DESIGNING A USER EXPERIENCE TO SELL PERSONALIZED KNITWEAR IN-STORE

Maartje van der Bie

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MSc. Graduation Project

Integrated Product Design
Industrial Design Engineering
Delft University of Technology

Supervisory Team

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Figure 1. (front cover) Long cardigan, sweater and skirt from STRIKKS' collection [2]

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Preface

Dear Reader,

You are about to advance through my master's thesis which describes the development of a personalised and customised knitwear experience. It has been written to fulfill the graduation requirements of the master Integrated Product Design at the faculty of Industrial Design Engineering at the Delft University of Technology. I was engaged in researching and writing this dissertation from October to June 2019.

This project was commissioned by Maartje Boer from STRIKKS. The project brief has been composed together with the company mentor Maartje Boer, my chair Toon Huysmans and mentor Anton Jellema. I would like to thank my supervisors for their guidance and support during this process. They were always available and willing to answer my queries. Furthermore, I would like to thank Maartje Boer for her useful insights and the practical work we have done together which I really enjoyed. I also wish to thank all of the respondents, without whose cooperation I would not have been able to conduct this analysis.

I hope you enjoy your reading!

Maartje van der Bie
Delft, June 2019

Executive Summary

This graduation report describes the development of a personalised and customised knitwear experience for the company STRIKKS. STRIKKS is a company that has developed such a concept. STRIKKS is a small design studio of two creative people who have a fascination for knitted fabrics and products.They are continuously searching for innovative possibilities and applications for knitting.

The goal was to design an interactive experience that will sell personalised knitwear in a retail environment. In this experience an accurate display of the garment should give the customer insights into how the garment will look on their body and will enable them to make decisions that will lead to a satisfied result. The experience should convince the customer of purchasing the garment but should also avoid disappointment after trying the garment on the first time.

The journey started with the analysis phase. During this phase, field research was done to evaluate the problems with the current customisation process. From this critical design elements were formulated and further investigated. Among these design elements were the garment (re)presentation in the store, the way to take measurements from the human body and finding the best way to visualise a garment to the customer.

From this research a list of requirements was made and a design proposal was formulated. To further develop the concept, some key decisions had to be made regarding the visualisation type, garment grading and adapting the measurements of the avatar for the visualisation. Once the decision was made to create a graphical representation of the human figure using an avatar in the Clo3D software the concept could be further enhanced. Material test were done to correctly visualise the fabrics and a design for the store and mirror was created.

The last, but most crucial step towards validating this concept was the user test. 6 Participants have used the garment visualisation to create their own unique sweaters which have then been produced by STRIKKS. Comparing the visualisation and knitted sweaters confirmed the value that is being added with a visualisation. Based on this test conclusions were drawn and final recommendations were given to STRIKKS for further development of the concept.

Contents

1 Introduction

1.1 Introduction

When shopping for clothing in retail shops, customers are often challenged to find garments that match their personal taste and at the same time have a good fit to their body. It is a struggle every woman recognises, whether your are short or tall, skinny or curvy, your body just does not fit the industry standards. These industry standards were developed when the mass production of clothing started, with the aim to provide consistency and clarity in garment size dimensions. However, these sizing charts are nowhere near standardised these days and may confuse people more than it is helpful. Therefore a shift in the fashion industry has taken place where customers do not want off the rack clothing, but something that properly fits their body.

Therefore during this thesis a concept will be developed where clothing for women will be produced that can be personalised/customised in both style and fit. This concept will contribute to the slow fashion movement, instead of fast fashion. Create clothes that are not ill fitting but are made to measure to suit every woman. And because it will be made to measure, it gives the customer the opportunity to personalise/customise their clothing in terms of style to create unique pieces.

Figure 2. One size fits none [2]

Fast fashion

A term used by fashion retailers to describe inexpensive designs that move quickly from the catwalk to stores to meet new trends (Kenton, 2017). H&M, Zara and Primark are some examples of retailers that use fast fashion to stock their stores and try to sell what is on trend for cheap.

Slow fashion

Slow Fashion is the movement of designing, creating, and buying garments for quality and longevity. It encourages slower production schedules, fair wages, lower carbon footprints, and (ideally) zero waste (Study NY, n.d.).

Made-to-measure

Made-to-measure typically refers to custom clothing that is based upon altering a pre-existing pattern to a few body measurements creating an individual fit.

Personalisation

A means of meeting the customer's needs more effectively and efficiently, making interactions faster and easier and, consequently, increasing customer satisfaction and the likelihood of repeat visits (Davis, 2018).

Customisation

The action (by a user) of modifying something to suit a particular individual or task (Davis, 2018).

1.2 STRIKKS

STRIKKS is a company that has developed such a concept. STRIKKS is a small design studio of two creative people who have a fascination for knitted fabrics and products.They are continuously searching for innovative possibilities and applications for knitting. They have done research on "Personalisation in knitwear, a contribution towards a sustainable wardrobe" (Boer, 2018) and with this research STRIKKS combines the change in the fashion industry and the demand for personalisation to create a profitable business. As consumers are more aware of how clothing is manufactured and consumed, they want to be more conscious of their behaviour and thereby contribute to society. STRIKKS has made this possible by creating a collection of knitted garments that can be personalised by the customer.

A concept is developed where the customer can configure her own garment in a retail environment. For this concept an interactive wall has been designed which guides the customer through the customisation process using projection. The customer starts by choosing a garment model (for example a dress). She then has the option to select between eight colours and eight knitted structures. In this way a personal and unique garment is created that fits to the style of the customer. During the customisation process the customer is able to view the created composition on a mannequin. After the garment is altered to personal likings, the correct dimensions of the clothing are determined by taking measurements of the body with a measuring tape and using Design a Knit software (SoftByte LTD, 2012) to translate this into the correct pattern. The garment thus not only fits with your style but more importantly fits with your body. The garments are produced by STRIKKS in their own studio using their own knitting machines.

1.3 Problem Statement

This thesis will focus on letting people leave the store with the right sized clothing in their personal style. This can be quite a challenge, and the way the concept is now proposed, is not an ideal situation. Let me explain why: as the concept is still in its early stages, a lot of things are done in a way which is quick and easy, but maybe not in the best way when you want to upscale to usage in multiple retail stores. There are a some important elements to consider about this concept.

The current interactive system (an interactive wall) shows the different options that the customer can interactively choose from (garment model, colour and knitted fabric), and during that process the end result is projected onto a mannequin. This system is based on a linear decision making process. First the garment is chosen, then a colour and then a fabric pattern. A combination of the three is shown on the mannequin. This process is literally walked through from left to right, and takes some effort to go back and forth between the options and to see the final result.

Secondly, the visualisation of the garment should be improved. The visualisation is used to directly show the changes that are made during the personalisation process, and should give confirmation on whether or not to apply that change. And, although the mannequin is showing a representation of the garment (see figure 3), it is far from optimal. The use of a projection onto the white cloth the mannequin is wearing results in less saturated colours and makes it difficult to create depth and structure in the clothing. Hence, it might still be difficult to imagine what the result is of combining certain colours and fabric patterns. Furthermore, the customer might want to see the garment that has been created, together with a top or bottom to see the full picture of the outfit. For example, the customer has created a sweater with her favourite pattern, but wants to see whether the pattern she chose would go well with her favourite green pants she is wearing. This is now however, not possible. The mannequin only shows the garment that has been created, and since the mannequin wears a dress, a projection of a pair of pants would not fit and not show the way it would flow around the body. Coming to the last point about the visualisation. The customer still has no idea of how the clothing will look on their own body. Certain clothes might look great on a mannequin but end up looking completely different once you are wearing it. This risk makes it difficult to convince the customer of buying such a garment and to avoid disappointment at the time of fitting the produced garment.

Thirdly, to make this concept successful, it is of most importance that the clothing will fit properly. This all starts with taking measurements of the customers body. But what methods are there to measure the human body? And, although a tape measure has been around for centuries, is this still the quickest and most accurate way or are there better solutions? Not only is it critical to get the right dimensions, these dimensions also need to be processed in such a way that they are useful. Thus this is something that needs to be carefully looked at.

Last but not least. Knitted garments can be produced in three different ways: cut & sew, full fashion and complete garment (see figure 4). The most conventional and common way is creating large fabric panels of which different garment pieces are cut and sewn together. This fabric can be made beforehand, so after an order has been placed, production time is short. The disadvantage however is that a labour-intensive post-knitting process is required and up to 30% of fabric is lost (Peterson & Mattila, 2010). As this is not an eco friendly way of working and results in less high quality products (because of a rough seam finish), STRIKKS has chosen to opt for the second option: fully fashion. Creating different panels using their knitting machine, resulting in no waste in materials. The garments are now produced using a Brother KH940, Brother KH270 or Passap Electronic 6000, and in the future with the Kniterate, which are able to create one panel (a piece of the garment, e.g. the front) at a time. These machines do not have a large enough needlebed to create garments that are wider (e.g. knitting the front and back panel side by side, so no seam is needed). This requires the machine to be programmed multiple times, whereafter these panels need to be sewn together manually. When upscaling the concept to multiple stores throughout the country, resulting in maybe dozens of orders each day, an option would then be to buy a bigger knitting machine that is able to produce garments as a whole. These garments are then ready to wear straight out of the knitting machine.

Figure 3. Interactive wall for personalized knitwear by STRIKKS [3]

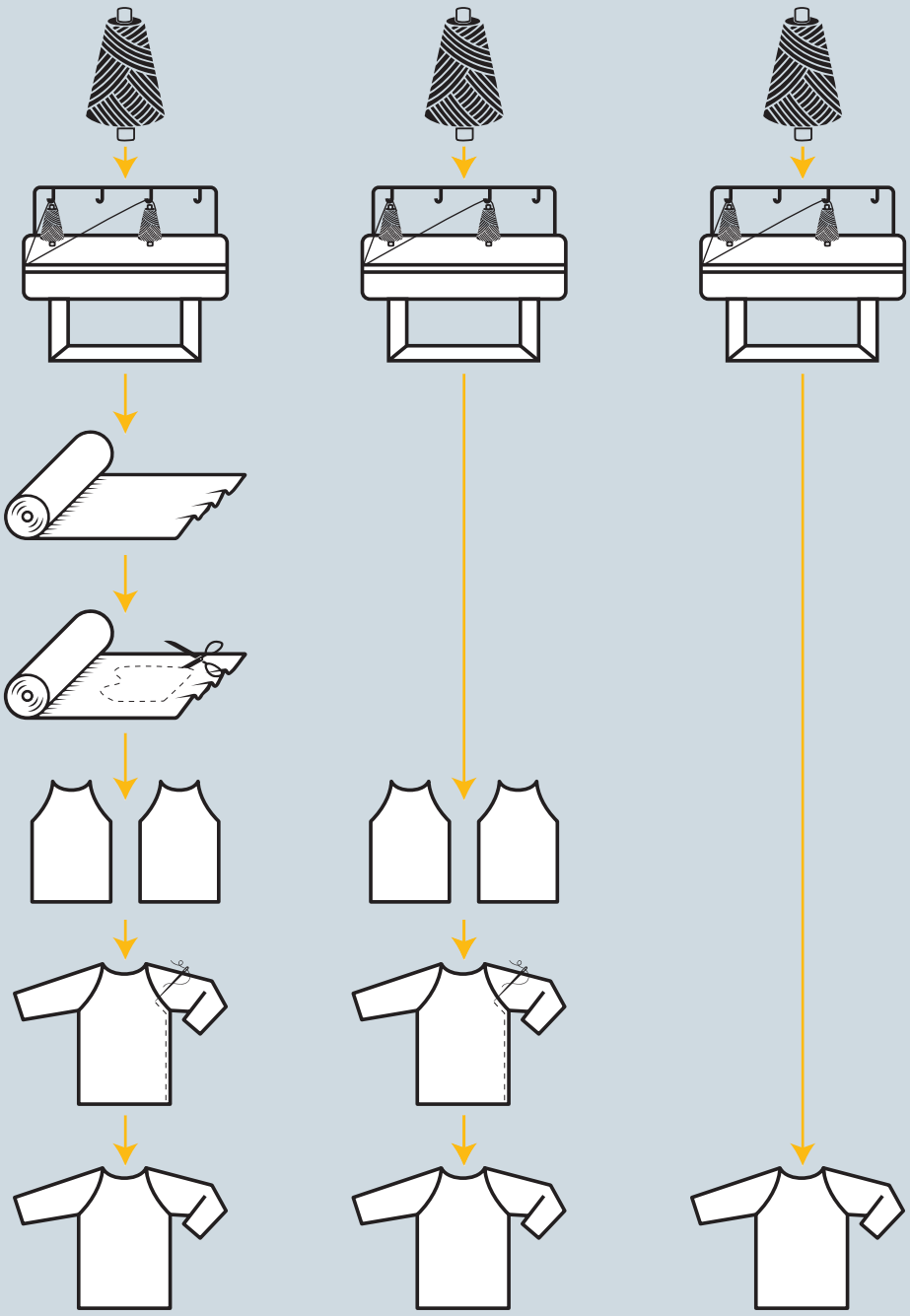


Figure 4. Different manufacturing methods for knitted garments.
FLTR: cut & sew, fully fashion and complete garment

1.4 Design Goal

The goal of this project is to design an interactive experience that will sell personalised knitwear in a retail environment. In this experience an accurate display of the garment should give the customer insights into how the garment will look on their body and will enable them to make decisions that will lead to a satisfied result. The experience should convince the customer of purchasing the garment but should also avoid disappointment after trying the garment on the first time.

1.5 Approach

This thesis consists of five phases representing the Basic Design Cycle by Roozenburg & Eekels (1998): Analysis, Synthesis, Simulation, Evaluation and Conclusion. The contents of the sections are described below.

Initially, the analysis phase will start with general search into the current retail environment and how experiences are evoked in these situations, together with defining the target group of personalised knitwear. Then, the technology that is already available for personalised garments will be analysed along side exploring what ways fabric can be visualised and simulated in general and how knitwear in particular can be shown. It is important to quickly get to know the differences between these fabrics, in order to be able to adapt a visualisation of a fabric to one of knitwear. This will be done with both literature research as well as talking to professionals in this field.

At the same time, it needs to be investigated how the size and shape of the customer will affect the visualisation/simulation, and how these measurements will be determined. These measurements will also be used to create the pattern that will be sent to the knitting machines. Therefore, a method needs to be found that can both be used for visualising and creating the pattern, that works as well for both situations.

During the synthesis phase, all the different options and combinations will be compared. Together with the customer a list of requirements and wishes will be made to see what is most important for the visualisation and what will persuade the customer to buy such clothing. Then the chosen visualisation method needs to be elaborated. To do so, the clothing designed by STRIKKS needs to be developed in the software that is chosen. The models, the colours and the different patterns need to be programmed separately, as well as the possibility to combine the different options.

During simulation, besides a digital model, a physical prototype will be made that is able to show the experience that has been designed. This prototype should show the visualisation, but also be able to translate the chosen options (from the physical buttons) to the visualisation.

Then the product-service system will be evaluated with potential customers in terms of experience and end result of the garment, and recommendations will be made to conclude the project.

2 Analysis

2.1 STRIKKS Collection

STRIKKS has designed a fashion collection that can be customised consisting of seven pieces. Of these seven pieces there are 6 types of garments and a scarf. These garments include: two types of cardigans, two types of dresses, a skirt and a sweater. These garments are illustrated in figure 5 through 10. For this project, the scarf will be disregarded as this item can only be personalised in colour and fabric and is available in only one size.

During the customisation process the customer can choose the colour and dessin of the fabric for the chosen garment. A different dessin/colour can be applied to every pattern piece. For example, for the sweater this means you can adjust the sleeves, front and back panel and the brim at the neckline, end of sleeves and bottom of the garment. Each dessin has a corresponding fabric, however these fabrics are not available in each colour. Therefore, by choosing a certain dessin, there are a limited number of options available. The complete overview can be seen in figure 11. Concluding, the customer can first choose for a colour, fabric or dessin, but is thereby limiting the next options to choose from.

Next to customising the look of the dress, certain dimensions and finishes of the dress can also be altered to the liking of the customer. For example, when buying a sweater the customer can choose to go for full length sleeves, extra long sleeves or maybe opt for 3/4 length sleeves. Depending on each garment, only certain items can be customised. All other dimensions of the garment will be are determined by the design of STRIKKS. In the following table (see table 1) an overview has been given off what the customer is able to customise.

