Designing an Interactive Coffee Table to Explore its Feasibility

Course
Bachelors Graduation Assignment
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UNIVERSITY OF TWENTE.

Preface

This report describes the process of designing an interactive coffee table. This interactive coffee table is designed for 100%FAT, which is a product design company situated in Enschede. During the design process of this interactive coffee table I have had a hands-on experience with product design from within a company context. This was a valuable experience that has allowed me to use a more practical approach to design a product.
Hereby I would like to thank Lieven Maes and Arie Paul van den Beukel for their good assistance and feedback during this graduation assignment for the bachelor program of Industrial Design at the University of Twente. Also, I would like to thank Robert Lubbers and Hennie Slotboom for all the effort they have put in producing the prototype of this interactive coffee table.

Summary

This report describes the process of designing an interactive coffee table for 100%FAT. This is a product design company that is specialized in designing interactive products. This company is situated in Enschede. To design this interactive coffee table, first the functioning of interactive coffee tables and the market on which it will be sold is shortly researched. The conclusion of the market research is based on 100%FAT its expectations, which means that the table will be sold in a business to business context to large companies. The size of these companies is comparable with companies such as Grolsch and Thales Hengelo, because these companies have more budget available for investing in devices such as interactive coffee tables.

After these short researches, the potential manners of using these kinds of tables are analyzed. This results in multiple usage scenarios to be developed, which serve as input for the design process. These scenarios are developed for both informal and formal business environments. Consequently, the requirements and wishes were made for this product design by checking the requirements and wishes of both 100%FAT and the customers.

After these requirements and wishes were developed, the design process started with an ideation phase, which resulted in three design directions for the concept development phase. These three directions are the: "Wing Design", "Simplistic and Angular Design" and the "Organic Design". Also an inspiration board was made for each design direction. The next phase in the process is the "Concept Development", in which the three design directions from the ideation are further developed. In these concepts the reality is also better considered, which makes it possible to make a choice of which concept should further developed towards a final design proposal. The chosen concept is the "Simplistic Design" concept, which especially performs best in its business appearance and in the ease of production.

Thus the "Simplistic Design" concept is further developed towards a final design proposal which is then translated towards a SolidWorks CAD model. This SolidWorks CAD model is consequently used to develop the prototype, which appeared to be quite difficult because of the complex design. Because the design of the table was too complex to be produced in the workplace of 100%FAT, some design changes needed to be made. Although these design changes made it possible to produce the table in the workplace of 100%FAT, it still costs a considerable amount of production time. The complexity of the design is caused by the number of angles that is integrated in the design, in both the aluminum frame and the wooden display frame. These angles however, do contribute to the aesthetics of the table and are important for distinguishing the table from the current products on the market. Therefore, more research is needed to simplify the production of this interactive coffee table. It is expected that the complexity of the aluminum frame can be reduced by using 3d printed connection components at each corner in the aluminum frame.

By integrating these 3d printed components the beams out which the aluminum frame consists do not need to be sawed in the right angle anymore. Because of the little costs of 3d printing, integrating these 3 printed components saves both in production time and in production costs. The complexity of the wooden display frame can be reduced in multiple manners. First by removing the tapered shape of the display frame at all. Second by using standardized wooden frame components. Third by using 3d print components for connecting the parts of the wooden frame. Thus there is more research required for determining what the best way of simplifying the production of this interactive coffee table is.

Concluding, the interactive coffee table that is designed can distinguish itself from the other interactive tables that are currently offered on the business to business market, with both its unique design and functionalities. Also the with the expectations that the production of this interactive coffee table can be simplified by using 3d print connection components and standardized frame components, the table is expected to be economically viable.

Samenvatting

Dit verslag beschrijft het ontwerpproces van een interactieve salontafel. Dit product is ontworpen in opdracht van 100%FAT; een productontwerp bedrijf gespecialiseerd in interactieve producten. Voordat het ontwerpproces zelf is gestart is, zijn twee kleine onderzoeken gedaan. Deze twee onderzoeken zijn gedaan naar de werking van interactieve salontafels en naar de markt waarop de tafel verkocht gaat worden. De markt waarop de tafel verkocht zal worden is aangenomen van de marktplannen van 100%FAT. 100%FAT is van plan om de tafel in een business to business context te verkopen. Hierbij worden grotere bedrijven zoals Thales Hengelo en Grolsch als klanten gezien, omdat deze bedrijven gemakkelijker budget kunnen vrijmaken voor investeringen in producten zoals interactieve salontafels.

Hierna zijn de mogelijke gebruikstoepassingen van deze soort tafels geanalyseerd. Het resultaat hiervan is dat er meerdere gebruiks-scenario's zijn opgezet. Deze scenario's zijn ontwikkeld voor een bedrijfsomgeving en dan zowel voor een informele als een formele setting. Vervolgens zijn de eisen en wensen van 100%FAT en haar klanten bepaald door middel van gesprek en een enquête. De informatie die verkregen is uit de scenario's, het gesprek en de enquête heeft gediend als input voor de ontwerpfase.

De ontwerpfase is gestart met een idee generatie, welke geresulteerd heeft in drie grove ontwerprichtingen voor de concept fase. Deze drie richtingen zijn: 'Wing Design', "Simplistic Design" en "Organic Design". Daarnaast is voor iedere ontwerprichting een inspiratie collage gemaakt. Deze bestaan uit verschillende afbeeldingen met interessante ontwerpaspecten voor de specifieke ontwerp richting. In de volgende fase "concept ontwikkeling" zijn de drie grove ontwerprichtingen tot op concept niveau uitgewerkt. Hierbij is meer rekening gehouden met de realiteit zodat een realistische concept richting uitgekozen kan worden om ver te ontwikkelen. Het concept wat gekozen is om verder te ontwikkelen is "Simplistic Design". Deze is voornamelijk gekozen vanwege de integratie van een zakelijke uitstraling en vanwege eenvoudige productie.

Dus het "Simplistic Design" concept is verder ontwikkeld naar een uiteindelijk ontwerpvoorstel, welke vervolgens vertaald is naar een SolidWorks CAD model. Dit SolidWorks CAD model is de basis geweest voor het produceren van het prototype, wat lastig bleek te zijn vanwege het complexe ontwerp. Doordat het ontwerp van de interactieve salontafel te complex was om in de werkplaats van 100%FAT te produceren, is er voor gekozen om enkele ontwerpaanpassingen te maken. Ondanks dat deze ontwerpaanpassingen de productie van de tafel eenvoudiger maakte, was er nog steeds een aanzienlijke hoeveelheid productietijd nodig. De complexiteit van het ontwerp wordt veroorzaakt door de grote hoeveelheid verschillende hoeken die geïntegreerd is in zowel het aluminium frame van de tafel als het houten display frame. Deze hoeken dragen echter wel bij aan de esthetische waarde en aan de kracht waarmee dit ontwerp zich onderscheid van de huidige producten op de markt. Daarom is er vervolgonderzoek nodig zodat de productie van de interactieve salontafel versimpeld wordt.

Hierbij wordt verwacht dat de complexiteit van het aluminium frame gereduceerd kan worden door 3d print connectie onderdelen te gebruiken op ieder hoekpunt van het aluminium profiel. Door deze 3d print connectie onderdelen te integreren in het ontwerp is het niet meer nodig om alle aluminium staven in de juiste hoeken af te zagen. Vanwege de lage kosten die verbonden zijn aan 3d printen, bespaard dit zowel in productietijd als in de productie kosten. De complexiteit van het houten display frame kan gereduceerd worden op meerdere manieren. Ten eerste zou de afgeschuinde vorm in zijn geheel weg gehaald kunnen worden. Ten tweede door standaard houten profielen te gebruiken en ten derde door hiervoor ook 3d print connectie onderdelen te gebruiken. Dus er is vervolgonderzoek nodig om te bepalen wat de beste optie is voor het vereenvoudigen van de productie van deze tafel.

Concluderend is de ontworpen interactieve salontafel instaat zich te onderscheiden van de overige interactieve tafels die momenteel op de Nederlandse business to business markt worden aangeboden, vanwege de unieke uitstraling en functionaliteiten die de ontworpen interactieve salontafel biedt. Met de verwachting dat de productie van de ontworpen interactieve salontafel versimpeld kan worden door 3d geprinte connectie onderdelen en standaard houtprofielen te gebruiken, is de interactieve salontafel naar verwachting een financieel haalbaar product.

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Chapter 1 | Introduction

1.1 | Introduction

The topic for this graduation assignment is the design and development of an interactive coffee table. The company for which this assignment is performed, is 100%FAT. This is a product design company which is situated in Enschede, The Netherlands. The objective of 100%FAT is to create interactive experiences by combining the newest technologies in a creative manner. The company has expertise in designing and producing interactive media concepts, which use amongst others augmented and virtual reality, position dependent audio, motion graphics, 3D art, 2D animations.

1.2 | Background of the Assignment

100%FAT its objective with an interactive coffee table[1], is to offer customers a way to meet in an interactive and informal manner. For example, during the coffee break. At this moment, the company already offers an interactive touchscreen table. This table, however, is quite bulky and requires the users to stand around it. Also because of its size, the table is too bulky and heavy to be placed in many lobbies. This combined with a high cost price, results in the product not being an accessible solution for many customers. Thus, to allow these meetings to happen in a more informal way, the company is interested in a smaller version of the interactive table. This version would be in the size of a coffee table for both stimulating an informal meeting and reducing the cost price.

1.3 | Aim of the Assignment

The main research question to be answered during this research is: "To which extend is it economically viable for 100%FAT to produce an interactive coffee table that features an interesting and differentiating design?". The approach for answering this main research question is to first design an interesting and differentiating interactive coffee table and then to research to which extend the production of this table is economically viable, by producing a prototype of the product design. During the process of answering the main research question multiple sub research questions have to be analyzed and answered.

1. *A "coffee table" is a (small and) low table, which is generally used by people that are meeting with each other purpose for people meeting with each other for example during lunch or for drinking coffee, for drinking thee, etcetera. Hence, it is not a table solely meant for drinking coffee.*

These sub questions are as follows:

1. How does an interactive coffee table function?
2. What are 100%FAT its requirements and wishes for an interactive coffee table?
3. What is an appropriate market to focus on?
4. How will the interactive coffee table be used?
5. What are the target group its requirements and wishes for an interactive coffee table?
6. Based on questions one to five, what concepts of an interactive coffee table are possible?
7. Which of the developed concepts for question 6, performs best considering questions one to five?
8. How to produce a working prototype of the specific design proposal from question 7, which is representative for the functions and the design of the interactive coffee table?
9. To which extend is it economically viable for 100%FAT to produce this product design proposal?

1.4 Definition of Terms

Multiple terms requiring some clarification, to prevent confusion, are used in this report. Therefore, each of these terms is clarified in this section.

100%FAT:
- The company for which this research assignment is performed. This company is situated in Enschede.

Interactive table:
- An interactive table is a table which integrates a display with "fiducial marker" recognition to offer an interactive experience.
- The interactive touchscreen table 100%FAT currently offers, is quite bulky. The table is sized at 2 by 3 meters.

Coffee Table:
- A table meant for people meeting with each other, for example to have a break or to weight for a while in a waiting room. A coffee table is not solely meant for drinking coffee.

Interactive coffee table:
- A smaller version of the interactive table. This one is sized at the size of a regular coffee table, with maximum dimensions of 1300 mm x 800 mm as the top display area and the height lays within 500 mm and 600 mm.

Fiducial Marker:

- A "ficucial marker" is a marker that is used to recognize the location and orientation of an object, while using a camera (Reactivision, n.d.). These markers are placed underneath the coffee cups, to allow the user to control the interactive coffee table via the coffee cups.

Target Group:

- The target group consist out of companies which have a lobby or a canteen in which they prefer to meet in an interactive and informal manner. Also, companies requiring a tool to impress people at an exhibition lay within the target group of 100%FAT.

Customer:

- The customers of 100%FAT consist out of companies which have a lobby or a canteen in which they prefer to meet in an interactive and informal manner. Also, companies requiring a tool to impress people at an exhibition are opted as 100%FAT its customers.

Functional Prototype:

- A functional prototype, is a prototype that will work and will be a good representation of the final design of the interactive coffee table. This prototype is also a basis for feedback for a follow-up version.

Economically viable:

- 100%FAT opts the interactive coffee table to be economically viable if it can be produced for 5000 euros or less.

UT:

- Abbreviation for University of Twente.

Chapter 2 Functioning of an Interactive Coffee Table

2.1 Introduction

This chapter is dedicated to explaining the functioning of an interactive coffee table. This will be done by first discussing the setup of an interactive coffee table and then by discussing the functioning of an interactive coffee table.

In this chapter, the research first research question will be answered: "How does an interactive coffee table function?". This will be done by the hand of the following sub-questions:

- Out of what components does an interactive coffee table consist?
- How are the components placed in the setup of an interactive coffee table?

2.2 Setup of an Interactive Coffee Table

The general setup that will be used for the interactive coffee table is shown in figure 2.1. From this figure it becomes clear that an interactive coffee table consists out of seven main components:

- Zotac PC;
- Beamer;
- Endlighten-T panel;
- Projection panel;
- IR-Lighting (beneath display);
- Two cameras;
- IR-Lighting for touch support (at edges of Enlighten T panel).

The complete list of the integrated components is placed in appendix A.6. The top part of the setup consists out of all display components, which are the Endlighten-T panel, the projection panel and the IR-lighting for touch support. Below the display components there are multiple other components present in the interactive coffee table. These components are the Zotac pc, the beamer, the IR-Lighting from beneath the display and the two cameras for object and touch recognition. The setup of the display will now be discussed. For getting an understanding of the required setup, articles have been read and youtube videos have been watched (Müller-Tomfelde, 2010) (PeauProductions, How to Build a Multitouch Table Part 1, 2010) (PeauProductions, How to Build A Multitouch Table Part 2, 2010).

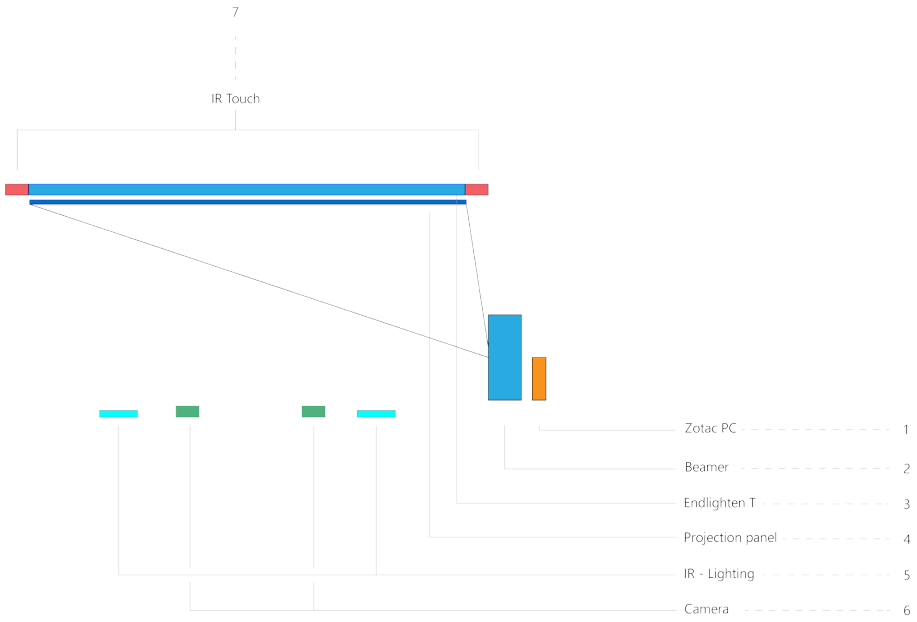

Figure 2.1; Setup of an Interactive Coffee Table

Display Setup

The Endlighten-T planel is the top layer of the display. This layer is integrated to ensure that the table integrates touch support. For this touch support an IR-LED strip will be placed at the edges of this layer. This strip projects IR-light through the Endlighten-T panel. Because of the properties of this panel the IR-light is evenly distributed through the panel. To do this, the panel integrates light diffusing particles throughout the whole panel. These particles ensure that the light emitted at the edges of the panel will be distributed evenly throughout the panel. Therefore, the whole panel will glow evenly. (Evonik, sd) However, if the panel is touched by a user with for example his/her finger tips, the evenly distributed light will break and scatter in multiple directions at that specific point. This causes an IR- light hotspot which is visible by the IR-camera underneath the display. This is illustrated in figures 2.2 and 2.3. Because the view of the camera is view mapped with the display and calibrated with the content shown on the display, the camera can determine the position of where the display is being touched. Thus, the user can control the interactive coffee table via the touch support.

