MESH.

INNOVATIVE INTIMATES

SOPHIE BAARS
Final Bachelor Project // semester 3.2
Crafting everyday soft things // coach: Loe Feijs

FINAL BACHELOR PROJECT SOPHIE BAARS

FIGURE 0.2 // Bra design final product back

CONTENT.

FIGURE 1.1 // final product

01 EXECUTIVE SUMMARY.

I went through an iterative design process, meaning that I went through the process of designing my project while continuously refining, revising and adjusting the concept with the help of user feedback (Enginess, 2018). I chose this approach to be able to refine and improve my project along the way, as this can be achieved through feedback collected in an interactive iterative process involving users (Abras, Maloney-Krichmar, & Preece, 2004, p. 5)

I designed a service for custom made bra design that focusses on making custom made bras more inexpensive, innovative and fashionable. Through the process of researching this subject I focused on the competency areas of Industrial Design to include all areas into the project. I started the process by exploring materials and the topic of bras itself, discovering that wearing the wrong bra size can result in problems like back and neck aches, damage of the breast tissue and a lower self-esteem, especially in women with larger breasts (Chen, LaBat, & Bye, 2010). I thought of an alternative to underwire, splint material, as this material can be molded to fit the body perfectly.

I interviewed experts to get inspired, more knowledge and to ask them questions. I spoke with an entrepreneur in the custom made bra industry, a sewing technician and a physical therapist in regards to the splint material.
I started developing my concept and making a first prototype. I researched people's current experiences with bras via a survey and created affinity diagrams according to their opinions.
I was able to further explore and develop the concept and after trying out several techniques I settled on the concept. The concept is a custom made bra of which a unique pattern is generated for each individual by an app and the underwire is made of splint material. I wrote the code for the app and developed a second survey to be able to develop a persona and discover the participant's opinion on the concept. From there on I was able to develop the persona and a customer journey map.

I continued by making my final prototypes, 5 bras, which were all uniquely made for each participant and tested by them. I tested the pressure in one of the prototypes to see the difference in support between my bra and a 'normal' bra. I developed a business model, determined the price and thought of how this would work as an actual business.

My goal was to make more inexpensive garments that are personalized to fit perfectly, to be able to make a product available to a younger audience.

Overall, the concept was received enthusiastically and positively by both participants and visitors during the final Demo Day. I believe that a concept like this is exactly what the bra industry needs, as, in my opinion, there is little innovation in the bra industry. The underwire as we know it can be traced back to 1893 (Vogue, 2019), while I believe better alternatives can be found if more research is done. From my research I can conclude that splint material would be a great alternative to underwire and that a program that automatically creates a perfect sewing pattern would be ideal for the production of custom made bras.

In my vision I write about the fashion industry, and how, although there is a big move towards more sustainable alternatives as well as other improvements regarding for example fit and customization, there is still a lot of room to grow. With the technology we have today, I believe it should be possible to make durable garments that are personalized to fit perfectly. I have been passionate about fashion for as long as I can remember and since I believe there is still so much room for innovation and improvement in this industry, I chose to do my FBP in the 'Crafting Everyday Soft Things' squad. Additionally, this squad has an immense amount of knowledge and experience in combining innovation, technology, society and fashion which makes me believe these people can help me develop into the Industrial Designer I want to become and achieve my goals for myself and within the squad.

02 PROLOGUE.

Experts: Loe Feijs, Marina Toeters, Annika Hupfeld, Troy Nachtigall, Koen van OS and Kristina Andersen // Project: Crafting Everyday Soft Things (CEST) // Coach: Loe Feijs // Student: Sophie Baars // Portfolio: sophiebaars.nl

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FIGURE 2.1 // final product

FIGURE 4.1 // Bra - practicing sewing

FIGURE 4.2 // Bra - practicing sewing

FIGURE 4.3 // lace bralette - practicing sewing

03 PROJECT GOAL & RESEARCH QUESTIONS.

My project goal strongly relates to my vision. As discussed in the previous section, I believe that with the technology we have today, it should be possible to make durable garments that are personalized to fit perfectly. I believe design can be used to make people feel more confident and comfortable. I want to design a bra that makes, in my case, women feel more beautiful, a bra that is innovative, easy to put on and take off. This bra should be comfortable, but still sexy with attention to details and aesthetic. I want to create a bra that fits each individual perfectly and is custom made and unique for each individual.

I want to research what components in current bra design can be improved to contribute to a better fit, how bra customization can be more inexpensive and thus available to more people, and additionally, how this fit contributes to someone's self-image.

It also might be interesting to research how modern techniques, like 3D-printing and bodyscans fit into bra design as well as what aspect make up the customer experience of bra buying/fitting and where this fits into my project.

04 EXPLORING MATERIALS.

To practice my sewing skills and discover what different parts a bra consist of, I decided to make a bra myself from scratch (figure 4.1 and 4.2). I wanted to discover which parts were most important regarding fit and which parts needed the most support. Regarding the fit, the cups of the bra are the most important and difficult to make fit perfectly. I experienced this when making a bra to fit myself. I will need to be incredibly precise in making the cups fit perfectly and it might be beneficial to ask a professional seamstress how to do this. The band needs to be the most supportive part of the bra. I experienced this when fitting the bra since it was not supportive enough. From speaking with Brigitte Kock and reading her FBP report, I also learned about the Finite Element Method. This method calculates the effect of force on physical structures. This model (figure 4.4) shows that the most support should be in the band. There should not be too much pressure on the straps, this would result in pain and digging of the straps into the skin around the shoulders. I will look at comfortable, strong and supportive materials for the band of the bra.

Additionally, I also made a bralette entirely from lace to see how that fabric responds when I sew it together (figure 4.3). I found that I could easily sew lace how I would like it. This means that I can include lace into my prototypes.

To make the bras and bralettes I needed the following supplies: Lycra fabric, Underwire material, underwire casing material, elastic for the band, fold over elastic for the edges, elastic for the straps (40-70% stretch), rings and sliders for the straps, closures for the back and lace fabric.

I asked the fabric expert in the fabric store in Eindhoven and at the fabric stand on the market for advice, both told me that lycra fabric was typically used to make lingerie. This fabric stretches and is comfortable on the skin, it does not make the wearer sweat and the fabric is light.

From my own experience with bras and after doing some online research, I expect the underwire to be the most uncomfortable component of the bra. The first designs of the underwire as we know it today can be traced back to 1893 (Vogue, 2019). Since then, the underwire has not changed much. I expect that this component of the bra leaves room for improvement and personalization.

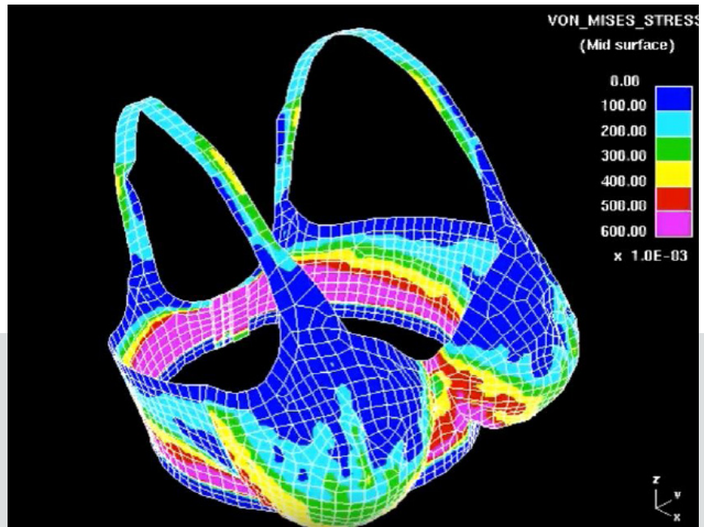


FIGURE 4.4 // Tekin, S. (2006, May 16). Finite element Method [Video file]. Retrieved April 18, 2019, from https://www.youtube.com/watch?v=-apBdyxcWZA

05
EXPLORING THE TOPIC.

FIGURE 5.1 // final product

The fashion industry currently is the second most polluting industry in the world, the main environmental problems include water, air and solid waste pollution. To produce 1 kilogram of fabric, 200 liters of water are consumed, most processes in textile production produce gaseous emissions that pollute the air and each year (Fabric of the world, 2017), 150 billion items of clothing end up being dumped, globally (Greenmatch, 2019). Additionally, the fashion industry is known for the bad working conditions in its factories. According to a recent study (War On Want, August, 2011) 'a garment factory helper's wage starts at just £25 a month month – far below a living wage,' '80% of workers work until 8pm or 10pm, after starting at 8am – in excess of the legal limit on working hour' and 'Three quarters of the women workers they spoke to had been verbally abused at work and half had been beaten' (War On Want, 2011).

These problems are the result of the desire for brands like 'Zara' and 'Primark' to follow the fashion trends as quickly as possible while producing and selling their products for the cheapest possible price. Not only does this result in the fast fashion industry as we currently know it, it also results in fast fashion companies chasing the same trends and selling similar items in only a small range of sizes (Roncero-Menendez, 2018). As a solution to these problems, an era of customization and personalization has emerged in the fashion industry. Consumers desire products they feel have been uniquely designed to fit their needs, style and size. Personalization also includes the shopping experience the consumer faces. This experience creates a bond between the brand and the consumer and results in brand loyalty and more word-of-mouth marketing (De Vries, 2018)

After doing my internship at Hunkemöller during my B3.1 semester, I discovered that lots of women face the same problems in mass production of bras that I face on a daily basis. All breasts are different, they differ in size, shape and position. Breast can even differ from each other when a woman has uneven breasts, 'one study of 100 women who wanted breast augmentation found that 88 percent had natural asymmetries' (Arpana Naik, n.d.). Since bras are produced in a few different sizes, they can never truly fit perfectly. Wearing the wrong bra size can result in problems like back and neck aches, damage of the breast tissue and a lower self-esteem, especially in women with larger breasts (Chen, LaBat, & Bye, 2010).

A recent study (Wood, Cameron, & Fitzgerald, 2008) found that over 80% of women wear the wrong bra size (Wood, Cameron, & Fitzgerald, 2008). After speaking with several women about this problem and doing this research I expect there to be a need for personalized bras, specifically regarding their fit.

I used the 'Analogies' paper (Interaction Design Foundation, n.d.) to observe comparisons between bras and for example nature or other industries. I used this to generate new ideas around the problem and to gain a fresh way of looking at an environment. The document in which I wrote about my findings can be found in Appendix I.
I found several comparisons in both nature and other industries. The most important finding was the splint material used in hospitals. These materials are stiff, but when put in water with a temperature of 70 degrees celsius can change in shape. In hospitals, it is then put around a joint to make sure is does not move. This could possibly be implemented in the underwire of the bra, as the materials forms completely to the body. This could be a simple, inexpensive way of creating underwire that fits perfectly and can be shaped to each unique body in a 3D-structure.

Additionally, I looked into the concept of biomimicry to find comparisons between nature and structure design. I found the honeycomb structure incredibly interesting as it is a naturally strong structure, but can still be somewhat flexible. This might be a good structure to keep in mind if I would like to, for example, 3D-print the underwire. I expect the structure to give enough support due to the strong structure, but still feel comfortable. The golden ratio could possibly also be used to find the right shape as this ratio can be found in lots of elements in the human body.

06
INTERVIEWS WITH EXPERTS.

After researching the underwire, I found a Dutch entrepreneur, Lidewij van Twillert, who designs personalized underwire and bras for women. I visited the launch of her first lingerie collection (figures 6.1 - 6.6) and spoke to her about her designs. She explained to me that the underwire as we know it is a 2D shape, while our bodies are 3D. She told me that a 2D underwire could never fit perfectly and that a bra with a perfect fit should include underwire that is shaped to fit a unique individual. She creates the underwire by doing a 3D scan of the woman's breasts and 3D printing the underwire. To me, this business seems like a great alternative to the mass-production of lingerie and a good solution to the problem of fit regarding bras. However, she told me that her bras cost around €850 per bra, which means most people would not be able to afford such a luxury product.

