If the Candle UI was more customizable, it might have a bigger audience. This, however, would require a different production process and maybe even the change of materials from delicate porcelain to common clay.

Q2: How was the designed candle user interface perceived as a tool for emotional communication?

About the prototype

The Focus group gave me design drivers to use for the final Candle UI design. Since it was first deemed as a gimmick that would be forgotten within few days, I redesigned the functions and added parts to it to be a two-way candle operated user interface to encourage the prolonging of the usage of the product in hopes that it would be received as a useful device for emotional communication.

The design of the user interface was perceived well with the Focus Group II. The shapes of the design were pleasant to the eye of the user and thus they would place the user interface to a place they could look at. Also the concept of the Candle UI / Connected Candles was well understood and the participants were able to imagine the demo in use in their daily lives. However the real flame brought up some concerns of fire safety issues.

Since the Candle UI was targeted towards long distance emotional relationships, for example, between lovers, friends or family members, I feel that that the Candle UI device fits in the task quite well. Because of the chosen parts of the Candle UI, mainly the wireless network adapters, the other pair of the candle stands can be anywhere in the world. This includes also users living in the same area like cities or towns, for there are no requirements of how long the distance between the candle stands should be. However, it seems that the user interface device works best when the distance of the users is not too large, for example, only couple of time zones away or the users are in different sides of the same country. People living half a world away do have difficulties to use the interface properly due to the time difference between them.

The Candle UI prototype has its pros and cons. Pros for being a unique product, which has no other product to compete. As shown in the chapter five, the benchmark results shows that there were no similar products that uses candles and ambient communication as part of itself. There were couple candle like products but when examined closer, there were no real flame used in the product.

Cons were about the cultural connotations of the candle in different cultures and how uses perceive them. These cultural connotations should be considered when using a candle as communication medium in certain cultures. Another was the fire safety issues with the real flame in use as part of the user interface.

About the functions

Like previously mentioned in the design process of the Candle UI, the user interface was designed to be a two-way interaction since the one-way – text or other signal to the candle as shown in the prototype evaluated in the focus group interview – felt too much one-sided. The focus group participants felt that

if the user has time to send a text message to the candle interface apparatus, they would have the same time to send an actual text message for the recipient.

By having the product requiring the user to perform two-way connectional tasks from both ends of the connection, it will engage the users to keep using the interface longer. This will prevent the product being one-or-two-time gimmick that would just be left in the shelf or closet to collect dust. This will also help to upkeep the emotional bond between the two users.

Since the Candle UI is essentially an ambient communication device, the sent message can be unseen in cases where the difference between the users time zone is great. The recipient of the emotional message could be at work or sleeping when the message is sent and thus be unnoticed.

The biggest requirements to the Candle UI hardware are, that the wireless network is up and running, there is enough stearin left in the candle to burn it properly and that the battery the electronic parts use has enough charging to keep sending the signal of the burning candle to the other candle stand. The user interface part that uses the real candle was designed to be easy-to-replace ephemeral part of the user interface and thus prolong the usage of the interface. The batteries inside the tea light used as the electrical flame and the electronic parts are also designed to be easily replaced. However, the other parts such as sensors would require more work to replace.

7.3 What went well?

This topic reflects the entire masters' thesis process. It also covers the parts of this research and design process that went well.

The Design Process

The design process was quite smooth and the final design came to me in early stages of the sketching phase of the design process. The benchmark was quite useful tool too, since I did not found any products that matched the Candle UI.

The Prototyping Process

The transformation from solid block of porcelain clay to liquid, casting clay was smoother than I expected and did not need additional materials usually used in making casting clay. The clay also set quite nicely in the mould and did not warp, as I feared when the casted clay part was removed from the mould.

Despite losing the second mould for the Candle UI flower cups the only mould endured the entire casting process quite well. Touching up the surfaces was the right choice to make, since they look a lot better now than in the original design.