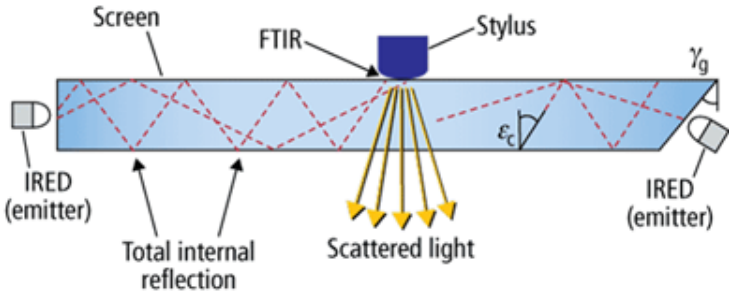

Figure 2.2; IR-Hotspot (ajithtech, sd)

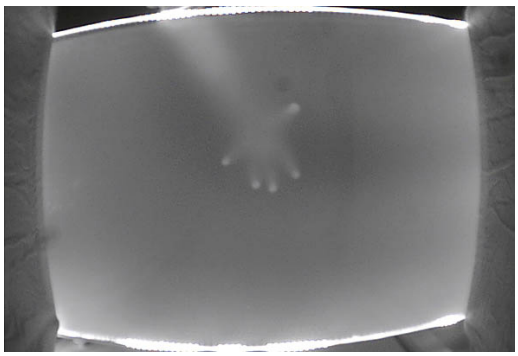

Figure 2.3; IR-Hotspot Real-Life (Lucid, 2010)

As stated above, this Endlighten-T panel is the top layer of the display. This means the user will come directly into contact with this layer. Therefore, it needs to be prevented that objects and liquids cause scratches and other damages to this layer. Therefore, it is protected with a coating which is both scratch and chemical resistant. Seeing this coating is also chemical resistant, it allows the user to clean the display with regularly used cleaning products. (Evonik, sd) Next to this coating, this layer is also protected by placing a soft layer at the bottom of the coffee cup holders. This prevents the cups from scratching the display.
Below the Endlighten-T panel is a layer of air. This is needed to preserve the evenly distributed light throughout the Endlighten-T panel. If there would not be a layer of air beneath the Endlighten-T panel, and it would thus lay directly on another display layer, there will be multiple touch points and thus multiple IR-light hotspots visible through the camera. The projection panel is placed beneath this layer of air. This panel is a transparent sheet of perspex which has one matte side. This matte side is necessary for the beamer to project visual content on it.

2.3 Functioning of an Interactive Coffee Table

The Zotac pc is the computer that is integrated in this table and it displays its user interface (UI) via the beamer on the projection panel. The user can then interact with this UI in two manners, either via the object recognition or via the touch support. The functioning of the object recognition will first be discussed, after which the functioning of touch recognition will be discussed. After this also another option for integrating both object and touch recognition will be discussed.

For the object recognition there is the need to light the display from beneath with IR-LEDs. These IR-LEDs make sure that the IR-camera can see where the coffee cups are placed on the display. There will be made use of IR-Light because this type of light is not visible for the human eye, and therefore does not influence the image quality of the display. The camera is positioned beneath the display and can register these mugs by the use of “fiducial markers”, which are attached to the bottom of each cup. This means, these markers will be visible from beneath the display and thus for the cameras. This allows the cameras to track both the position and the orientation of these fiducial tags (Reactivision, n.d.).

Figure 1: AprilTag 36h11 ID = 12

Figure 2.4; Fiducial Tag (Walters, sd)

For the touch recognition IR-lights needs to be placed at the sides of the Endlighten-T panel. As explained in section "2.2 Setup of an interactive coffee table", this will result in an evenly distributed IR lighting through the Endlighten T panel. Thus if someone touches the panel, a hotspot of IR-light is created. This hotspot can be registered by the IR-cameras, after which it is associated with a touch point by a finger. This makes it possible to control the UI via touch too.

An alternative to using the camera setup for object and touch recognition is to use a Displax Skin Ultra foil (Displax, sd). These foils can be attached to the bottom of the display layer and allow for both object and touch recognition. There are some important advantages of using one of these foils. The first that is that it integrates both object and touch recognition, and thus makes the need for the Endlighten-T plate for touch recognition superfluous. This foil is also more accurate and faster in the tracking of objects and touch by the user. Next to this, a TV panel instead of a beamer can be used, which results in the display to have a higher resolution, better image quality, better brightness and better viewing angles. There are however some important disadvantages that make it much more interesting to first test the camera setup. First, a 55 inch foil would costs 1637 euros and one set of 6 pucks costs 250 euros. The foil is not capable of distinguishing these pucks from each other, which means people will not be able to get a personalized experience. Second, this foil needs to be attached with adhesive by hand to the top layer of the display. This process is rather sensitive to errors when this is done for the first time. Thus it is rather expensive test this and there is too little guarantee that the foil will be successfully attached to this display layer.

2.4 Summary

In this chapter the components and the general setup that is used for this interactive coffee table was discussed. Next to this the functioning of the interactive coffee table was discussed up to a basic depth. Therefore, the research question: "How does an interactive coffee table function?", has been answered.

Chapter 3 | The Market

3.1 | Introduction

This chapter provides an insight in the market on which 100%FAT will sell this interactive coffee table. However due to the limited amount of time available for this project, there has been chosen to make assumptions about the market on which the interactive coffee table will be sold. This is needed to save time in this part of the project to enable more in depth research in the other phases of the project. The assumptions made about the market and the customer are coincident with the market plans of 100%FAT. This means the central research question to be answered in this chapter, will be answered by making assumptions on 100%FAT its market plans. There will, however, shortly be researched what kind of companies are competitors of 100%FAT and what kind of products these companies offer.

The research question to be dealt with in this chapter is as follows: "What is an appropriate market to focus on?". This question will be answered by the hand of the following sub-questions:

- What are the competing companies on the market?
- What are the competing and substituting products available on the market?

3.2 | The Chosen Market

As previously stated, the market on which the interactive coffee table will be sold is assumed from 100%FAT its plans. These plans are to sell the interactive coffee table in a business to business context.
The table is close to a custom-made product, which means the production costs per unit are relatively high compared to mass production products. Therefore, customers will be larger corporate businesses, which have a higher budget available. Examples of these companies are Thales Hengelo, Grolsch and Urenco Almelo. These companies are already customers of 100%Fat. Next to these three companies, Madlab is a customer because the table will be placed here for exhibition means. The selling price 100%FAT will maintain will lay between 10 000 and 15 000 euros, which depends on the final production costs. The goal for the production costs will be a maximum of 5000 euros, and preferable less (if possible).

3.3 Competing Companies

There are multiple competing companies on the market on which 100%FAT plans to sell this interactive coffee table. These companies can influence to which extend the interactive coffee table will be a success. Therefore it is necessary do a market research to create an image of the competitors and its products. This makes sure that the design for this coffee table will be differentiating from the current offers on the market. An overview of the most important competitors that appeared from the market research is visible in figure 3.1. The sources for the websites of these competitors are placed in appendix A.7. The most important competitors of 100%FAT consist out of somewhat smaller (also Dutch) companies and larger multinationals with a commonly known name, for example Microsoft and Samsung.

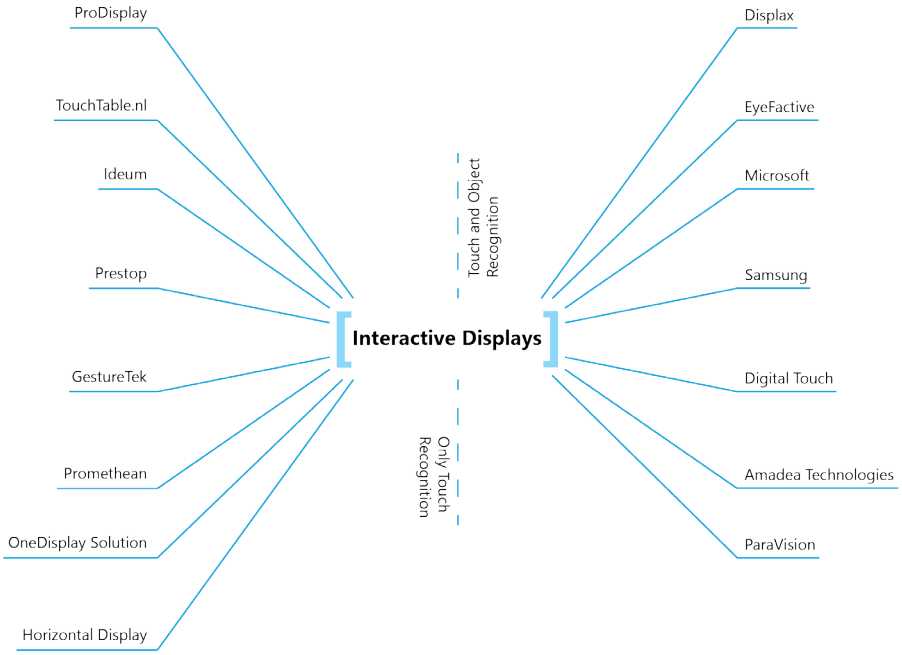

Figure 3.1; Competitor Overview

3.4 Competing and Substituting Products

As appeared from the market search, there are multiple companies that offer competing and/or substituting products. The most important competing products are the regular touch screen tables. These products offer almost the same functionalities as the interactive coffee table will offer. The only difference is the ability to track objects. There are also tables with object recognition integrated by using for example a foil or the Microsoft PixelSense technology. These are, however, quite expensive and regularly have a limited display size and shape. When using 100%FAT its approach by using a beamer in combination with object tracking by the hand of cameras, the display is more flexible in its shape. There are also some products on the market that use the same approach as 100%FAT does. These companies however maintain a higher price point. The company EyeFactive for example sells multiple components which all offer an interactive display and can then be combined in multiple shapes. This will then create a larger interactive table, which is mainly aimed at usage for during exhibitions. This product however offers a rather small display per component and each component costs 12500 euros.

When comparing this to the approach of 100%FAT of offering a larger display with the same object tracking and touch functionalities, it will cost between the 10 000 and the 15 000 euros. Thus, 100%FAT is able to offer a larger display with the same functionalities in the same price range.

3.5 Differentiation from Competition

To make sure the interactive coffee table is an attractive offer compared to 100%FAT its competitors its product offers, there are multiple points on which 100%FAT opts to differentiate. These differentiating points are the following:

- The product has an open look, in contrast to competing systems. These systems are often a rather closed and bulky box. An example of this is the Microsoft surface 1 table.
- Large and flexible shaped display in contrast to the regular touch tables and to the pixel sense displays, which also integrate object recognition and object tracking
- The table seams to float above the ground because the rather large display which hangs on one leg close to the ground.
- In contrast to other systems, this table is positioned low above the ground. This combined with the large display of 700 millimeters by 1300 millimeters creates a magical effect, the wow factor 100%FAT opts to create with this table.
- Open software system; software can be optimized for each customer and, if required, the customer himself can make changes too. Next to this, the software that is used is open source. This means 100%FAT and the customer do not need to pay any charges for using this software.
- The table is more flexible in its construction. This means 100%Fat can easily change some settings to the wishes of the customer, which could for example be the height of the table.
    - Thus the table is a more custom build type of product, which allows the customer to buy a more customized product. This means the table can fulfil the wishes of the customer better.
- The table uses a rear projection display by the hand of a beamer, which means that the display is tougher than regular display panels. This means the table is better suitable as a coffee table because people should be able to use a coffee table as a table, and not solely as a display.

3.6 Summary

This chapter provided limited insight in the competition, competing and substituting products and in how 100%FAT opts to differentiate from these products on the market. In answering the first sub question: "What are the competing companies on the markets?", there appear to be many companies that produce similar products. An overview of some of these companies can be found in figure 3.1.

In answering the second sub question "What are the competing and substituting products available on the market?", there are quite a lot of products can at least partly deliver the same functionality as the table by 100%FAT. These tables are most of the time regular touch screen tables which are not able to recognize and track objects. There are also some companies that do offer similar touchscreen tables that do integrate object recognition and tracking. There are also some tables that integrate both object and touch recognition by the use of the camera setup. Both of these types of tables, however, are considerably more expensive and less flexible in its usage than the version by 100%FAT.

For answering the research question for this chapter: "What is an appropriate market to focus on?", assumptions have been made on 100%FAT its market plans. These are to sell the interactive coffee table in a business to business context to larger companies with a size comparable to Grolsch and Thales Hengelo.

Chapter 4 | Potential Usage of an Interactive Coffee Table

4.1 | Introduction

In this chapter the central question "how will the interactive coffee table be used" will be answered. This question needs to be answered to ensure the product is designed in an appropriate manner for the target group. Thus, this question should steer the design process in such a way that a design is developed that is suitable for the target group of 100%FAT. This question is answered by the hand of the following sub questions:

- By whom will the interactive coffee table be used?
- For which tasks will the interactive coffee table be used?
- Under which circumstances will the interactive coffee table be used?
- In which environment will the interactive coffee table be used?

These research questions are analyzed by the hand of the following tools:

- Company interviews;
- Usage testing at Maker Festival;
- PACT;
- User characteristics;
- Scenarios.

4.2 | Company Interviews

To gain a better understanding on how 100%FAT its customers use an interactive coffee table and on the expectations of 100%FAT its customers of this table, a questionnaire has been made. This questionnaire is filled in by two potential customers and contains multiple questions on the: usage environment, appearance, usage of the interactive coffee table and on the costs of the interactive coffee table. These potential customers who have filled in the questionnaire are Urenco Hengelo and Buro Blink. Next to these two companies, StudioMAD (from within MADlab) has given information during a meeting and Twentse Welle has provided feedback during a conversation at the Maker Fair in Enschede. The conclusions from these interviews are discussed in this section and the filled in questionnaire can be found in appendix A.5

Usage Environment

An important characteristic of the usage environment in a company building, is that there are often security regulations which also include the company network. This means it is not always possible to connect the interactive coffee table to the network of the customer. Seeing the table its functionalities might depend on the availability of a network connection, it is important to develop a software for the table that is also able to function without a network connection.

Appearance

The table should impress people who are using it. Thus people visiting 100%FAT its customers should be impressed by this table. Therefore the appearance should not be strictly aimed at a business and productive character, because these designs often are not aimed at the aesthetics which are required to impress people (Norman, 2004) (Shrivastava). It needs however, to be taken into account that the table still needs to be placed in a business environment and thus needs to be both businesslike and appealing. Another characteristic is that the table should have more of a technology advanced appearance than solely the appearance of a regular coffee table. This is also needed to impress people with the appearance. Next to this the content offered on the table should be impressive. This however, will not be a topic of this thesis. This thesis is focused on the design of the table itself, while the software and the user interface development will be done by other employees and partners of 100%FAT.

Usage of the Interactive Coffee Table

The primary goal of this table is to function as a conversation tool, as also stated by a contact person at Urenco: "The goal should be to serve as a conversation piece and, secondarily, to bring across information to those who stand around it.". Another valuable remark by this person is that she also sees possibilities to use this table for structuring meetings and/or brainstorm sessions or to use it for handing over shifts. Next to this, Buro Blink indicated that the table could serve for temporary usage in for example shops, museums, etcetera.

Because of these functionalities of the table, it will be used by multiple people and if the table can be used from two sides, it will be used by small groups of four to six people. These people will have experience with technological products, and thus enough knowledge of these products to be able to work with an interactive coffee table. The interface however, should not be overcomplicated. It should remain basic and logically in usage to ensure a user-friendly interface.

Other functionalities that should be integrated in this table are collaborative tools via the interactive controls and a platform which allows the user to make content by himself/herself. Next to this the questionnaire indicated that these companies are possibly more interested in a version of this table that is placed at desk height instead of at coffee table height. Therefore, it is also interesting to research the possibilities of a table that both offers usage at coffee table height and at desk height.

Costs of the Interactive Coffee Table

The smaller company Buro Blink indicated five thousand to ten thousand euros is an appropriate price for this kind of table. The larger company Urenco Hengelo on the other hand indicated an appropriate price is in the category of ten thousand to fifteen thousand euros. Because 100%FAT earlier stated it opts to sell this product for ten to fifteen thousand euros to larger corporate businesses such as Urenco Hengelo, the pricing category of ten thousand to fifteen thousand euros appears to be appropriate. An interesting possibility Buro Blink indicated is to offer a subscription to this product, instead of a one-time payment. Therefore it can be interesting for 100%FAT to for example offer these tables in a leasing plan instead of as an one-time purchase.

4.3 Maker Festival

During the Maker Fair in Enschede, 100%FAT showed some of its products at its stand. One of these was the concept design "Wing Design" of the interactive coffee table. This concept was modified into a simplistic and easy to produce version of the table, which allowed the table to be produced by the FABlab Enschede. This translation step from concept to CAD models of this version of the table has been done by Vera Hutman, a 100%FAT employee. This version of the table is shown in figures 4.1 and 4.2.