	Cardigan Long	Cardigan	Dress	Circle Dress	Skirt	Sweater
Length Garment	x	x	x	x	x	x
Length Sleeves	x	x	x	x		x
Width Front Panel	x	x				x

Table 1. Overview customisation options

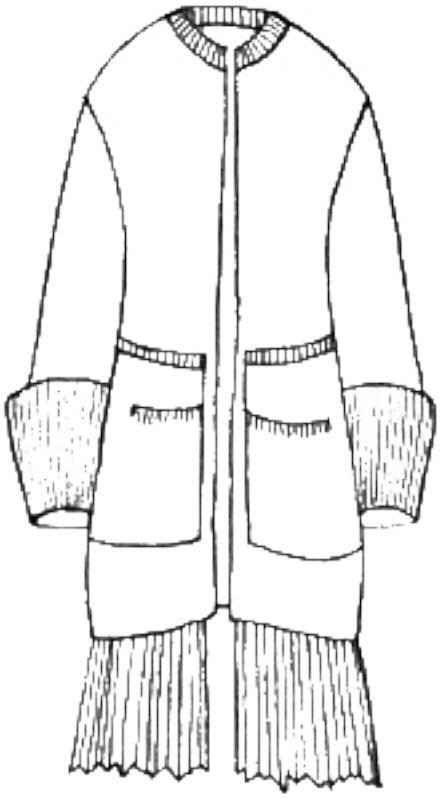


Figure 5. Cardigan Long [4]

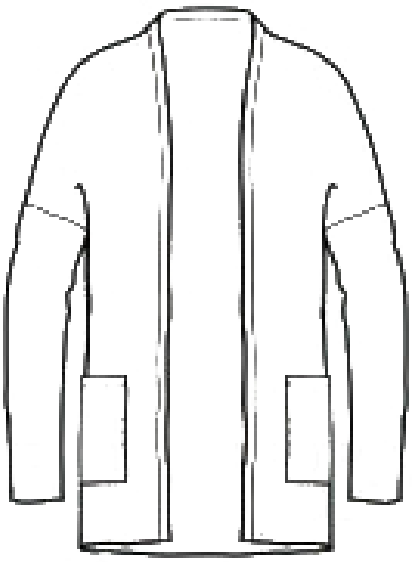


Figure 6. Cardigan

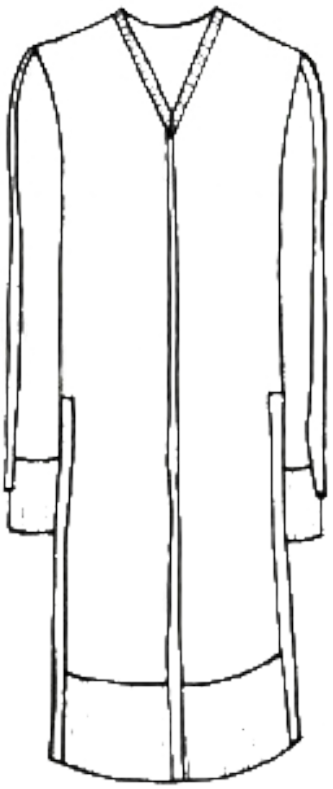


Figure 7. Dress

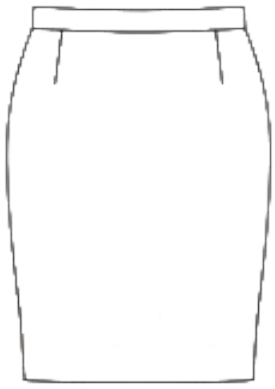


Figure 8. Skirt

Figure 9. Sweater

Figure 10. Dress with circle skirt

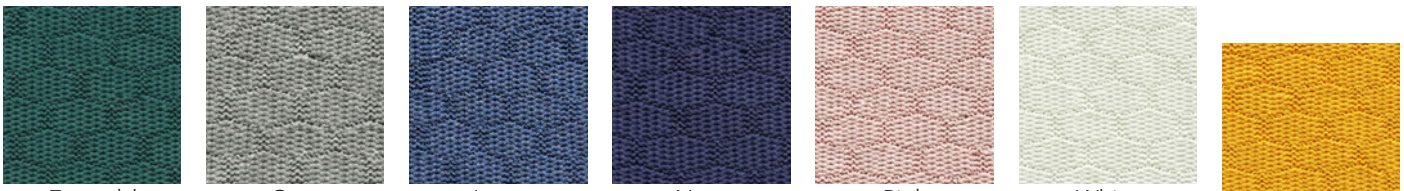
Binary - merino wool

Dark-Grey Grey Jeans Mint Pink

Ecoplanet - recycled textile

Dark-Jeans Grey Jeans White Emerald Mint Ochre

Honey - organic cotton



Emerald Grey Jeans Navy Pink White Ochre

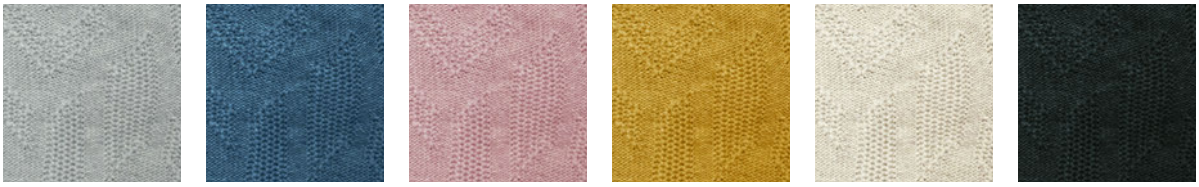
Plisse - organic cotton

Emerald Grey Jeans Navy Pink White Ochre

Mohair Grid - mohair

Grey Jeans Mint White

V-dessin Tuck - wool



Grey Jeans Pink Ochre White Emerald

Figure 11. All fabrics now available for customisation ordered by dessin [5]

Motif/Dessin

A decorative image or design, especially a repeated one forming a pattern.

Fabric

A fabric is a material made through weaving, knitting, spreading, crocheting, or bonding that may be used in the production of further goods (garments etc.). In this case the there are different fabrics made of materials including: two types of wool, recycled textile and organic cotton.

Pattern

A model or design used as a guide in needlework and other crafts.

To showcase the different types of garments and the ability to customise, STRIKKS has made of each garment one or multiple samples. These samples have been used to promote STRIKKS at fairs, but has also been used for the few people who have customised their personal garment. The collection as it is now consists of the following compositions:

- A long, close-fitting cardigan with Dark-Jeans Ecoplanet fabric as a basis together with Navy Pleats at the bottom to give a playful effect. Furthermore, it has double pockets on each side.
- A different type of cardigan that is much more loose in Mint Mohair (mohair has been taken out of the collection during the project and is replaced by the mohair grid).
- Another loose cardigan in Dark-Grey thicker yarn (not shown in collection fabrics).
- A jumper with Pink Binary fabric that has a curved bottom finish. The sides and back of the jumper are lower than the front.
- A jumper with White Honey fabric.
- A long dress with Ochre Honey fabric that has extra details on the sleeves and side seam.
- A skirt with Jeans-Blue Binary fabric as basis with a White & Transparent overlay. However, the transparent overlay is not available for personalisation anymore although it is very nice, it is too fragile. The fabric can easily be snagged, where a loop is pulled in the fabric that then needs to be repaired.
- Multiple scarfs in different colour combinations. combinations.

2.2 Current Customisation Process

Now that we know in theory what can be customised, it is good to get a better understanding of how this works in practice. Therefore, one participant was invited to customise her own garment. She was kind enough to help us understand what a customer goes through while creating her own garment. For this test the office of STRIKKS was rearranged into a test set up (see figure 12). The garments that are described previously where displayed on a clothing rack, as it would be in a retail environment. The interactive wall however, was not available due to technical reasons, therefore a sample (approximately 30 by 30 cm) of the fabric combinations of dessin and colours were all present as these could not be visualised as done on the interactive wall. Furthermore, a mirror was at hand for the customer to see how the garments would fit, and Maartje Boer took measurements for production of the garment. The whole process has been filmed and an interview was done subsequently to get more insights into why certain things were done the way they were.

The goal of this try out was to see how the customer would perceive this customisation process, what influences the decisions that were made, what were the points of improvement and what was missing completely. This try out also gave an indication of how long such a process will take, and which elements have influenced this.

Before the participant was able to start the customisation process, the concept was shortly explained. So before starting, she knew what choices she had to make. Besides, she had been told that the concept is still in development and that we are looking into adding a visualisation to the system to help with the decision making process. In the next section, the insights of this try out will be discussed. To read the full transcript of the video and audio recording head over to Appendix 7.2.

Insights

Making the concept clear before people start shopping

STRIKKS' concept is about creating customised garments that will be made specially for you to fit to your body. Although this was explained beforehand, she did not act upon it when looking through the garments. She criticised the garments on the way they were represented and did not take into consideration that this is not the way they have to be. As customising garments is not something people do on a regular basis, their habits and behaviour has to change in order to see that the representation is not equal to the final result. Therefore, it is especially important that people should already realise that this shop is not a regular clothing shop before they enter.

The importance of convincing people that a garment is nice although they might not like it at first glance

As mentioned above, the garments that are available in the shop are only a small selection of the possibilities people have to customise the garment. The chance that the item is not exactly how you would like it is big, and the chance that it is not your perfect size is even bigger. However, when looking at the clothes, there should be something that attracts the attention of the customer to make them realise this is something they would like to have. It is thus important that the garment is presented in such a way that it attracts as many people as possible. This might be done by using mannequins that do not have size XS but have a more common size representing a bigger part of the target group. Furthermore, it would help to show the customers what the customisation possibilities are for every garment. This was also the case for the participant. At first, she was not utterly convinced of the long cardigan as it would be too big for her. Once Maartje Boer suggested to try it on anyway, and made her realise what would be changed to make it a good

fit for her, she was persuaded to take this cardigan and customise it. However, this decision would have probably not been made if Maartje did not interfere in the process. In the shop, she might have walked away as the garment itself did not convince her enough of trying it on. Therefore the garment itself should be appealing enough to start the customisation process.

Figure 12. Test set up try out session with participant.

Figure 13. Participant doubting what kind of fabric she would choose

Insights continued

What can be visualised?

During the customisation try out, the participant has mentioned multiple things that could be interesting to show in the visualisation, among which: a good representation of the different colours/dessins, their combinations and the way they behave during movement, but also the way certain things fit together (garment with skin tone or other clothing items). During the session the participant was comparing the sample fabrics with the cardigan while looking in the mirror. She needed confirmation that the samples were indeed the same, or different from what she had on. She even doubted whether the sample and the real fabric were even the same. This was due to the chosen fabric, recycled textile, that changes feel and texture over time. Therefore, these fabrics of garments that people can try on, may behave different from the samples, or the visualisation that is shown. This is something that is hard to imagine for some people and therefore needs to be taken into consideration when designing the visualisation.

Furthermore, she ended up choosing a "safe option" as she only changed the colour of the garment and not the dessin. The pleats fabric, at the bottom of the cardigan, has a playful effect that some other fabrics might not have. This was something that she could not imagine and therefore decided to stay with the initial fabric. Showing other fabric combinations either real life or by using a visualisation is crucial as these are hard to depict.

What maybe doesn't have to be visualised

As the participant was only able to try on one garment size, she was not able to compare it to any other sizes. However, because the cardigan was a bit too large she was able to fold and hold the garment in such a way that it would represent the garment as if it was the correct size. This helped when making decisions about the length of the cardigan and the length of the sleeves. Initially, she thought she wanted 3/4 length sleeves, but in the ended opted for the full length sleeves, as the simulation did not convince her of getting shorter sleeves. Furthermore, she said she didn't miss the visualisation or the other sizes in the shop as she had the confidence that the garment would fit her well. In this case the customisations about the garment were talked through with the designer, which could have increased her confidence. In the case Maartje Boer or any other professional would not have been available, a visualisation might have been needed to persuade her.

Lineair versus circular process

In this try out, she went through a linear customisation process. This was not obligated, but done from her own intuition. She started looking at the garments first, and expressed what elements she liked and which she did not. She thought the fabric with the honey dessin was nice, but the garment itself not, and that the cardigan was nice, but the size was too big. However, during this process she had not thought for a moment to combine the two. She picked out the cardigan first, then the fabric and then had her measurements taken. If she liked the honey dessin that much, she could have also started from the fabrics point of view, but she didn't. However, this does not mean that all customers will go through the process like she did. It is therefore important to keep both options open, and let the customer decide which element of the design is most important and therefore the starting point of the customisation process.

How does the customer customise the garment

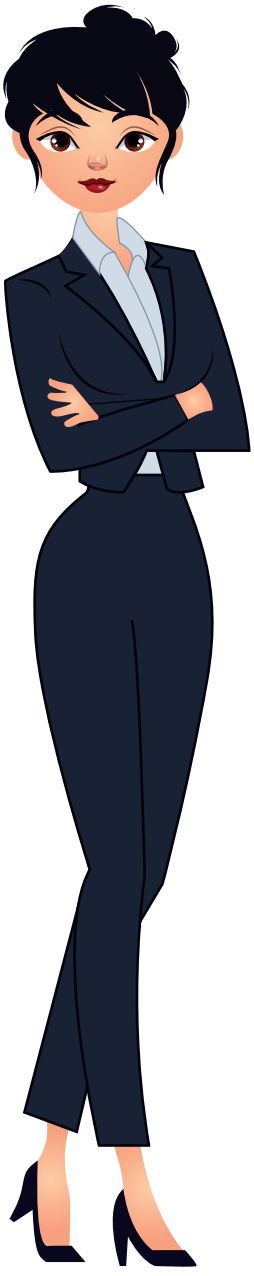
As the interactive wall was not present for this customising experience, all 27 fabric combinations were spread out on a table, organised by colour. Pascale had to make a choice between these 27 combinations, and it looked like the amount of fabrics was overwhelming her (see figure 13), even though she did not recognise that herself. In comparison, the interactive wall separated the choice for dessin and colour, making you choose between 7 colours and 5 dessins. Even though in the end the number of combinations is still the same, it does not feel the same. So depending on how the different dessins and colours are represented, the customer might find it easier to choose a combination. Furthermore, what was noticeable during the process of choosing the right colour of the fabric is that she felt the need to compare the samples to the garment in order to see if they were indeed different. The downside of this was that after a while all the samples were mixed up and chaos arose. So when customising the garment, there should be a way to have the samples close to the garment, but still in such a way that they can be easily put back where they came from.

What should the customer be able to customise?

As STRIKKS you need to produce garments that are fitting to the customers, but also represent the style of your company. As these garments are designed with certain aesthetics in mind, it is important to keep the customised garments as close as possible to this aesthetic. However, as was found out with the participant, is that every customer wants to hide and accentuate certain parts of their body which means that often a standard decrease or increase in size will not be sufficient enough. Deviating from this standard is something that can be done for the customer as a made to measure garment is created. However, STRIKKS must be careful not to create custom clothing for each and every individual as this will hinder the automation of production and thereby increase production costs. Furthermore, as the participant was talking with the designer, she asked if other customisations such as another neckline or even adding more fabrics to the design was possible. So where do we draw the line between giving the customer not enough options or too many options to choose from, as this often leads to more confusion than benefits? A compromise needs to be made between giving the customer as many options as they want, and a profitable concept.

2.3 Target Group

The clothing line designed by STRIKKS is suitable for adult women. As the size for the garments can be adjusted, most women are able to fit into their clothes. However, not all garments will be suitable for all body types. Depending on the style of the garment, and the preference of the customer, certain clothes will fit certain body types better than others. These women are willing to spend more on quality clothing that is sustainably produced, and are also willing to wait for their pieces to arrive (M. Boer, personal communication, September 11, 2018). The personas created below are two examples that represent a part of the target group. They have been composed of information gathered from the try out and information Maartje Boer has given from her previous experiences with potential customers at different fairs throughout the Netherlands.



Joelle Geller is a workaholic and likes to spend the rest of her time exploring the city. She likes to express herself through unique clothing that say something about the individual she is. However, at work as a lawyer this is not always possible, which makes her casual wear even more important. Because of her little time, shopping is not her first priority. So when she does, she spends lots of time finding the garment she is looking for. Therefore, she wants to find a place where she can shop for unique items.

Goals:

- Wants to express herself through clothing
- Desires to be more relaxed and enjoy life more
- Wants to try new unique experience

Frustrations:

- Does not want to look like every other woman
- Needs everything to be perfect
- Getting a tailor made suit always takes up so much time

Name	Joelle Geller
Age	31
Occupation	Lawyer
Family	Single
Character	Ambitious

"I want something unique to wear outside of the office"

Valeri Jacobson is a passionate healthcare assistant that is always willing to help. She puts her patients first and herself second. Friends always tell her to treat herself more instead of working all those long nights. Outside of work she likes to spend her time with friends and family. However, she keeps struggling to find outfits that work for her odd-sized body. Now that she has gotten older, she needs durable, well-made clothes that are flattering and well cut that will last her a lifetime.

Goals:

- Find an outfit that fits properly she can wear no matter where she is going
- Make the world a better place
- Wants to be treated like every other girl

Frustrations:

- Wants to feel comfortable without looking like a bag of potatoes
- Does not like to be intimate with strangers
- Is very indecisive

Name	Valeri Jacobson
Age	40
Occupation	Healthcare Assistant
Family	Married, 2 children
Character	Charismatic

"Everyone should be treated equally, no matter shape or size."


Shoe Club
Jeans
Jeans
OPEN
DURABELT

2.4 Envisioned Customer Journey

To understand what the customer goes through, what her thoughts might be and what emotional journey they experience, a customer journey has been made. This customer journey is a graphic representation of the different stages and activities a person experiences. In this case, it starts when a person is walking through the city looking for shops to buy clothes at. The concept that has been explained in the previous chapter will take place in a store specifically designed for this concept and where no other brands will be sold.

The customer journey can be explained from the viewpoint of different types of people, leading to different customer journeys. In this customer journey the persona Valeri described in the target group will be used to go through the process. In this representation of the customer journey, the customer will go through 10 different phases, with in between a few phases that are not that important for the customer, but especially for STRIKKS, so they know what needs to happen before the order can be delivered to the customer.

In the next image the graphic overview of the customer journey is represented. Each step is then further explained on the following pages.

Figure 14. Graphical representation of Customer Journey

January 15, 16:10. The possible customer is walking happily through town with a friend and having fun. They want to shop for clothes and Valeri wants to find an appropriate outfit that she can wear to family events. She usually doesn't get much compliments so she wants to impress this time. However, thus far they haven't had much luck finding something for her body type; odd-sized, which is frustrating her. Clothes are often ill fitting or not to her taste, and thus she keeps walking. They are nearing the end of the day and Valeri is getting anxious whether or not she will be able to find something this time. Her friend in the mean time found lots of nice clothes which makes her a bit jealous, she really wants to find something! They then walk past the STRIKKS shop and she looks at the shops front window: Customised Knitwear. This is something she has not seen before which makes her fascinated. She has the urge to go inside and see if there is something for her.