FIGURE 6.1 // Display table Ari van Twillert

FIGURE 6.2 // Bralette & briefs Ari van Twillert

FIGURE 6.3 // Bras ari van Twillert

FIGURE 6.4 // 3D-printed underwire Ari van Twillert

FIGURE 6.5 // Fabrics, 3D-printed underwire & bra Ari van Twillert

FIGURE 6.6 // bra with 3D printed structure Ari van Twillert

I also spoke with a sewing expert at the university. She told me that she expected elastic to be a great alternative to replace underwire. I expressed my concern regarding support if underwire would be replaced by only elastic, but she explained to me that if the band gives enough support, elastic would be a good alternative to a more comfortable bra. Additionally, this would also make the fit of the bra easier, since the elastic would stretch according to a women's size.

Additionally, I spoke with Sandra Baars, a physical therapist working in the Anthonius hospital in Nieuwegein. I asked her about the splint material, whether she thought a material like this could work in a bra and how much support a material like this could give. As previously mentioned, she explained to me that the material is typically used to put around joints to make sure they do not move. A splint is a temporary treatment to relieve the patient of any pain or to prevent further injuries. The material is thermoplastic, meaning it can be altered to find a desired shape after putting it in boiling water. The material then hardens at room temperature. She believed depending on the type of splint material and its density, that the material can be supportive enough to use as underwire and that splint material would be great to quickly create a 3D shape that fits the body perfectly. She gave me left over splint material to use in my project.

07
CONCEPTUALIZATION & FIRST PROTOTYPE.

To further experiment with bra design and practice making bras myself, I decided to try out the technique previously discussed with the physical therapist. I made a bra with splint material as underwire (figure 7.1 - 7.6). I made the underwire to fit myself and discovered what the experience of making such a piece of underwire would be like. The material is comfortable to the skin, and although, according to physical therapist Sandra Baars who gave me the material, it needs to be put in water with a temperature of at least 70 degrees celsius, it is still comfortable when put to the skin. I soon discovered that the piece of material I had was too small and stretched it too far to get the right length. When it hardened, the material was not as strong as before because of this.

Additionally, I put the material underneath the breasts without a bra on. As a bra lifts the breasts up when wearing it, the splint material had the shape of the breasts when they are not lifted. Because of this, the material did not fit as well as expected when put into a bra.

When I make a new bra with this material as the underwire, I should not stretch the material as much when it is hot to keep the strong structure when hardened. I could also use tape to lift the breasts up while applying the splint material to the skin. I could also try to find a different way to lift the breasts up while applying the material to the skin. Additionally, the edges of the splint material are relatively uncomfortable, so I will need to find a way to make these more comfortable.

After making the first bra much too small, this bra was a little too big but a much better fit. I can conclude that I should make the pattern a bit smaller to get the right fit.

FIGURE 7.1 // Setting & first prototype finished

FIGURE 7.2 // Different splint materials

FIGURE 7.3 // Pattern for cups

FIGURE 7.4 // Splint material in underwire casing

FIGURE 7.5 // Process of making the bra

FIGURE 7.6 // Process of making the bra

FIGURE 8.1 // Book & first prototype

08
MIDTERM DEMO DAY.

I presented my prototypes and ideas during the midterm demo day. The bras were well received. I discussed the problems I found with the women present at the midterm demo day and all told me that they had experienced problems, like discomfort or problems in fit, too. I noticed that people liked the simple bralette a lot due to the amount of lace in the bralette. I will ask in future surveys whether this would be a must in a bra. I received lots of positive feedback and advice on how to move forward. I will continue by including the user more in my project and by making several other prototypes. Figure 8.1 and 8.2 show what my set-up was like during the midterm demo day.

FIGURE 8.2 // setup midterm demo day

09 SURVEY.

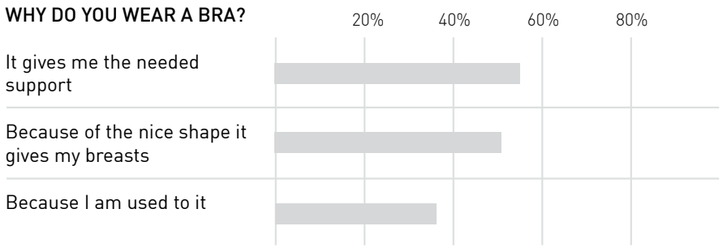
To further research the topic of bras, I decided to make a survey and discover the needs, experiences and opinions from the user. The survey is anonymous and I got 84 responses. I based the design of the survey on a Journal called 'The Power of Survey Design: A User's Guide for Managing Surveys, Interpreting Results, and Influencing Respondents' (Iarossi, 2006). I used this book for, for example, the order of the questions, the wording of the questions and the length of the survey. I tested the questionnaire by piloting, meaning I had a few people walk through it and give me feedback. This resulted in the following survey.

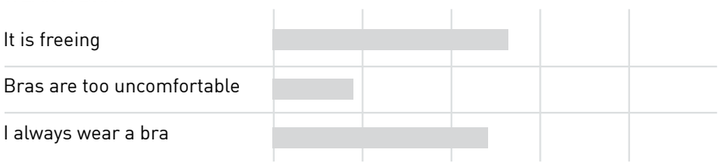
When making my survey, I decided to include as little open questions as possible, since I know most people find it much easier to choose something they agree with rather than thinking of something on the spot. In every question I left room for the participants to choose 'other' and elaborate so that they could also fill in a different answer than the ones I provided for them. I decided this would give me much more valuable information right now. If I would need some more information regarding a specific subject, I could always interview more people face-to-face and ask them to elaborate further. I did include one open question, in which I got 54 responses.
I divided the questions in different sections. The first section asks the participants questions about their experiences with bras. From these questions I can conclude that 90,5% of all participants wear a bra at least 4 times a week, of which 65,5% even wear a bra every day. They explained they mostly wear a bra because of the support it gives and because of the nice shape it gives the breasts. Another answer that was often chosen was 'because I am used to it.'
The reasons for not wearing bras were that it can be freeing and that bras are too uncomfortable.
When I asked what part of the bra is the most uncomfortable, there was a clear answer, 67,5% of participants chose the underwire as the most uncomfortable part of a bra. I expected the underwire to be the most uncomfortable, this question confirmed this hypothesis. From this I know that I would like to continue the project by designing an alternative for the underwire. The cups and the material of the bra were found to be the most comfortable. I will look into the current bra design and keep the cups and fabrics as consistent as possible.

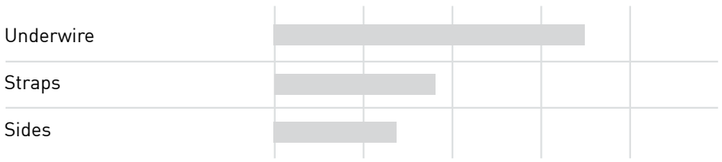
As previously mentioned, a recent study found that over 80% of women wear the wrong bra size (Wood, Cameron, & Fitzgerald, 2008). However, 71,1% of participants in my survey seem to think they are wearing the right bra size. From this, I expect that women are not wearing the right bra size, but are not aware of this problem. This can result in them experiencing discomfort in their bra from wearing the wrong size.

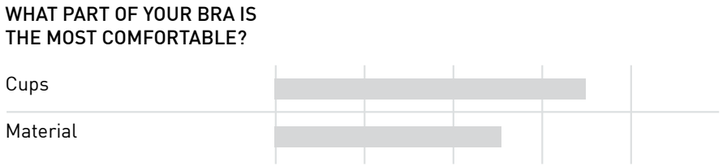
The biggest problems mentioned in bras were the poking underwire, and the edges of the cup that open up, which is a result from a worn out bra.

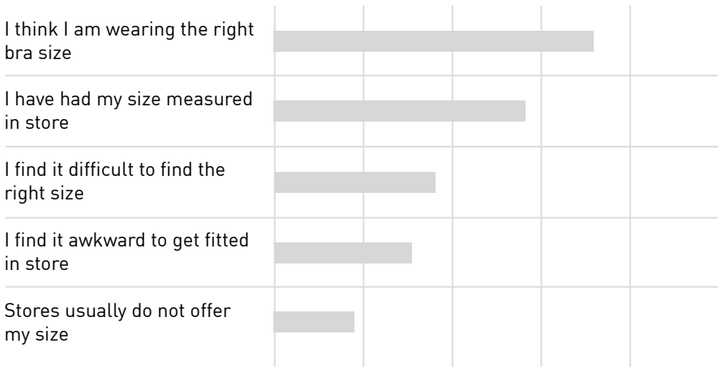
The next section asks the participants about their perfect bra. I included an open question asking them: "If you could change anything about your bra, what would it be?" I used the 'Affinity diagrams' paper (Interaction Design Foundation, n.d.) to group all gathered answers to rank each need according to the amount of similar answers given. I will use the same paper and method again to find the central point in my project, so in the next section of this report, I will go more into depth on how the method works and what I did exactly. . I have included pictures of the final result of the method. From this affinity diagram I found that most answers given were regarding the sagging bra straps and the underwire. I can also conclude that comfort and support is an important need.

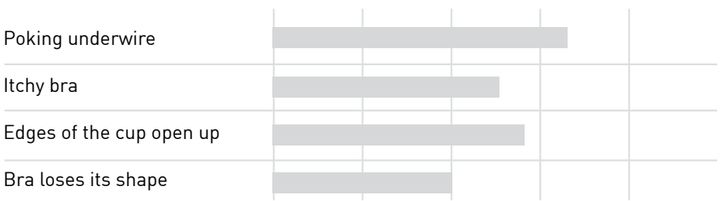


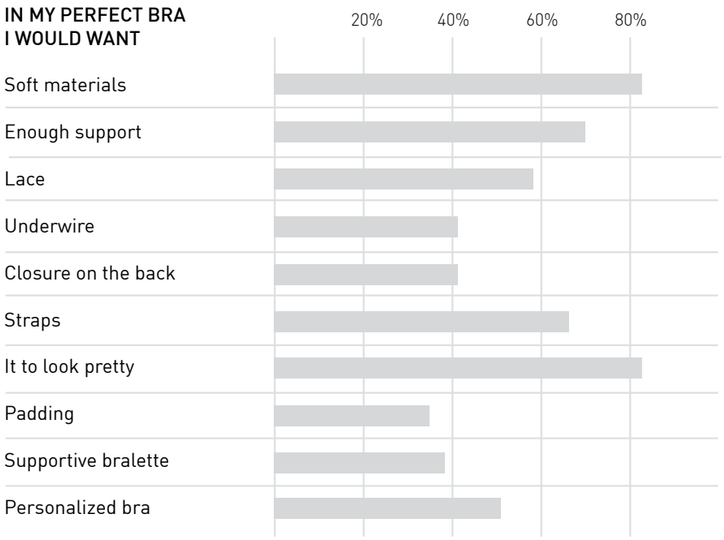


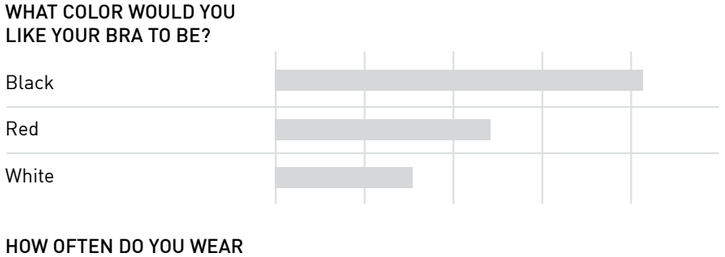












I asked the participants what they would like to have in their perfect bra. From this list, I conclude that I should include soft materials, lace, enough support, a closure in the back, straps and padding. 83,1% of participants wanted the bra to look pretty and almost 50% wants a bra personalized to their body. A bralette with the amount of support a bra has was also a popular option.

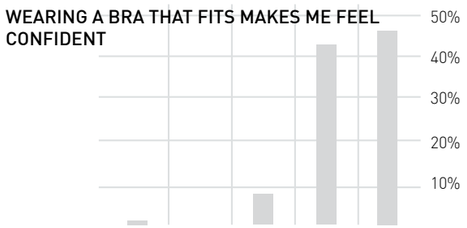
41% of participants said they wanted a bra with underwire. I think that from this, I can conclude that finding an alternative for underwire would be a good option, since although the participants find this the most uncomfortable, more than 40% would still like to include it in their perfect bra.