Figure 4.1; Maker Festival Table Front

Figure 4.2; Maker Festival Table Rear

During the fair the interactive coffee table appeared to be an interesting gaming device for young children. This was mainly caused by the interactive combination of a real-life puck that was being followed by a white spot on the display. This appeared to be a fascinating effect for children, they seemed to be surprised by it. Also, because the table was placed at the height of a coffee table (0,52m), the table has a perfect height for these children. They can easily bend over the table and reach the display and the pucks, which makes it a perfect device for children. This also meant some children almost climbed on the table to reach the puck when it was on the middle of the display. This is shown in figure 4.3 and in figure 4.4. Therefore, the table its display should be able to resist these kinds of pressures when it will be used in a context with children. Another aspect is the stability of the table. During Maker Fair, the table appeared to be somewhat unstable at the front corners. This was caused by the placement of the legs, because these were placed too much in the middle of the table. The stability, however, is an important aspect of the table. For example, if someone is kneeling beside the table, he/she should be able to push him/herself up from the ground by pushing at a corner of the table. In such a situation, the table can not stagger. This means the legs should be placed in a manner that provides better support for the table.

Next to these findings, an employee of TwentseWelle provided a different view point for the usage of the interactive coffee table. He explained it might not be good to use the table as a productivity tool which employees can use during a coffee break, because the employees should be taking a break and clear their mind during the coffee break. These employees need to clear their minds so they can go on with their work after a short break with a clear mind. Also, he provided a good manner of usage for the interactive coffee table. He explained it could be a good tool to use during the "scrumming" at companies. The employees can then easily explain their progress in an informal setting in an interactive manner. This scrumming process could be assisted by the table by providing every employee with a personal tag attached to his/her coffee mug or puck. Then each employee can easily show his/her progress and planning in an interactive manner on the table.

Finally, during the fair many people compared the table with the "Tovertafel". This "Tovertafel" is aimed at demented elderly (https://tovertafel.nl/).

Figure 4.3; Maker Festival Children 1 (Bakuchava, sfeerimpressie-maker-festival-twente-2017, 2017)

Figure 4.4; Maker Festival Children 2 (Bakuchava, 2017)

4.4 PACT Analysis

A PACT analysis is performed to analyze by whom, for what purpose and in which context the table will be used. This has been done by the hand of the PACT analysis format given in the book "Designing Interactive Systems" by David Benyon (Benyon, 2014).

People

There will be two groups of people who will use the interactive coffee table. The main user group will use the final production version of this product, while the second and smaller user group will use the prototype that will be placed in MADlab.

The main user group for this product will be the employees of the companies that buy this product and the visitors of these companies. These people will have a lower understanding of how the product functions and of how to interact with this specific product. This is because these groups of people have not been closely connected to the development of the table. This lack of understanding will mainly be during the first few moments in which these people use the table. It is expected that these people will quickly learn how to use the table, especially because user interface of the table is rather simplistic and easy to use. This means little knowledge of this product is required to be able to interact with this product. Next to this, these users have experience with technologically advanced products because of the daily usage of products like smartphones, tablets, laptops, computers, etcetera.

The second user group will use the prototype of the interactive coffee table. This prototype will be placed in MADlab, which means that this user group consists out of the employees of 100%FAT, StudioMAD and ReCreate that will be present at MADlab. These people will at least have a basic understanding of how to interact with an interactive coffee table. This is because 100%FAT, StudioMAD and ReCreate have been connected closely to the development of the table. Therefore, the employees of 100%FAT, StudioMAD and ReCreate will have a good understanding of how the product functions and of how to interact with the product. Thus, these groups of people are also not opted to be a problem for the user interaction.

Activities

People can use this interactive table in multiple manners. It is either usable in an informal business setting as a coffee table set-up, or in a more businesslike setting as a conference table. In both settings, the table serves as a conversation tool. The table should allow employees to discuss for example data retrieved from an experiment. Then this table allows the employees to display this data in an intuitive manner; the employee can twist his puck or coffee cup to select the right file and use the touch support to scroll through this file. Therefore, the main activity the users of this product perform, is the selection of files and to walk through these files. This is supported by feedback from the system, which explains how the user can perform this action. An example would be subtle arrows that indicate the possible movement directions of the section tool (the coffee cup or the puck).

Context

Physically the interaction with this table takes place in either an informal business setting with couches placed next to the coffee table, or it will take place in a more formal business setting in a conference table setup in a meeting room. Both settings take place inside. Socially, the interaction takes place with at least two users of the table. For the coffee table setup, this can expand to a group of four to six people. For the conference table setup, this can expand to larger groups of people. This depends on how many tables will be connected to each other; per table component there is place for 2 persons. Organizationally, the implementation of this interactive table can influence how meetings are organized in a company and which devices the employees use during these meetings. Currently, the combination of laptops and televisions/beamers is often used. This might move to only using this table during an informal meeting or to a combination of only one laptop in combination with these tables. The second combination is in the case of the conference table set-up, because then there will always be the need of someone who takes notes of the meetings. The others, however, can then use the table its display instead of laptops to show the required documents.

Technologies

There are multiple technologies present in the environment in which the interactive coffee table will be used. This environment is a business environment, which means multiple regulations are present to preserve a secure company system. This means that there might not always be the possibility to connect this table to a network, which results in the need of a table that is also usable without a network connection. Also, it could be possible that before the table can connect to the internet, the table must meet some safety regulations. In this environment the users of the table will mainly be employees of a company. These people often use products such as smartphones, tablets, laptops, etcetera. This means that if these people will go to for example the lobby in which this table is placed, these people might still carry these products on them. Therefore it could be interesting to offer users the possibility to log in via for example a smartphone or a company-pass to offer them a personal environment within the software of the table. In these business contexts it is expected that there are enough power-outlets to allow the employees to use their laptops on other places than at their desks. These power-outlets can also be used for the table. Another technology characteristic of a business environment is that most of the time there is an alarm system active outside office hours and possibly also during office hours.

4.5 Stakeholders

To design a product that meets the requirements and wishes of the user and other people involved in the development of this product, it must be clear who the stakeholders are. For this product design the stakeholders are derived from the PACT analysis. This results in the following stakeholders to be present for this product:

- 100%FAT;
- MADlab;
  - The prototype of the interactive coffee table will be placed here in a showroom with the purpose to show the capabilities of 100%FAT to multiple potential customers that visit MADlab.
- StudioMAD;
- Recreate;
- Customers (companies) of 100%FAT;
- Employees of the customers of 100%FAT;
- Customers and other people who will visit these customers of 100%FAT.

4.6 User Characteristics

The people who mainly use the final version of this product are the employees of the customers of 100%FAT. This is because the customers of 100%FAT are companies who buy these kinds of products so that their employees can use them. Next to these employees, also visitors of these companies will use this product. This can for example be the case when someone has a business meeting at a customer of 100%FAT. Then this table can be used to show data during this meeting. In this context the table could also be used to show the company portfolio to the customer, which makes it a sales tool.

Overall the people that will use this table will be employees of companies, which means that most users for this type of product will be aged between 25 and 55 years. Also, these users will at least have a basic level of understanding on technological and interactive products through the daily usage of smartphones, tablets, laptops, computers, etcetera. Another characteristic of these people is that they are interested in technology advanced products.

4.7 Usages Scenarios

The table can be used in multiple manners. Therefore, usage scenarios are used to analyze how the table is used in these different manners. These scenarios are made for the coffee table variant and the conference table variant. The conference table variant is essentially a higher version of the interactive coffee table, so that these tables can be connected to each other to create one large conference table.

Informal Business Setting; Customers Scenario

In this scenario the table is placed in the lobby of a company. Some people that have a business meeting at company X in a quarter decide to wait for a while in the lobby and to sit on a couch with the interactive coffee table. After getting a cup of coffee and placing it on the table, the display lights up and it becomes clear to these people that the interactive coffee table is not a regular coffee table. The display indicates with subtle arrows how to interact with it and these people understand it quite quickly.

The company has loaded its portfolio on the table so that people waiting in the lobby can discover the specialties of the company in an interactive manner. This exactly what these people are doing, they are scrolling through the company its portfolio and after spending only a few minutes on the table, they have quite a good idea of what the company is capable of.

Informal Business Setting; Employees Scenario

In this scenario the table is placed in the lobby of a company. During a short coffee break two employees (Bas and Joost) that are working together on a project start discussing a problem in the mechanics in a product. After a while they experience the need to show each other some visuals because of a lack of understanding. Each employee has a company pass by which he can log in on the interactive coffee table to have access to his own files. Thus Bas and Joost sit down on the couch to further discuss this problem in an informal setting. Then Bas swipes his card over the scanner that is integrated in the table and he opens some visuals to illustrate what he is trying to explain. By the hand of the visuals shown on this table, Bas and Joost can discuss this problem better. Also because the interactive coffee table is a coffee table placed in a couch setup, Bas and Joost can discuss this problem in a more relax business environment which can open the mind to new ideas (Prashant, 2012).

Scrum

At company X the interactive coffee tables are also used for Scrum. During Scrum employees update each other on the progress of their projects. This makes sure that all employees know what is happening at the company and what the progress of each project is (Scrum of Scrums, 2017) (Daily Meeting, n.d.) (Scrum of Scrums, n.d.) (Scrum (software development), 2017). At company X this is done every Monday so that everyone is updated in the start of the week. The employees use the interactive coffee table for this because it allows them to do Scrum in an informal setting. Next to this, there is no need to prepare a PowerPoint presentation to present the progress. Instead, employees only need to open their progress files on the table by placing their personal coffee cup or puck on the display. After all updates on one project are discussed, the next person can also open his/her files by a swing of this personal coffee cup or puck. This means that the employees can discuss the progress of each project in an informal and interactive manner.

Formal Meeting

For a formal meeting a table with a higher frame is available, and because of the connectivity of the table the customer can choose for itself how large the table should be. In this way the customer can configure a conference table for in a meeting room.
Company X has bought multiple interactive tables with a higher frame and placed these in a conference table setup in a meeting room. This room has a formal appearance which is meant for business meetings. During these business meetings there is always a minutes secretary who takes notes of the whole meeting. This person can now share these notes real time to everyone at the meeting by using the interactive tables. The minutes will then be shown on each table, which means that only the minutes secretary needs a laptop to take these notes. Thus, people will be less distracted by amongst else incoming e-mails on their laptops. This sharing function is also used to share other files that are needed during a discussion. Thus if for example Dirk (CFO of company X) needs to explain the financial performance of the company during last quarter, he can simply share graphs to all tables to support his story. The other people at the meeting then only need to accept this sharing request by Dirk and then these people can also see this graph. This is considerably quicker and easier to do than if Dirk first needed to connect his own laptop to the beamer to show the graph.

4.8 Summary

In this chapter the potential usage of the interactive coffee table was discussed. This was done by first gathering knowledge about the customer and the user via interviews and the maker festival. This was followed by a PACT analysis which clarified more on the usage of this table and the environment in which it will be placed. Also multiple usage scenarios were described for both an informal and a formal environment. This resulted in enough information to be gathered for answering the research questions.
To answer the first research question "By whom will the interactive coffee table be used?", the users will mainly be employees of the customers of 100%FAT. These customers are bigger companies with a size that is comparable with Grolsch. The users are aged between 25 and 60 years and have enough experience with technological product to be able to work with an interactive coffee table.
The second question 'For which tasks will the interactive coffee table be used?" can be answered by the hand of the developed scenarios and the PACT analysis. The table will be used as a conversation tool, which allows people to show each other visuals in an interactive manner. These visuals can for example be the product portfolio of a company, which means that the function of the table can be to inform customers on the specialties of the company. Next to this, the table can also be used by employees to discuss some topics for which visuals are needed for a good understanding of each other. Also, the table can be used as conversation tool for Scrum. Lastly, a conference table setup of the table can be used during business meetings. This means for third question "under which circumstances will the interactive coffee table be used?" and for the fourth question "In which environment will the interactive coffee table be used?", that the table will be used in a business environment. This business environment can be informal when the table is placed in for example the lobby and formal if the table is used as a conference table.

Chapter 5 | Requirements & Wishes

5.1 | Introduction

In this chapter the requirements and wishes for an interactive coffee table are clarified. These are derived from the insights gained in the previous chapters one until four. These requirements and wishes are derived for both the customer of 100%FAT and for 100%FAT itself. Thus the research questions to be answered in this chapter are the following:

- What are 100%FAT its requirements and wishes for an interactive coffee table?
- What are the target group its requirements and wishes for an interactive coffee table?

5.2 | Requirements

The requirements of the interactive coffee table are shown below. First the requirements 100%FAT stated for the product design and second the requirements customers have stated that are not included in the requirements of 100%FAT.

100%FAT

- The production of the interactive coffee table costs less than 5000 euros;
- The area dimensions of the housing of the table have a maximum value of: 1,52m by 0,92m;
- The display area dimensions of the display have a maximum value of 1,30m by 0,70m;
- The distance between the ground and the projection panel (display) should at least be 0,50m;
- The interactive coffee table can recognize tagged mugs that are placed on the display for interaction;
- The coffee table can withstand a weight of 105,63 kg outside the display area; for if someone leans or sits on it;
- The interactive coffee table does not weigh more than 57 Kg;
- The production of the interactive coffee table will not cost more than 5000 euros;
- The interactive coffee table is equipped with custom mugs, for control means;
- The custom mugs are equipped with fiducial markers, for tracking means;
- The custom mugs do not scratch the display of the interactive coffee table;
- The interactive coffee table is equipped with its own computing unit;
- The display layer is flat, not (slightly) curved;
- The interactive coffee table uses one Casio XJ UT 310WN beamer.

The 105,25 Kg which the table should be able to withstand is based on the average weight of a man of 20 years and older. This because man weigh on average more than woman. Also a safety factor of 25 percent is used for if someone sits down with more speed, which means the weight needs to be 84,5 Kg * 1,25 = 105,63 Kg. (CBS, 2017).

Customers

- The table has touch support;
- The table should have a user-friendly interface, so all visitors and employees can use the table;
- The table its cost price lays between 10 000 and 15 000 euros;
- The lifetime of the coffee table should be 6 years.

5.3 Wishes

The wishes for the interactive coffee table are shown below. First the wishes 100%FAT stated for the product design and second the wishes that customers have are stated. The wishes by customers are only the ones that 100%FAT did not have.

100%FAT

- The height of the interactive coffee table can be preset to a specific height by 100%FAT, to the wishes of the customer;
- The height of the interactive coffee table is adjustable by the customer at any time;
- The touch display supports multi touch of 10+ fingers;
- The skin of the table can be switched;
- The display is placed horizontal; otherwise it is more complex to set the beamer up for object recognition. It needs to be possible to place mugs on the table (those should not slide of the table).

Customers

- Scratch and bullyproof

5.4 Summary

In this chapter the requirements and wishes for the customers of 100%FAT and for 100%FAT itself were defined. These are the basis for the following steps in the design process. This makes sure that the product design suites the people that will buy and/or use the product. Therefore the research questions "What are 100%FAT its requirements and wishes for an interactive coffee table?" and "What are the target group its requirements and wishes for an interactive coffee table?" have been answered by providing an overview of these requirements and wishes of both parties.

Chapter 6 | Ideation

6.1 | Introduction

The design process of the interactive coffee table has started with an idea generation. This idea generation phase has been done before searching for inspiration, which makes it possible to start the process with a fresh and uninfluenced mind. The objective of this phase is to create many interesting shapes for the table and finally to create three design directions that will be input for the next phase that is covered in this chapter, the creation of inspiration boards. These inspiration boards are created out of inspiring aspects that can be interesting to integrate in the product design. Therefore, an inspiration board is developed for each of the three design directions.