16:15. They enter the shop and are surprised by their first impression. This does not look like any retailer they have gone before. At the same time this makes her confused. Why are all these fabrics hanging around and why do these mirrors not look like normal mirrors? They are doubting whether or not this is something after all. They can either decide do proceed or to leave the store and continue their shopping journey through town.

16:17. They decide to proceed and look through the shop. At first glance, Valeri does not know where to start and feels overwhelmed. She feels the different fabrics that are around and starts looking at the inspiration wall. She looks at what other people are doing and is slowly understanding what is so special about this shop. People are composing their own garment.

16.22. She then heads over to the clothing racks and looks at the different silhouettes that are available. If nothing had suited her, she would have left the shop, however she gets enthusiastic. This specific silhouette is something she desires, nothing too crazy but also not too plain. The details are just perfect! However, she doesn't find the grey colour very appropriate with her skin tone.

She decides to still try the silhouette and tries to find the size she needs. She starts doubting if they even have something in her size. She still grabs the garment she likes and tries to find someone who can help her out. She asks for advice to the shop assistant and she tries to explain the concept to Valeri. Valeri steps hesitantly in front of the "mirror" in the middle of the shop. She is insecure about what is going to happen and does not want to attract attention from the other shoppers. However, her friend encourages her to do it anyway and this is what happens.

16:28. As Valeri steps in front of the mirror, an image appears. It is her silhouette, that has been recognised by the camera, but with the clothing on she just had in her hands. It is not on her physically, but digitally. She is enchanted by the result. This is something she had never experienced before, and it had a pleasant surprise. Her friend, who had been wandering around the shop herself, tells Valeri that she should personalise the garment. She confirms that she can change the colour to for example pink or blue or change the binary dessin to the honey dessin or a more basic fabric such as the mohair. That is the reason why all those fabrics are around the shop. Valeri starts playing around and is thinking about what colour goes well with which dessin. She then remembers that there was actually another item that had a dessin she liked. She tries to match this with the colour of the garment, but unfortunately it is not compatible. She asks for advice from her friend and ends up with a combination she is satisfied with.

16:40. She is then escorted to another room where the measurements will be taken in private. She was surprised when she the room looked empty and was wondering what was going to happen. The shop assistant told her that her measurements would be captured using a 3D scanner, which would result in a 3D avatar that could be used to get the data that was needed for the production of the garment. She felt excited and thrilled to try something so futuristic. Not many could say that they have tried this. But, she also got nervous and felt ashamed as she did not want to see a fat 3D image of herself, which would be shared with who knows what. She gets reassured however that this data will be protected and not distributed. She gets changed into tight fitting clothes and her measurements are taken within a few minutes. The shop assistant takes some notes of things that Valeri wants the clothing to pay extra attention to and what her preference of fit is: slim fitting, regular fit or loose fitting clothes.

16:50. She walks over to the register to finalise the process. As she gets to see the final garment composed once again, she quickly reassesses whether or not she made the right decision about her personalisation, but as soon as her friend reassures her, she makes the commitment. The order has been placed, and she receives a print out of the visualisation of the garment and a tracking code to follow her garment as it goes though the production process. It is now time to wait for her garment to arrive.

January 16, 9:00. At this point in the customer journey, it is just a matter of waiting for Valeri to see how her garment turns out. For STRIKKS however, this is the point where the production itself starts. STRIKKS gets information about the customer, including information about the person, such as measurements of the body and the body scan, and information about the garment: which garment model, colour(s), dessin and fit preference.

9:15. This information is then processed and the pattern will be adjusted to the correct body dimensions of Valeri. STRIKKS uses software to make this process easier and quicker. The correct parameters are put in the software and the pattern will be created. This pattern is then programmed into the digital knitting machine. The machine is prepared with the right yarns and the knitting is started.

Each panel of the garment is knitted separately. So after each panel is done, it needs to be finished off and the next one can be started. Once all panels for one garment are completed, they can be sewn together.

February 5. In the next step the garments are prepared for shipping. Each garment is washed, pressed and packed into a nice gift box. The customer has been waiting for their purchase so a nice gift wrapping will make the unpacking experience more pleasant. The package is then collected by the delivery company and shipped to the client.

February 7. Valeri waits eagerly at home for her package to arrive. She is euphoric when the doorbell finally rings and the delivery man hands over her package. Alternatively she could have had the package delivered at STRIKKS, but she prefers to try the garment on in private. She goes to her dressing room and opens the package, and gets her first impression. The colour and fabric look just the way she had anticipated. She tries the garment on and is very relieved that it fits. She is very satisfied with the result and cannot wait to show her friends and family how it turned out.

2.5 Critical Design Elements

This customer journey and the current customisation process that has been tried out with Pascale have helped to identify which elements of the product-service system still need to be developed further to make this a viable concept. These elements still have uncertainties that do not only determine the experience of the customer but will also determine how the shop will look and run in the future.

These elements include:

- **How will the customer be introduced to the concept of this shop?** The shop window should already give enough clues to suggest that this is not your regular retail shop and should attract the target group. But the concept should be self explanatory from entering the shop.

- **How will the garments be (re)presented in the shop?** Should all garments be available to try on? If so, a decision needs to be made in what sizes and what colours/dessins the garments should be presented.

- **What will be visualised on the screen and with which technology?** Depending on what the main value of the added visualisation will be, a choice has to be made what will be visualised. Will it be dynamic or static, showing the garments on an avatar or projected on you.

- **How will the customer interact with the visualisation to make changes to the appearance of the garment?** This can be done using physical or digital buttons, using hand gestures of maybe even voice commands.

- **How will the measurements of the customers body be taken?** A method needs to be chosen depending on how many measurements need to be taken and which measurements are most critical.

- **How will these measurements be converted into a knitting pattern?** Is there a direct link between the body and garment measurements? How will the customisation of the garments and the preference of fit be taken into account?

- **Will the customer be updated during the production process and how?** How many times should the customer be updated and what information will need to be shared to create a positive experience for the customer.

From these seven elements there are three elements most critical now to make this concept work. These elements are intertwined with each other, meaning that one element will influence the design of another (a representation is given in figure 15). The most critical elements are:

- How will the garments be (re)presented in the shop?
- What will be visualised on the screen and with which technology?
- How will measurements of the customers body be taken?

The two elements that are most dependent on each other are the garment presentation and the visualisation. These two elements should complement each other. Because showing all the garment possibilities in real life is not possible, this should be done by the visualisation. However, fully experiencing the garments as it will be on a screen might also not be possible. That is where the garment has to fulfill the extra requirements. Then, depending on how the garments are manufactured, different measurements will need to be taken. If this means that there will be a few basic sizes to choose from, then these could be present in the shop to try on. However, if that is not the case and more things can be altered during the personalisation, then that should be visible in the visualisation. Furthermore, if for creating the avatar a 3D scan is needed, then this could also be used for taking measurements.

For each element, research is done into what possible solutions there are in the current market and how they could be of use for STRIKKS.

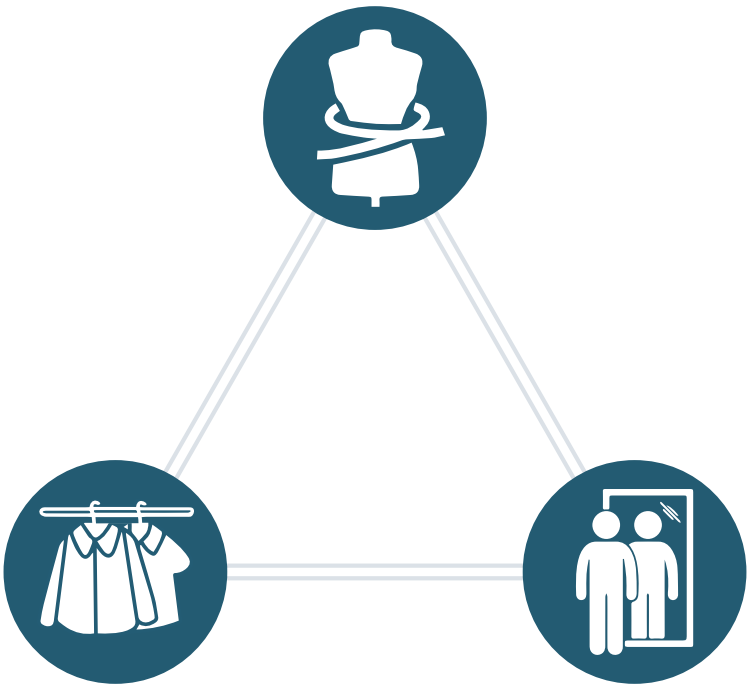


Figure 15. Critical Design Elements

2.5.1 Garment (re)presentation

When entering a regular shop a handful of mannequins will show a combination of garments that represent the style of a certain brand. All other pieces of clothing from that same collection can be found in the numerous clothing racks across the store. Of each garment a few colour options could be available as well as multiple sizes to try on. What you see is what you get. If the clothing in your size does not feel or fit nice, then that is a shame, but nothing you can do about.

With the customisable clothing of STRIKKS this is different. Because all clothing will be personalised in size, it will not be possible to provide a correct size and colour combination that will fit every customer that walks in. This would mean that a few thousand options should be present to find something that fits everyone. Furthermore, you are not supposed to take something home on the same day, as making you wait for something forces you to think about your decision more carefully and will withheld you from making impulsive and irrational decisions.

Not showing anything, creating almost a digital store in a physical store, is also not something desirable. Customer might still want something tangible, as a screen will not give you the same information that something physical can. On avergage about 20% of Europeans do not shop online because they do want to feel and touch the product (Angelovska, 2018). To satisfy the consumers, a compromise should be made. A combination of digital visualisation and physical representation should allow the customer to make an informed decision. Nonetheless, there are still different options that could be considered.

One of them is the idea of STRIKKS that some samples of the garments in different sizes should be available that the customer is still able to try on. Although the fit might not be perfect the first time, it could still give the customer the impression of how a garment would feel on. This requires the customer to have some imagination into how the garment could be optimised for their body. This is also the way it is done now, as was shown with the try out of Pascale. She was able to try on the garment after which only the alterations were measured instead of the whole garment. This could be seen as the bridge between the way we shop now, and the way clothing can be purchased in the future.

As a designer however, I do not agree with the vision of STRIKKS. I think the physical garments should complement the digital visualisation of the garments, and there are a few different reasons for this:

- First of all, by giving the customer something to try on, you might give them a wrong impression. As someone said: "First impressions are lasting impressions" and you only get to make a first impression once. If they completely dislike the way something looks, how will you be able to convince them otherwise. Especially if you assume that there is not a shop assistant available to help and convince every customer. In my opinion it would be better not to give the option to try something on in real life, but only use the virtual fitting to show how the garments look on the customers body.

- If the customer is trying on the garment in front of a normal mirror, and this garment can be adjusted to their liking using clips, pins and needles it would look more like a dress fitting of the expensive gown you already bought, instead of trying something one you might buy. This would also require someone to help you visualise how the garment would fit. And what would be the added value of the visualisation then? Would that just be used to show a different fabric combination?

- Last but definitely not least! With only having a few sample sizes available, you might risk the chance of people entering the shop who are not able to try on anything. These people, who are most probably on the heavier side, are precisely the customers who you want to attract with your personalised clothing! People who are always struggling to find something they fit will not be pleased if a brand that offers customised clothing for every woman excludes those who might need it the most.

So what would be a good solution for the garment (re)presentation?

First and foremost, the garment presentation and the visualisation should complement each other, meaning that, for example, if the visualisation is able to show how a garment will fit on a specific body, the physical garments could show how a garment will fit on a general body. The garments on mannequins should represent the vision of STRIKKS and how they want their clothes to look. Based on that, customers can make a decision whether they like that particular silhouette or not.

Furthermore, I believe that, since the visualisation does not give the customers the opportunity to feel the fabrics, that is something the garments should represent. The fabric samples should be large enough to see how their knitting pattern will influence the properties of the garment. The same silhouette sweater might look completely different using the ecoplanet recycled fabric versus the binary pattern.

Lastly, the garments that are present in the shop could be used as inspiration for the customers:

- Different fabrics on the same silhouette can show the diversity of these clothing items. For example the mint mohair and thick grey yarn on a cardigan could give two completely different looks; respectively a summer and winter look.

- Combinations of fabric that you might normally not choose could be shown, or even combinations that are not even possible to order. This would be an eyecatcher to show that anything is possible. To show what is possible a garment could be designed that consists of parts of multiple fabric/ dessin combinations that you would normally not be able to combine (see figure 16 as an example). It could have two different sleeves, a bodice and skirt of two different materials and some fine details that together could really impress the potential customers.

- Furthermore, this could not only be done to the appearance of the fabrics, but also with the sizes of the clothing. Some odd sized mannequins could be used to show how to what extend STRIKKS is willing to personalise your clothing. Do you have one long and one short arm, no problem! STRIKKS will design something that fits to your body and needs.

As a final remark, something that could make the clothing of STRIKKS even more special, is a unique clothing tag. No general sizing number of letter is necessary as this is YOUR size. These tags could be inspired by the British lingerie brand Neon Moon who has replaced the usual S, M, L etc. tags with: Lovely, Gorgeous, Beautiful, Fabulous and Stunning (Goldstone, 2017). Meaning that going a size up doesn't feel as bad as when buying your XXL garment

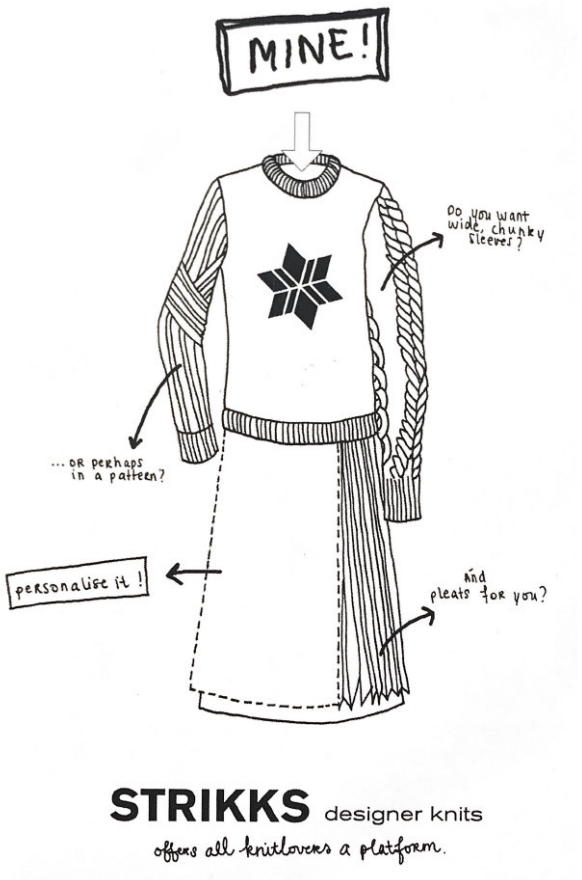


Figure 16. Garment possibilities [6]

2.5.2 Visualisation/Simulation

One of the most important elements for the customisation concept is that people are able to see what they will buy. This will not only help in showcasing the different colour and dessin combinations, but might also help to convince the customer of buying. How this visualisation will look like depends on which hardware together with which software will be used. However, the main question that needs to be answered is: What is the goal of this visualisation?

The answer.
The visualisation should illustrate the different colour/ dessin combinations but especially how the garment will fit on the customers body. As, in my opinion, the customer is not able to try on these sample sizes, the customer should see how the garment realistically drapes around their own body. This will give them insights into whether or not this is something that will suit their body type as well as their personal taste.

There are many different possibilities depending on software and hardware, computational power but mostly time and money. The concept as it is now, is the least ideal situation as explained in the problem statement (chapter 1.3). The most ideal situation, however, might not be achievable within the next few years. An overview is given from least ideal to most ideal, which represents what is possible now, and what might be possible in the future.

Table 2. Overview possible visualisation solutions

	Type of visualisation	Detail level fabric	Static vs. dynamic	Avatar	Should convince	Property visualisation
Not ideal situation (as the concept is now)	Knitted structure is projected onto white cloth	Time increases with amount of measurements taken	Static	White mannequin wearing a white dress	Tries to convince buyer of colour/ dessin choice	None
Less ideal situation	Pre-rendered visualisations on screen	Knitted fabrics simulated as woven fabrics	Static	Standard avatar (could use different presets)	Mostly used to convince colour/ dessin choice	Realism colour and fabric structure
Ideal situation	Magic mirror: clothes projected onto mirror image	Fabrics simulated as woven fabrics	Dynamic	Mirror image of user	Colour/dessin choice	Realism colour and movement
More ideal situation	Visualisation on screen that can be live adjusted	Knitted fabrics simulated as woven fabrics	Static or dynamic	Avatar adjustable with body measurements	Should convince buyer of garment fit and colour/ dessin choice	Realism colour and draping
Most ideal situation	Visualisation similar to looking in the mirror	Yarn level simulation	Dynamic simulation	Almost identical copy of customer, but then digital	Able to convince buyer of colour/ dessin choice and fit of garment	Realism fabric structure, colour, draping and motion

An improvement from the current situation would be a visualisation of the different garments that are available with all colour/dessin combinations. The fabric in these visualisations would behave similarly to woven fabrics, but would look like the knitted fabrics using the correct textures (images). These garments would be pre-rendered on a standard avatar to be able to show them quickly (see image 19. this is an example of how Clo3D is able to show the cardigan that our first participant has composed). Depending on how many variables you would like to include, the avatar could be rendered with a few different presets including: body shapes and sizes, or different poses). The advantage of using the avatar over a mannequin is that every type of garment can be shown without restrictions such as what the person is wearing herself. The more variables, the more rendered images would need to be stored. This would not mean that the time to visualise it would increase, as all images are rendered beforehand. This type of visualisation would mostly be used to convince the buyer of a colour/dessin choice.