7.4 What could have been done differently?

This topic reflects the entire master thesis process. It also explains what parts could have done differently in retrospective.

The Design Process:

During the design process, I might have been stuck on one design only and maybe I should have considered other shapes too. Though now it could be called arctic design. More sketches of the possible shape might have had a positive impact on this. However, the final shape of the Candle UI just felt right when I first sketched it on paper.

The Prototyping Process:

During the prototyping process what could have done differently was the mould itself. After actually making the Candle UI parts with the mould I noticed, that it would have survived with half of the mould parts. The mould was made based on previous experience on casting clay and working with porcelain clay, which was quite bad. More mould parts also caused friction between the parts and thus the mould started to crumble towards the end.

The first mould did not make it because I did not use enough plaster while making it. This made it never harden fully and thus it was unusable for casting the porcelain parts for the Candle UI. Therefore, in total I made three moulds that only one was used to produce the Candle UI flower cups. By not making the mistake in the first place, I would have saved some time during the prototype making process.

Making the Candle UI parts would have been faster if I had not misplaced the other flower cup moulds. Though it might have been good thing too, since the surface of the smoother Candle UI looked much better as it is now than if it had been just a smooth surface. In the end, I am just glad that the only mould lasted as long as it did, because while making the last bits the mould started to fall apart from the edges the mould parts touched each other.

Glazing the Candle UI flower parts could have gone better. I applied too much of the liquid glazing made from a powder and during the firing it dripped everywhere and I had later to remove the excess glazing with a diamond drill bit.

The leaf base could have been larger than what the final prototype were, but the porcelain clay shrank during the kilning process more than I anticipated. In addition, few of the first ones were warped due to the fact that I did not make enough support on the inside of the leaves to endure the heat of the kiln during the firing.

7.5 Future work

This chapter covers the topic of what can be done based on this research. It covers also the future options to add on the prototype or the final product.

Research

The future research could cover more in-depth of the transferring of emotions and feelings via a product usage, since this was a product design masters' thesis and not psychology or social science thesis. In addition, there could be research done how to improve the ambient communication between the users. Another topic could be on how to exploit emotional aspects in ambient communication in public spaces.

The Prototype

There are few things to add in the future prototype or even to the finished product. The different emotes could be added to the product by including the tilting motion which was dropped in the early stages of prototyping. The tilting motion would set the emotion, which would be sent when the real candle is lit up, however it cannot be changed when the candle is still burning. The lampshade inside the electrical candle would then turn to face the right emote or symbol. This would require an angle sensor for it to sense on what direction it is tilting towards to. This might make the prototype a bit larger but that would not look too bad since the unfired clay was larger than after the final firing.

The said emotes to choose the electrical candle would illuminate can be done to the inside of the Candle UI flower in couple of ways. One is to paint the symbols and emotes on the clay before the first firing with underglaze. Under glazing is quite commonly used with stoneware. For the symbols to look like approximately the same a stamp or a stencil could be used, too. Other is to add emotes and

symbols inside the flower cup with objects emotes and symbols have been cut out of. Either way, the light needs to be guided to the right way with a small lampshade type of structure, much like in the first prototype used in the first focus group evaluation. Inside the electrical part also should be a small motor to rotate the small shade towards the right symbol or emote. Adding emotes and symbols to the Candle UI parts would also mean that they would be visible all time in the flower cup of the real candle.

The symbols and emotes could also be customisable by adding a set of different ones to the user to choose from. However, this would also mean that the users add the right emote or symbol to exact location on the Candle UI to prevent miscommunication. One could be that for one slot of emote or symbol would only fit specific set of emotes or symbols. This way the Candle UI stands would both contain the same set of emotes and symbols.

The electrical flame could change colour, but for what purpose, since the changing of burning flame was so poorly perceived in the focus group evaluation. However, the Focus Group II had a different perspective to the coloured electrical flame, for it could add expressiveness to the user interface. Another purpose for the colour changing flame is to indicate how much the real candle has left to burn, but it would require other kinds of sensors, such as for example a really small scale.