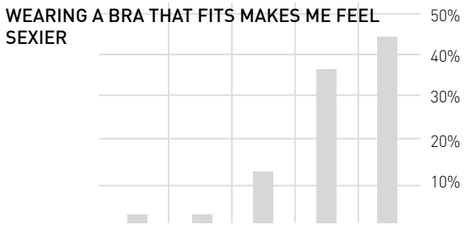
The clear winner in terms of color was 'black.' Additionally, to produce the bras as quickly and cost efficient as possible, it is important for me to choose only one color. This can be traced back to Henry Ford who said "A customer can have a car painted any color he wants as long as it's black" to improve the quality of his cars and the efficiency of his production lines (Hyperwrite, n.d.). This means that my prototypes will be black.

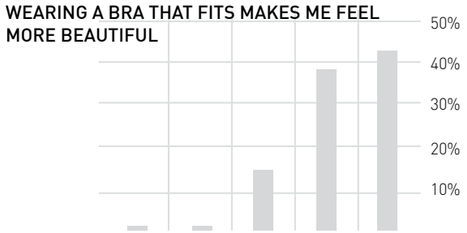
Finally, I asked about the participant's self-image in relation to bras. These results can be found on the right. The results on the left equal "completely disagree," the results on the right equal "completely agree." More than 90% of participants said that wearing a bra that fits makes them feel more confident. More than 80% of participants said that wearing a bra that fits makes them feel sexier and more beautiful. 54,9% of participants said that they feel more insecure if their bra does not fit.
I asked the participants how comfortable they are with other people (except their partner) seeing their bra since I was thinking about designing a bra with extra details that might possibly be visible from underneath their clothes. Only 25,6% of participants said they do not want anyone to see their bra. Which means that including these details might be an option.
More than 50% of participants said they were happy to take their bra off at the end of the day.

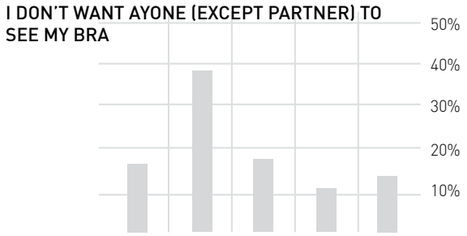
All this information tells me that wearing a bra that is comfortable and more importantly fits contributes to the participant's self-image and would make the participant feel more confident, sexy and beautiful.

I asked the participants whether I could approach them for more surveys or interviews and 24 people shared their email. The full images of the results can be found in Appendix II.









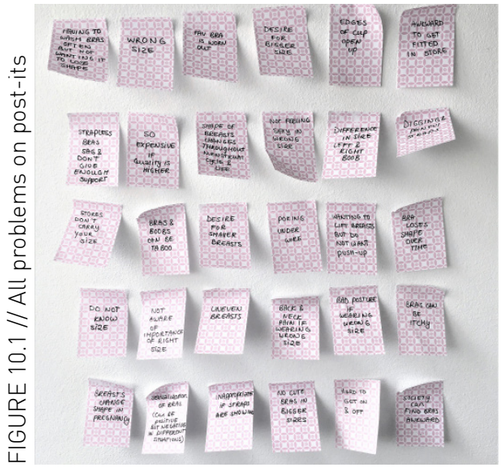


FIGURE 10.1 // All problems on post-its

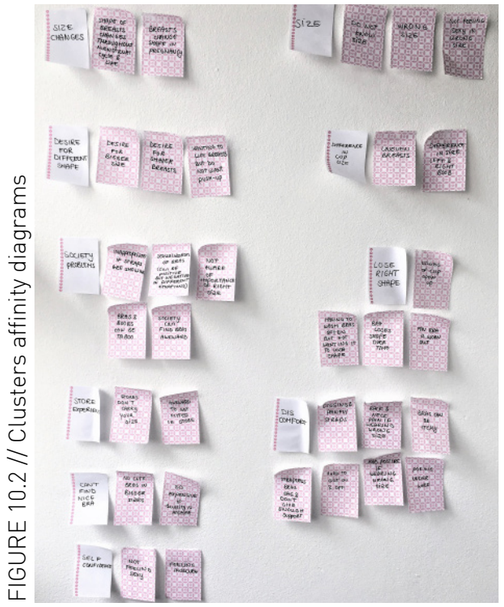


FIGURE 10.2 // Clusters affinity diagrams

FIGURE 10.3 // Clusters with connections

10 AFFINITY DIAGRAMS.

After gathering lots of information, I was left with lots of problems regarding bras. I wanted to group and bundle all gathered information and determine which problems could be a central point to the project. To do so I used the 'Affinity diagrams' paper (Interaction Design Foundation, n.d.). With this paper I could make sense of my data. I wrote down all problems related to bras on post-it notes. I then pasted one of them on the wall, taking another one and deciding whether the problem related to the previous problem. I did this for all the problems, creating 10 clusters in the process. I then named these clusters. They consisted of: Self-confidence, difficulty to find nice bras, store experience, uneven breasts, societal problems related to bras, desire for a different shape/size, changes in size over time, size, worn out shape and discomfort. I then ranked the problems according to what the women in my survey claimed to have the biggest problems with. I also connected some of the problems to different clusters is they seemed related.

From this method, I could conclude that most problems link to size. For example, most problems in the discomfort cluster are a result of an ill-fitting bra. I can conclude that size or fit is the biggest problem according to this method and the women who participated in my survey. If I were to design something related to this problem, problems from other categories linking to fit/size could also be solved.
More detailed pictures of the diagram can be found in Appendix III.

I also used the affinity diagramming method to find the most important clusters in the answers to my question: "If you could change anything about your bra, what would it be?" from my questionnaire. Pictures of the process and results of the second affinity diagram can be found in Appendix IV. This diagram told me that most people would change the underwire or the straps. As the support needs to be in the band rather than the straps, I know the problem with the straps is a result of a problem regarding the fit of the bra.

11
CONCEPT FURTHER DEVELOPED.

After researching the customer's experiences, needs and problems regarding bra design and speaking with several experts I decided to further develop my concept by testing and comparing three different techniques regarding the underwire. I used the bra I previously made with the splint material as underwire, I made one bra with elastic as underwire and one bra with 3D printed underwire (figure 11.1 – 11.2). I soon discovered that the bra with elastic as an alternative to underwire did not have the right shape as well as did not shape the breast like I wanted them to be shaped. Additionally, the elastic was not as supportive as I had hoped.

I made a model for the underwire in SolidWorks (Figure 11.3), I measured myself to find the length the underwire should have. I measured the distance between the two ends the underwire should have, how far back the underwire should end on the side and the height. I soon discovered that the underwire could only be printed flat on one side, which resulted in a slightly different model (Figure 11.4). I 3D printed this model (figure 11.5) and discovered that the material was very flexible and not supportive. I could have gone to D-search to make a less flexible and more stable and supportive 3D print, however, as the splint material would have a much quicker and similarly accurate result, I decided to continue with the splint material as underwire. 3D printing would include having to make a 3D scan, 3D model and finally the actual print, resulting in a total time of at least 3 hours per side, while the splint material would take approximately 5 minutes to make for the total bra.

FIGURE 11.1 // Bra with elastic as underwire

FIGURE 11.2 // Bra with elastic as underwire

FIGURE 11.3 // 3D model underwire

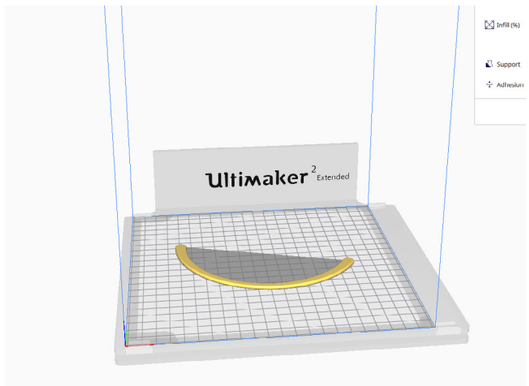


FIGURE 11.4 // 3D model underwire after alteration

FIGURE 11.5 // 3D printed underwire

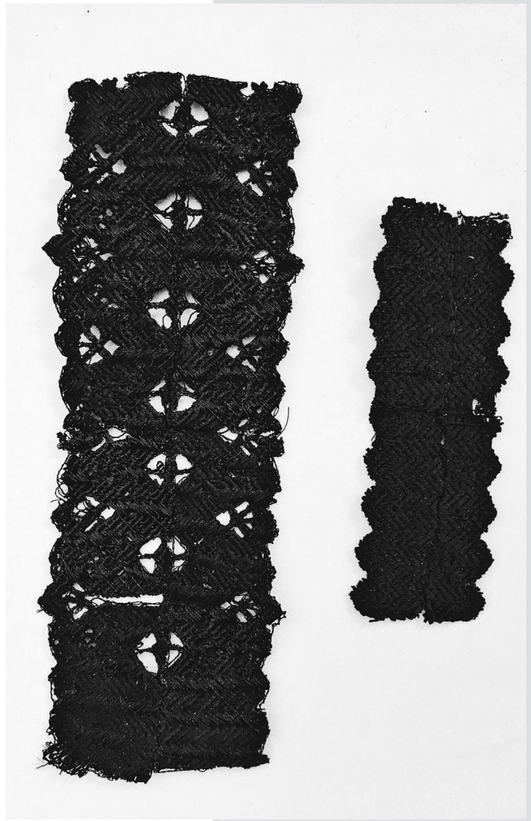


FIGURE 11.6 // Embroidery tryout

FIGURE 11.7 // Fusible web tryout

As one of my goals for the project is to find a less expensive way of making custom made bras, making the production process as quick and easy as possible is important. Choosing for the splint material will result in a much better and faster customer journey and thus a less expensive final product.

In an approach to make my own lace, I tried to use embroidery to do so. I made 2 designs for the lace and embroidered them onto material that dissolves in water, so that it leaves just the embroidered part. These parts can be found in Figure 11.6. I soon noticed that the embroidered parts were very stiff and felt like burlap material, meaning that this would not be comfortable as lace. I decided to simply buy lace and maybe use embroidered parts into the design of the bra to make them more aesthetically pleasing without touching the skin.

I also tried to apply Fusible web material (Vliesofix in Dutch) to the mesh material to see if this would make the material more supportive. Marina Toeters adviced me to try this out. I tried 1 to 4 layers of Fusible web material to see the difference (figure 11.7). However, the material did lose the strechyness and became much harder and more uncomfortable. As the fabric in combination with the fusible web material is stronger than the fabric by itself it will most likely be more supportive. I did not use the fusible web material in the final prototypes because of the uncomfortable feeling, however it might be interesting to see whether a more comfortable fabric can be created with the material in the future.

Finally, I tried different splint materials to test which one would be most supportive. I chose the white splint material as it is the thickest , giving me more freedom to stretch it if I want to and because the thickest material will give the most support

FIGURE 11.8 // Splint material tryout

12
CODING.

To eliminate as many steps of the production process in regards to custom made bras, I decided to write a program to automatically make the sewing pattern. Making the sewing pattern usually takes a professional seamstress 1 hour (BraTheory, 2018). She then makes several prototypes, and as even professionals can be inaccurate in making the pattern, this requires 3-5 prototypes. Each prototype costs 30 minutes for a fitting, 1 hour to revise the pattern, and 1-2 hours for actually making the prototype. Once the prototype is perfect, she will continue by making the final bra, which takes her 3-4 hours. With 4 prototypes, making a bra for a customer would cost a seamstress at least 14 hours and 40 minutes. These calculations can be found in appendix V.

If the making of the sewing pattern would be automated, the time it takes to draw the pattern would be eliminated. Additionally, the pattern would be much more accurate and the pattern would not have to be revised throughout the process. It is still possible that the production of the bra would not be entirely accurate which is why I expect that one prototype is still necessary before starting the final product. Writing a program to automate the making of the sewing pattern would result in a total time of 6 hours and 12 minutes. These calculations can also be found in appendix V.

I decided to write the code in R shiny as this program can quickly create an easy to use app. I have some experience with R as I had to analyze data with this program in a previous course. I wanted to learn more about the different possibilities this program has besides data analysis. Additionally, I know several people with experience in R, who could help me with the code whenever I would get stuck. For example, it was difficult to import the figures into R and I could quickly ask one of these people to help me with it.