6.2 | Idea Generating Sketches

The first phase to be discussed is the generation of idea sketches. Most of these sketches are visible in figure 6.1. These sketches show many different possible shapes of the table. These sketches are created with a limited thinking of reality to stimulate a creative process, which can lead towards new and innovative designs. An important goal for the design of the interactive coffee table is that it should integrate a floating effect with the display. This should create a somewhat magical appearance and the so-called wow factor. Since this is an important requirement that 100%FAT has given for this product design assignment, it is also considered in the idea generating sketches. An overview of all sketches of this phase is placed in appendix A.2

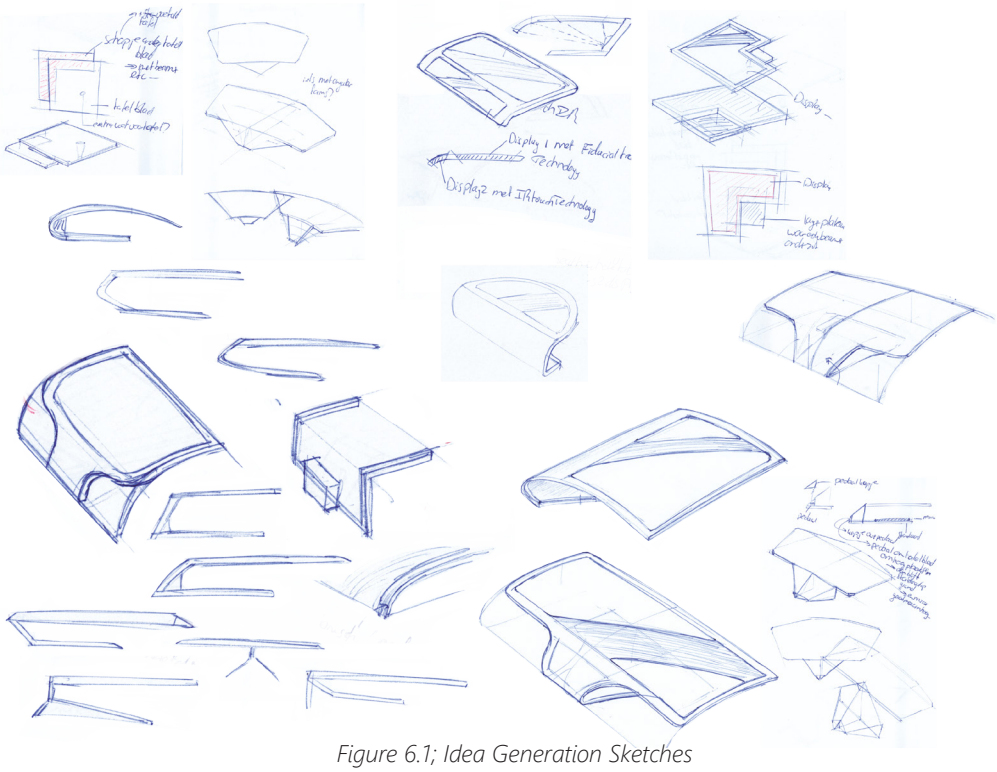

Figure 6.1; Idea Generation Sketches

6.3 Design Directions for Concept Development

Many different design directions were explored during the idea generation, as shown in section 6.2. From these directions, three are chosen to further explore by developing these into concepts. The choice of these directions has been made together with 100%FAT to make sure it is coincident with 100%FAT its expectations of the interactive coffee table. Now each direction is shown and shortly discussed.

Wing Design

The "Wing Design" direction is designed to integrate a floating effect with the display. Therefore, the table is designed in a low profile and because its leg slowly bends towards the ground it seems to come out of the of the ground. This while the leg actually goes on below the table surface. This leg also hinders the user in using the table from the side of the leg, which means it is more logically to use the table from the side opposite to the leg. This is also the side at which the display is best visible. Next to this, the display of the table is offered to the user by slightly bending it towards him/her. This concept version is shown in figure 6.2.

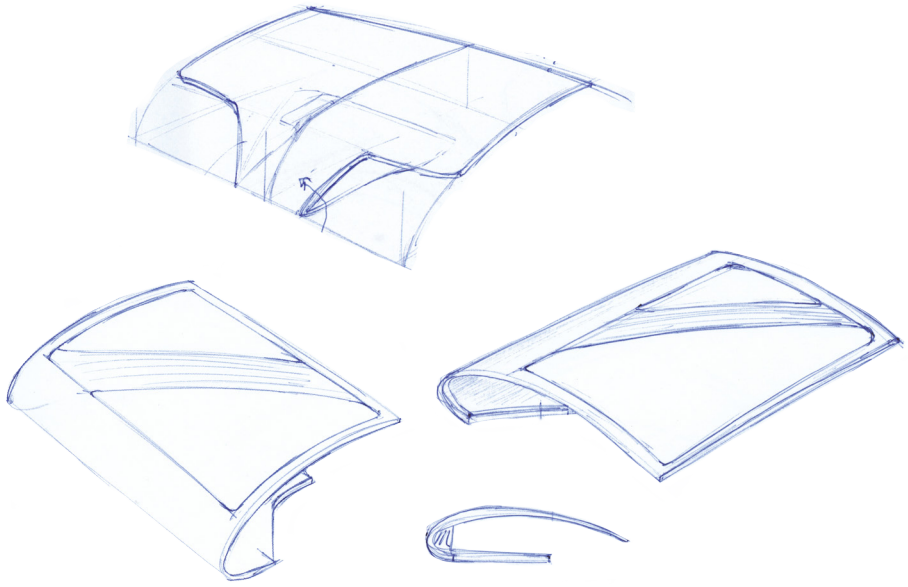

Figure 6.2; Wing Design Design Direction

Simplistic and Angular Design

The simplistic and angular design direction is designed to offer a simplistic design that is suitable in more contexts. These can be either business like or the more informal environment of the lobby of a company. This design direction also strives to combine a technology advanced appearance with the appearance of a regular coffee table. This design direction is shown in figures 6.3 and 6.4.

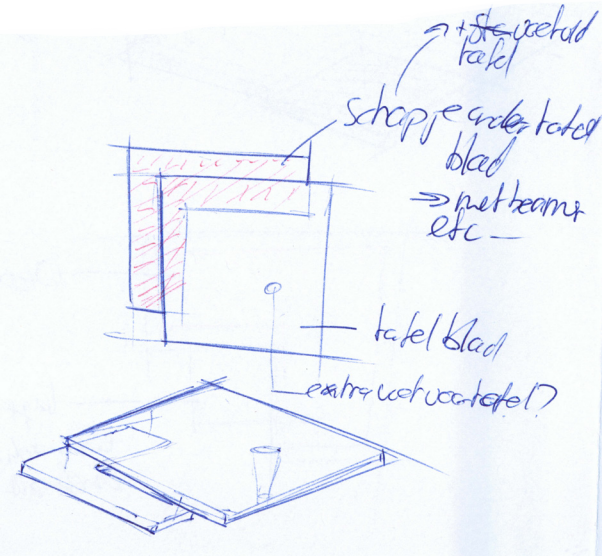

Figure 6.3; 1.Simplistic Design, Design Direction

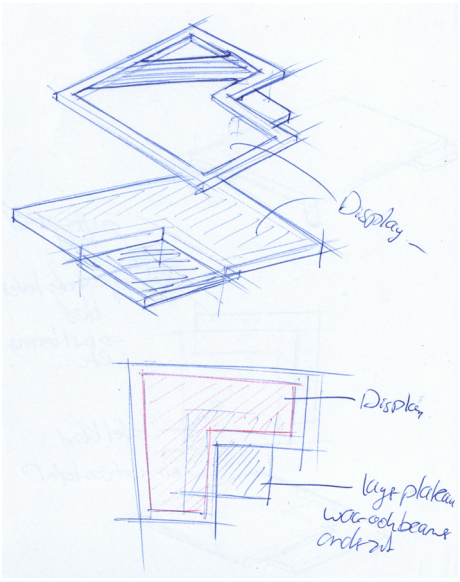

Figure 6.4; 2.Simplistic Design Design Direction

Organic Design

The organic design direction consists out of more organic shapes. The design is build up out of a frame, which is bend into the organic shape, and a projection panel that is placed in the frame. This projection panel seems to hang loosely in the frame and is quite thin compared to the frame, which creates a magical effect. This effect is enhanced by using a beamer that is set to project up to the edges of the projection panel. This will remove the bezels from the display and creates a high-end appearance with a thin borderless display. This design direction is shown in figure 6.5.

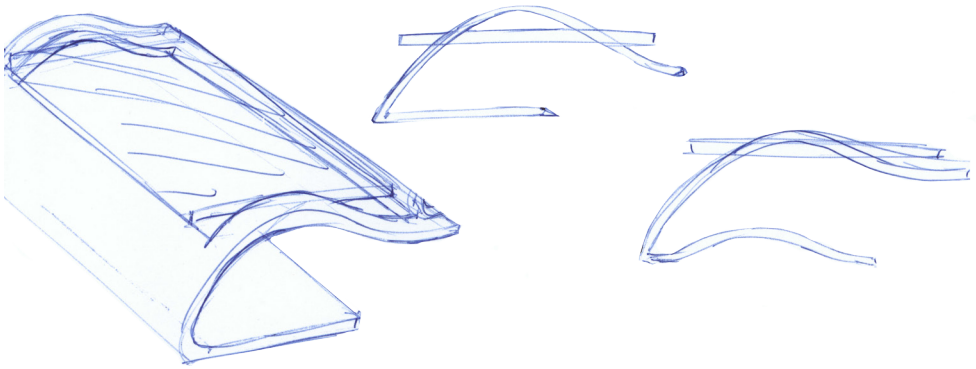

Figure 6.5; Organic Design, Design Direction

6.4 Inspiration Boards

After the three design directions have been determined in the previous section "6.3 Design Directions for Concept Development", the next step is to search for interesting aspects in existing products. These interesting aspects are used as a source of inspiration during the design process. There is searched for inspiration images for each of the design directions and these are placed in inspiration boards. Therefore each of these inspiration boards will be shown and briefly discussed in this section.

Inspiration Board Wing Design

The inspiration board for the wing shaped design direction shows many rounded tables, which mostly have one obvious leg of have a tabletop that goes over in a leg. This results in a more magical effect of a thin looking table tabletop which seems to lean on one leg. An interesting design aspect in this inspiration board is the combination of the wood patterns and the curves of the tabletop. When the direction of these wood pattern corresponds with the direction of the tabletop its curves, it creates a rather good looking design. This also creates a table that looks like one entity instead of a clear separation between the legs and the table top. This inspiration board is shown in figure 6.6.

Figure 6.6; Inspiration Board Wing Design

Inspiration Board Simplistic

The inspiration board of the simplistic design direction shows tables designed in a simplistic manner. These tables are also rather angular shaped. From the inspiration board for this design direction, which is shown in figure 6.7 "Inspiration Board Simplistic", it becomes clear that the combination of a simplistic shape with materials like matte silver aluminum with wood creates both a premium appearance and a businesslike appearance. This makes the simplistic design direction suitable for a set-up in companies. Next to this, the simplistic style is suitable for a coffee table that will be placed in a more informal environment like the lobby of a company.

Figure 6.7; Inspiration Board Simplistic

Inspiration Board Organic

The inspiration board for the organic design direction shows many rounded shapes and many tables that have a visible frame. Seeing the organic direction sketches were aimed at developing a table with an organically shaped frame and a flat display, mostly the tables with a glass tabletop and a bended wooden frame are a good inspiration for this design direction. This inspiration board is placed in figure 6.8.

Figure 6.8; Inspiration Board Organic

Additional Inspiration Board

During the search for inspiration for the design of the interactive coffee table, multiple inspiration images that were not specifically aimed at one design direction were found. These are displayed in the inspiration board shown in figure 6.9.

Figure 6.9; Additional Inspiration Board

Material Inspiration Board

Next the search for inspiration for the design directions of the coffee table, also multiple inspiration images for the material appearance of the interactive coffee table have been searched for. These are shown in figure 6.10. From this inspiration board it appears that using wooden patterns can result in interesting looks. It also creates an interesting appearance when these wooden materials are combined with glass or metal parts.

Figure 6.10; Inspiration Board Material

6.5 Summary

During the idea generation phase the goal is to explore many different design directions and to develop these up to a rather basic level. This is done while keeping a limited view of what would be possible in reality to stimulate a more creative thinking process. The result of the first phase that is discussed in this chapter are three different design directions that serves as input for the second phase of the chapter. These directions are the "Wing design", the "Simplistic and Angular Design" and the "Organic Design". The inspiration phase that was discussed has resulted in multiple inspiration boards to be developed. These inspiration boards are used during the design process in the next phase, the concept phase. These inspiration boards are together with the design directions, that are derived from the idea generation phase, input for the further development of these design directions into concepts.

Chapter 7 | Concept Development

7.1 | Introduction

In the concept development phase the chosen design directions will be further developed towards concepts for the design of this interactive coffee table. For these concepts the reality is better considered, to ensure a realistic design proposal can be developed. The goal of this phase is to find out which of the three design directions performs best considering the requirements and wishes of both the customers of 100%FAT and of 100%FAT. Therefore the research questions to be answered in this chapter are:

- Based on questions one to five, what concepts of an interactive coffee table are possible?
- Which concepts developed for question 6, performs best considering questions one to five?

These will be answered by making a concept choice at the end of this phase, for which the requirements and wishes will be the basis.

7.2 | Concepts

For the concept development of the three design directions the outgoing point is to use one beamer. This contrasts with the "Thales Table" which is previously developed by 100%FAT. In this table there are two beamer integrated to make sure that the display has good viewing angles from all sides of the table. In the coffee table variant, however, there is not enough budget to integrate two beamers. Besides there is no need to integrate two beamers in the table because it will be placed in a couch setup. This means that the table will only be used by people sitting on a couch which is placed in front and next to this table. Therefore, the display does not need to offer a good viewing angle for the rear side of the table. This also means the table should be designed in such a manner that it stimulates usage from the front side of the table.

Next to this, there is an important reason for 100%FAT not to integrate multiple beamers. This reason is the amount of extra time that is required for the calibration of these beamers on each other. Hence, the two beamers should not overlap each other's projection. Another difficulty involved with using two beamers is that the calibration will be lost after using the table for merely two hours. This is caused by the heat development of the beamers, which causes the lenses to be slightly deformed. This was the case with the "Thales Table", which 100%FAT strives to prevent in the coffee table variant.

Now the developed concept for each of the design directions is discussed.

Concept 1; Wing Design

The "Wing design" concept is designed with a more futuristic and high-tech appearance. Therefore, this concept is more suitable for a modern high-tech business environment. A visual of this concept is placed in figure 7.1. The concept stimulates the user to use the table from the front side. This is done by placing the leg of the table in such a way that it makes it inconvenient for the user to use the table from the rear side. This is also combined with a rather large bezel at the rear side compared to a smaller bezel at the front side. Next to this the display is slightly curved towards the user, which gives the user the impression that the display is offered to him/her. Thus, it is more logically for the user to use the table from the front side. When placing this table in a couch setup in the lobby, the user is even more stimulated to use the table from the front side. This is because the couch on which the user sits is placed at this side of the table.

In this concept the projector and the computing components are placed in the leg, as indicated in figure 7.1. By placing these components in this place these are less visible. This means that it is less obvious to the user that there is quite a lot of space reserved for these components, which helps creating the magical floating effect of the display. In the leg there is also space reserved for the camera which is needed for the object and touch recognition. This is done via the mirror that is integrated in the horizontal part of the leg.

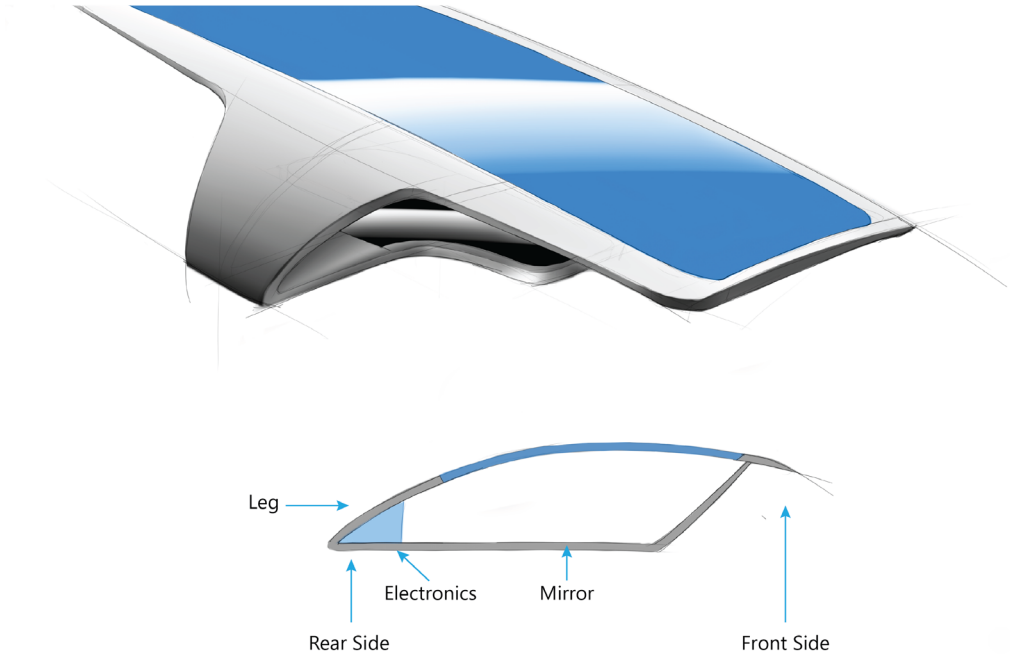

Figure 7.1; Concept Wing Design

Concept 2; Simplistic Design

The "Simplistic Design" concept is designed with a simplistic and open character. When combining this with the silver aluminum frame, the wooden frame for the display and the shiny glass display surface, a rather premium appearance is created. This makes the concept suitable both formal and informal environments within companies. Thus this concept is suitable for multiple business environments. The concept is shown in figure 7.2.