The scent would be easily added when the user uses scented tealights instead of regular ones. The scents are perceived differently by the users, so by adding their own scented candles they can choose the right scent that pleases them than just settle with the one provided with the Candle UI package.

8 Conclusions

In conclusion, the Candle UI has its pros and cons as an ambient, emotional communication device. How the user receive the user interface depends greatly based on how candles are perceived in the users' culture. The cultural connotation can often dent the user experience in any possible way, but mostly it seems to be a negative connotation.

The candle UI demo was able to do the job it was designed for; to deliver a message that your chosen special one is thinking of you when they are far away. By lighting the Candle UI, the user can send an invitation to the receiver to relax with them and thus establish a moment together even they are not in the same location. By sharing the time together, it may help to strength the emotional bond. This, however, works the best if the users are living not too far from each other, for example, living in the same country but have quite a distance between them, or in the neighbour country, so the time difference would not have such great impact like seen in the Focus Group II commentary. This would also help to minimise the differences in the cultural connotations between the users, if they come from different cultures.

There are few researches and projects of usage of ambient communication in public spaces and their impact on customer behaviour, but not so many researches have been done on emotional aspect of the ambient communication, nor about the usage of the candles as part of the ambient, emotional communication. The research I made for this thesis was a small step towards it, but it still managed to gather promising results of how the users perceived the user interface. I hope that in the future there will be new researches on how to exploit or modify the materials that are already here for the usage as parts of ephemeral or tangible user interfaces. These include also the usage of natural materials, such as the candle flame used in this project.

The functions of the Candle UI still needs some fine tuning to hopefully be perceived in more positive way, despite the cultural connotations of the candle itself. The expressiveness could be enhanced by adding the previously mentioned emotes or symbols. This way the Candle UI is customisable, which was aired as a question in the Focus Group II. There are few parts of the user interface, which could be customisable with todays' technology. As previously mentioned, emotes or symbols can be added in a way that the chosen set of emotions or symbols can be handpicked to the users likings.

What comes to the customizable shape, it will probably be achievable in the future when the 3D printers become more sophisticated with printing different types of clay, porcelain included. Todays' methods still have too rough texture from the 3D printing not to be taken into consideration, for the design requirements of the Candle UI would not be met.

The colour changing electrical flame could work in some cultures and user environments, but it would need some further research and discussion. Though adding a function to the Candle UI app and having the electrical candle carry a RGB- LED light, it can be achievable without additional customization work on the product itself. This would help adding the expressiveness to the product. Though this reminds me one of the Focus Group evaluation tasks, where there were suggested prototype contained two discs, other had colours and the other had emotes or symbols. By using a combination of emotions and colours in the user interface would require the user to learn and memorise longer chains of interactions and thus it would thus increase the mental load of the user.

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10 Appendices

Appendix 1: Background information questionnaire for first focus group interview, three pages

Appendix 2: Focus Group Interview Product Reaction Chart

Appendix1: Background information questionnaire for first focus group interview

KYNTTILÄ UI-TUTKIMUS

UNIVERSITY OF LAPLAND
LAPIN YLIOPISTO

TAUSTATIEDOT 1/2

ID _____

1. **Sukupuoli:** *Nainen* ◯ *Mies* ◯
2. **Syntymävuosi:** _____
3. **Koulutus ja ammatti:** _____
4. **Oletko vasen- vai oikeakätinen?** *Vasen* ◯ *Oikea* ◯ *Molempikätinen* ◯
5. **Omistatko älypuhelimen?** *Kyllä* ◯ *En* ◯
6. **Jos vastasit kyllä, kuinka monta vuotta olet käyttänyt nykyistä älypuhelintasi?** _____
7. **Älypuhelimesi käyttöjärjestelmä?** *Android* ◯ *iOS* ◯ *Windows Phone* ◯ *Muu, mikä?/* _____
8. **Kuinka usein tekstiviestittelet pelkkiä emoji-merkkejä/hymiöitä?**

Melkein aina ◯ — *Usein* ◯ — *Joskus* ◯ — *Harvoin* ◯ — *En koskaan* ◯

9. **Miltä sinusta tuntuu kun saat vastaukseksi pelkkiä emoji-merkkejä/ hymiöitä?**

_____

_____

10. **Poltatko/sytytätkö tulia?**

Sisällä ◯ — *Ulkona* ◯ — *Molemmissa* ◯

Millaisia tulia?