In the program, each segment of the sewing pattern is scaled on the x- and the y-axis. There are several geometrical rules and equations included in the code. For example, line T1 needs to be the same length as BC1 and SC1 combined, the length of line BC2 is identical to the length of line SC2 and the bandwidth is (the width of segment B + the width of segment S) times 2.

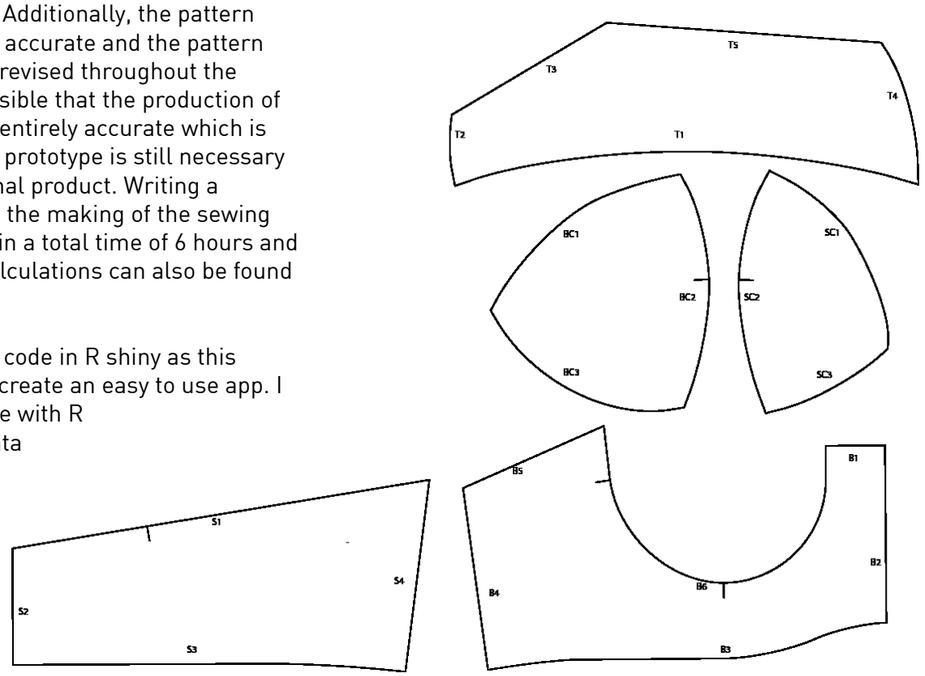


FIGURE 12.1 // Sewing pattern based on bra pattern from AF atelier, retrieved from https://afiatelier.com/allpatterns/maya-bra/#tab-id-4

As each segment only scales on a x- and y-axis, not all equations could be used in the code. The code could be improved by measuring and determining the length of each individual line, rather than the width and height of each image. This improvement would make a more accurate pattern. For example, in a revised program, the Pythagorean theorem (A^2+B^2=C^2) could be used on segment SC and BC and the equation SC1^2+SC3^2=SC1^2 could be used.

For the program, the seamstress needs to take 5 different measurements, the bandwidth, the distance from the nipple to the side, the distance from the nipple to the middle, the distance from the nipple to the bottom of the breast and the length of the underwire. These measurements directly determine the width of parts BC and SC, the height of parts BC and SC and the length of line B6. All other dimensions are a derivative of the other dimensions as previously mentioned. All measurements can be filled in as accurately as desired in centimeters.

All equations and geometry can be found in Appendix VI. The entire code can be found in Appendix VII.

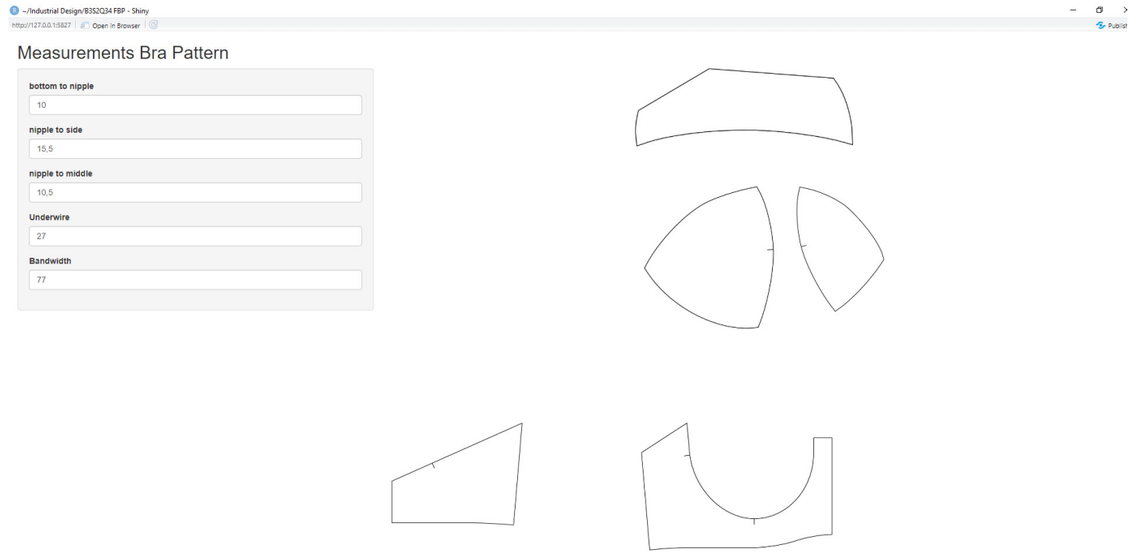


FIGURE 12.2 // Output app in R shiny

13 SURVEY 2.

To make my persona and determine who my target audience is, I decided to make a second survey to determine the traits of the people that are interested in the products I am developing. I divided the survey into three sections, one regarding demographics, one regarding their personality, one section about bras in general and the final section is specifically about my project. 28 women participated in the survey. Again, I based the design of the survey on a Journal called 'The Power of Survey Design: A User's Guide for Managing Surveys, Interpreting Results, and Influencing Respondents' (Iarossi, 2006).

One question asked the participants how much money they were willing to spend on a custom made bra. In making the persona, I only included the data of the participants that were willing to spend €40- €60,- or up as I know the bra will most likely cost more than €40-€60,- and thus, people that are not willing to spend as much cannot be included as a target customer.

In the demographics section, I found that, from the women willing to spend at least €40-€60 on a bra, 79% is between the age of 20 and 24, all participants are female and all are currently studying.

29% of participants have a disposable income of less than €300 a month, 50% of participants have a disposable income of €300-€500 and 21% have a disposable income of €500-€1000. 71 % of participants

WHAT IS YOUR AGE?

WHAT GENDER DO YOU IDENTIFY WITH?

WHAT IS YOUR CURRENT JOB SECTOR?

WHAT IS YOUR HIGHEST OBTAINED LEVEL OF EDUCATION?

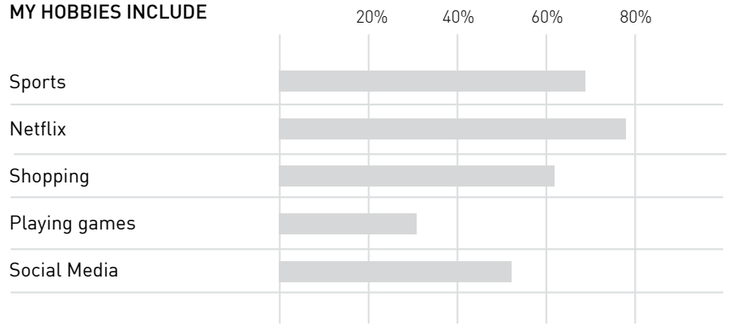
WHAT IS YOUR AVERAGE MONTHLY DISPOSABLE INCOME?

WHAT IS YOUR LIVING SITUATION LIKE?

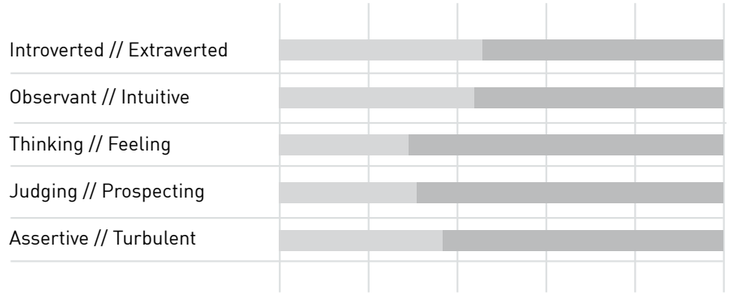
WHAT IS YOUR RELATIONSHIP STATUS?

WHAT ENVIRONMENT DO YOU LIVE IN?

MY HOBBIES INCLUDE

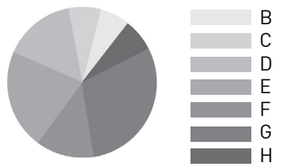


PERSONALITY



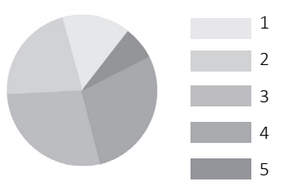
WHAT IS THE BANDSIZE OF THE BRA YOU ARE CURRENTLY WEARING?

WHAT IS THE CUPSIZE OF THE BRA YOU ARE CURRENTLY WEARING?



HOW MUCH DO YOU SPEND ON AVERAGE ON EACH BRA YOU BUY?

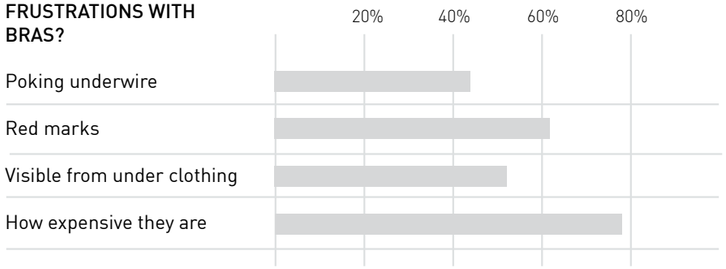
HOW MANY BRAS DO YOU BUY EACH YEAR?



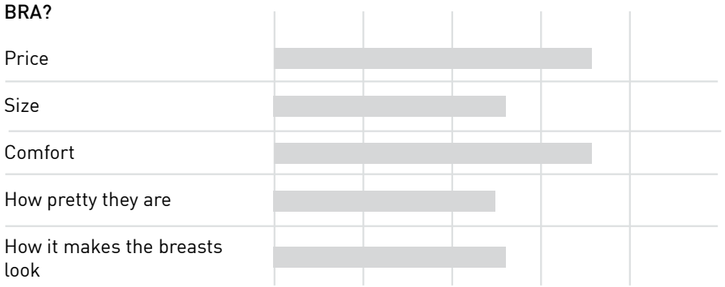
live with roommates, 64% are in a relationship and 86% live in a city. The most popular hobbies were watching Netflix, shopping, sports and social media.

Regarding the participant's personalities, I used a personality test (16personalities, n.d.) to determine the target audience's personality traits. They were mostly extraverted, intuitive, feeling, prospecting and turbulent. More information regarding these traits can be found on the website of 16personalities.
The average bandwidth of the participants is 70, and the most common cup size is a G cup. From this I can conclude that the women willing to spend more on a custom made bra are usually the women who have a smaller bandwidth and bigger cup size, making it much more difficult for them to find a bra as their size is usually not available in a store.
Regarding the bras they currently buy, the participants spend an average of €46,79 on their bras, of which they buy an average of 2,9 bras per person. The participants were mostly frustrated with the poking underwire, red marks, their visibility under clothing and the price of bras. The participants' most important aspects of bra buying relate to price, size, comfort, how pretty they are and how they make their breasts look. For a custom made bra these women are willing to spend an average of €71,79. 21% of participants expect the custom made bra to be ready in 5-7 days. 43% expect the bra to be ready within 1-2 weeks, and 36% expect it to be ready in 2-3 weeks. Personally, I expect the bra to be ready in 5-7 days, depending on the amount of business, which means that the customer will be satisfied with the time it takes until the bra is ready.

WHAT ARE YOUR BIGGEST FRUSTRATIONS WITH BRAS?



WHAT ASPECTS ARE MOST IMPORTANT IN BUYING A BRA?