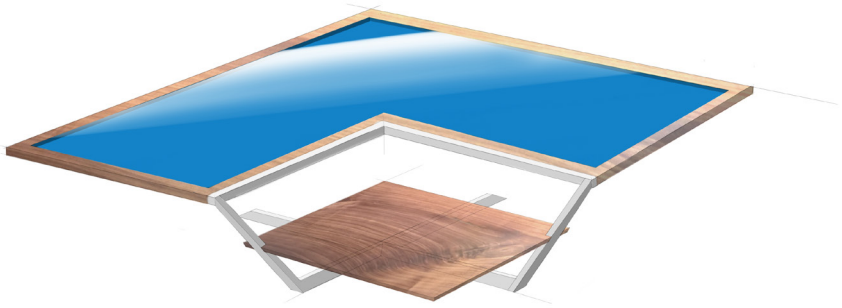

Figure 7.2; Concept Simplistic Design

This concept is designed from the outgoing point that couches are often placed in a corner setup with two couches, which is illustrated in figure 7.3. In this situation a rectangular interactive coffee table, with the normally used rectangular display, would only be usable from one of the two couches. To solve this problem the display integrates this corner shape of the setup of the couches. This results in an interactive coffee table that is usable from two sides. This is illustrated in figure 7.4. This corner shaped display also shows that a display does not need to have the regular rectangular proportions when a beamer is used. This also contributes to the magical effect that is created by such a large display positioned low above the ground.

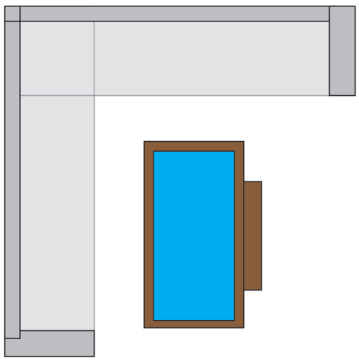

Figure 7.3; Corner Couch Setup 1

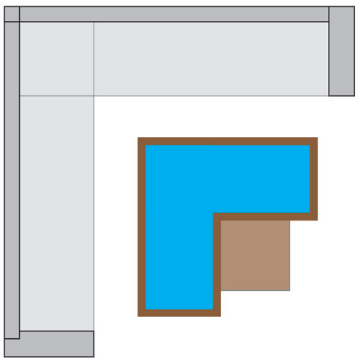

Figure 7.4; Corner Couch Setup 2

This stimulate usage from the correct side of the display, this concept integrates a wooden cover panel. this panel is indicated in figure 7.5. This panel blocks the user to use the display from the wrong side of the table. Now it is more convenient to use it from the correct side. This panel also allows the user to place objects such as a coffeepot and files etcetera out of the display. This prevents the display from becoming too stuffed with objects so that user does not have enough space left on the display to use the interactive functionalities. Another function of the cover panel is hiding the hardware such as the beamer and the computer. These components are to be placed in a compartment below this cover panel. This is, however, not fully worked out yet in this phase thus it is not shown in the sketch of this concept.

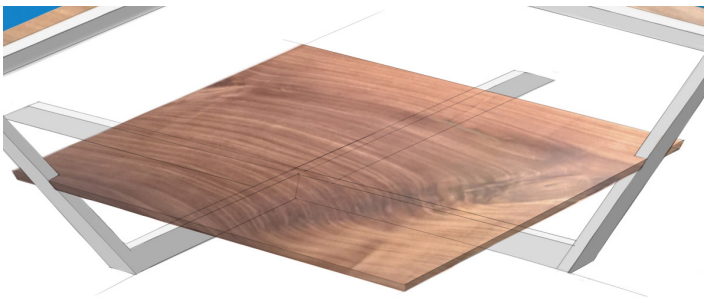

Figure 7.5; Simplistic Design Cover Panel

Concept Direction 3; Organic Design

The third concept is the "Organic Design". A sketch of this concept is shown in figure 7.6. This concept integrates an organic shape in the frame to create a fluid shaped and elegant table. The display hangs in the frame and this frame offers the display to the user. In this concept it is possible to create thin bezels because the display glass is mounted at merely four points in the frame, and it does not lay on an edge to keep it sturdy. Because the display is mounted at only four points, it seems to hang loosely in the frame. When combining this with the rather thin and almost borderless display, it creates a magical effect.

This small bezel around the display creates a more technology advanced appearance. This concept fits in a more informal environment in a technology advanced company. It is not suited for a formal business environment, because the organic shape can be interpreted as too playful for employees to have a more formal business conversation.

The "Organic Design" concept also uses the leg to prevent people from using the table from the wrong side. This leg also houses the components such as the beamer and the computer. This again makes these components less visible to the user and thus contributes to the magical appearance. For the construction of the table it is, however, questionable whether this setup is sturdy enough for a coffee table. This is because there is only one leg at the rear side of the table, which means that a small force at the front side of the table creates a large moment on curve in the leg. This problem, however, is not opted as a problem because it can simply be solved with an extra leg at the front side of the table. This leg should not be placed in the view of the user to keep the magical effect of the display.

An interesting idea for further developing this concept might be to use a shiny chrome finish on the frame. Then the table is more elegant than when a matte aluminum frame is used.

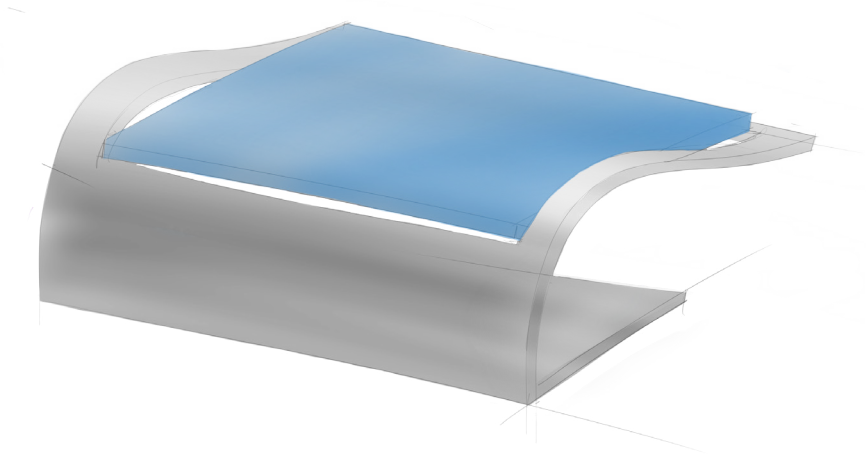

Figure 7.6; Concept Organic Design

7.3 Concept Choice

Three concepts have been developed and a well-considered choice needs to be made for the further development of this table. Therefore the strong and weak points of each of the concepts will be discussed here, after which a the concept choice will be discussed.

Wing Design

The "Wing Design" concept features a rather futuristic and high-tech appearance. This means it is mainly suitable for a high-tech business environment, which limits the target group of 100%FAT to these more high-tech companies. Also, this table does not look like a coffee table which means people might be confused and not know whether it can be used as a coffee table. Thus people might not place coffee cups, coffeepots, etcetera on the table its display, while this is the purpose of this table. Another disadvantage of this concept is that is not easy and cheap to produce because of the free and non-angular shaped design. This means 100%FAT is not able to produce this table design in its own workplace, which results in higher production costs and thus a higher cost-price. Seeing 100%FAT opts for a costs-price of 5000 euros it is rather important that the table is relatively easy and low-cost to produce. Lastly, a functional problem with this design is that the display is slightly curved which means that the beamer and object- and touch recognition do not easily function. This is because this curve needs to be considered in developing the software for this table, which is not an easy job. Therefore it is expected that this curved display panel will considerably increase the cost-price of this table. Thus to make this concept function, the design needs to be adapted in such a way that the display is flat while the curved wing design is somewhat maintained.

In this concept it is easy to project on the display with the beamer, because of the single rectangular shape. Also the display is integrated with the frame into one part, which means there are no difficulties with exactly aligning the projections with the display glass. This is because the beamer can now also project slightly next to the display glass while it is not visible for the user, which means the beamer does not need to be calibrated exactly to the display. Another advantage of this concept is that the hardware such as the beamer and the projector can be easily integrated without being obviously present to the user. This is because these components are placed in the curve of the leg, of which the inside is not good visible to the user.

Simplistic Design

The "Simplistic Design" Concept integrates a simplistic and premium appearance. This simplistic appearance results in the design to be quit "calm" and to blend in with a business environment in which it will be placed. This means the design does not distract employees at a company, which is why this concept design is opted as suitable for both an informal and a formal business environment.
An important disadvantage of this concept is the placement of the electronic components such as the computer and beamer. As explained in the previous section 7.2, these are placed beneath the cover panel. This means that below this panel there should be quite a large box for these components, which is well visible to the user. Seeing this harms the open look of this table, it is not desired that such a large box is placed below the table. The presence of this box can, however, be minimized by designing it in such a way that all sides are beveled. This makes is less obvious for the user that this thin cover panel actually covers a rather large box. This is also often done in other products such as the IMac by Apple. With this product there is also a thin front panel which covers a thick rear part that houses many components. Another point at which this concept needs to be improved is the sturdiness of the table. In the sketch shown in figure 7.2 there are only legs at the side rear of the table (at the cover panel).

This means that the tabletop is not sturdy enough and will most certainly bend when someone leans on it. Therefore the is a need of two extra legs at the other side of the table. These legs can simply be integrated in the design by letting the existing legs continue towards the tabletop at the other side. By doing this the open design is maintained and these new front legs are integrated in the design. Another disadvantage of this concept is the rather large bezel around the display. This might result in people placing their coffee cups on the bezel instead of on the display, because users might think that the display is not supposed to be used as a coffee table. It is, however, the purpose of the table that it will be used by placing coffee cups on the display. Therefore, this large bezel is not desirable and the design should be adapted so that the user is stimulated to place coffee cups on the display instead of on the bezel.
An important advantage of the "Simplistic Design" concept is the integration of the corner shaped display. This allows the table to be placed in a commonly used corner setup for couches, while the display can be used from both couches. Another advantage of this concept is that the construction is not complex, which means it is not hard to produce. This is because the table is built up out of rectangular shapes and standard frame components. This means that 100%FAT can produce this table in its own workplace, which results in lower production costs. Because 100%FAT opts for a budget of 5000 euros to produce this table, it is preferred that the table can be produced in 100%FAT its own workplace.

Organic Design

The "Organic Design" concept is because of its organic shape and high tech appearance more suitable for an informal environment in a technology advanced company. It not suitable for in a working environment because of its rather distracting organic shape. This means that the target group for this concept will be limited to these informal and high-tech environments.
An important complication with the "Organic Design" concept is the calibration of the beamer on the display glass. This is because the display glass hangs on only four points in the frame and it is not surrounded by a large bezel. This means that if the beamer is not calibrated exactly on the projection glass, the beamer will project next to this glass. Because this concept does not include a large bezel, the user will see this light that is projected next to the projection display. Therefore the beamer needs to be calibrated exactly on the display glass which means it will be a time consuming activity to calibrate the beamer. Another implication with the way the display is mounted in this concept is that the display glass will slightly bend at its ends because of its own weight. This bending of the display glass will happen especially when someone leans on it. Because this will result in the beamer not to be aligned with the display glass anymore, it is desirable that the design is slightly changed so that the display glass can be mounted in the frame at more than four points. This will result in a studier display and prevents the beamer from projecting next to the display because the display will not bend easy anymore. Another complication in this design is the rigidity of the frame of the table, because it only uses one leg at only the rear side to support the table. This, however, can be easily solved by integrating another leg at the front side of the table. When placing this extra leg at the front side of the table it should be considered that this leg should be neatly integrated in the design so it will not be obvious for the user. Therefore this is not opted as a problem.
A more important issue is the production cost of this table. This is because the table integrates an organic shape which is not producible by 100%FAT. This means the frame of the table should be produced by an external company, which makes the production this table more expensive. Something else to consider is that these industrial production companies require customers to place large orders. This is because when only a single production item is ordered it is not profitable for these companies to produce these frames. This is something 100%FAT has experienced with another product before. Therefore, it is preferable for 100%FAT to be able to produce the table largely by itself.

An advantage of this concept is that the bezels of the table are minimized so that users can only place coffee cups on the display itself. Therefore, users are triggered to place coffee cups on the display instead of on the bezel. Because the user should be stimulated to place his/her coffee mug on the display, this is opted as a great advantage of this concept. At the same time, however, this display can be a bit confusing for the user, because he/she is not sure whether the display will damage when something is placed on it.

Concept Choice

Considering the advantages and the disadvantages of each concept direction, the "Simplistic Design" concept appears to perform best out of the three concepts. This is mainly because the table is suitable for multiple business environments, because of its production advantages and because of the integration of the corner shape setup. Next to this the problems that that exist with this concept can be solved by making some slight design changes. Since these design changes do not drastically adjust the appearance of the table, this is not opted as a problem. Therefore, the "Simplistic Design" concept is chosen to further develop towards the final design proposal.

7.4 Concept Development

As clarified in the section above, the "Concept Choice" section, the simplistic design concept has been chosen to further develop. The most important reason for this choice is the extent to which this concept direction is suitable for multiple company environments. Now the next step is to further develop this concept towards a realistic design proposal. Thus the development of this concept is discussed here. The final design proposal will be discussed in Chapter 8. Final Design Proposal.
The first step in the development of this concept is to check how the appearance of this concept appears in a more realistic view. This is done by developing a SolidWorks CAD model of this concept and then to apply the required material appearances to the model. The result is visible in the render shown in figure 7.7. As visible in this render the concept is indeed rather simplistic and by combining this simplistic look with the shiny metal and wooden finish a premium appearance is created. Next to the premium appearance, the simplistic design style also makes the table suitable for both a formal and an informal business environment.

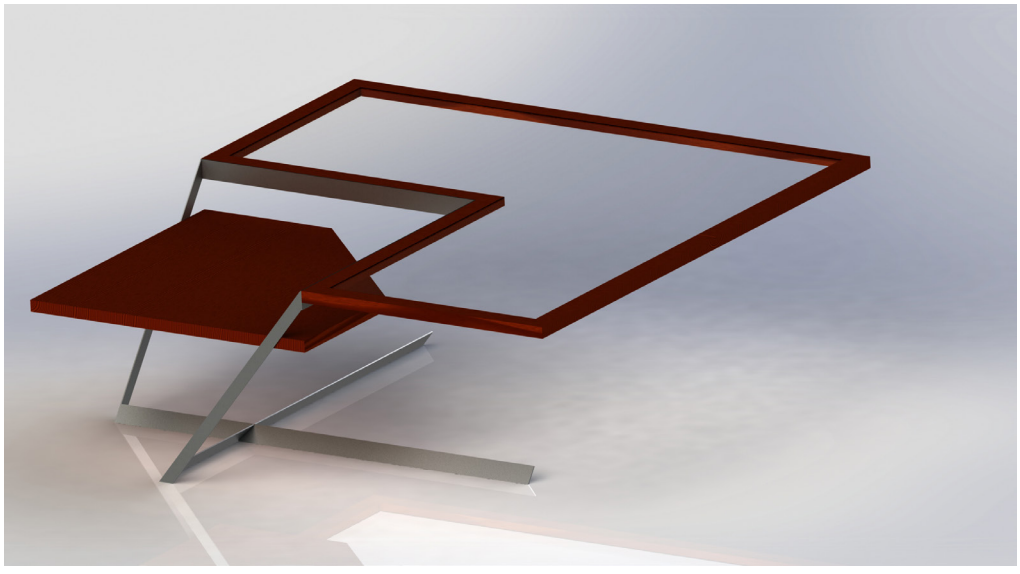

Figure 7.7; Material Render Simplistic Design

At this point however, it became clear that was a problem with the design of this concept. This problem is caused by the corner that is integrated in the design. This corner results in the table to be significantly more expensive to produce. This is because this corner makes it more difficult to project on the whole projection surface. However, this is still possible with some sacrifices. This can either be done by using one high resolution beamer or by using two beamers.

For the first option the beamer will need to project in the shape shown in figure 7.8. For this solution a high-resolution beamer is required to prevent a pixilated display, because the beamer will project most of its projection next to the display. This is quite expensive to integrate in the product. A normal 4k beamer with a minimal projection distance of 1,3 meters already costs at least 2000 euros (CoolBlue, sd). There is however the need of an ultra short throw beamer and these are rarely available in these high resolutions. An example of one is the "Sony 4K Ultra Short Throw Projector", which costs 50 000 euros (BeamerExpert, sd). This on itself is a reason not to go for this solution. However, when it is also considered that this solution only uses about half of the beamer its actual resolution, it is most certainly a too expensive option for the display resolution that is achieved by it. Next to this, it is a waste of the beamer its potential when so little of its resolution is visible on the display.