Another option that could already convince the customer more whether or not a certain garment would fit her style and skintone would be to project a 3D image of the garment onto the mirror image of the user. This is done is some parts of Asia where the customer can 'try on' clothing (New Tempo, 2016). The clothing however, is often just scaled, and not fitted to the body. From this viewpoint you cannot determine your actual size. Thus, this method can mostly be used to evaluate colour/dessin choice. By using your own mirror-image, you do however, get a better idea of whether this fabric choice fits your skin tone.

Further improvement would include: different fabric properties for different dessins, an adjustable avatar, live alterations and thus the ability to use the visualisation for fit purposes. This simulation can be static or dynamic, depending on the software and computational power (dynamic would require a lot more power). The avatar that is being used should be altered with the body dimensions of the customer. Then a garment will be draped on top of the avatar to show the garment fit. After the customer has chosen or altered the garment, colour or dessin choice, the software will recalculate and show the new composition. These features should be able to convince the buyer of both fit of the garment as well as the colour/dessin choice.

The most ideal, but not yet realistic situation would be similar to what Cirio, Lopez-Moreno & Otaduy (2017) and Yuksel, Kaldor, James & Maschner (2012) have shown that is possible. They have both developed a simulation technique that is able to show knitted fabrics on yarn-level. This means that the simulation will take into account what yarn is used, which stitches can be formed and how these are deformed depending on the stitches around them. This model gives such realistic results, that it is almost identical with the real fabric. A comparison is made by Yuksel et al. (2012) between the simulated fabric (top, see image 17.) and the real fabric (bottom). The similarity is impeccable. Cirio et al. (2017) on the other hand have shown how a fabric would behave around a human body (see figure 18). What is nice to see in these figures is that the stretch applied to the fabric at places where the body shows some curves (hip and bust area) is visible on yarn level as well. Knitted fabrics behave differently when stretched and compressed in comparison to woven fabrics. Some stitches will be stretched out more than others, resulting in a non-uniform displacement, which is visible using the yarn level simulation, but is not detectable using textures on woven fabrics. What makes these simulations not yet usable for STRIKKS, is that a single image may take at least half an hour to render, making your customisation process never ending.

Something that would make this situation complete, is a realistic avatar. Using a 3D scan that is also able to capture surface textures, an avatar could be generated that is identical to the customer. Adding some movement to the avatar that is copied from the customer using motion capturing data, would result in an almost mirror-like image. Making the background look like the store environment would complete the picture.

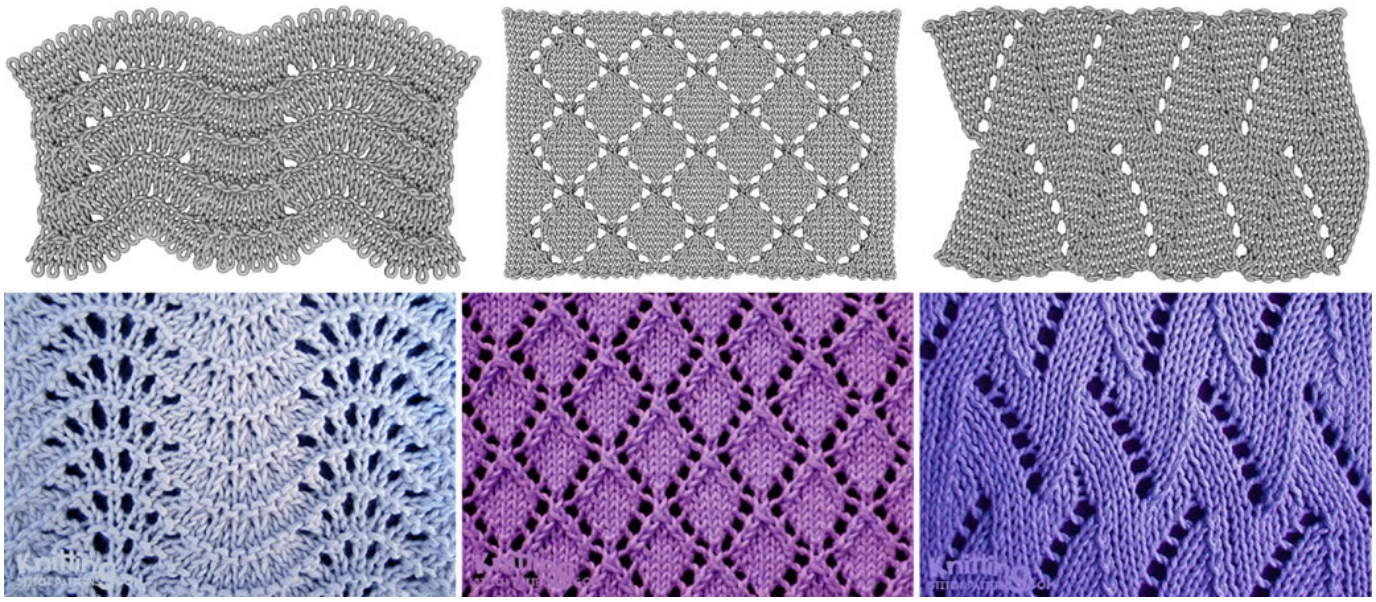


Figure 17. Comparison simulated knitted fabrics on yarn level & original knitted fabrics. [7]

Figure 18. Simulated knitted fabrics on human figures. [8]

Figure 19. Garment visualisation Clo3D

2.5.3 Measuring System

To overcome the problem of ill fitting clothes, an increasing effort is put into manufacturing made-to-measure clothing, where the individual is no longer at the end of the clothing chain, but instead forms the start of it. However, in the apparel industry the ability to personalise garments to someones body requires a comprehensive and accurate set off measurements. To obtain these measurements, different methods can be used. Including them, is the old-fashioned tape measure. A way of measuring that has been used for over a century, but to get a good result a basic set of skills and knowledge is required, which the average sales person at a retail store does not possess. However, with the technology that is available nowadays, different ways of measuring are used with each its advantages and disadvantages. For this concept, each way of measuring will be analysed and compared to determine what the best method will be for STRIKKS and her customers. These measuring techniques include: the above mentioned measuring tape, measurement prediction, and the 3D scanning technique.

Figure 20. Common tape measure [9]

Measuring Tape

The measuring tape is a very common, cheap tool that is widely available and can be used everywhere by everybody. Young children and elderly included. It is a flexible ruler that can be placed around a body part to determine its size. However, such a method is time-consuming and subject to the skills of the measurer (Bond, 2008).

First and foremost, the right tool is needed. The most used tool is the old school measuring tape (figure 20) but as more people are shopping online, and thus need to know their own measurements, some companies have come up with a digital measuring tape (see figure 21). This measuring tape makes it easier to measure yourself, without the help of a friend or family member. These tape measures do not require you to bend forward and try to read what is on the tape measure when measuring waist circumference, but store your data digitally which you can access through their app. Bagel Labs Inc. has produced two types of digital tape measures including Bagel and PIE: the smart tape measure for your body (see figure 22.). You can wrap the retractable tape around the body part you wish to measure and use the lock hook to securely fasten the tape. You can then fine-tune the tightness of the tape using its scrolling gear, tap the button and it is saved to your mobile app.

Once you have got the right tool, you still need to use it correctly to get the right measurements. It is necessary to know at what place to take measurements and how. For example, to take the bust circumference, it is important to take the measurement at the place where the bust is the fullest, and be sure to keep the tape level. Furthermore, it is preferred to take the measurements on bare skin, requiring the person to

take off their clothes, but as an alternative tight fitting clothes could be used. It is important to adhere to these instructions and to practice to get a correct and useful result. Webshops recognise that this might not be the easiest thing to do and often offer some guidance. This is done with either instruction photo's (Eshakti, n.d.), video's (Rita Phil, 2019) or as Entre Donovan is offering, a video consultation with a professional who will guide you through the appointment (Entredonovan, 2019).

If you still do not trust your own measurements, a professional is always able to take your measurements. This can be done at a local tailor, or at shops that are offering customised clothing in-store.

Figure 21. Digital tape measure Bagel connect to its application [10]

Figure 22. Digital tape measure PIE used to measure waist circumference [11]

Measurement Prediction

In order to save time and the hassle of measuring yourself, predictive softwares have been developed that are able to determine what size of clothing you need depending on a few questions. FitAnalytics is such an organisation that has developed this software (FitAnalytics, 2018a). It is currently used by Wehkamp, ASOS and Hugo Boss among others (FitAnalytics, 2018b). It uses the valuable personal information shared by customers together with the world's largest database of garment and fit information. The link between customer and product powers the rest of their sizing platform. This is now mostly used for online shopping, but could also be used on an interface in-store.

This platform is just one of the many available for online shopping. Others include Bodyblock (Bodyblock, n.d.), TrueFit (TrueFit ®, 2019) and Virtusize (Virtusize, n.d.). What all of these companies have in common is that they ask some information and use this to compare the measurements to the ones of the clothing that the customer wants to buy. The type of information that is being asked can be categorised into two groups: demographic information about the person or information about previous purchases.

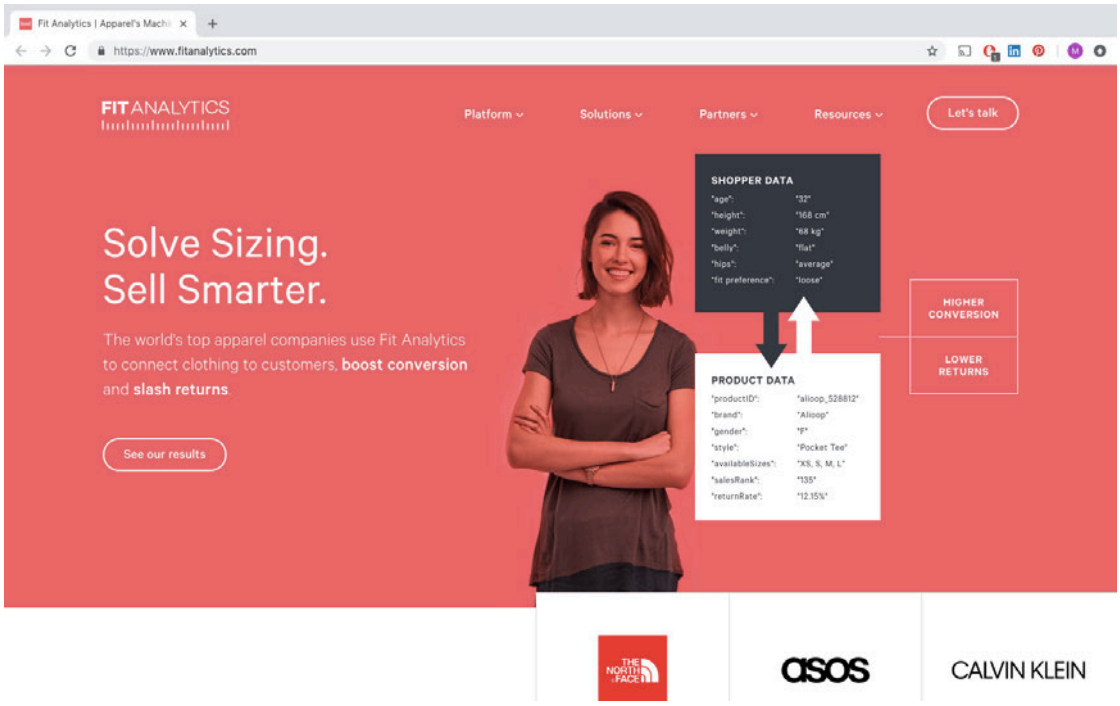


Figure 23. Website of FitAnalytics showing what their predictions are based upon [12]

Demographic information

Using body length, weight, bra size, and age these prediction softwares can determine what size you need. They compare the given information to a database containing thousands of people similar to you. Depending on what size they have bought and whether or not this item was exchanged for another size, they can suggest if this item fits you. In the case of FitAnalytics, it can assure you with a certain percentage that this size will fit you. If you still doubt whether this will fit you, it suggest whether or not to go a size up or down and shows which percentage of shoppers similar to you have bought this size.

Previous purchases

The predictive software of Virtusize works differently than the one of FitAnalytics. It does not ask you for demographic information and use the information of other people to determine the size of your next purchase. Instead, it uses items you have already bought and liked the fit off. You can do this in two ways. The first is useful when you want to buy something from the same store you bought before. You select which item you want to use as reference and it will find the dimensions belonging to this item. The other option is to choose an item you have at home from a different store and measure it yourself to use as input. The software will then show you visually how the garment that you have already bought compares to different sizes of the new item. You are then able to choose your own size depending on your preferences.

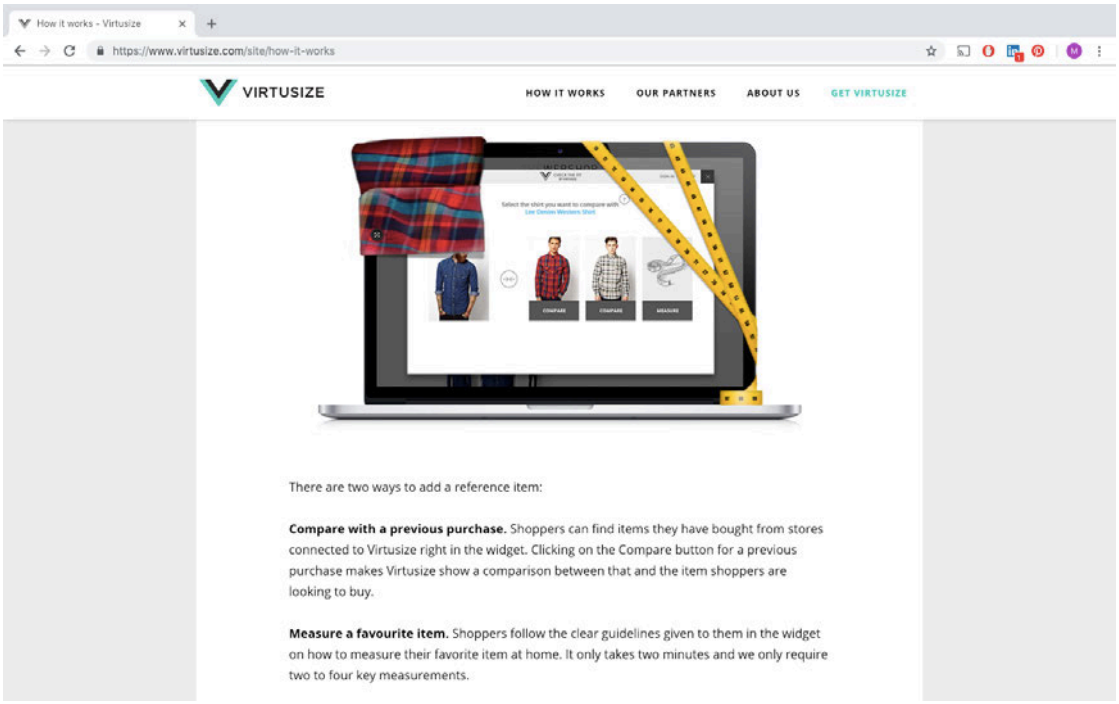


Figure 24. Website of Virtusize showing what their predictions are based upon [13]

3D Body Scanning

The 3D scanning technology has been used in the apparel industry since the 1990s to capture body information. Such technology is fast and can generate accurate body measurements (Gill, 2015). It is the process of capturing digital information about the shape of a real-world object. This digital information can be classified either as geometry, texture or both. Data of texture (e.g. colour) can be used to create visualisations, while data of geometry allows software to create a digital 3D model of which measurements can be taken. This is useful for capturing surfaces that are otherwise hard to describe the form of. This is also the case for processing human body dimensions. Single, one dimensional measurements, such as hip circumference (often used to describe the size of pants), can be acquired after the body is scanned and the data is processed.

There are different ways in how this digital information about the shape can be captured. There are a variety of technologies able to acquire the shape and these can be divided into two main types: contact and non-contact 3D scanners. Contact scanners, for example, need to probe the entire surface of the object through physical touch. This is not only an uncomfortable process to go through to get a body image, but also a lengthy one. Something that is impossible in the apparel industry as the customer has to stand completely still and make no movement during that process. To make the body scanning procedure more comfortable, a non-contact scanner will need to be used. These scanners use optical technology in combination with lights or lasers to collect 3D data. Non-contact solutions can further be divided into two main categories: passive sensing and active light sensing (Curless, 1999). There are a variety of technologies that can be classified in these categories, but only those that are often used for 3D scanning the human figurine are shown in the figure below.