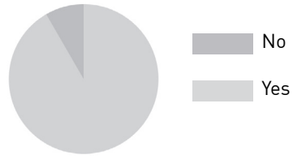


HOW MUCH MONEY WOULD YOU SPEND ON A BRA THAT IS PERSONALIZED AND CUSTOM MADE TO FIT YOUR BODY PERFECTLY?

HOW LONG WOULD YOU EXPECT HAVING A CUSTOM FIT BRA MADE WOULD TAKE?

WOULD YOU WANT A PERSONALIZED, CUSTOM FIT BRA?

WOULD YOU BE INTERESTED IN SUCH A MATERIAL {SPLINT} IN YOUR BRA?



WOULD YOU BE INTERESTED IN THIS CONCEPT {APP FOR AUTOMATED SEWING PATTERN} ?

WOULD YOU BE COMFORTABLE WITH THE SEAMSTRESS MEASURING YOU?

WOULD YOU PREFER TO GET A BODY SCAN RATHER THAN HAVING A SEAMSTRESS MEASURE YOU?

WOULD YOU PREFER TO MEASURE YOURSELF?

86% of the participants would like to have a custom made bra, 93% say that wearing a custom made bra would make them feel more confident and 71% say that wearing a custom made bra would make them feel sexier. Their reasons for this mostly included an increase in comfort and because it is difficult for them to find a bra that fits.

93% would be interested in splint material in their bra and 100% of participants would be interested in a program that automatically generates a sewing pattern. Their reason for both these techniques was that it would be a quick way of finding a perfect size resulting in a more comfortable bra. 92% would feel comfortable with a seamstress measuring them, only 14% would prefer to get measured by a body scanner and only 21% would prefer to measure themselves. From this I can conclude that the customer would feel most secure by getting measured by a seamstress. Their reason for that was that a seamstress is professional and accurate, while a body scan would become a privacy issue and measuring yourself would not be accurate.

All additional data can be found in appendix VIII

14 PERSONA.

Photo by bruce mars from Pexels

NAME:	EMMA JANSSEN
AGE:	22
GENDER:	FEMALE
OCCUPATION:	STUDENT
RELATIONSHIP STATUS:	IN A RELATIONSHIP
LIVING ENVIRONMENT:	IN THE CITY
HOBBIES:	SPORTS, NETFLIX, SOCIAL MEDIA AND SHOPPING
BANDSIZE BRA:	70
CUPSIZE BRA:	G

Emma is annoyed with the bras as we currently know them. With her small bandsize and big cup size, her size is not available in stores. She needs to go to specialty stores to buy her bras, but she is unhappy with the designs of the bras in the specialty stores.

The best option for her would be to buy a custom made bra, however, as she is a student, she does not want to pay as much money for a bra, as these bras are at least 300 euros. A custom made bra would be best for her, because it would fit great, be more comfortable and she would

She buys approximately 3 bras a year. She is annoyed with the poking underwire, digging straps, the red marks the bra leaves on her skin, how expensive the bra is and the fact that she can't find a bra that fits her well.

She would like a bra to make her feel sexy, it needs to look pretty, needs to be comfortable and it needs to fit well. A custom made bra would make her feel more confident and sexier.

She would want to spend around 80 euros on a personalized bra. She is interested in new technologies and innovations regarding fashion.

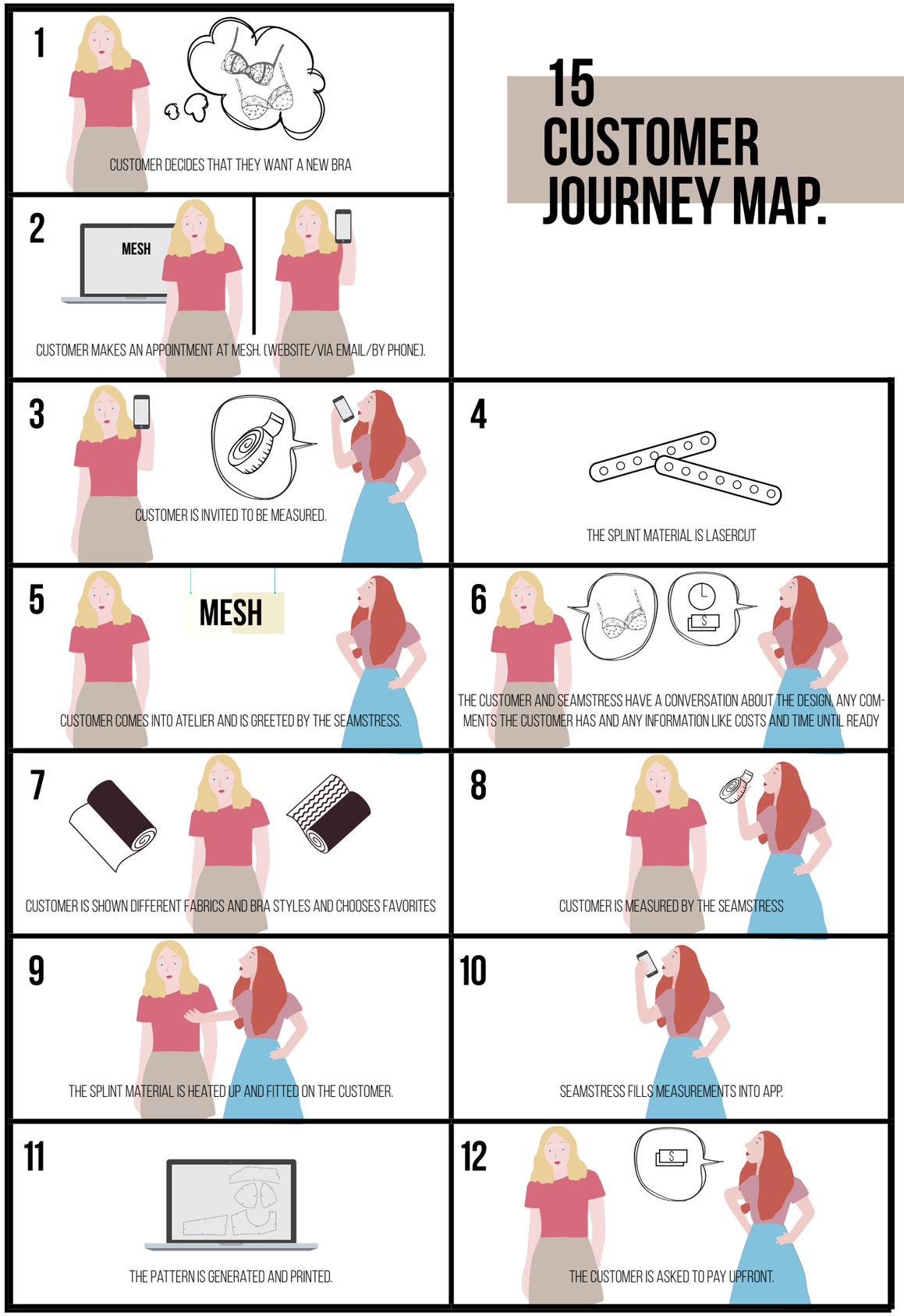
PERSONALITY

INTROVERTED (46,25%)		EXTRAVERTED (53,75%)
OBSERVANT (42,25%)		INTUITIVE (57,75%)
THINKING (30,75%)		FEELING (69,25%)
JUDGING (32,75%)		PROSPECTING (67.25%)
ASSERTIVE (38,5%)		TURBULENT (61,5%)

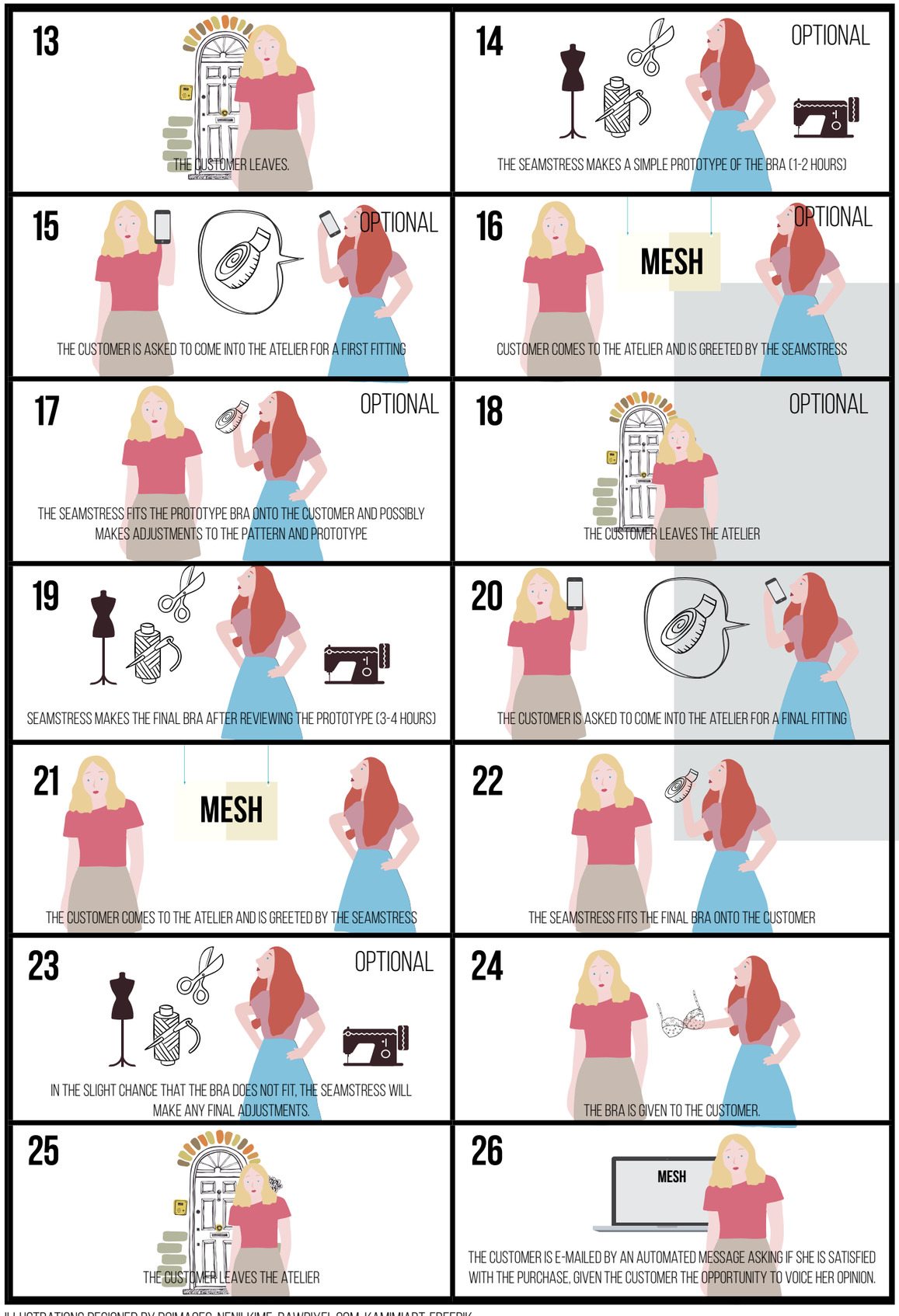
I made a persona to be able to identify with my target audience better and find what their needs, problems and desires are. I made this persona based on the 'engaging personas' paper (interaction design foundation, n.d.). According to this paper, there is a 10 step process to creating an engaging persona and scenario. In step 1, 'collect data,' I analyzed the data gathered in the previous chapter and based the hypothesis of the persona on that data (step 2, 'Form a hypothesis'). I showed this hypothesis to several potential customers and asked them whether they supported or rejected the initial persona. All accepted and could identify with the persona, which concludes step 3, 'Everyone accepts the hypothesis.' In step 4, 'Establish a number,' I decided upon the number of personas I would create. I decided to create just one as the participants in the survey had many similarities and they portray the audience I would like to target. Figure 14.1 shows the persona I have created, which concludes step 5, 'describe the persona.'

Steps 6 through 10 will be described in the next chapter, 'customer journey map,' as these steps are about creating scenarios for the persona.