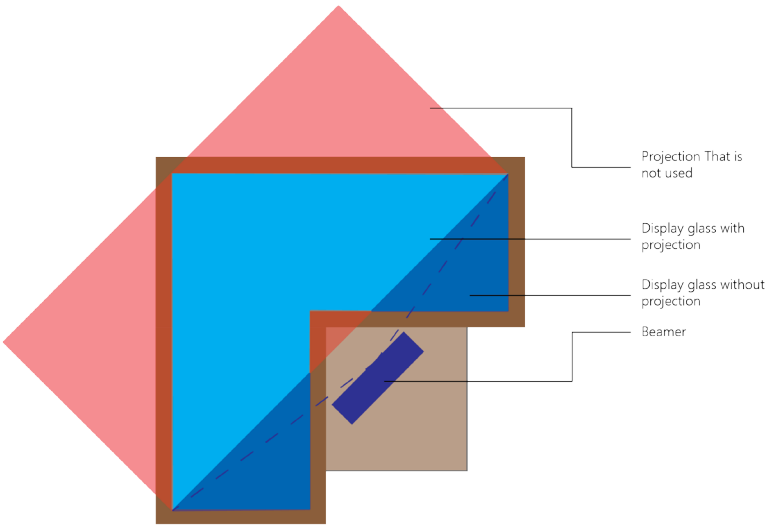

Figure 7.8; Beamer Projection One Beamer

The second option is to use two beamers, this setup is shown in figure 7.9. This setup will reach the same result. For this option however, the amount of unused pixels remains limited. Therefore, there is no need to integrate a high resolution beamer in the interactive coffee table. This is however still a rather expensive manner to create a display. One Casio ultra-short throw projector with a resolution of 1280 by 800 pixels costs 1700 euros (BeamerExpert.nl, sd). Because 100%FAT already uses these beamers and has some in supply, it is necessary to use these beamers.

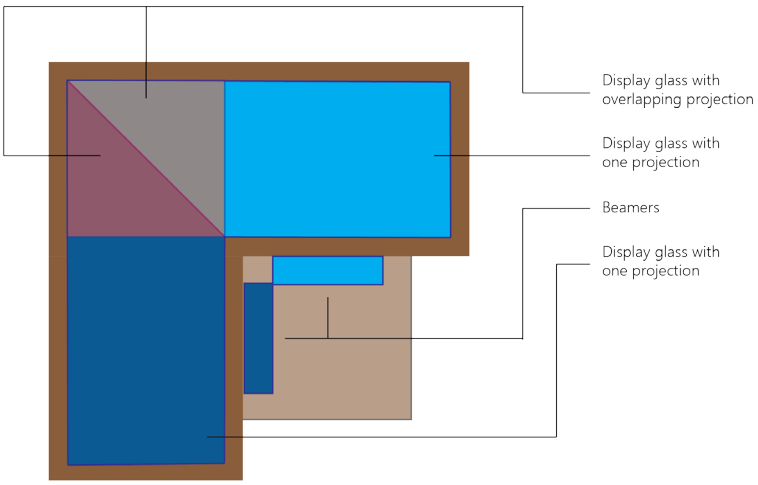

Figure 7.9; Beamer Projection Two Beamers

Thus both options will result in a higher cost-price and thus in a higher selling price. This selling price is expected to increase too much for many customers. Therefore integrating only one beamer (Casio XW UT 310 WN) is considered as a better option. At first the intention was to do this by using only one part of the table its projection glass as a display.

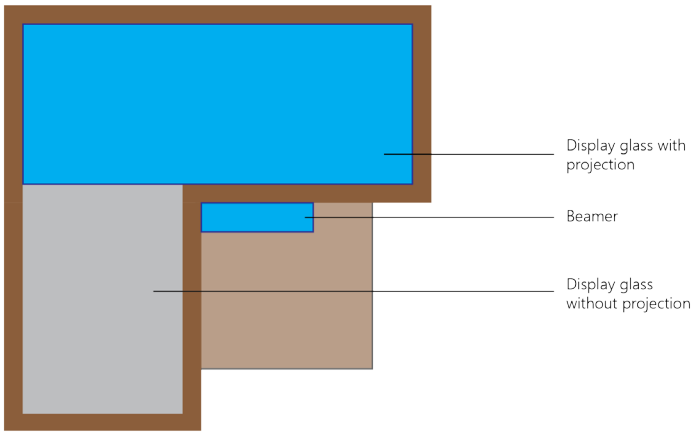

Figure 7.10; Beamer Smaller Projection One Beamer

This is illustrated in figure 7.10. By doing this it will result in an interactive coffee table that is only usable from one side, while the usage from two sides was an important advantage of this concept. Next to this it can be misleading to the user because he/she will expect the whole glass surface to be usable as a display. Therefore the choice has been made to further develop this concept into a more feasible concept which integrates a solution to this struggle with the beamer.
The solution that has been found is to split this table design in two separate table components that can be connected to each other to create the table with the corner display. This is shown in figures 7.11 and 7.12. Each component can function as a separate table and if two or more are connected to each other they function as one table. Thus the customer with a smaller budget can buy only one component and the customer with access to a larger budget can configure a setup to its wishes. This offers the customer more flexibility compared to the previously developed concept "Simplistic Design" and possibly results in a larger target group. Next to this, the solution makes it possible not to exceed the budget of 5000 euros because only one beamer needs to be integrated in the entry level of the table. This entry level consists out of one table component.
The sketch shown in figure 7.12 has been translated to new concept for the "Simplistic Design" concept which is shown as a SolidWorks CAD render in figures 7.13 and 7.14.

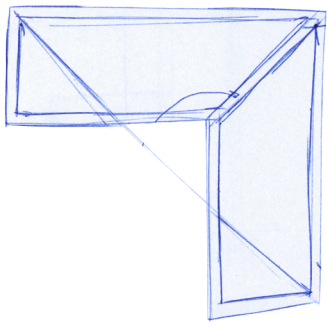

Figure 7.11; 1.Simplistic Design Revised

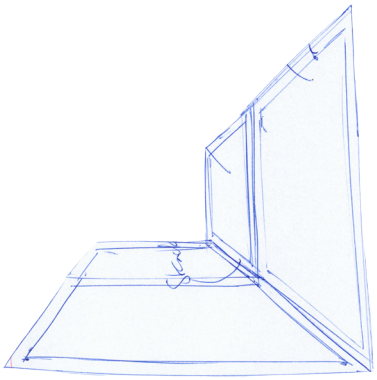

Figure 7.12; 2.Simplistic Design Revised

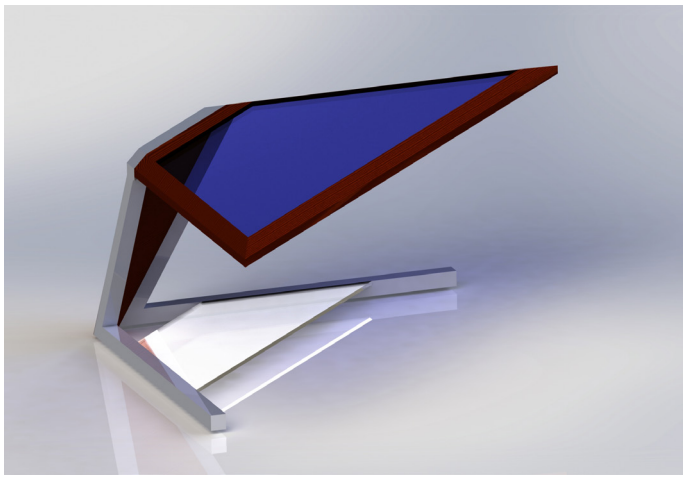

Figure 7.13; Render 1 Simplistic Design Revised

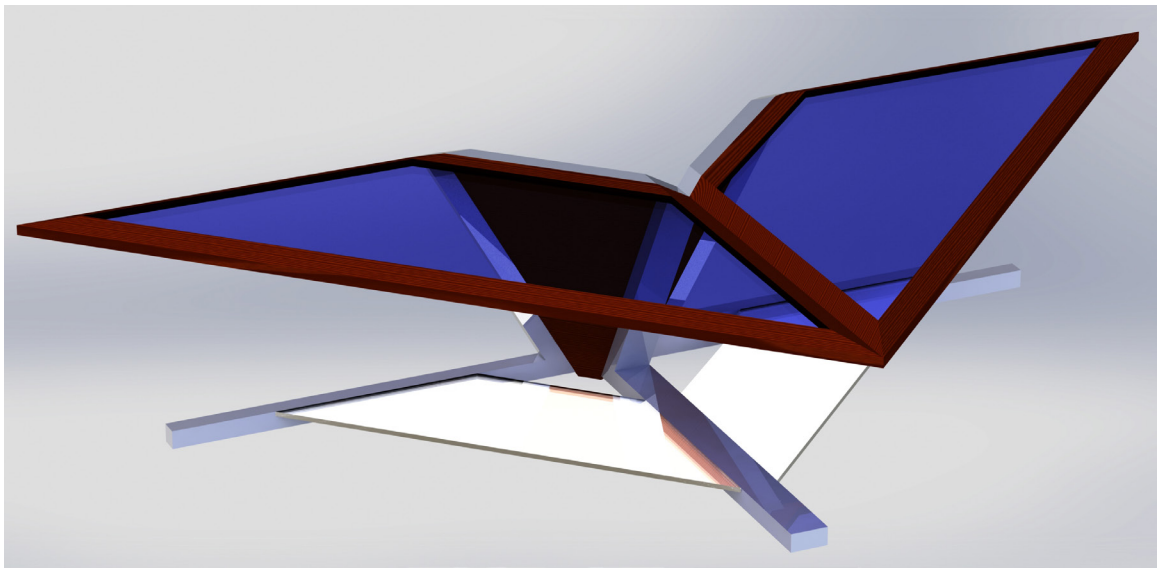

Figure 7.14; Render 2 Simplistic Design Revised

7.5 Summary

In this chapter the following two research questions have been answered:

- Based on questions one to five, what concepts of an interactive coffee table are possible?
- Which concepts developed for question 6, performs best considering questions one to five?

First, thee concepts were developed from the three design directions that were developed in chapter 6. Ideation. For the development of these three concepts the information gathered in the previous chapters and from the research questions one to five were used as input. This resulted in the concepts “Open wing design”, “Simplistic design” and “Organic design”, from which the “Simplistic design” was chosen to further develop. After further checking the appearance and the functioning of this concept, the production of this concept appeared to be too expensive. Therefore, this concept has been further developed to a concept that is better suited to fulfil the requirements and wishes of both 100%FAT and its customers. This has resulted in a product design that is more flexible in its usage and thus may be able to serve a larger target group. The developed concept design is further developed towards a final design proposal and this is discussed in Chapter 8. Final Design Proposal.

Chapter 8 | Final Design Proposal

8.1 | Introduction

The final design proposal is discussed in this chapter. This is done by first showing and clarifying multiple visuals and design choices of the design proposal and then by discussing the developed CAD -Model and prototype. For the final design proposal also the topics "user behaviour", "ergonomics", "materialization" and "differentiation form competition" will be discussed. Also multiple production problems that appeared during the production of the prototype will be discussed.

The research questions to be dealt with in this chapter are as follows:

- How to produce a working prototype of an interactive coffee table, which is representative for the functions and the design of the interactive coffee table?
- To which extend is it economically viable for 100%FAT to produce this product design proposal?

8.2 | The Final Design

The previous chapter "Concept Development" resulted in the concept shown in figure 7.14. This new version of the "Simplistic Design" concept is more beamer friendly because there is no need to project on a corner shaped display. There is, however, still a problem with this design. This problem is the narrow-shaped leg. This means that the leg too narrow is at the bottom to house the beamer and computer. Therefore, this concept is further developed towards a more feasible final design proposal.
The final design proposal is shown figure 8.1 until 8.5. Compared to the second version of the "Simplistic Design" concept there are five major changes in the design. The first of these is that there now is a box in the design that houses the beamer, computer, power brick, etcetera. This also visible in figure 8.3. The second change is the frame of the table. In the concept there were only legs at the rear side of the table. In the final design proposal there are also two legs at the front side of the table. These are integrated to create a sturdier table. The third change is the presence of a UI-Box at the front side of the table, which is shown in figure 8.6. The user has the possibility to control some settings of the table via this UI-box. The user can power the table on, adjust the volume and the change the display channel via this box. The display channel button is meant for connecting multiple tables to each other and allows the user to select which tables should be connected to each other. The fourth change is the presence of a connection panel for connecting two table components to each other. The user now needs to connect the two tables to each other via this connection panel if he/she requires a 90 degree angle between the two components. This is shown in figure 8.4. If it is not required to have a 90 degree angle between the two tables, the user can connect two table components directly to each other. Next to this there is a coffee cup designed for this table, which integrates the fiducial tag for object tracking in the bottom of the cup. This cup is shown in figure 8.5. The cup consists out of a regular cup and a 3D printed holder which houses the fiducial tag.

Next to the coffee table version of the table there is also a version meant for the conference table setup. This design is essentially the same as the coffee table variant, except for the higher frame and the more sloping shape of the electronics box. This electronics box is more sloping in its shape because it would become bulky if it would just be enlarged together with the frame. Also there is no need for more space to house the electronics, which means it is better to keep integrating the "open and light" appearance of the table. Therefore the electronics box is designed in a slimmer shape, which results in the box to integrate a more sloping shape. Another item that is integrated in this higher frame is a beam in the corners at the front legs. This beam is meant for strengthening these corners, because there is a larger moment at the corners compared to the coffee table variant. A two-dimensional sketch of this version is shown in figure 8.3.
Next to the design aspects clarified above, multiple other design related choices have been made during the design process. These design choices discussed in appendix A.1.