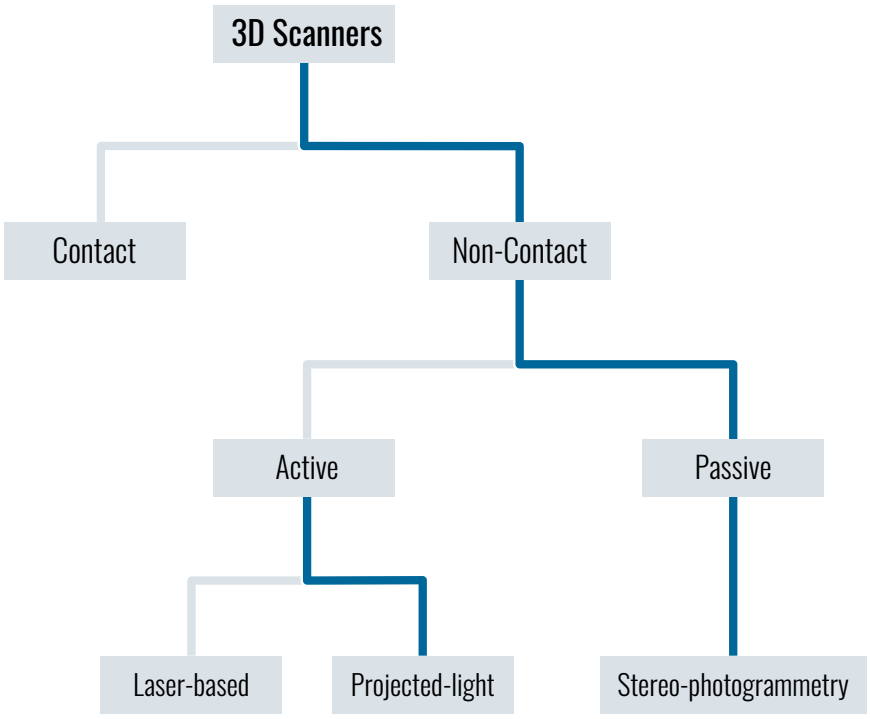
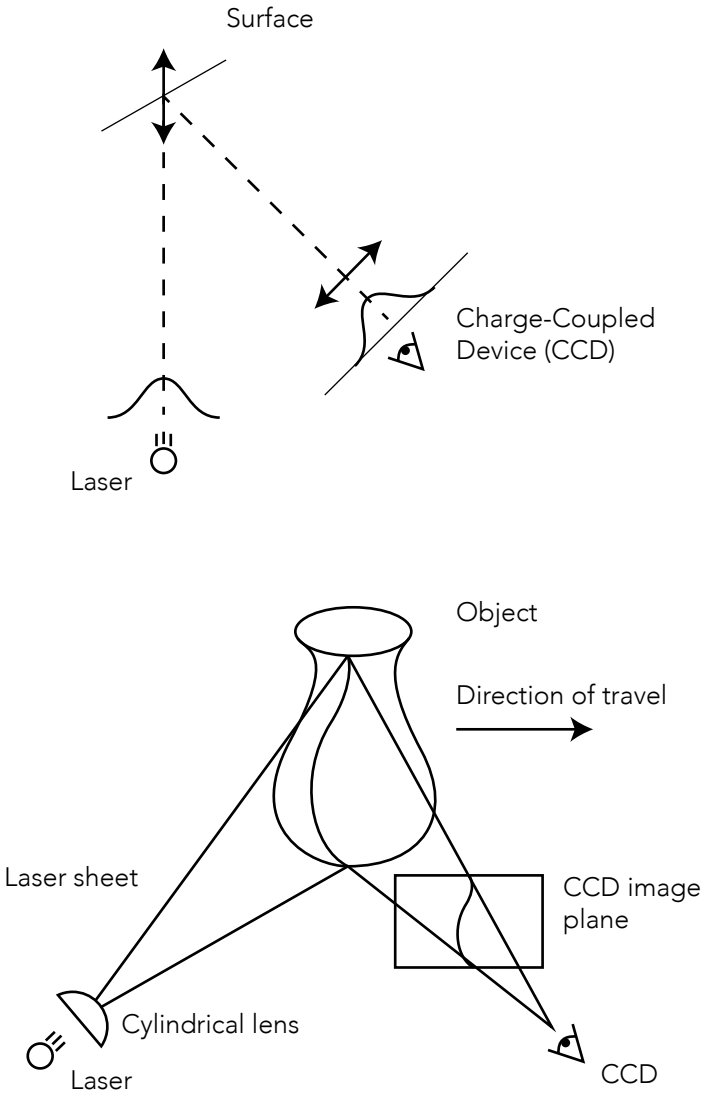


Figure 25. Taxonomy 3D scanners for the apparel industry



Active sensing 3D scanners include laser range finding and structured light projection scanners. Both scanners determine the spatial coordinates of the object by calculating the deformation of the laser/ projected light (see figure 26). For laser-based 3D scanners, a laser line is projected onto an object which deforms on contact. Through the camera, the 3D scanner analyses the deformation of the line emitted by the laser, and determines the position in space. The angle formed between the camera and the beam of the laser, the distance from the camera to the object and that of the laser source to the object, are all parameters which make it possible to determine the spatial coordinates of the object. As the laser moves over the surface of the object, multiple points in space can be determined, creating a point cloud that can be converted into a mesh, creating a 3D shape.

Figure 26. Working principle laser range finding and structured light projection 3D scanners.

While laser systems typically sweep only one laser line over the surface, a structured light system projects an entire pattern. This structured pattern is projected onto the scene and from the sensed deformed pattern a full 3D image is calculated. This pattern can consist of dots, bars, or any other light pattern (Daanen & Ter Haar, 2013). So although laser-based and structured light scanners use similar technologies to capture the human body, there is a difference in precision and costs and speed. The advantage of a single laser line is that the sensor can easily detect it and very accurately compute how the projected 2D line is deformed on the 3D surface (Daanen & Ter Haar, 2013). The disadvantage however, is that because only one single line is projected at a time, it is slower than when a full pattern is projected onto the surface. On the other hand, because a structured light pattern is more difficult to convert into an accurate 3D image, the accuracy and resolution of these scanners are less. Therefore, laser based scanners are often more expensive than structured light scanners.

Another technique, classified as a passive sensing 3D scanners, is stereo-photogrammetry. In photogrammetry stereo, two cameras view the surface from slightly different angles. Corresponding features are matched between the two images, and the 3D surface is then constructed by triangulation. An advantage of photogrammetry over structured light is that the natural appearance of the surface is captured as a normal part of the process. A disadvantage is that it relies on there being enough features in the surface texture (visual appearance) for matching to take place (Wu, Tillett, McFarlane, Ju, Siebert & Schofield, 2004). Some companies have recognised this disadvantage of stereo photogrammetry, and have added a textured garment that should improve the recognition of these features. These companies include ZOZO Suit (ZOZO Inc., n.d.) and Elasizer (Elasizer, n.d.) which is still under development. ZOZO Inc. has developed the ZOZO Suit that has more than 350 unique white dots that are essential measuring the human body. The ZOZO app will take 12 photos, using your smartphone, of the person turning clockwise and captures where each unique dot is in space (see figure 27), thereby creating a 3D scan from which the body measurements are taken. Although this seems like the perfect solution to increase the accuracy of stereo photogrammetry, the ZOZO Suit has not succeeded yet. According to Charlie Wells (2018) ZOZO's marketing had led him to expect perfection. However, he said: "What I ended up with were the kind of clothes you might buy in a hurry from Uniqlo or Gap if you go on holiday and your suitcase gets lost in transit". Therefore, the use of regular stereo-photogrammetry, might be a better option for the apparel industry. It has been proved that using multiple camera's simultaneously can get an accuracy of up to a few mm (Wu et al., 2004).

Figure 27. Using the ZOZO app and suit to scan the body [14]

As described above, there are different technologies available to scan the human body. However, to get a full 3D image, the body has to be scanned from directions in order to get the complete picture. This can be done in a few different ways. In a static setup, the human figure can be scanned from multiple directions only by using multiple sensors. An example of such a body scanner is the SizeStream SS20 Classic (SizeStream, 2018) as shown in figure X. This scanner has infrared depth sensors in four corners of the setup at different heights (20 in total). Although multiple sensors decreases scanning time, it increases costs. Therefore, there are also solutions available that use a dynamic set up. In this way only a single or a few sensors are needed. There are solutions available that have a static sensor where the person that is being scanned needs to rotate, or the person can stand still and the sensors rotate around the body. This can be either done manually or using a rotating platform in both cases. Two examples where the person is rotating are the TC2-19R Mobile Scanner (TC2 Labs, n.d.) and the Home Body Scanner from Naked Labs (Naked Labs, n.d.)(see figure X). A scanner where the sensors are rotating instead of the person is the Artec Shapify Booth from Artec 3D (2019) (see figure X). This scanner however is quite large and might not be suitable for a small store. Another alternative would be the Shape Scale from Shape Labs Inc. (2019). It is a small 3D scanner that is supposed to be used at home, and thus is small enough to fit into any room as can be seen in figure X.

Figure 28. SizeStream SS20 Classic [15]

Figure 29. Home Body Scanner from Naked Labs [16]

Figure 30. Artec Shapify Booth [17]

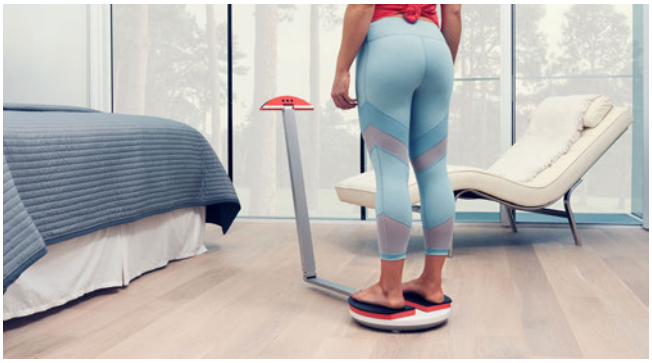


Figure 31. Shape Scale from Shape Labs Inc. [18]

What is left after a body scan is a point cloud. A point cloud is a set of data points in a coordinate system, in this case a three-dimensional one. This coordinate system defines these points with an x, y and z coordinate which together represent the external surface of the object, in this case the human body. There are two types of methods that can be used to process this information and to transform the point cloud to a usable 3D figurine, namely non-parametric and parametric methods.

Non-parametric methods take 3D points as input by scanning a human body in several views. Then a body mesh is acquired through registering or merging scan views and hole filling steps. This kind of method relies on the accuracy of scanners and restricts human to keep still with minimal clothes when scanning.

Parametric methods deform a 3D template body with a series of parameters. Input information is used as constraints to work out parameters and such information can be 3D or 2D which is more accessible. At early stage, parametric methods reconstructed 3D bodies using minimally-dressed information. Nowadays, more and more researchers utilize parametric human body model to estimate 3D body shapes from dressed-human information, the input of which is more convenient for users to get (Song, Tong, Chang, Yang, Tang & Zhang, 2016). Zhu and Mok (2015) showed a method for reconstructing precise 3D body models from customer's photos (front and side). Their results showed that even when participants wore loose-fitting clothes, their model compared to a 3D body scan was able to reconstruct customer's body with realistic appearance and accurate size measurements were mean discrepancies were lower than 2.0 cm which is within the size tolerance of the clothing industry.

Comparison Measurement Techniques

Now that we know what the available measurement techniques are, the question is still: What will be the best technique to use for the concept that is being developed by STRIKKS? To be able to compare these techniques, it first should be evaluated how these methods will influence the customer, STRIKKS as a company but also other people who might need to be involved in the shopping process, for example a shop assistant. Then the advantages and disadvantages will be set side by side to see which is most beneficial for STRIKKS.

Measuring Tape

Taking measurement using a measurement tape would be a cheap, but labour intensive method. It requires at least one other person than the person who is being measured. This procedure needs to be done by a professional who has the knowledge and skill of measuring people. While taking the measurements, the customer can still be clothed, but should not wear any thick clothes that will alter the measurement. The tape measure can be tightened to make up for the clothing, but too much tightening will again make the measurement unusable. Taking measurements can be a lengthy procedure depending on how many measurements need to be taken, and whether or not they need to be double checked. Some people may find that this lengthy procedure is uncomfortable and intrusive, while others say that is shows craftsmanship and quality, as attention is required for the practice and person. If multiple people need to be measured at the same time, multiple experts should be around to do so. This procedure can take place in the shopping environment if the customer is all right with that, as there is no need to undress.

For STRIKKS, the outcome of the measuring tape will be a list of numbers. The person who is processing this data will have no idea of the shape of this person. To overcome this, a single photo could be taken to give more insight into this, as this might help during the pattern alterations.

Measurement Prediction

Measurement prediction is a good way to predict the size someone needs if there is a standardised sizing system. To do this, excess to a database is needed, or a new database needs to be created. STRIKKS is producing custom orders and needs to know data specific about each customer. Demographic information could give a suggestion of what people will look like and what their measurements could be, but no one is the same, so relying on measurements that are being guessed might not be the best idea. The other method that is described above, is using a piece of clothing of which the fit is already liked. For this, the customer should bring this piece of clothing with them to the shop to get the measurements checked, while in the same time the measurements of the person could be taken. Overall, using measurement prediction is a good way to help solve the overload of returning items for online retailers, but is not the best alternative for making made to measure clothing in-store.

3D Body Scanning

To be able to use a 3D scanner, STRIKKS would need to purchase one for every shop they want to open. Therefore, a 3D scanner needs to be purchased that is not too expensive, but still gives the desired result. This would most probably result in a scanner with only a few sensors that either rotates around the body, or where the body needs to be rotated. This 3D scanner would need a separate room in the shop, especially when

laser or projected light is needed, as other sources of light would interfere during the scanning process. The customers would need to get changed into tight fitting clothes, that could be provided by STRIKKS. To operate the 3D scanner one shop assistant is needed that is able to start the 3D scanner and save the acquired data. As this method is quick in use, only one 3D scanner would need to be used.

	Measuring tape	**Measurement Prediction**	**3D Body Scanning**
Time	Time increases with amount of measurements taken	Quick	Quick
Costs	Mostly labour costs	Access is needed to database	Ranging from couple hundred to few thousand euro's
Data Acquired	Geometry	Geometry	Geometry, Shape & Texture (for visualisations)
Amount of Data Acquired	Only as much as needed	Only as much as needed	Unlimited
Data Processed	Manually	Manually/ Automatically	Automatically
Equipment Needed	Tape measure & someone with the knowledge and skills to measure	Demographic info about customer or garment that fits as is desired	3D scanner
Repeatability	Difficult	Easy	Easy
Privacy	Customer is clothed (no thick clothes), can be done in separate room if neccessary	Demographic info is needed	3D avatar is saved in database (online) and customer must wear tight fitting clothes during process

Table 3. Comparison different measurement techniques

3 Synthesis

3.1 List of Requirements

Findings from both literature and field research led to the making of a list of requirements. This is done based on the MoSCoW method (Media LAB Amsterdam, n.d.) which allows to prioritise the requirements based on which features need to be implemented first. This method divides the requirements into four categories: "must have", "should have", "could have" and "would like but won't get". "Must have" are features that are critical for the concept and need to be implemented to have a successful product. "Should have" are features that are important but not critical. "Could have" are features that are desirable but won't make a significant change in the user experience. "Would like but won't get" are features that the product won't have at this time because they are too difficult to implement. The "must have" features can be seen as the real requirements that the products must have in order to succeed. The other features could be more classified as wishes, as they are not a necessity but would be nice to have. The next list of requirements is specified for the design of the visualisation/simulation, as that is the most important part in convincing the customer of the fit of the garment.

1. Must Have

1.1. The customer must have the ability to change the garment model, fabric dessin and fabric colour during the use of interface.

1.2. Changes made to the garment must be visible as quickly as possible, but it should take no longer than 10 seconds as customers get impatient and stop the customisation process if it takes too long. (Nielsen, 2009)

1.3. The whole garment must be visualised in full size (scale 1:1) to give the customer the idea that she is looking in the mirror and to show enough details of the fabric.

1.4. The garment must be able to be viewed from at least 8 different angles (e.g. front, back and side), but preferably more. This will give the customer more insight into how the garment will fit their body.

1.5. Visual representation of the colours and dessins must be realistic and close to real life (adapted to different store environments) to avoid disappointment from the customer after purchase. This visualisation is based upon woven textiles.

1.6. Corresponding measurements between avatar and customer give the customer the possibility to evaluate the fit of the garment.

1.7. The size of the garment must be predicted by the system according to STRIKKS' vision of how the clothing should look on a customer.

1.8. The interaction with the visualisation must be intuitive and easy to use, so that no help is needed from a shop assistant. The design should take advantages of prior experiences with the physical and cultural environment (Mortensen, 2019). The customer should be able to perform actions without considering them.

2. Should Have

2.1. The ability to increase and decrease garment size (positive/neutral or negative ease) to allow the customer to change the fit preference in case the customer is not satisfied with the fit provided by STRIKKS.

2.2. Each knitted fabric (different dessins), still shown as woven fabric, should have its own fabric properties to give the customer more insight in the behaviour of the different fabrics. As knitted fabrics, using the same yarn, have different properties depending on what stitches are used, every dessin should get its own properties.

3. Could Have

3.1. The garment could be combined with other pieces of clothing (e.g. pants and shirt).

3.2. The avatar could be placed in different environments (e.g. outside, work, party).

3.3. Could show comparison of garments side by side to let the customer choose between two compositions that are equally liked.

4. Would like but won't get

4.1. As the final shape of a particular stitch depends on the types of stitches around it, constructing realistic knitted clothing requires a simulation at yarn level (Yuksel et al., 2012). Stitches can be formed using various knitting operations, leading to a rich variety of possible knitting patterns with drastically different appearances and behaviours, therefore it is important to simulate each fabric individually to get the most accurate result.

4.2. The avatar mirrors customers movement to give a better illusion of looking in the mirror.

3.2 Process Tree

From the design proposal, a process tree is made that schematically shows a diagram of the activities that the product encounters before, during and after use. This method can be used during the conceptual stage of the product design, to force you to think ahead. You need to think about who will be using the product, when will they be using it and most importantly how will the product be used? This overview helps in setting up requirements and defining functions for the product. These requirements can be found in the next section.