15 CUSTOMER JOURNEY MAP.



ILLUSTRATIONS DESIGNED BY D3IMAGES, NENILKIME, RAWPIXEL.COM, KAMIMIART, FREEPIK



ILLUSTRATIONS DESIGNED BY D3IMAGES, NENILKIME, RAWPIXEL.COM, KAMIMIART, FREEPIK

I made a customer journey map to describe the process of buying a bra at Mesh. and to determine the amount of moments of interaction for each customer. I made this customer journey map based on steps 6 through 10 from the 'engaging personas' paper (interaction design foundation, n.d.) as these steps focus on creating a scenario for the persona from the previous chapter, and another paper on 'Understanding Customer Experience Throughout the Customer Journey' (Lemon & Verhoef, 2016). This paper explains, for example, the importance of how the touch points between company and customer should contribute to the customer experience. In my customer journey map, the customer has three physical touch points with the company, as she needs to get measured, fitted for the prototype and finally fitted for the final bra. The customer and company also have two (online) touch points when the customer contacts the company to make an appointment and when she is asked whether she is satisfied with her purchase at the end of the process. This final step also asks for the customer's confirmation of satisfaction, which will make the customer more loyal and will help the company improve where necessary. The persona created in the previous chapter is the customer in the customer journey map. This customer is seamlessly included in the process as much as possible to affect her final evaluation and loyalty to the brand (Lemon & Verhoef, 2016).

16
FINAL PROTOTYPES.

To test the concept, I decided to make 5 final prototypes. I made one for myself and 4 for other girls as I expect others less involved in the entire process to have different insights to me, while I will have more in depth insights from my knowledge about bras. With each of the participants I walked through the customer journey map. I lasercutted the splint material so that all underwires would have the same size before heating them. I also made the edges round for a more comfortable wear. By lasercutting the material, the edges of the sides also became softer, making it more comfortable. The lasercutting file can be found in appendix IX.

As the subject of bras can be an intimate subject, I made each participant aware of the project beforehand and made sure they were comfortable with the study. I then asked the participants to meet with me to measure them and to fit the splint material to mold it to their body. I asked each participant to fill in a consent form, which can be found in appendix X. I then continued by asking them which materials and designs they liked. Finally, I measured and fitted them. I made a unique pattern and moodboard for each participant, which can be found in appendix XI. I then made the bra for each participant in a slightly different design that fits their personal style. The bras can be found in figures 16.1 to 16.10. I used the embroidery previously mentioned in the design of Ilja's bra (figure 16.6) After finishing the bras I asked the participants to each wear their bra for one day and fill in a feedback form about the bra.

For the bras, I used a somewhat seethrough mesh fabric and three kinds of lace. During the measuring, I recorder the session in which they told me which fabrics they would prefer and in which they shared other opinions on bras. The transcriptions of these sessions can be found in appendix XIII.

FIGURE 16.1 // Bra for Sophie front

FIGURE 16.2 // Bra for Sophie back

FIGURE 16.3 // Bra for Isabelle back

FIGURE 16.4 // Bra for Ilja front

FIGURE 16.5 // Bra for Ilja back

FIGURE 16.6 // Bra for Isabelle front

17
FINAL USER TESTS.

FIGURE 16.7 // Bra for Lisa front

FIGURE 16.8 // Bra for Lisa back

To determine whether the bras fit and what each participants opinion on the concept is, I had each participant fill in a feedback form, all feedback forms are included in Appendix XII. I asked the participants about the fit of the bra regarding the cups, sides, back, straps, underwire, middle part between the cups and the total bra. I asked about the comfort regarding the same subjects. I asked the participant about the design of the overall bra, about the shape of the bra and about the concept of the bra. I finally asked them whether they had any thoughts while wearing the bra and any additional comments.

Regarding the fit, for most participants, the cups of the bras were a little too big, the top of the sides gaped a little and the straps were too long. The middle part between the cups did not lie on the skin as much as I hoped. All this is due to the fact that I am not a professional seamstress and thus not able to sew as accurately. A professional seamstress would solve this problem. The underwire fit everyone perfectly, just like the back of the bra and the bottom of the sides. For some the cups did fit great.

Regarding the comfort, some people found the fabrics a little ticklish, which would be solved by finding softer fabrics. Most participants said they hardly felt the underwire made from splint material and told me this underwire was incredibly comfortable.

All participants liked the design and thought the overall design of the bra was pretty. Ilja says: “I love the shape of the cups, that cover my boobs just enough and do not cause for any unwanted “double boob” effect” and “I love the material and the back is really pretty yet practical.” Isabelle says: “I think the back is super pretty.” Tara says: “I liked the

FIGURE 16.9 // Bra for Tara front

FIGURE 16.10 // bra for Tara back

combination of the different fabrics, this really gave a creative twist and made me feel I was wearing something special and exclusive!” Lisa said: “Love the idea of picking your own fabrics and colors in order to make a custom bra!”

Regarding the shape, most participants would prefer it if their breasts would be pulled up a bit more. This problem can be solved by better straps, a better fit and a tighter bandwidth. The current straps on the bras are too low quality and should be changed. Also the part between the cups should be shorter and lay on the skin for a better shape.

If a professional seamstress and a software engineer would be used to improve the accuracy of the pattern and production of the bra, all participants would find the concept interesting. According to Isabelle “It feels like I am not wearing a bra and that is what you want.” Ilja said: “if this bra fit and shaped me better, it would make me feel sexy.” Lisa said: “To find a bra that fits nice, is your favourite colour and fabrics, has nice straps, etc. isn’t as easy in a regular store.... Bra’s are a big expense and going this extra mile through personalization has a lot of potential.”

Most participants said they needed to adjust to the feeling of the underwire because the material partly lies on the bottom part of the breasts rather than only on the ribcage. However, after a while they all liked the underwire and thought it felt very comfortable. Tara said: “It was really lightweighted and I had the feeling I wasn’t wearing a bra.” Lisa said: “Unlike other bra’s I did not feel like I was wearing a bra.”

18
TESTING SUPPORT AND PRESSURE.

After testing the prototypes with the participants, I wanted to take on a lab approach for the final testing of the bra to combine a scientific approach with a more user focused approach.

To test the amount of support in the bra, I wanted to test the pressure in one of the prototypes. I wanted to compare one of my bras to a 'normal' bra to see the difference in support. Unfortunately, due to limited time, I was unable to gather all necessary supplies for the circuit. I have included a drawing of the desired circuit (figure 18.4) to show how I could measure the pressure in the future.

I started the process by finding a pressure sensor that I could paste into the bra with a sticky back. I was advised to use this specific sensor by Geert van den Boomen and decided to used a FSR406 pressure sensor (Figure 18.1). Because I was unable to make the actual circuit, I simply used a multimeter to quickly determine the amount of pressure in each bra. I measured the position of the sensor on the breast to make sure the sensor had the exact same position for both bras. I expected the bra I made to be less supportive than a normal bra due to the fact that I am not a professional seamstress and because of the feedback I received from the user test.

When measuring the pressure, there was more pressure in the normal bra (1.5 MΩ) than in my bra (1.2 MΩ), meaning that the normal bra is more supportive or tighter than my bra. This confirms my hypothesis. However, the measured values are not completely accurate as I was unable to make the entire circuit, which means that an additional measurement could be done in the future with the right circuit to ensure an accurate measurement.