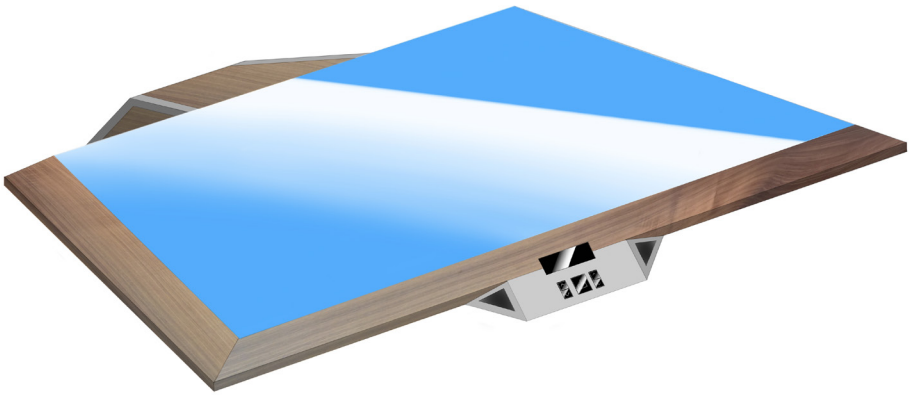

Figure 8.1; Final Design Front View 3D

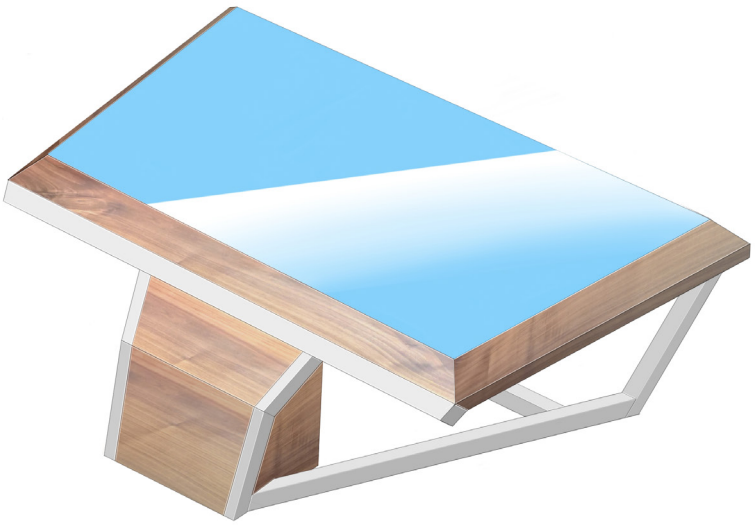

Figure 8.2; Final Design Rear View 3D

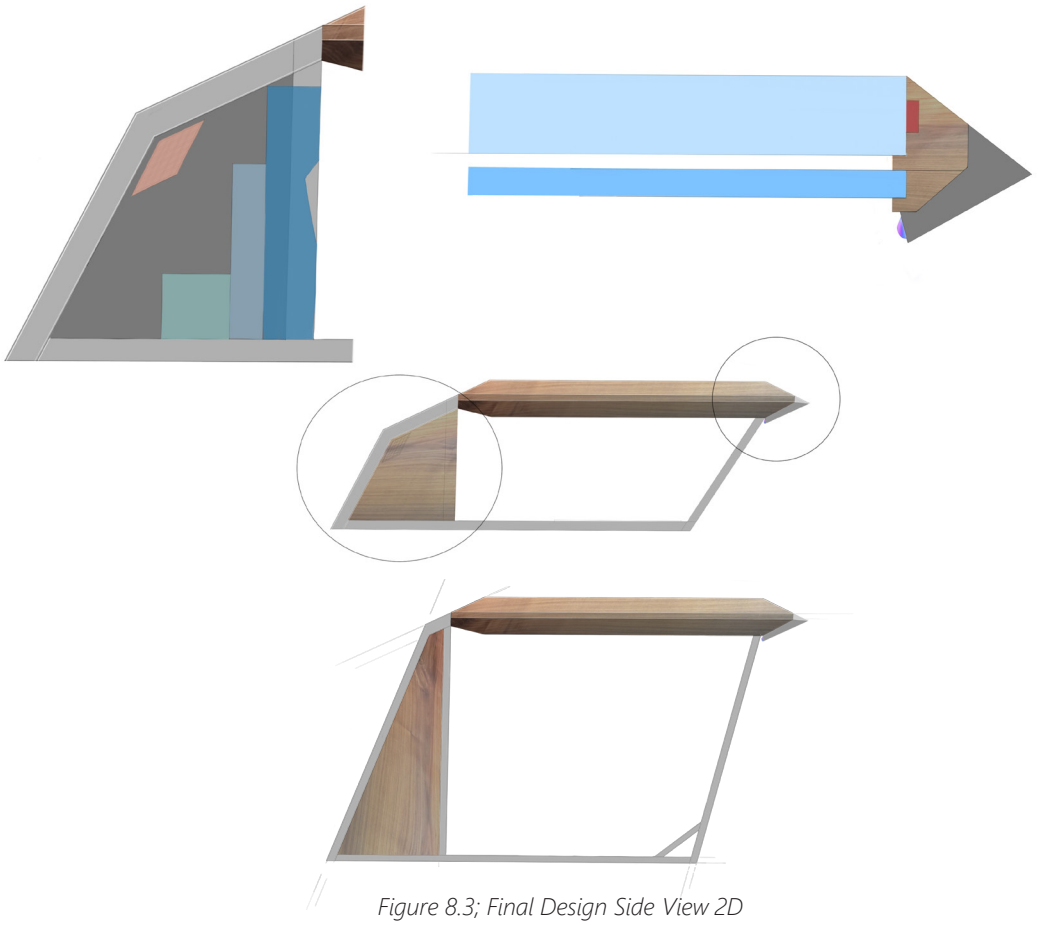

Figure 8.3; Final Design Side View 2D

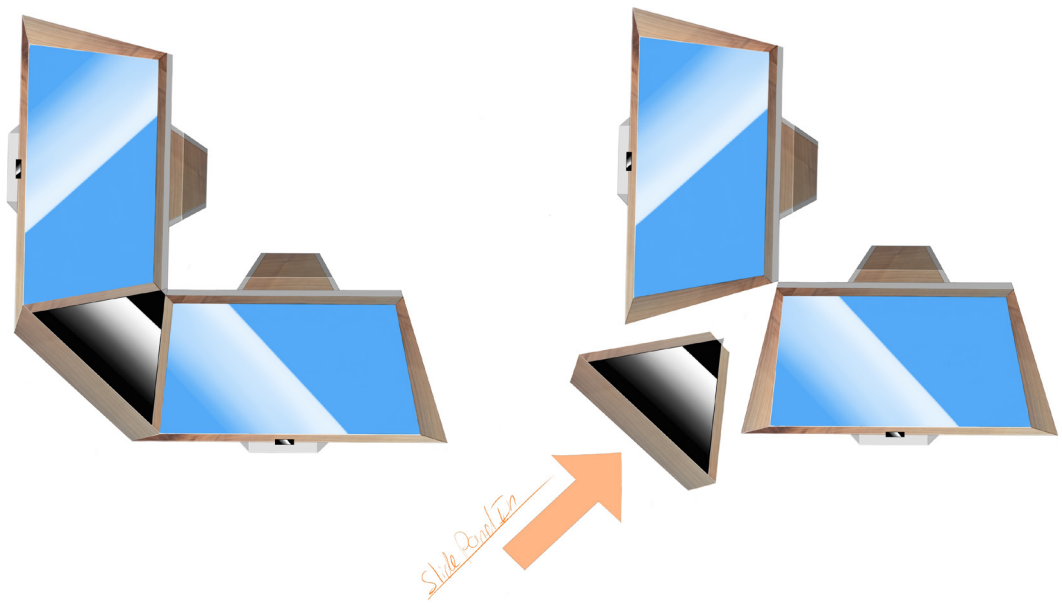

Figure 8.4; Final Design Top View 2D

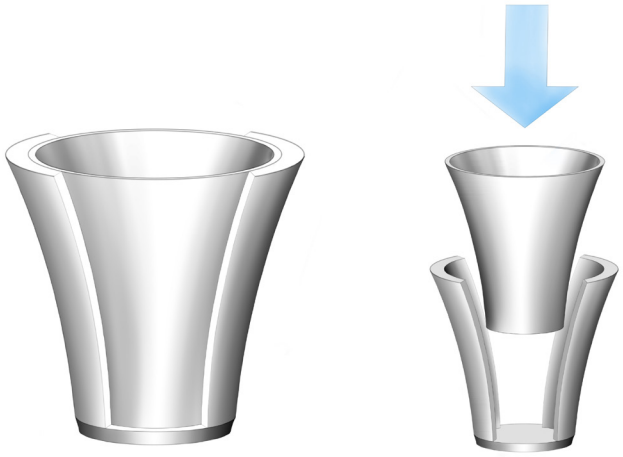

Figure 8.5; Coffee Cup

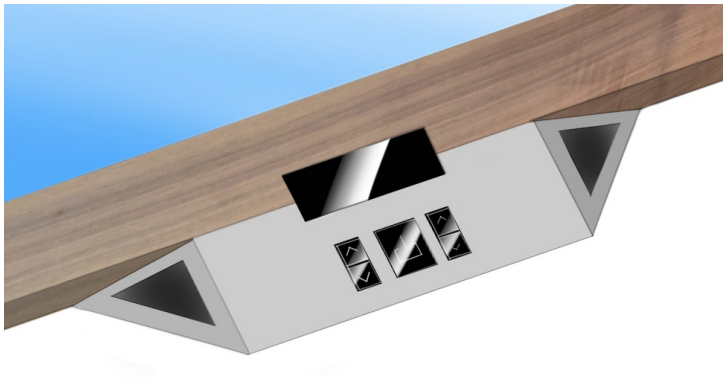

Figure 8.6; Final Design UI-Box

Influencing User Behaviour

The design of the interactive coffee table integrates some aspects to influence the user in how he/she uses the table. First to make sure that the user uses the table from the front side and not from the rear side, the design integrates an electronics box at the rear side. This is visible in figure 8.3. This box is placed in such a way that it is inconvenient for the user to use the table from this side, and more logical to use the table from the front side. When this combined with a couch setup it is even more logical to use the table from the front side. This aspect is integrated because the display is optimized for a viewing angle from the front side and because the UI does not allow for usage from the rear side of the table.

The second aspect is to stimulate the user to place coffee cups on the display, and not on the border of the display. This is necessary because people might not be sure whether the display of the table will remain intact if objects such as coffee cups are placed on it. This might result in users placing cups on the border of the display instead of on the display itself. Therefore the border integrates a chamfered edge, which makes it impossible to place objects on the border. Another way to stimulate people to place objects on the display is to already place other objects such as magazines on it, so that other people are also triggered to use the table as a coffee table.

The third aspect is to discourage people to sit on this table, because it is not good for the construction of the table if people often decide to sit on it. Therefore the design integrates a glossy finish on the wooden parts and on the display itself. This is because people often see glossy materials as more sensitive to damages than matte materials. An example is a glass table, on which people are not likely to sit on. This is also the case with the display of this interactive coffee table, because its appearance matches with the appearance of a glass surface.

Ergonomics

Two aspects were taken into account for the ergonomics of this table. These are the height and the weight of the table. For a convenient height of the coffee table a short market research was done. The goal of this market research is to check what the industry standard is. This is mainly done by researching the height of coffee tables offered by companies such as IKEA and LeenBakker. The result is that these sorts of companies maintain a height differentiating between 0,3 and 0,6 meter. The height of 0,6 meter is the strict maximum in this. (Ikea, sd) (Leenbakker, sd). Because the interactive coffee table also integrates a display and should be controlled via the coffee cups or pucks, the choice is made to set the height of the table more in the upper category at 0,55 meter. This is done to prevent that people need to bend over the table too much for controlling it.

The second aspect is the weight of the table. The table needs to be easily movable by two persons, which means that the weight can not be more than two times the advised carrying weight for one adult. The advised weight to be carried by employees is 23 kg at a maximum according to the NIOSH Method. However, there are no legal regulations for this outside the construction industry. (Arboportaal, sd) When also considering that a table is not likely to be moved often, this weight of the table can deviate slightly from the advised weight. Therefore also a test has been done to check with which weight it still is comfortable to lift and move this table. This test consisted out of a simple setup of a wooden plate on which bags of sand and pebble stone were laid to consequently test whether the weight was comfortable to lift. A picture of this setup is shown in figure 8.7. From this test it appeared that 57 Kg is a comfortable weight for lifting and moving a coffee table and especially over small distances. This weight consists out of two bags of sand with a total weight of 50 Kgand the wooden plate which has a weight of 7 Kg.

Figure 8.7; Weight Test Setup

Materialization

Also, before further developing the three concept directions, an early material analysis has been made for during the concept generation. This has been done to establish an image of which appearances are interesting for the coffee table. Thus, these findings can be used as input for the final design of the interactive coffee table. This analysis has been done by collecting interesting visual material of multiple comparable product which use interesting materials. Also, other visual material of other products (which use interesting materials) has been searched for. The conclusion of this analysis is that a wooden finish can create a beautiful appearance. Next to this the table needs to be quite durable to resist the weight of the display layers and the possibility of people deciding to sit on it. Therefore teak wood is chosen for the display frame and the electronics box panels. For the frame of the table the standard aluminum beams by Misumi are used. Because of the standardized beams and connection pieces, these beams are suitable for building the frame of the table without difficulties. Thus these beams make it possible for 100%FAT to produce this frame in its own workplace.

Differentiating from Competition

This product design differentiates itself in multiple manners from competing product offers. The most important differentiating point is that it is suitable for multiple usage scenarios. Thus the table is more flexible in its usage. The table can be built in two heights, either in a coffee table height or in a conference table height. This make sure that the table can be used in either an informal setting in for example the lobby of a company, or in a more formal setting such as the conference room of a company. Next to this, the table is designed to feature a modular setup. This allows the customer to adjust the size and shape of this table to his own wishes. Because of this, the table is better able to fit in the environment in which it will be placed.

Besides the flexibility in the setup of this table, the table is also more customizable by the customer. When comparing this product to competing products, these are only available in one configuration. This while 100%FAT can easily change some design aspects of this table to the customers its wishes. An example would be to apply a different color to this table to make it match more with the customer its brand identity.

8.3 CAD-Model

The final design sketch is translated to a SolidWorks CAD model, which also takes the material appearance of the table into account. Next to this the standardized beams by Misumi are also used in the CAD model, because Misumi provides the CAD files of these beams via its website. figures 8.8 until 8.13 show renders of the CAD model for only a single table component. Figures 8.14 until 8.16 show the CAD model when multiple table components are connected to each other. As visible in these figures there is no mirror present in the bottom of the table. This is because at this point it became clear that there were small and cheap cameras available that were fast enough for the object tracking. Therefore the need for using a camera mirror setup exists no longer and is not integrated in the SolidWorks CAD model.

Because of a lack of time only the coffee table setup of the final design is translated to a SolidWorks CAD model. Therefore figure 8.16 shows the idea of a conference table setup by using the SolidWorks CAD model of the coffee table variant.