1. Before use (standby modus)
    1.1. Information is being displayed on the screen (such as a commercial or different garment compositions as inspiration)
2. During use by the customer
    2.1. The screen is activated by clicking onto the screen
    2.2. The customer looks at the home screen
    2.3. The "click here to start" button is pressed
    2.4. The customer reads the how the customisation process works and clicks next
    2.5. User details are entered to create an account
        2.5.1. Full name
        2.5.2. E-mail address
        2.5.3. 3D scan or body measurements are used as input to create avatar *this is done by a shop assistant*
    2.6. Start the customisation process *the next options can be chosen interchangeably*
        2.6.1. A garment is selected
        2.6.2. A fabric dessin is selected
        2.6.3. A fabric colour is selected
    2.7. Spin the avatar to see the garment from different angles
        2.7.1. Clockwise/counterclockwise is pressed
    2.8. The garment composition is changed
        2.8.1. A different garment is selected
        2.8.2. A different fabric dessin is selected
        2.8.3. A different fabric colour is selected
    2.9. The garment composition is saved to the account
    2.10. A comparison of garments is shown
    2.11. A garment composition is deleted
    2.12. A purchase is made
        2.12.1. Make a screenshot of the selected garment and print/e-mail to customer
        2.12.2. Send bill to register
        2.12.3. Send product technical specification to STRIKKS factory
3. After use
    3.1. Customer will log off
    3.2. Software is restarted for the next customer
    3.3. After x amount of time that the screen is not used (read: touched) the screen will display information again

3.3 Design Proposal

From this list of requirements a new design proposal is formulated (which is portrayed in figure 33). At the end of this graduation project a physical prototype will showcase what could be located in the future stores of STRIKKS. This prototype will be a working model that uses the input of the customer (measurements, garment model and fabric choice), which is acquired in an interactive way, to create a custom outfit that will be visualised on the screen. The life size visualisation will be shown on a screen that represents the mirror in the fitting room. Figure 32. shows a possible design of the visualisation. Based on this visualisation the customer can alter the garment or choose to make a purchase or not.

The journey to get to this working prototype: the physical screen set up that is able to show the visualisation, together with a working interface to customise clothing, is illustrated in figure 32. The blue line represents the most important input that is required to make this work. To let the customer customise their garment, a visualisation needs to be shown on a physical screen with which the user can interact to change the garment composition. For this visualisation an avatar is needed that has the correct measurements of the customer. This can be done by either uploading a 3D scan of the customer or by manually altering the avatars dimensions with the input of the customer. This second method is chosen as it is easier to implement in the time of this project. Onto this avatar, clothing needs to be projected. This clothing is composed of a garment model and a fabric (consisting of a colour and fabric dessin) and needs to be shown in the correct size to allow for the analysis of the virtual fitting. This size will be suggested automatically by the system.

Figure 32. Design Proposal

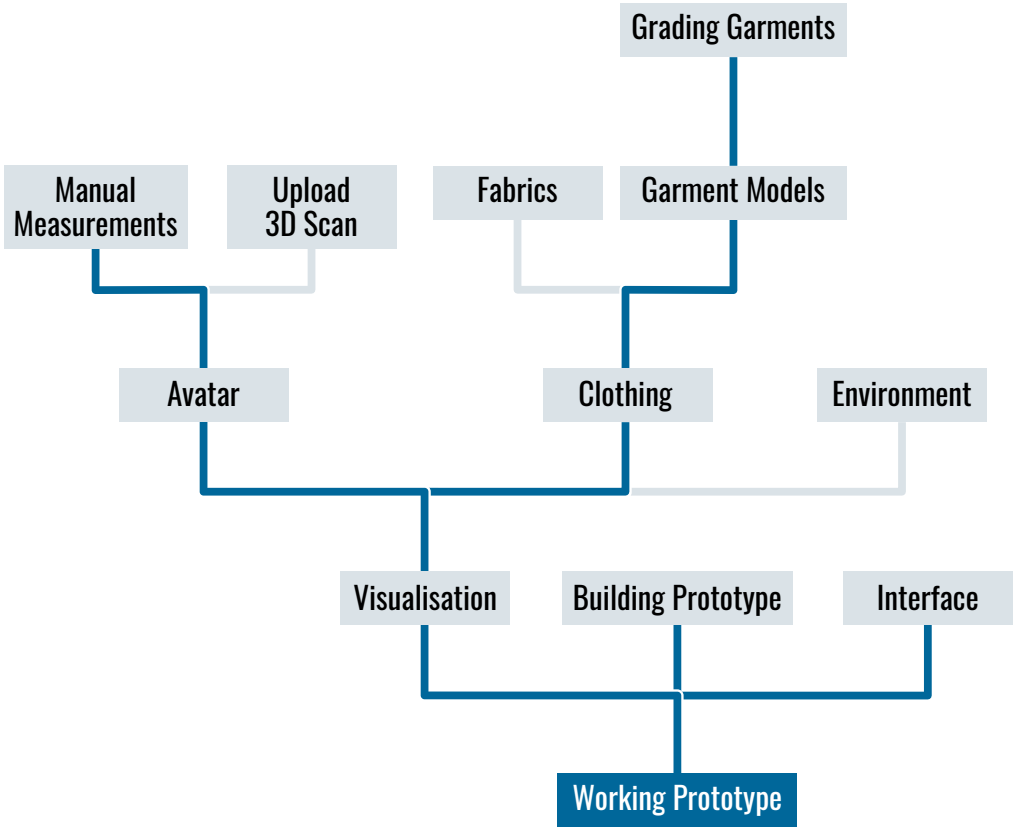


Figure 33. Steps to take to get to final result: a working prototype

3.4 Key Decisions for Design Proposal

3.4.1 Type of Visualisation

As mentioned in Chapter 2.5.2., a choice needs to be made on what the visualisation will look like. And although there are different ways in which a garment can be shown to the customer, in this case a choice has been made to between showing a graphical representation of a person wearing the clothing and a projection onto a real image of a person. In the end, a choice has been made to show the graphical representation. The reason for this will be illustrated with the current state of the art of both visualisations. Furthermore, the use of an avatar promotes virtual fitting, doesn't show the clothes of the customer that she is currently wearing, and gives the ability to show the garments in different environments.

State of the art magic mirror vs Clo3D

First of all, to give an idea of what nowadays is possible with both a magic mirror and a visualisation on an avatar the two figures on the next page (figure 34. and 35.) are shown. The 3D fitting room of New Tempo projects a garment on to the customer. The camera recognises where the customer stands and tries to match the garment as best as possible by increasing or decreasing the size (zooming in and out) and moving it up and down to find the correct position. As she is moving, the garment tries to mimic her movements and although this works fairly good, there is always a small delay revealing the actual clothes she is wearing underneath. Through the interactive screen, she can choose different styles and colours but not different sizes.

On the other hand is the Clo 3D's AR Smart Mirror which was unveiled at CES 2019 in Las Vegas. The AR Smart Mirror integrates CLO Virtual Fashion's 3D avatar creation and virtual fitting API 'BeneFit-by-CLO' with LG's touch screen signage and automatic body scanning technology using 3D camera. Consumers can now have their body scanned automatically, and virtually try on clothing on the Smart Mirror interface without getting undressed. Once the consumer's body data is extracted from body scanning, a customised avatar is created in real-time by AI. Based on the body data of the user's avatar, AR Smart Mirror then recommends the right sizing for clothes created in 3D, and users can accurately check fit by looking at the fit maps in real time (CLO Virtual Fashion LLC, 2019).

So although both types of visualisation show the same clothing: a 3D representation of a garment, the way they are shown is different. As the clothing in the magic mirror has to keep up with the movements of the user, it cannot take too long to compute the garment. Therefore, the garment often has a lower resolution. As the visualisation on the avatar can both be dynamic and static, the quality can be improved (especially for static situations). The level of detail that can be achieved in Clo3D can be seen in figure 36. In this image the Fabricant shows a collection of sports clothes that they were able to create using the Clo3D software.

Figure 34. State of the art Magic Mirror [19]

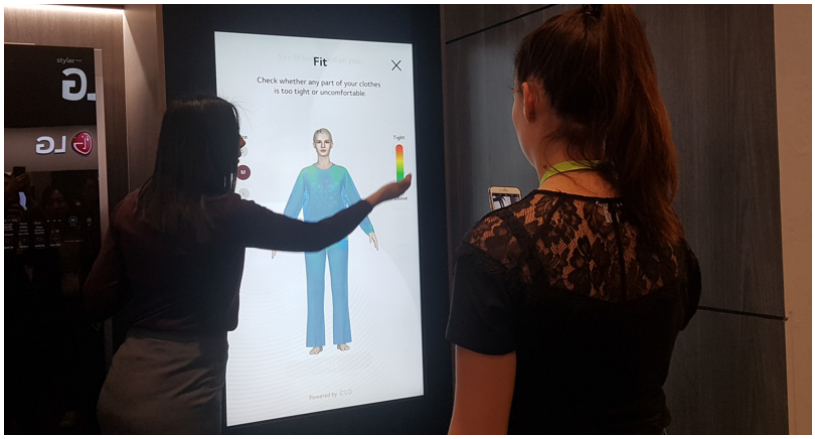


Figure 35. State of the art AR Mirror [20]

Figure 36. Possibilities with Clo3D [21]

Virtual fitting

The use of a 3D representation for both the avatar and clothing has the advantage that it can be used for virtual fitting. The advantage of this is that it can be used to predict the correct size for the customer and to analyse and show the fit of this size. From this the customer cannot only evaluate whether the clothing fits with her style and personality, but also whether the clothing 'physically' fits to her body.

For this visualisation, a 3D CAD software for fashion design has been used called Clo3D. Clo3D's garments are pattern-based to maximise precision and technology in deterring how garments will truly drape. By using these actual patterns, a virtual fitting will produce an almost identical garment fit as it would in real life. By comparing the measurements of the garment and the measurement of the body and incorporating the fit of ease, a prediction can be made on which garment size fits the best with each customer. In this case, STRIKKS has chosen to design their clothes with positive ease, meaning that the garment dimensions should be bigger than the dimensions of the body. This means that when a size will be predicted, all sizes that have a negative number when the body dimensions are deducted from the garment dimensions should not be recommended. From the remaining sizes a choice can be made that is closest to the amount of ease that STRIKKS has designed for that particular garment.

Then the recommended size will be visualised on the avatar with the possibility to show fit maps (strain/ stress maps). This will give the customer the ability to examine the fitting of the clothes in both a visual and physical manner. In this way, customers can try on the clothing virtually and see whether they like the way the garment is draped around their body.

Naked avatar vs clothed human

One of the main advantages of using an avatar with respect to the magic mirror is that the avatar is naked or only wearing underwear. If a customer wants to see what a dress looks like, then it is unwanted to also show the jeans that she might be wearing at that time. However, when projecting the clothing onto the customer in the mirror, this is inevitable. However, the customer is not supposed to see the avatar naked as this might evoke negative emotions. So whenever the customer chooses only a top or bottom piece, the other will replaced with a basic top or jeans.

Different environments

Changing the environment the customer is in, is something unique that can be added to the visualisation. As the avatar is in a virtual world, this can be adapted to the customers likings. Changing the colour of the background and adapting the lighting conditions. This gives the opportunity for the customer to get a more realistic look of what the clothing will look like outside of the store. Who wouldn't want to know how your summer dress would look like city tripping or wearing your warm sweater on a snowy winter night?

3.4.2 Garment Grading

As STRIKKS is offering personalised clothing, each garment should be altered to the customers likings in both style and size. To accommodate for all different sizes and shapes of people, there were two options to consider regarding garment grading. STRIKKS could choose for an extensive size chart that would fit most people of their target group, or go with a parametric design that would include all customers. A size chart would mean that for example the sweater of STRIKKS will be scaled proportionally to create multiple different sizes. A customer then only has the option to choose between the sizes that STRIKKS has available. However, if the pattern will be used for parametric design any size can be made. Algorithms are used to alter the dimensions of the sweater based on your input and body dimensions. To be able to choose between these two options, a list of advantages and disadvantages was made.

Advantages size chart:

- The biggest advantage of using a size chart is that the aesthetics of the design, as it is intended by STRIKKS, will remain the same for each size. STRIKKS has designed the clothes to be worn in such a way and these clothes will be graded proportionally.
- There is less work in altering the pattern for each individual. A size is chosen based upon the visualisation and from that point STRIKKS already has most of the measurements for producing the garment.
- Using standardised patterns speeds up the manufacturing process.
- As all different size patterns can already be programmed in the software it can be quickly visualised for the customer.

Disadvantages size chart:

- Making a custom size chart for STRIKKS' target group will take time and effort and needs to be done correctly to include most of their target group. A bad size chart will result in less sales as customers won't prefer the fit of the clothes.
- This size chart should include 95% of target group as otherwise "personalisation" will not be taken seriously.
- Effort should be taken to make sure that customers don't know that STRIKKS is working with a regular size chart, otherwise they might feel deceived. The clothes inside the store should not be labeled as normal brands do (XS to L or 36 to 44) but could be labelled such as Neon Moon has done : Lovely, Gorgeous, Beautiful, Fabulous and Stunning (Goldstone, 2017).
- As every body has a different size and shape not all people might like the way the garments drape around their body. This however is the way STRIKKS has designed the clothing, and that means that not all clothing will be right for everyone.

Advantages parametric design:

- All customers are included and each of them can get a garment. Especially people who have a body that is different from the 'standard' who might be looking for personalised clothing will get something fitted.
- Automatically adjusts other dimensions when one dimensions is changed. For example, if the opening for the arm is adjusted, the width of the sleeve needs to be adapted similarly.

Disadvantages parametric design:

- Clothes can be disproportionally scaled to fit the customer which might result in oddly looking garments.

As the dimensions of the body do not scale proportionally it will be difficult to find a size chart that can accommodate all potential customers of STRIKKS. However, it is still very important to STRIKKS to show their own style and vision in their clothes. Having people not like their clothes or not fitting their clothes the way they would like is still part of this business. However, if you still want to include a larger population, an alternative could be to make a more advanced size chart that can be composed of different sizes for both the body of the garment as the sleeves. The different parts of the garment can be mixed and matched.

3.4.3 Adapting the avatar to your dimensions

As discussed in chapter 2.5.3., there are different methods that can be used for creating an avatar. When this concept will be displayed and used in store, it is recommended to use a 3D whole body scanner to take measurements of the customers. The reason for this is that the scan compared to the measuring tape can be used as part of the visualisation, for retrieving measurements as well as a visual reference for STRIKKS as to how the body dimensions relate to each other. The 3D scanner will also create a more repeatable result as the measurements don't depend on the skill of the measurer. In this case, a 3D scanner could be implemented into the screen for visualisation so that it is first only used for visualising and then when the customer decides to buy something, the measurements will be extracted separately for production.

However, during the development of the concept in this graduation project, the shape of the avatar can be adjusted using two techniques. The first one is manually adapting the existing avatar in Clo3D. Clo3D allows you to give as much input as you need. The more input you give the more accurate it becomes. This input, however, also needs to be measured manually, so it is a lengthy process. The second option consists of predicting the shape and size of the avatar using several measurements of the customer also taken using a measuring tape. This prediction of this shape is done using the Benefit by Clo API based upon a database of 3D scans (for more information see chapter X). This Benefit avatar is created depending on the height and weight measurements. Besides, there is the option to enter 5 more measurements: chest, waist and hip circumference, and arm and leg length.

The question is whether this prediction software can be just as accurate as creating an avatar by yourself. Being able to use this web API could save a lot of time in the customisation process. The accuracy of the API is tested by taking a sample of 3D scans form the CAESAR database and using the corresponding measurements to create an avatar with the Benefit by Clo API. Each time another dimension is added and the avatar is again compared to the 3D scan. From left to right you can see the original 3D scan (black outline), then the result of the API with only the weight and height measurements (red) and then respectively the weight and height measurements plus chest circumference (dark green), waist circumference (light green), hip circumference (blue), arm length (purple) and leg length (pink)(see figure 37). Once these images have been laid over each other, the difference can be seen in figure 39. The first image shows the change when entering a new measurement. For example, the yellow and red outline (most left) shows what the difference is between the predicted chest circumference and the actual chest circumference. When laying all outlines on top of each other, a large difference can be seen. With entering each of these measurements one by one, you would suggest that the shape of the whole avatar would be altered as the number of 3D scans that still match your input would decrease, and thus a new 3D scan would be chosen to represent your customer. Unfortunately, this is not the case. This shows that the original prediction is not very accurate, and thus not altered along the way. This would mean that if you would like to use the avatar shape and size prediction, you would at least need to enter all 7 measurements.