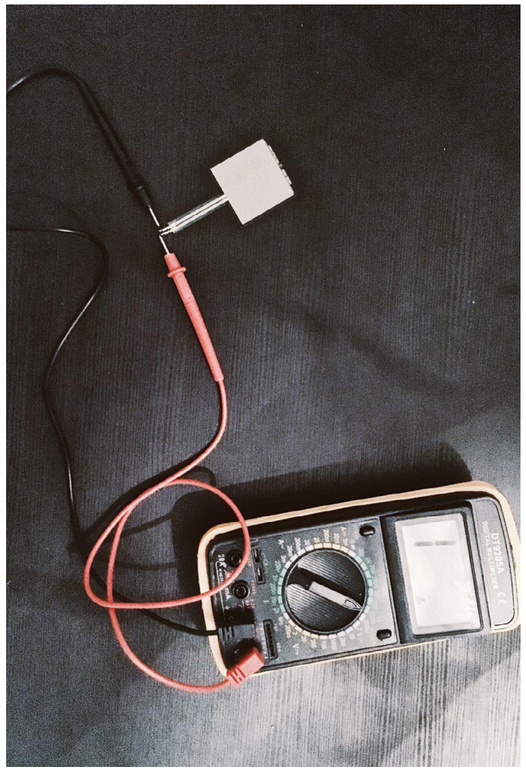


FIGURE 18.1 // Measuring equipment

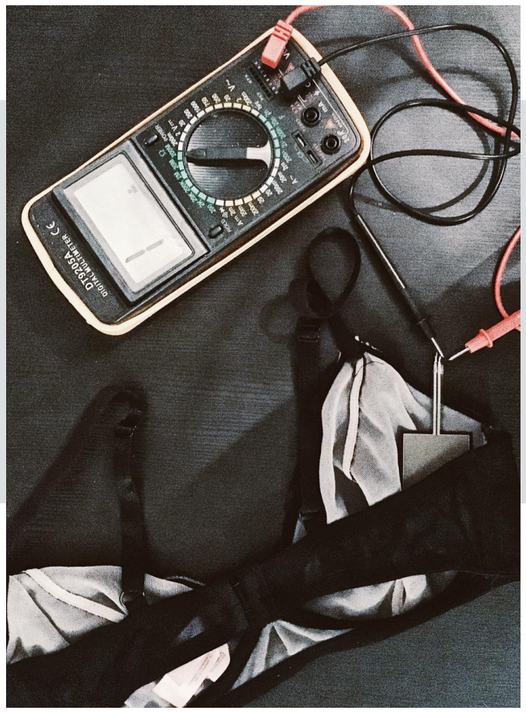


FIGURE 18.2 // measuring pressure in 'normal bra

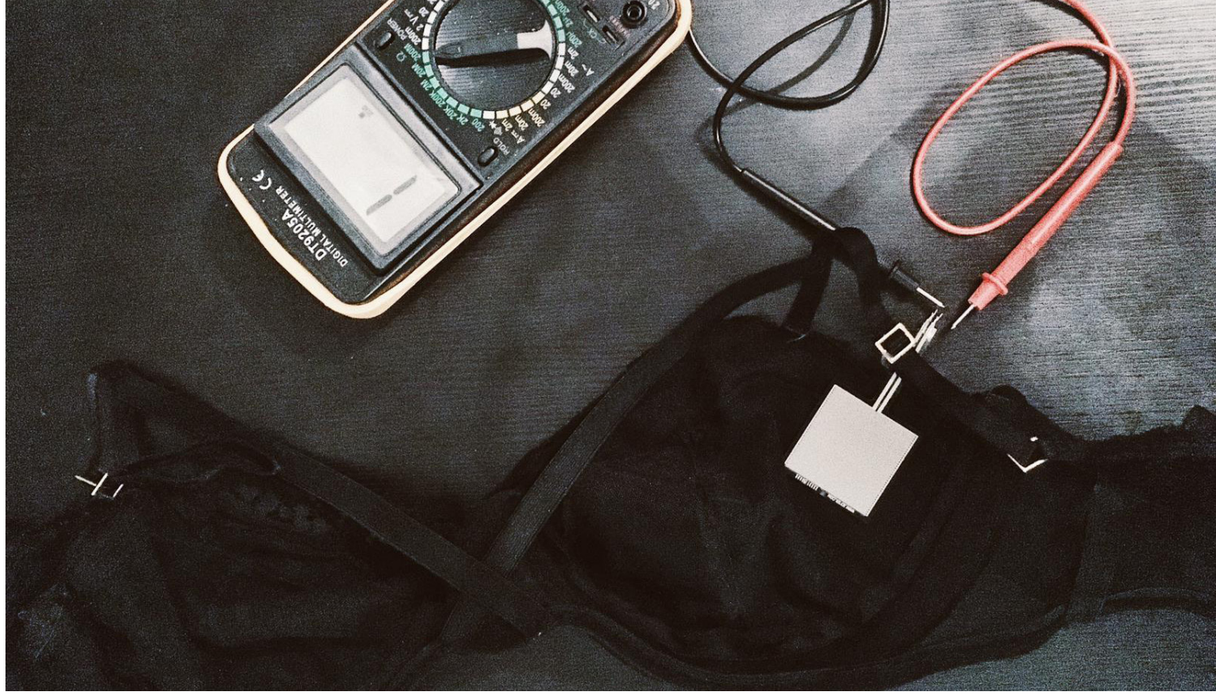
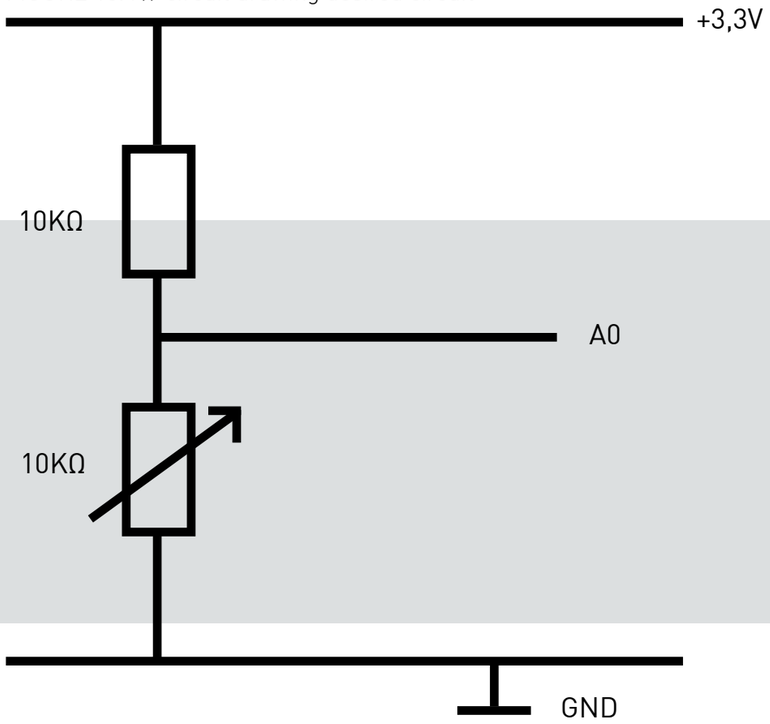
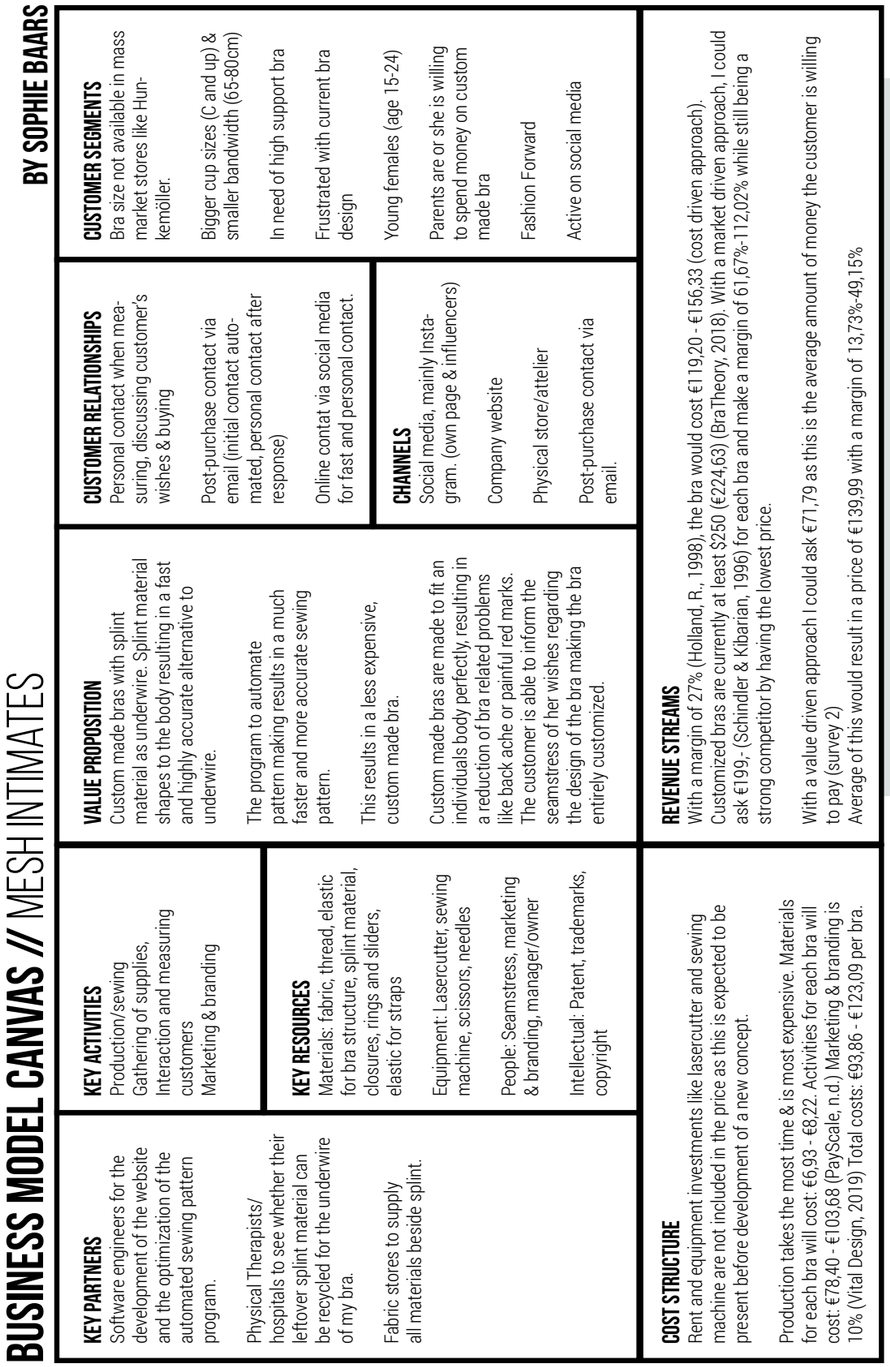


FIGURE 18.3 // measuring pressure in my bra

FIGURE 18.4 // circuit drawing desired circuit



19
BUSINESS MODEL.



As the Business Model Canvas is a method to explain a value proposition and feasibility of a business through a short summarized logic (Türko, 2016), I decided to create one for the concept of Mesh. This tool will help me to show how the potential business could be profitable and how feasible it would be in a real life setting.

Key partners will consist of software engineers, Physical therapists or hospitals and fabric stores. I would need these partners if the product was to go on the market.

Key activities would be production/sewing, gathering of supplies, interaction and measuring of the customers and marketing & branding.

Key resources would consist of the materials and equipment needed to make the bras, the people who could realize the business and the intellectual property necessary.
A good customer relationship is necessary to obtain loyal customers. The customer will have personal contact with the seamstress when measuring and will be able to voice wishes and needs regarding the bra. There will also be post-purchase contact to ensure the customer is satisfied and online contact via social media for fast and personal contact.

The *channels* used consist of the company website and a physical atelier. The customer and the company can also contact each other via social media, mainly Instagram and via e-mail. Influencers on Instagram will also be used to target the audience in a more personal and trustworthy way.
The customer segment is based on the persona, I will target women whose bra size is not available in mass market stores, they have a bigger cup size and smaller bandwidth. They are in need of a high support bra and frustrated with current bra design. They are young and their parents, or the customer herself is willing to spend money on a custom made bra. They are fashion forward and active on social media.

Regarding the *cost structure* and the *revenue streams*, if a cost-based pricing approach would be used for this concept, a Mesh. bra would cost between €93,86 and €123,09 (excluding margin).
If this product were to go on the market, I would need an experienced seamstress to make the bras. According to the PayScale website (PayScale, z.d.), an experienced seamstress will cost me $14.29 per hour. According to an article by BraTheory (BraTheory, 2018), there are several steps involved in the process of designing a custom fit bra. Measuring will take 20 minutes, a conversation with the customer will also take 20 minutes and the pattern making will take one hour. The seamstress will then make a simple prototype, which takes one to two hours, she will do a fitting with the customer of 30 minutes, do alterations to the bra (60 minutes) and will then make the final bra, which will take her 3 to 4 hours.

Within my project, I can exclude the pattern making, as a pattern will be created automatically by the program I have written. In my project I would also have to include the molding of the underwire to the desired shape, this will take approximately 5 minutes and is included in the 20 minutes of measuring as less measurements need to be taken because of the app.

The splint material will be just as easy to integrate into the bra as the underwire as we currently know it would be, resulting in a similar production time of the final bra. This would result in a total time of 6 hours and 20 minutes to 8 hours and 20 minutes of labour (Appendix V) and thus $88,60-$117,18 of labour costs for each bra. This translates to €78,41-€103,70. The material costs for each bra are between €6,93 and €8,22 (Appendix V). Marketing and branding will be an extra 10% on top of the costs (Vital Design, 2018) and with a margin of 27% (Holland, R., 1998) the total, cost-based, price of the bra would be between €119,20 and €156,33. All calculations for this can be found in Appendix V.

If I would take a value based approach, I would look at the value I am offering compared to my competitors and the price the customer would be willing to pay for such a product. According to my second survey, the customer is willing to pay an average of €71,79 for such a product. If I would exclude the prototype from the process, the price of the bra would be between €75,04 and €94,51 with a margin of 27% (Appendix V), which would be much closer to the price the customer would be willing to pay, however, without a first prototype, the fit would be less accurate then with a prototype. To reach the price of €71,79 I would need a margin between -0,04%(maximum costs) and 21,5% (minimum costs)

If I would take a market based approach, I would look at the current prices for custom made bras. Custom made bras are currently at least $250 (€224,63) (BraTheory, 2018). I could ask €199,- (Schindler & Kibarian, 1996) for each bra and still be a strong competitor as my bras will be the least expensive. This would generate a margin of 61,67% (maximum costs) to 112,02% (minimum costs).

If I would combine the techniques, I could take the average of the prices of the different approaches. This would be between €130,- and €142,37. If I would choose a price ending in ,99 (Schindler & Kibarian, 1996), I would make the bra €139,99 resulting in a margin of 13,73% (maximum costs) to 49,15% (minimum costs).

Mesh. is expected to perform as a sub-brand, which means that it is expected that costs like rent and equipment investments like a laser cutter and sewing machine are not included in the costs. This is expected to be present before the development of this new concept.

Regarding the *value proposition*, Mesh. offers a custom made bra with splint material as underwire. The splint material shapes to the body resulting in a quick and highly accurate alternative to underwire. Mesh. has an app that automatically makes a unique sewing pattern after filling in 5 different measurements. This results in a more accurate sewing pattern in only +/-2 minutes. The result is a less expensive custom made bra.

Custom made bras are made to fit an individual's body perfectly, resulting in a reduction of bra related problems like back ache or painful red marks. The customer is able to inform the seamstress of her wishes regarding the design of the bra making the bra entirely customizable.