Figure 8.8; Final Design CAD Front/Side View

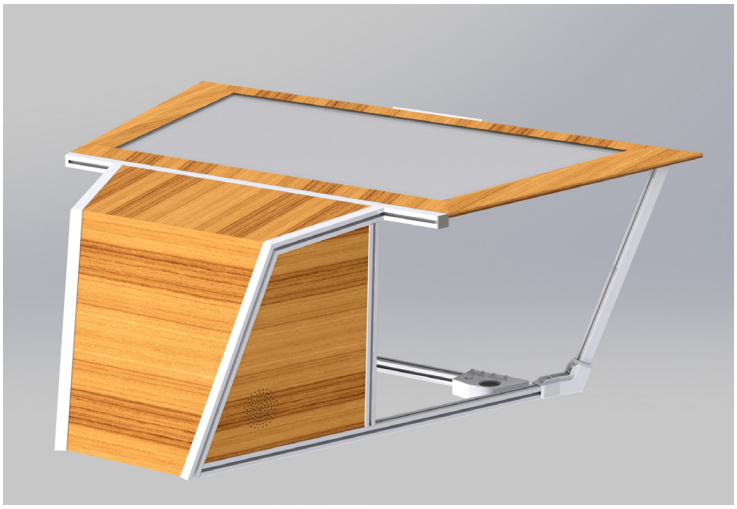

Figure 8.9; Final Design CAD Rear/Side View

Figure 8.10; Final Design CAD Rear View

Figure 8.11; Final Design CAD Front View

Figure 8.12; Final Design CAD Top View

Figure 8.13; Final Design CAD Bottom View

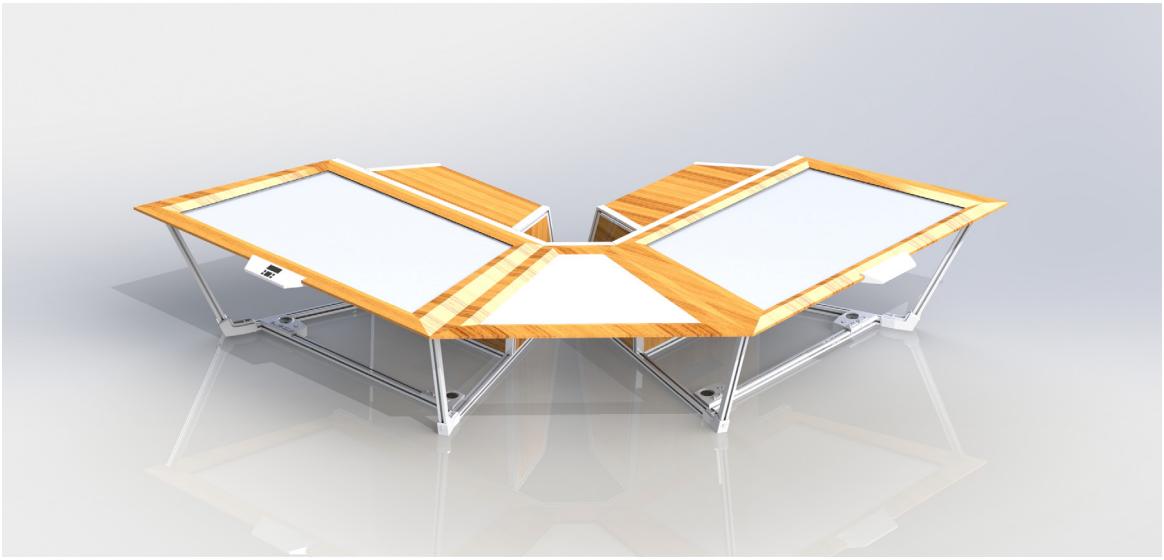

Figure 8.14; Final Design CAD Connected Tables Front View

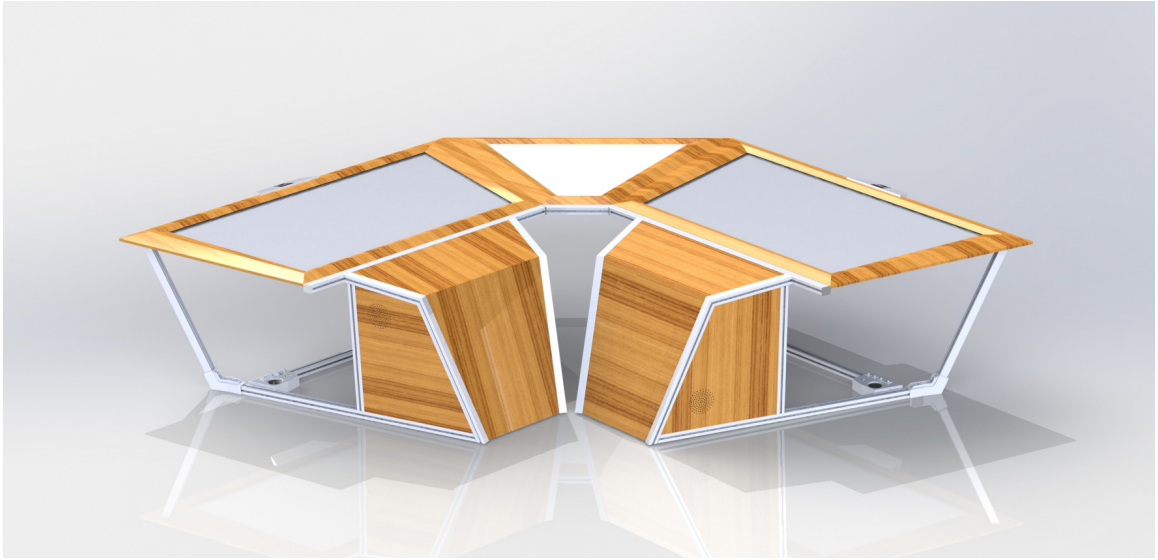

Figure 8.15; Final Design CAD Connected Tables Rear View

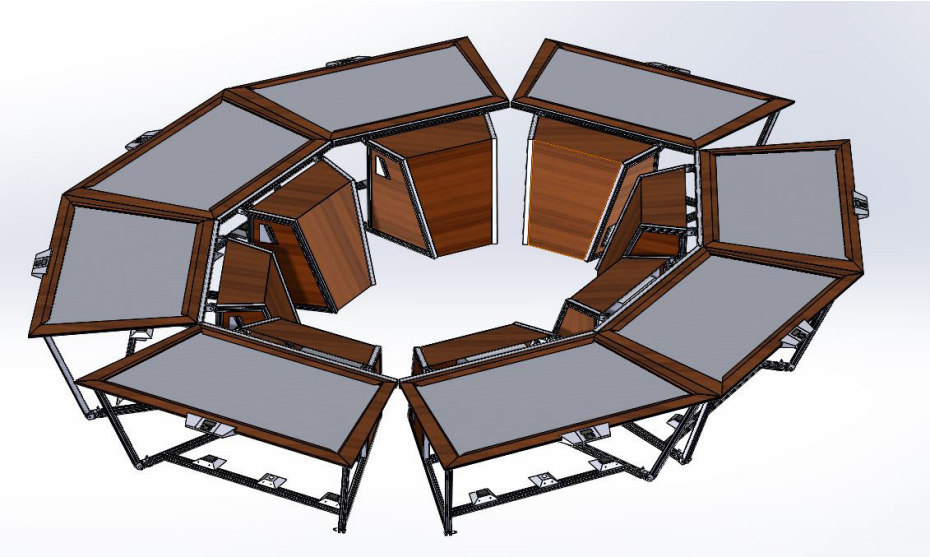

Figure 8.16; Conference Table Setup

8.4 Prototype

After the SolidWorks CAD model was finished and discussed with 100%FAT the prototype was built. This was mostly done together with employees of 100%FAT. This however, appeared to be more complex to do than previously expected. Hence the goal was to design an easy and low-cost to produce prototype. The final design of this table however has been developed towards a rather complex to produce product. This means the workplace employees need a considerable amount of time to produce this table, which results in the cost-price to increase. This complexity in the design is mostly caused by the shape of the display frame, which is tapered. Next to this, the components out of which the display frame is built are also tapered. This tapered shape can not be produced with the machines available in the workplace of 100%FAT. Thus this tapered shape could only be produced by handiwork, which costs too much time to fit within the budget of 5000 euros. Therefore, the display frame was slightly modified to make the production of the prototype more feasible. Thus, the tapered shape of the separate components of the display frame has been removed. Although it still is a complex job to produce the display frame, it is now possible in the workplace of 100%FAT. Thus for a follow-up version of this table it can be interesting to adapt the design of the display frame so that it is easier to produce. Three possible manners for this are as follows. First the tapered shape of the display frame can be removed at all. Second, standard wooden beams with a shape that is comparable with the display frame components can be used. Then these beams only need to be sawn of in the correct angle. Third by using 3d print components for connecting the parts of the wooden frame.
Next to the display frame, the aluminum frame of the table also was not easy to produce. This is caused by the number of angles that is integrated in the design. Also, these angles were not in the standardized angles of the connection components by Misumi, which means that 90 degree connection components needed to be bend in the correct angle. A picture of a 90 degree connection component is shown in figure 8.17. However, it was still possible to build the aluminum frame without making modifications to the design. A solution to make the aluminum frame easier to produce is to weld the frame instead of using 90 degree connection components that needs to be bended in the correct angle. Also as noted by Lieven Maes, an option for the aluminum frame would be to use 3D print components to connect all Missumi frames to each other, which results in a new design style. Then the aluminum frames can be covered with for example wood so that the protruding edges of these 3d print components will not be visible.

Figure 8.17; Frame Corner Connection Component

Another item in the production of the prototype is that the object and touch recognition did not function well enough in a test setup by 100%FAT. This means that the display plates are not included in the prototype, and the prototype is not functional at this moment. The problem with the object and touch recognition is caused by the Endlighten-T plate, that is used to enable touch recognition. This plate makes the image of the camera too blurry, which means the camera can not recognize the fiducial tags that are placed on the display. However in a later version of this test setup, both the object recognition and the touch recognition appeared to function as required. In this version all edges of the Endlighten-T plate were covered with tape, so that the IR-Light is better reflected into the Endlighten-T panel. Also, a thinner Endlighten-T plate was used for this test setup to minimize the blurry image. Thus to make the object and touch recognition fully functional, only the software needs to be adapted. Another item with the Endlighten-T plate is that the plate appeared not to be rigid enough, which caused the plate to sag roughly one centimeter in the middle of the display. This is not acceptable in a display, which means there is the need of an extra toughened glass layer beneath the Endlighten-T plate. Something else that did appeared from the test setup by 100%FAT is that the Endlighten-T plate is quite good at lighting the bottom of the fiducial tags, if an IR-LED strip is attached to the edge of the Endlighten-T plate. Also the Endlighten-T plate is produced to distribute light equally throughout the plate, which makes it needless to also light the bottom of the display with separate IR-LED modules. The prototype that is built is shown in figures 8.18 until 8.21.

Figure 8.18; Prototype Front View

Figure 8.19; Prototype Front/Side View

Figure 8.20; Prototype Rear/Side View

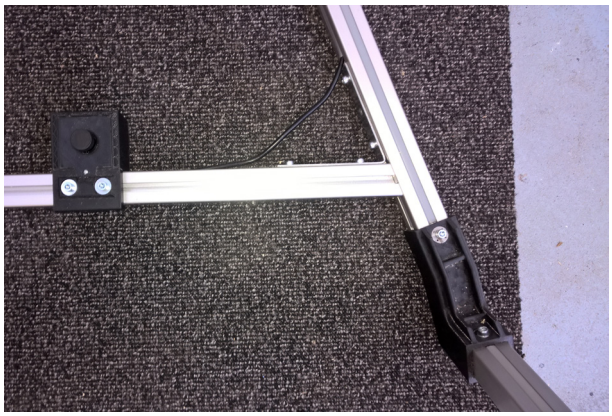

Figure 8.21; Prototype 3D Prints

8.5 Cost-Price

The cost-price calculation is done in a Microsoft Excel file. The layout of this file however, is not suitable for in this thesis. Therefore, this file is attached in a separate appendix. Next to this 100%FAT must make its own decisions on the financial topic, which means this section will only provide the information for the cost-price calculation and an advice regarding this data. There will, however, no decision be taken in thesis regarding the further development of this product. Therefore, the choice of further development and in what direction this development may proceed remains for 100%FAT.

The cost-price calculation is done via 100%FAT its method for a cost-price calculation. This means that instead of first calculating all costs for producing this table and then to calculate a profit margin over these costs, another method is used. In this method all component costs and hourly employee costs are indeed calculated. However instead of calculating a profit margin over all costs, the profit margin is included in the hourly employee costs. For normal production and assembly work 100%FAT uses a ratio of 65 euros per hour and for software development 100%FAT uses a ratio of 85 euros per hour. This is also visible in the table shown figure 8.22., in which the man hour costs are considerably higher than all other cost points. Also because the man hour costs include two cost points which can be distributed over the amount of tables that sold, the cost price of one table is too high. This is visible in the table shown figure 8.23. Hence, the opted selling price range set by 100%FAT is 10 000 euros to 15 000 euros. When the table is sold two times, however, it almost fits the selling price range for this table.

Also an interesting number is if 100%FAT sells 2 corner setups of this table instead of only two times one table component. In that case the required selling price per component drops considerably to 11114,48 euros. This price point would be rather interesting because it lays in the lower part of the pricing category that 100%FAT opts for, and may increase the amount of times that 100%FAT can sell this table. An important aspect of the cost-price estimation is that 100%FAT works with open source software, which means there is no need to pay for licenses. Next to this for the cost-price estimation a full HD beamer by Optoma is used. This is done because a full HD beamer results in a clearer and better readable projection, which means more textual content can be used on this table.
With this cost-price calculation the table is opted to fit 100%FAT its goal of selling the interactive coffee table for a selling price that lays in a range of 10 000 euros to 15 000 euros. For this, however, outgoing point is that the company manages to sell two and preferably three or more of these tables, to maintain an acceptable selling price.

Distribution of costs

Topic	Amount of Costs (euros)	Subcategories of Cost Topic	Amount of Costs (euros)	Note
Screws and Inserts Costs	97,12			
Beam Components Costs	80,68			
Display Frame & Electronics Box Costs	373,4			
Electronics Costs	3290,11			
Left Over Materials Costs	- 49,455			
Man Hour Costs incl. Hourly Profit Margin	22573,17			
		Software Development	6800	Variable Per Production Capacity
		Production	1198,17	
		Maintenance	975,00	
		Further Design Development	13600	Variable Per Production Capacity

Figure 8.22; Distribution of Costs

Total production costs for 1 table incl. hourly profit margin	26414,48
Total production costs per table if 2 tables sold incl. hourly profit margin	16214,48
Total production costs per table if 3 tables sold incl. hourly profit margin	12814,48
Total production costs per table if 4 tables sold incl. hourly profit margin	11114,48
Total production costs per table if 6 tables sold incl. hourly profit margin	9414,48
Total production costs per table if 8 tables sold incl. hourly profit margin	8564,48
Total production costs per table if 10 tables sold incl. hourly profit margin	8054,48

Figure 8.23; Selling Price Per Production Capacity

8.6 Summary

In this chapter the final design proposal was discussed by first discussing the design itself on multiple topics, after which the design was translated to a SolidWorks CAD model and to a prototype. During the development of the prototype the design appeared to be too complex to produce the table in the workplace of 100%FAT. Therefore some adjustments were made in the workplace, which made it possible to build the prototype of this table. The prototype however is not functional yet, because in a test setup by 100%FAT the object and touch recognition did not function as required. Therefore, the display panels were not integrated in the prototype. In a later version of this test setup however, the object and touch recognition did function as required. However due to the little amount of time left for this project, it was not possible to integrate these display panels in the prototype at this moment.

In answering the first research question of this chapter; "How to produce a working prototype of an interactive coffee table, which is representative for the functions and the design of the interactive coffee table?", a prototype needs to be designed in such a way that the prototype can be built in a time-efficient manner. This is important because otherwise the production of this table will be needlessly expensive. Therefore it should be taken into account that there are many limitations in workplaces which result in the need to make some design simplifications.

Consequently, the cost-price calculations were discussed. These indicated that the table would fit 100%FAT its opted selling price range if at least two tables and preferably three or more are sold. In answering the second research question "To which extend is it economically viable for 100%FAT to produce this product design proposal?", the costs highly depend on the amount of tables that will be sold. In the case of this interactive coffee table, the costs appear to come close to required range if two tables are sold. However, it is desirable to sell at least three tables because the selling price can then lay in the middle of the pricing range 100%FAT defined.

Chapter 9 Conclusion and Recommendations

9.1 Conclusion

In this graduation assignment the goal was to answer the following question: "To which extend is it economically viable for 100%FAT to produce an interactive coffee table that features an interesting and differentiating design?". The approach for this was to first design an interesting and differentiating interactive coffee table and then to research to which extend the production of this interactive coffee table is economically viable. This question was split up in multiple sub-research questions that were discussed in the chapters.

In the last chapter, amongst else the final design proposal, the prototype and the cost-price were discussed. This leads to the conclusion of the main research question to be formed. As it appeared from the production of the prototype, the design of the interactive coffee table is too complex to be produced in the workplace of 100%FAT. Therefore, some design modifications were made for producing the prototype. Despite these design modifications the production still took a considerable amount of time. Since the budget for this table is relatively low, it is not desirable that the production takes much time. The cause of these production difficulties lays in the number of angles that is integrated in the design of this interactive coffee table. These angles however, do contribute to the aesthetics of the table and are important for distinguishing the table from the current products on the market. Therefore, more research is needed to simplify the production of this interactive coffee table.

It is expected that the complexity of the aluminum frame can be reduced by using 3d printed connection components at each corner in the aluminum frame. By integrating these 3d printed components the beams out which the aluminum frame consists do not need to be sawed in the right angle anymore. Because of the little costs of 3d printing, integrating these 3 printed components saves both in production time and in production costs. The complexity of the wooden display frame can be reduced in multiple manners. First by removing the tapered shape of the display frame at all. Second by using standard wooden beams. Third by using 3d print components for connecting the parts of the wooden frame. Thus, more research required for determining what the best way of simplifying the production of this interactive coffee table is.

In the cost-price calculation it became clear that 100%FAT needs to sell at least two interactive coffee tables. This number of interactive coffee tables needs to be sold before it becomes a profitable product in the selling price range of ten thousand to fifteen thousand euros. In the past 100%FAT has sold an interactive table to the company Thales Hengelo. Thus when it is considered that companies of the size of Thales Hengelo are customers 100%FAT and the interactive coffee table offers a unique design and a unique set of functionalities, it is opted to be realistic that at least two of these tables can be sold.

Concluding, the interactive coffee table that is designed can distinguish itself from the other interactive tables that are currently offered on the business to business market, with both its unique design and unique functionalities. Also the with the expectations that the production of this interactive coffee table can be simplified by using 3d print connection components and standardized display frame components, the table is expected to be economically viable.

9.2 Recommendations

During this graduation assignment there appear to be multiple points on which extra research is recommended for further developing the produced prototype towards a fully functional final product.

The first recommendation is to adapt the design of this interactive coffee table slightly so that it is more production friendly. The production of the aluminum frame can be simplified in two manners. The first option is to weld the Misumi beams to each other instead of bending 90 degrees connection components to the required angle. This option means that the current design style remains intact. It is however, still hard to saw all the different Misumi beams in the required angles. The second option is to use 3d print components to connect all Misumi frames to each other, which results in a new design style. Then the frames can be covered with for example wood so that the protruding edges of these 3d print components will not be visible. This would simplify the production of the interactive coffee table considerably, because the Misumi frames then only need to be sawed at the right length. Thus then there is no need to saw the Misumi frames at these angles anymore, while the angles are still integrated in the design of this interactive coffee table. Next to this, 3d printing is rather cheap and only requires some waiting time. A doubtful aspect of this option is the strength of these 3d printed connection components. It is not certain whether these 3d printed components can provide enough support to create a sturdy frame for the interactive coffee table. However, when it is considered that there is less time required to produce the frame and that the production becomes less sensitive to errors, it is recommended to first test the strength of these connection components in a test setup.

For the wooden display frame, multiple options for reducing the complexity exist. The first is to remove the tapered shape, this however leads to a rather unimpressive appearance. Thus, then it is questionable whether the customer considers this product to be special enough to pay at least ten thousand euros for it. The second option is to use standard wooden beams that (partly) integrate the chamfered edges of the display frame, which means that the components only need to be sawn of in the correct angle. The third option is to also use 3d print connection components for connecting the parts of the wooden display frame to each other. Since the second and the third option integrate the tapered shape in the display frame and thus contribute to the aesthetics of this interactive coffee table, it is recommended to do further research into these options. For the second option it needs to be researched whether there exist standard wooden beams that have a shape that is comparable with the display frame components. For the third option it needs to be tested whether a 3d printed connection component is strong enough for this use. If both option two and three appear to be possible, these can also be combined into one solution. This combination means that standard wooden beams will be connected to each other by using the 3d printed connection components. Then the beams only need to be sawn of at the correct length, which simplifies the production of the display frame considerably.

Last recommendation is to perform a user-test if the prototype is fully functional. This can lead to interesting findings in the usage of this table, which means the UI and the design of the table can be slightly adapted to these findings. This user-test has not been done at this point because the prototype and its UI are not functional yet.

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