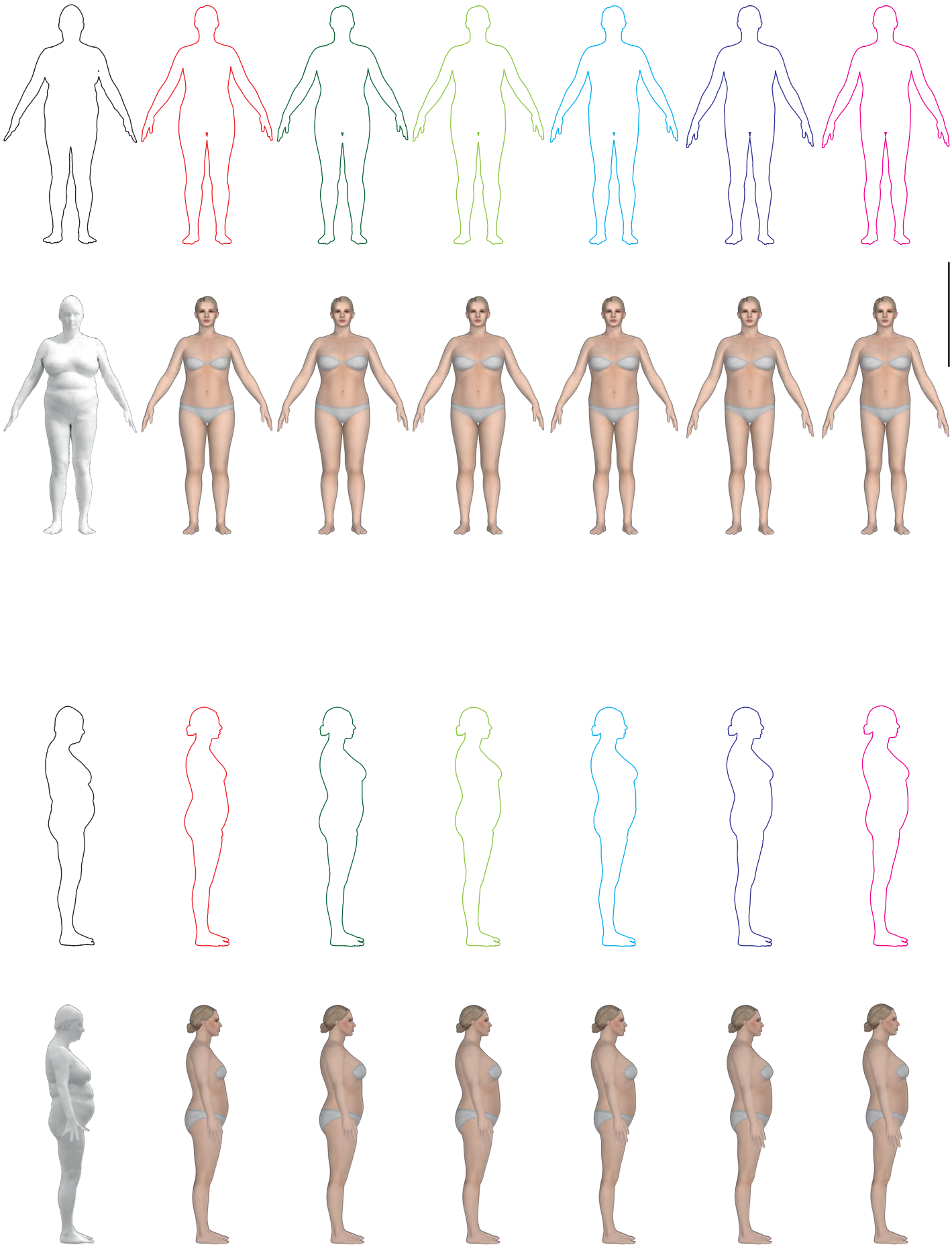


Figure 37. Evaluation Benefit by Clo avatar creation. From left to right each step another dimensions is used to create the avatar

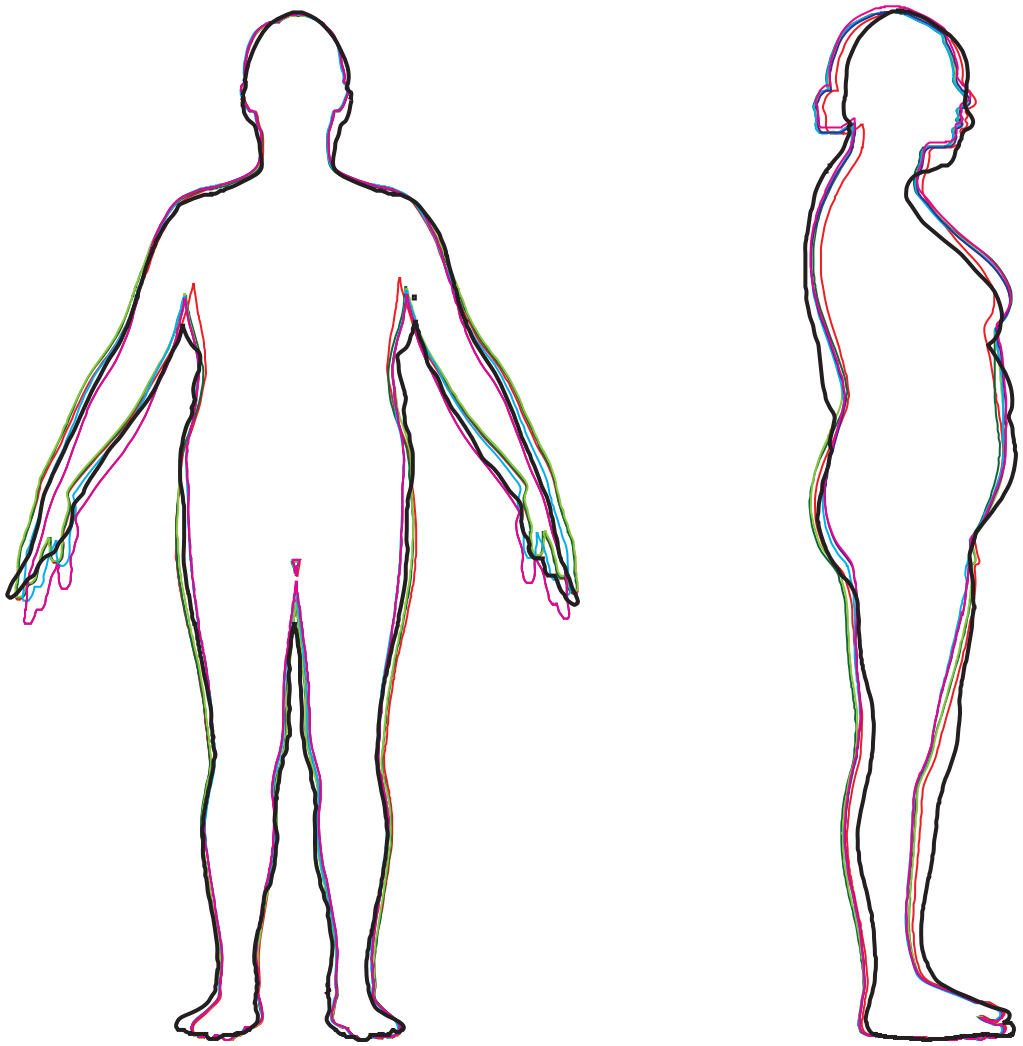


Figure 38. Comparison avatars created using Benefit by Clo API. Should all represent the same person

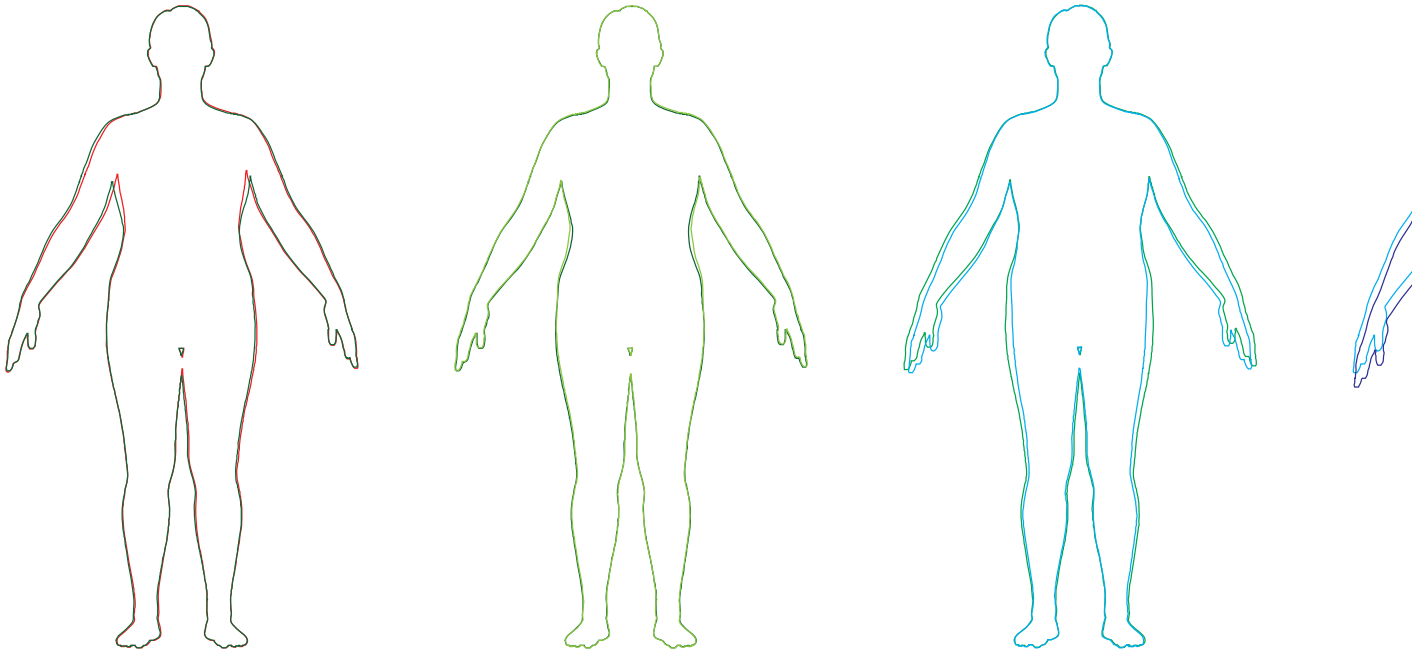
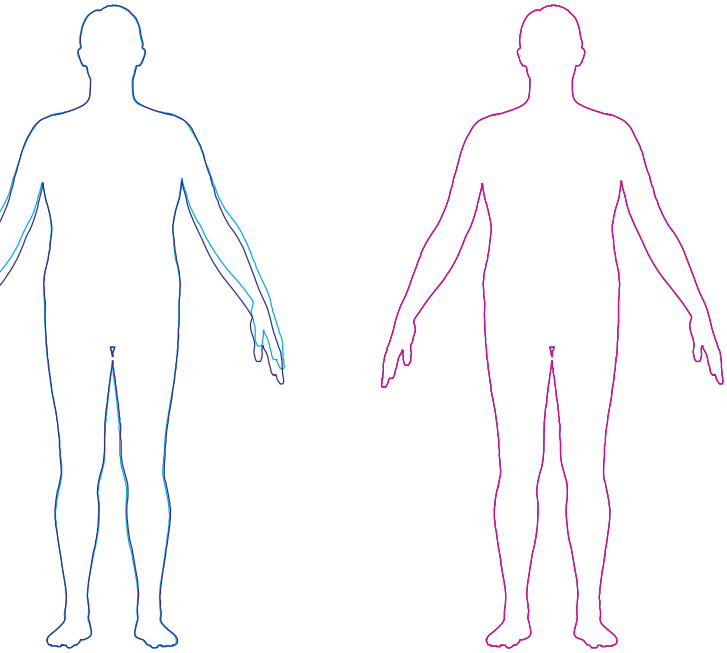


Figure 39. Difference between avatar using x amount of measurements and x+1

This way of creating an avatar is quick and dirty, but still gives a reasonable representation of the customer. Using a 3D scan would require more post processing to get the avatar to the same state (extract standard Clo3D avatar, wrap it around a 3D-scan and import it back recalculating underlying skeleton and skinning so that the custom avatar represents body shape of real person and preserves all the features of standard avatar like cloth arrangement, pose changing and animation (Russian3DScanner, 2018).



4 Simulation

4.0 Simulation

In this chapter, a digtial prototype will be made that is able to show the visualisation and with which the customer is able to interact.

To be able to show the clothing on the visualisation, the fabric properties have to be determined and the appearance has to be added to the fabric. Then, combined with a standard pattern for the garment a visualisation can be made. The avatar, on which the garment is draped, has to be adjusted to represent the correct body dimensions of the customer, after which the garment pattern can be adjusted to the correct fit.

After a first visualisation is shown to the customer, she can interact with the software to adjust the garment to her personal likings.

4.1 Fabric Visualisation

Visualising how the different fabrics look and behave is one of the most important things to realise a correct visualisation of the garment. The look of the fabrics is a key thing in convincing the customer of purchasing an item from STRIKKS. Clo3D, the software that is being used has its own fabric emulator allowing you to create custom fabrics. This tool has been used to determine the fabrics physical properties whereafter textures have been added to give it the visual look of the fabric. For each dessin, the fabric properties have been determined using multiple test including weighing the fabric, determining the thickness as well as a tensile and bending test.

In Clo3D the following physical properties can be adjusted for each fabric:

- Stretch weft, warp and shear. Shows the resistance against the horizontal, vertical and diagonal elasticity.
- Bending weft and warp. Shows the resistance to being bent. The higher the number the higher the stiffness of the material is.
- Buckling ratio weft and warp. This property refers to the tendency of the fabric trying to preserve its shape (see figure 41).
- Buckling stiffness. Is used to show how much percentage of total bending intensity is used to decide the stiffness of the corners of the fabric. A higher percentage means it is harder to fold the corners, while a lower percentage makes it easier.
- Internal damping. Shows the resistance against the bouncing of a fabric. This property is mostly visible during movement of a fabric, but not when garment is in a static position.
- Density. Used to express the weight ratio per m3.
- Friction coefficient. The friction coefficient affects the friction between the garment and another garment.
- Thickness. Refers to the thickness of the fabric.

Weft, warp and shear refer to the direction of the fabric that a test has been performed on. Image 40 shows the different directions.

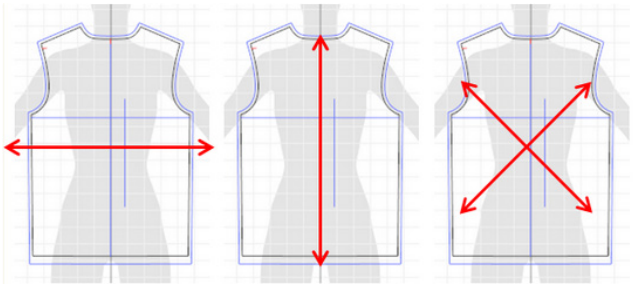


Figure 40. Weft, warp and shear directino of fabric [22]

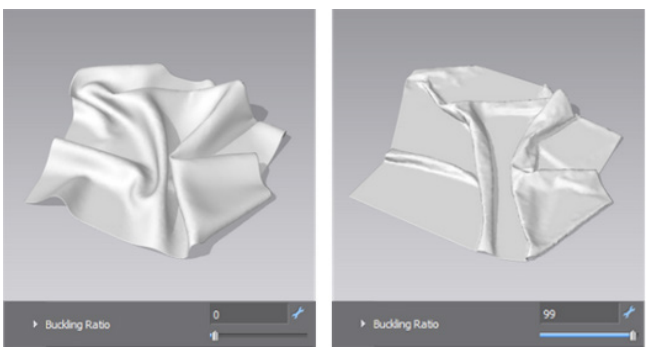


Figure 41. High and low buckling ratio [23]

The emulator in Clo3D allows you to use input from multiple fabric tests to create a custom fabric. For this, you need to prepare fabric samples: one in the horizontal, one in the vertical and one in the diagonal direction for the weft, warp and shear measurements respectively. This can be easily done for woven fabrics, as the fabric samples can be cut from a larger piece of fabric. However, for knitting, cutting in the fabric means that it will start fraying and eventually fall apart. Therefore, STRIKKS has prepared samples that are knitted to size (120x50mm) so that they won't fray. The disadvantage of this is that making a diagonal sample becomes nearly impossible. As this sample was only needed to analyse the shear stretch it was decided not to test this. In stead, an estimation was made. According to the website of Clo3D (Erica, 2016), when weft and warp intensities are the same, increasing the shear intensity will express materials that crease easily, while decreasing the intensity value expresses more elastic materials. Therefore, this value has been adjusted to 0 after the emulator calculated the physical properties to represent the knitted fabrics.

To use the emulator of Clo3D, 4 tests have to be performed. First of all the weigth and thickness have to be measured. Then a tensile and bending test is performed on each of the samples in both weft and warp direction. In the next section each test protocol will be explained using the Binary dessin as an example, other results can be found in Apendix X. In figure 42, you can see a fabric sample that has been used.

Weight

The weight has been determined by measuring the larger fabric samples (approximately 250 by 250 mm) of all colour options available, in this case 5, and converting the measured weight to the 120x50 mm samples. An average is taken from all colour options to get a more accurate result, and also because there are slight differences between the colour options. Let me explain. As STRIKKS tries to limit the amount of stockpile they have, yarns are ordered from a factory in small bunches, and they have to choose from the colour options that are currently available in that factory. This could mean that the composition of the yarn can slightly differ among batches, as well as the fact that the dyes used to colour the yarn are made from different chemicals. Darker fabrics usually require more dye to get their rich colour, and are therefore often heavier than lighter yarn colours. For Clo3D however, an estimation is made and thus the average is used.

For the Binary fabrics, this has lead to a weight of 1.35g for the fabric sample.

Thickness

To measure the thickness, a similar approach has been used as with measuring the weight. The average is taken from all 5 Binary fabric samples and resulted in a thickness of 1.47 mm.

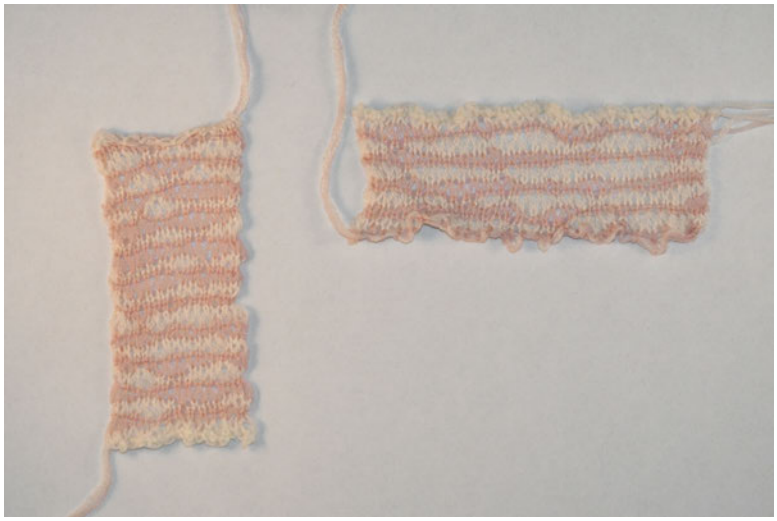


Figure 42. Fabric sample binary pink

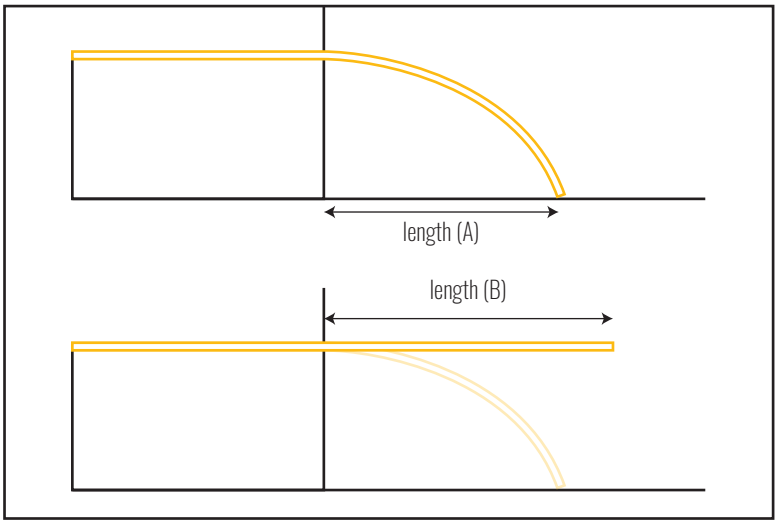


Figure 43. Bending test set up

Bending test.
The bending test is used to determine the stiffness of the fabric. For this, a test set up as shown in figure 43 has been used.