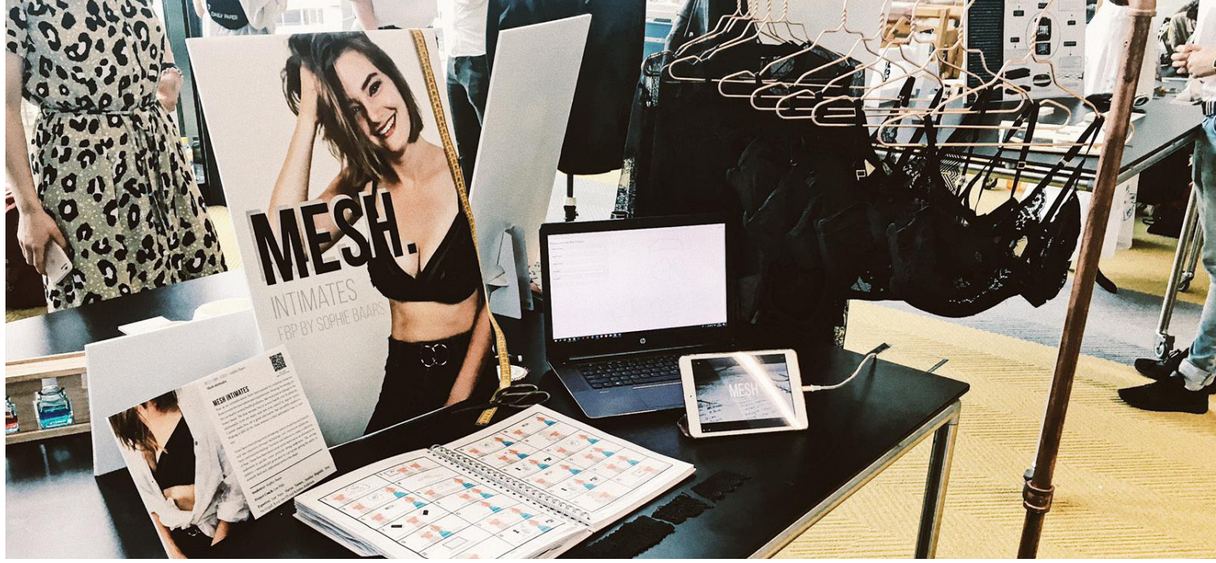


FIGURE 20.1 // Demo Day setup

FIGURE 20.2 // Demo Day setup close up bras

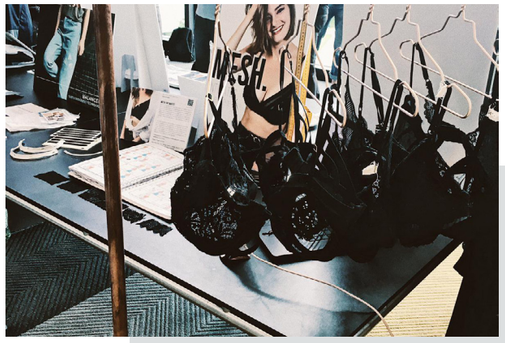


FIGURE 20.3 // Demo Day setup

FIGURE 20.4 // splint material displayed

20 FINAL DEMO DAY.

During the final demo day, I presented my prototypes, video, poster, app, materials and workbook. The setup of my stand during the Final Demo Day can be seen in figure 20.1-20.3. My prototypes consisted of the 5 bras that I hung onto a copper industrial rail to make the bras the center of attention. I noticed lots of visitors liked the rail and both the rail and the bras sparked their interest. The video I made was mostly a video with ambiance shots to show the production of the bra and one of the bras. The video can be found on https://youtu.be/HwPkd0_VL_M . I made one poster to spark the visitors interest and to gather attention, while the small, A4 poster I made was to inform the visitors about my project. I showed the app in which visitors could put different measurements and see the pattern change. I showed the splint material in the form of the underwire and in the form of a sheet to show the difference (figure 20.4). I also showed the different fabrics used in the bras. Finally, I showed my workbook in order for the visitors to be able to view my entire process, see the persona, business model and customer journey map.

I got mostly positive feedback and lots of people asked me why a product like this was not on the market yet. From this I can conclude that they think a product like this is interesting. I was also asked several times whether I would continue with this project in the future, also telling me they were interested in any further developments of the project.

21 CONCLUSION.

During this project, I went through an iterative design process, meaning that I went through the process of designing my project while continuously refining, revising and adjusting the concept with the help of user feedback (Enginess, 2018). I chose this approach to be able to refine and improve my project along the way, as this can be achieved through feedback collected in an interactive iterative process involving users (Abras, Maloney-Krichmar, & Preece, 2004, p. 5)

I designed a service for custom made bra design that focusses on making custom made bras more inexpensive, innovative and fashionable. Through the process of researching this subject I focused on the competency areas of Industrial to include all areas into the project. The bras I made were received were well both by the participants of the user study as well as by the visitors during the demo day. I especially found my validation in the amount of pleasure I delivered to the participants in the user study. All participants were incredibly enthusiastic when I gave them the bras and found them beautiful. I think one of the most important observations is seeing how special each participant felt after receiving something custom made for them. This tells me that after buying a bra once, the customer will stay loyal to the brand if they like the quality because of the satisfying feeling it gives.

My goal was to make durable garments that are personalized to fit perfectly. The bra should make women feel sexy, confident and beautiful, be innovative and easy to put on and take off. Attention should be paid to details, fit and aesthetic, while researching what components in bra design can be improved to contribute to a better fit and a more inexpensive custom made bra. I also wanted to research how modern techniques like 3D-printing and body scans fit into this research. I believe that I achieved my goals in this project. I looked into these modern techniques, even though they eventually did not fit into the customer journey. In the future, more research could be done regarding these techniques to either find a faster and more inexpensive way of integrating them or to target a different audience willing to spend more money on custom made bras.

Overall, the concept was received enthusiastically and positively. I believe that a concept like this is exactly what the bra industry needs, as, in my opinion, there is little innovation in the bra industry. The underwire as we know it can be traced back to 1893 (Vogue, 2019), while I believe better alternatives can be found if more research is done. From my research I can conclude that splint material would be a great alternative to underwire and that a program that automatically creates a perfect sewing pattern would be ideal for the production of custom made bras. There is still so much more room to research bras, for example the straps, the closure the pattern itself, more research regarding the underwire or a similar research but with padded bras. I feel like I have only discovered and researched a very small part of the subject, there is still so much room to innovate and discover and I would love to continue exploring the subject of bras.

FIGURE 21.1 // final product

22 DISCUSSION.

I discovered there are so many components when it comes to bra design, that it is incredibly hard to master every component in only one semester. If I were to realize the concept I have developed, I would need to have a professional seamstress to make the bras and optimize the pattern and a software engineer to optimize and improve the app. I would also have to do more research regarding the materials to find softer fabrics and stronger straps to create a more supportive bra.

The bras were only worn for one day, which means that I can't see the long term effects the bra has. For example, a bra from Primark can seem comfortable once you start wearing it, but it wears out so quickly that it is not supportive anymore and gives problems like back ache. I was unable to test this as this would mean that the bras should have been worn for several weeks.

While testing the bras, I did not make a prototype for each bra before making the final bra. I did this due to time restrictions and as a test to see how well the bra would fit without any prototypes. This meant that some of the bras did not fit as well as I had hoped. This contributes to different answers on the feedback form. If the bras would have fit, I would most likely have received more in depth comments about the comfort rather than mostly about the fit. In the future, I could make an extra prototype for each person, as portrait in the customer journey map to ensure a great fit. Additionally, it is always possible that the participants in the user study were more enthusiastic, because the bra is free for them, as well as because they know me and are interested in the project itself.

Finally, in the second survey, I would have preferred to have more participants, as I needed to filter out participants who were not willing to pay more than €40 for a custom made bra. The survey would have been more reliable if more data was collected. However, I noticed that because I made two surveys in total, people were less willing to participate after the first one.

FIGURE 22.1 // final product

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APPENDIX I
ANALOGIES.

CLICK TO OPEN ANALOGIES FILE

APPENDIX II
SURVEY I.

LINK TO SURVEY

CLICK TO OPEN FILE WITH DATA

APPENDIX III
AFFINITY DIAGRAM 1.

CLICK TO OPEN PICTURES

If links to Appendix files cannot be opened, please find them on: https://drive.google.com/open?id=11j-D-I2a0DYk41ZSX8rfhs6Cx9uf1jRD

APPENDIX

APPENDIX

APPENDIX IV
AFFINITY DIAGRAM 2.

CLICK TO OPEN PICTURES

APPENDIX V
TIME & PRICING.

CLICK TO OPEN TIME & PRICING FILE

APPENDIX VI
EQUATIONS AND GEOMETRY.

CLICK TO OPEN EQUATIONS & GEOMETRY

APPENDIX VII
CODING.

CLICK TO OPEN CODE

APPENDIX VIII SURVEY 2.

LINK TO SURVEY

CLICK TO OPEN FILE WITH DATA

APPENDIX IX LASERCUT FILE.

CLICK TO OPEN LASERCUT FILE

APPENDIX X CONSENT FORM.

CLICK TO OPEN CONSENT FORM

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APPENDIX

APPENDIX

APPENDIX XI PATTERNS AND MOODBOARDS.

CLICK TO OPEN MOODBOARDS

APPENDIX XII FEEDBACK FORMS.

CLICK TO OPEN FORM BY ISABELLE

CLICK TO OPEN FORM BY ILJA

CLICK TO OPEN FORM BY TARA

CLICK TO OPEN FORM BY LISA

CLICK TO OPEN FORM BY SOPHIE

APPENDIX XIII TRANSCRIPTION OF MEASURING SESSIONS.

CLICK TO OPEN TRANSCRIPTION TARA

CLICK TO OPEN TRANSCRIPTION LISA

CLICK TO OPEN TRANSCRIPTION ISABELLE

CLICK TO OPEN TRANSCRIPTION ILJA

APPENDIX XIV ADDITIONAL PICTURES WORKBOOK.

CLICK TO OPEN PICTURES

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APPENDIX

APPENDIX XV REFLECTION.

When starting my FBP, I wanted to create something I was proud of, that reflected me as a designer and that included all competency areas.
My goal was to make durable garments that are personalized to fit perfectly.
The bra should make women feel sexy, confident and beautiful, be innovative and easy to put on and take off. Attention should be paid to details, fit and aesthetic, while researching what components in bra design can be improved to contribute to a better fit and a more inexpensive custom made bra. I also wanted to research how modern techniques like 3D-printing and body scans fit into this research. I believe that I achieved my goals in this project.
I looked into these modern techniques and tried, for example, 3D printing, laser cutting and embroidery. I tried different materials, like splint material and fusible web to find innovative solutions to bra related problems. Through these techniques and by doing lots of sewing, I developed my skills in the area of Technology & Realization.

In the future, more research could be done regarding for example 3D printing in bras to either find a faster and more inexpensive way of integrating it or to target a different audience willing to spend more money on custom made bras.

I decided to write a program that automatically generates a sewing pattern to make the process of making custom made bras more accurate, quick and inexpensive. Behind the code are geometric equations that make up the sewing pattern. I also analyzed all user tests done using scientific methods.

Writing the code, developing the equations and analyzing the user test data all contributed to my development of the competency area of Math, Data & Computing during this project.
I did two quantitative user studies via surveys and a more qualitative user study by interviewing the participants for whom I was going to make bras. I also researched the societal issue of fit and sustainability in the fashion industry, developing my skills within the area of User & Society.

Regarding the competency area of Business & Entrepreneurship, I developed a persona, customer journey map, and business model canvas. I did market research and determined the competition regarding pricing. I determined how the concept would work as a business and how it would be profitable. I spoke with multiple stakeholders and experts about the subject of bras and about my project.

Regarding Creativity & Aesthetics, I developed several mood boards, designs for the bras, posters and a video. As part of the customization process, I designed a different bra for each participant in their personal style, creating a small collection of bras. I used programs like Illustrator, Indesign, Photoshop and Premiere pro and developed my skills regarding these programs. I focused on graphic design as well as the design of the bras I developed from scratch. I explored the topic, possible techniques and materials to inspire me in the creative process. I went through an iterative design process, reflecting and revising every step of the process to be able to improve my work.

Finally, I developed myself in the area of Design & Research processes too. I researched the societal context of the problem of sustainability and fit in bras. I researched the subject by doing online research, reading papers and by doing research myself via for example surveys and user studies. I combined objective information and my personal experiences to develop a project that matches my vision. I approached several experts and companies to find different perspectives on the subject.

I feel like I developed myself into the designer I wanted to become. My project perfectly matches my vision in which I speak about the fashion industry, and how, although there is a big move towards more sustainable alternatives as well as other improvements regarding for example fit and customization, there is still a lot of room to grow. With the technology we have today, I believe it should be possible to make durable garments that are personalized to fit perfectly. I have been passionate about fashion for as long as I can remember and since I believe there is still so much room for innovation and improvement in this industry, I chose to further explore the topic of fashion, and more specifically bras.

I am now ready for the next adventure, my masters at the Amsterdam Fashion Institute. I will start 'Fashion enterprise creation,' in which I will use my scientific knowledge and skill to my advantage as I will be able to develop a business in the fashion industry with a strong background in all competency areas at industrial design, including technology, business and creativity.

I feel like I have learned everything I wanted to learn from Industrial Design and I have finally developed into the designer I wanted to become when I started my bachelor.