_____

11. **Mitä elävä tuli merkitsee sinulle?**

_____

_____

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12. Poltatko kynttilöitä kotona?

Päivittäin — *Lähes päivittäin juhlapäivien lähellä* — *Juhlapäivinä* — *Kuukausittain* — *Harvemmin* — *En koskaan*

13. Millaisia kynttilöitä?

Tavallisia — *Hajustettuja* — *Muu, millaisia?* _____

14. Millaisessa asiayhteydessä poltat kynttilöitä?

15. Millaisella alustalla poltat kynttilöitä?

16. Mitä kynttilä merkitsee sinulle?

17. Mikä miellyttää sinua kynttilöissä eniten?

18. Miten luonnehtisit sähkökynttilöiden ja elävien kynttilöiden eroa?

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19. Miltä laite tuntui käyttää?

20. Millaisia mielikuvia laite herätti?

21. Mistä pidit laitteessa?

22. Mistä et pitänyt laitteessa?

23. Miten kehittäisit laitetta?

Appendix 2: Focus Group Interview Product Reaction Chart

Kynttilä UI -Fokusryhmä ID:____

Valitse viisi (5) sanaa, jotka parhaiten kuvaavat käyttökokemustasi. Jos sanan yhteydessä on +/- merkki, kerro (ympyröimällä), tarkoititko sanaa positiivisessa vai negatiivisessa merkityksessä.

Choose five (5) words from the grid below which best describe your experience of using the application. If the word is followed by the sign (+/-), please mark whether you mean the word in a positive or negative sense.

Fast (+/-) Nopea (+/-)	Useless Hyödytön	Useful Hyödyllinen	Inspiring Innostava
Rigid Kankea	Consistent Johdonmukainen	Too technical Liian tekninen	Stressful Stressaava
Clear Selkeä	Uncontrollable Hallitsematon	Businesslike (+/-) Asiallinen (+/-)	Controllable Hallittavissa oleva
Unfamiliar (+/-) Vieras (+/-)	Creative Luova	Undesirable Epämieluisa	Predictable (+/-) Ennalta-arvattava (+/-)
Time-saving Aikaa säästävä	Unpredictable Ennalta arvaamaton	Familiar (+/-) Tuttu (+/-)	Time-consuming Aikaa vievä
Dated Vanhanaikainen	Empowering Mahdollistava	Slow (+/-) Hidas (+/-)	Frustrating Turhauttava
Desirable Mieluisa	Unpleasant Inhottava	Exciting Jännittävä	Entertaining Viihdyttävä
Dull Pitkästyttävä	Fun (+/-) Hauska	Playful Leikkisä	Ordinary Tavallinen
Un-approachable Luotaan työntävä	Inconsistent Epäjohdonmukainen	Simple (+/-) Yksinkertainen (+/-)	Restful Rauhallinen
Responsive Helposti reagoiva	Approachable Helposti lähestyttävä	Serious Vakava	Complex Monimutkainen
Difficult to use Vaikeakäyttöinen	Visually unpleasant Visuaalisesti epämiellyttävä	Innovative Innovatiivinen	Easy to use Helppokäyttöinen
Restrictive Rajoittava	Pleasant Mukava	Unclear Sekava	Boring Tylsä
Visually pleasant Visuaalisesti miellyttävä	Poor quality Heikkolaatuinen	Novel Uusi	High quality Laadukas