The fabric sample is placed on top of a platform of 40 mm high. The fabric sample is slowly pushed forward until the fabric specimen touches the plane the platform is standing on. The horizontal distance between the platform and the fabric is measured, the contact distance (A), as well as the distance when the fabric is lifted in a horizontal position (B)(see figure 43). This test has been performed 4 times with the specimen at each end and again when the strip was turned over. These 4 test were combined to an average value that has been used in the emulator of Clo3D. The results for the Binary Pink fabric sample are as followed.

	weft	warp
contact distance (A)	13	11
length (B)	46	45

Table 4.. Bending test results Binary Pink

Tensile test
Last but not least, a tensile test has been performed to measure the stretchability of the fabric and the threshold at which a fabric will no longer stretch. It illustrates the relationship between the length of stretch and the force applied to the fabric. This test was done on the Zwick / Roell Z010 tensile tester at the Faculty of Industrial Design Engineering. The fabric sample was clamped so that 100 mm was the initial starting position. Then slowly force was applied to stretch the sample until the yarn was at its breakage point. The result is showed in figure 44 for the weft direction and 45 for the weft direction.

From these graphs, 5 points have been measured before the fabric sample started to fail to determine the stretch of the fabric. These measurements have been used as input for the emulator. In case of tensile test for the weft fabric sample, a single thread broke after which the test was continued. Breaking this single thread however did have influence in the fraying of the fabric. That is why the measurements are taken from the first peak.

	Weft		Warp	
	Length (mm)	**Force (kgf)**	**Length (mm)**	**Force (kgf)**
1	20,0	0,17	75,0	3,44
2	21,0	0,28	77,0	3,98
3	22,0	0,40	79,0	4,54
4	23,0	0,52	81,0	5,19
5	24,0	0,62	83,0	5,82

Table 5. Results Tensile test Binary Pink

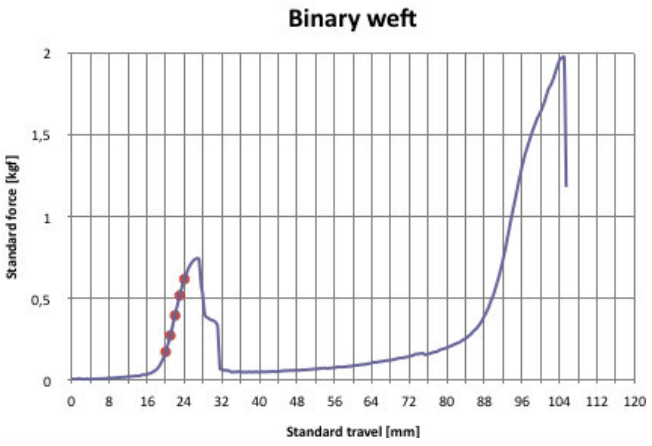


Figure 44. Graph tensile test Binary Pink in weft direction

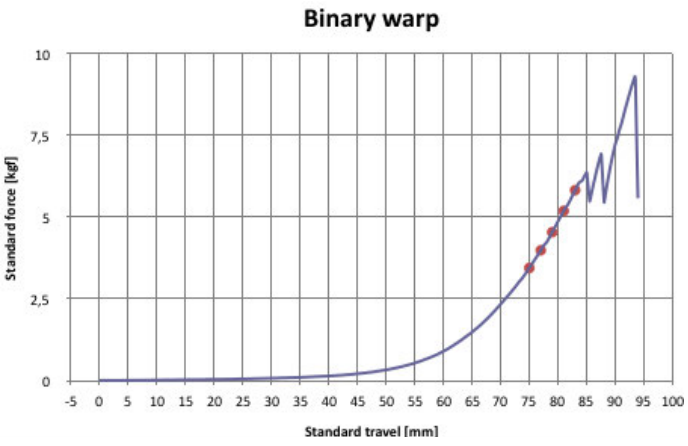


Figure 45. Graph tensile test Binary Pink in warp direction

After all inputs were given, the emulator calculated the fabric physical properties. This process was repeated for all dessins. In the next step a texture was applied to express the visual appearance of the fabric. These textures were created using photographs of the actual fabric samples and transforming them in a 2 step process.

First of all, from the photographs that were provided, a seamless tile should be made. Seamless tiles allow you to create a larger image by placing these tiles side by side without showing the seam. Without seamless tiles, the borders of repeated images would be visible creating an unpleasing image. This process was done using PixPlant software and an example is shown in figure 46.

Then, the size of the image used as a texture on the fabric needs to be adjusted for every individual fabric to show them as the real size in the visualisation. For example, the Binary Pink image is in the photograph 210 by 297 mm and the seamless tile is 1058 by 1058 mm. When down sizing the seamless tile until it matches the pattern of the original one, the seamless tile is then only 226 by 226 mm big. This new value needs to be used in Clo3D to show the actual size of the pattern of the fabric. This process is repeated for every fabric.

Last but not least, to finalise the appearance of the fabric in Clo3D a normal map has been added. This normal map has also been created with the PixPlant software and is different for every fabric (see example in figure 47). This normal map creates something that looks like additional resolution or detail on the surface of the geometry, although it is not. A normal map creates the illusion of depth detail on the surface of a model (https://www.pluralsight.com/blog/film-games/bump-normal-and-displacement-maps). This helps to better visualise the 3D structure of the knitted pattern. In figure 48. on the next page, the difference between the use of a normal map (left) and no normal map (right) can be observed.

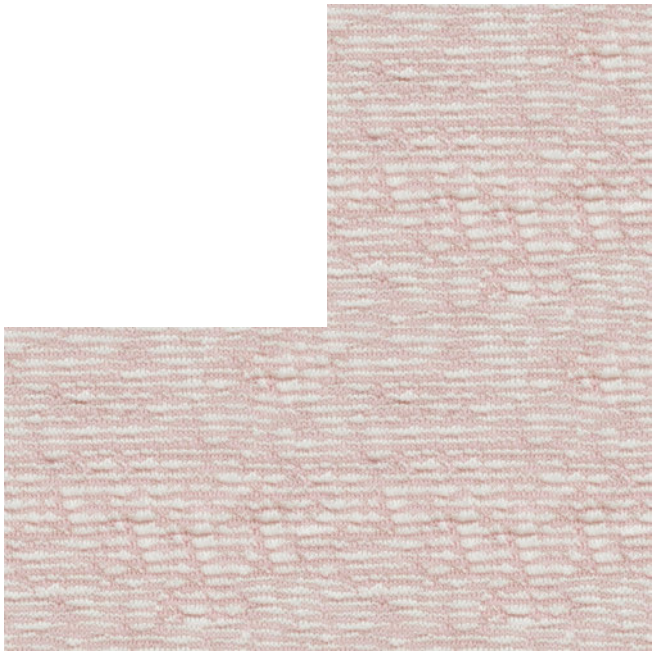


Figure 46. Seamless fabric: Binary Pink.

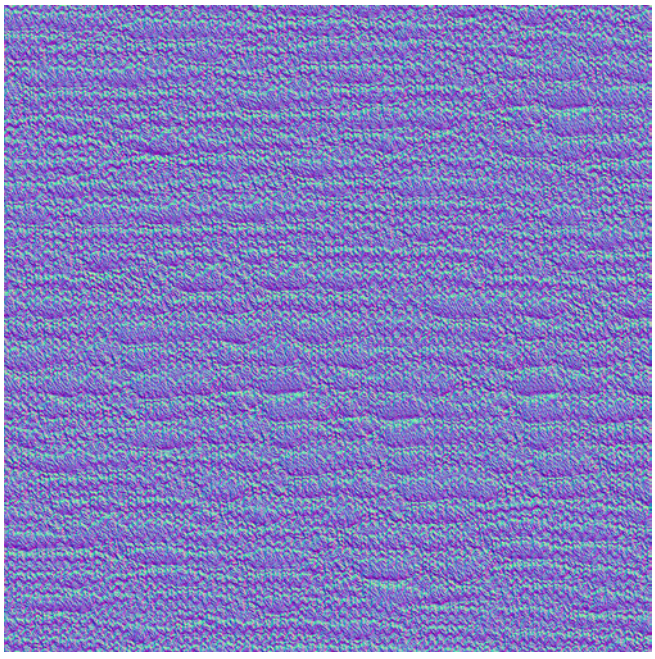


Figure 47. Normal map binary pink

Figure 48. Left: texture honeycbomb + normal map; Right: no normal map

In the illustration on the right the differences between the fabrics are shown. This is done by draping a square piece of fabric over the sphere. The results are shown in figure 49. from front view (left), side view (middle) and 3/4 view (right).

Figure 49. Fabric simulations of the 6 different dessins seen from the front, side and 3/4 view.

4.2 Basic Sweater Pattern

During this graduation thesis I have been mostly focussing on a sweater that STRIKKS has in her collection. The sweater is one of their most basic items and is therefore easier to work with in the digital environment and will also take less time on the knitting machine, which is a great advantage during user testing.

The sweater consists of 4 panels: a front panel, a back panel and two sleeves. All edges are finished off with a border.

During the customisation process, the user can customise the length of the garment, the length of the sleeves and also the width of the sweater. The neckline, the width of the border and the sleeve width will remain the same.

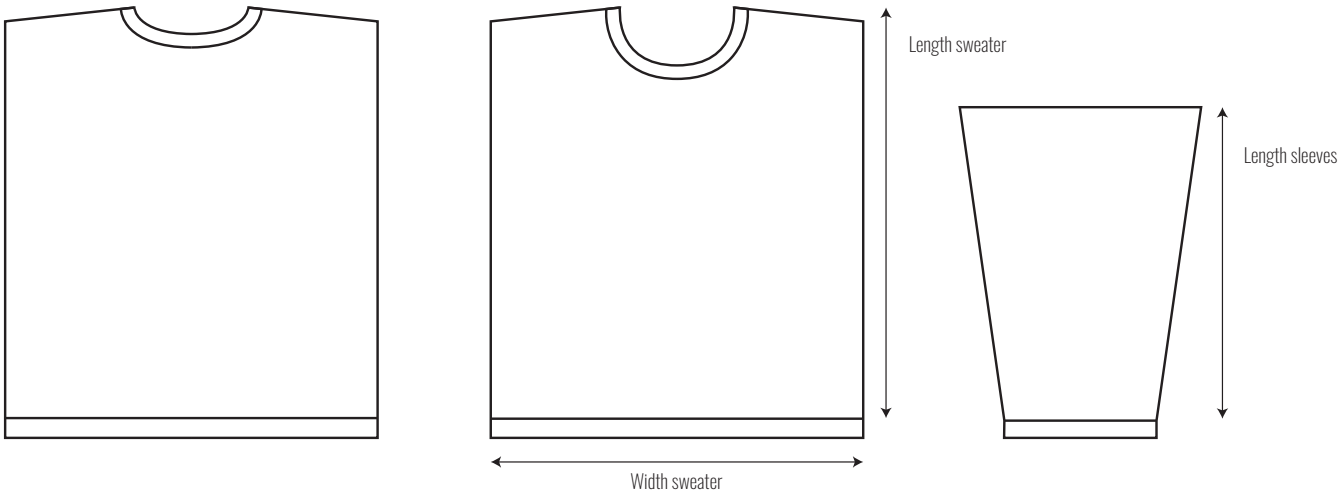


Figure 50. Basic sweater pattern in size 38 on a scale of 1:10.

4.3 Garment Grading

From the basic pattern of the sweater, the size has to be adjusted to fit the female body. Every brand that develops clothing has their own sizing system, which sometimes even varies within the brand. As STRIKKS is creating a new clothing line, creating a sizing chart is also important. As a designer you need to know what human dimensions should fit into your clothing to be able to determine later if a certain clothing item will fit. The fit specialist had created the sizes 36 to 46 for the basic sweater based upon the pattern in size 38 (see fig 50 previous page). As the image shows below, the garment is not increased the same amount at every place. The garment is increased more in width than in length (10 mm difference), and the neckline and shoulders stay very similar (only 2.5 mm each side). The step increase for each size however, is the same. So the image below could show size 36 (black) and 38(red) or 42 (black) and 44 (red).

Now there is still a difference between the garment sizes and the body dimensions that fit in a size. For this a size chart should be set up. For knits (cardigans, sweaters & T-shirts) the primary dimension that should be looked at for women is the bust girth (maximum size along the bust). The secondary measurements would be the height. The first table below shows what bust measurements should coordinate with which letter code according to the EN 13402 standard. This however, does not relate yet to the sizes 36-46 that have been created. However, the sizes that had been developed did not have a specific target group in mind. The sweater had been graded as she would normally do for other grading jobs. This could mean that that gradation then is not suitable for STRIKKS, or maybe not even for other companies. As there was still a need for a relationship between body dimensions and garment dimensions, I searched for the 'standard' confection sizes of 36-46 and came across several websites that had more or less the same outcome, as well as their bust range would fit with the EN 12402 standard (berekenen.nl, n.d.)(confectiemaat.nl, 2017) and (Monstyle, n.d.).

Furthermore, the size system converter as shown in (Bogusławska-Bączek, 2010), suggest that, for example, a size S corresponds with size 36 and 38 which have a bust range from 82 to 90 cm circumference. These two tables combined, together with the result of the confection size search, results in the third table on the next page. This will be used as a standard for STRIKKS as they have not developed their own sizing system yet. This table will be used to determine to what size a customer will belong. To test how good the sizes are developed and fit with the target group of STRIKKS (female, 35 to 60 years old), some 3D scans have been taken from the CAESAR database to evaluate.

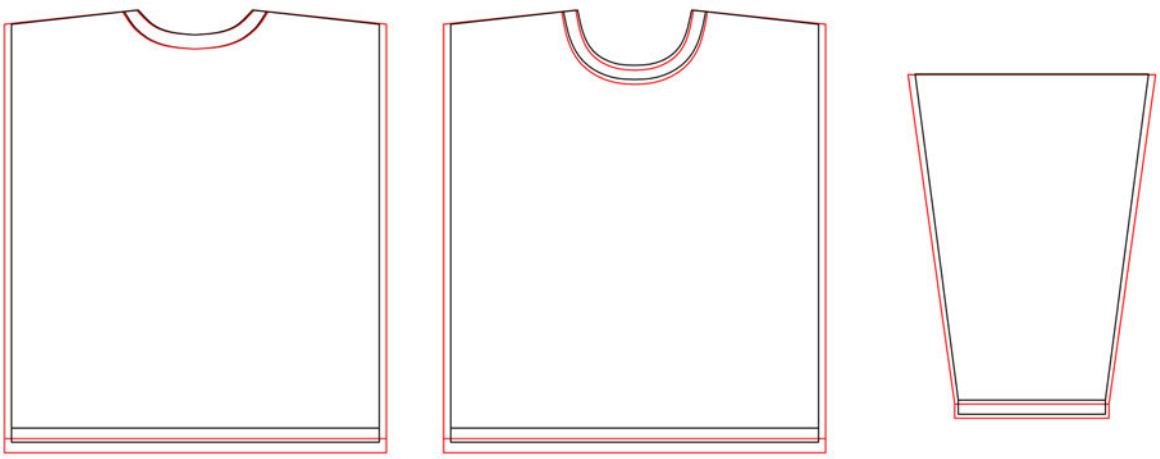


Figure 51. Difference between two sweater sizes

Bust	68	72	76	80	84	88	92	96	100	104	110	116	122	128	134	140
Letter code	XXS		XS		S		M		L		XL		XXL		XXXL	
Range	66/74		74/82		82/90		90/98		98/106		107/119		119/131		131/143	

Table 6. Letter code for women's clothing according to standard EN13402-3 "Size designation of clothes. Measurements and intervals"

Country	Size Women's Clothing													
Internatioanl Sizes	XS		S		M		L		XL		XXL		XXXL	
France, Spain & Portugal	32	34	36	38	40	42	44	46	48	50	52	54	56	58

Table 7. Converter of clothing sizes systems

Size	XXS	XS	S	M	L	XL	XXL	XXXL					
Confection size	32	34	36	38	40	42	44	46	48	50	52	54	56
Chest circumference	74-77	78-81	82-85	86-89	90-93	94-97	98-101	102-106	107-112	113-118	119-124	125-130	>131

Table 8. Combination of tables 6 and 7: Size standard for STRIKKS

From top to bottom:

Subject number: 16608

Bust size: 857

Arm length: 786

Size wearing: 36

Subject number: 15935

Bust size: 844

Arm length: 715

Size wearing: 36

Subject number: 16408

Bust size: 1068

Arm length: 747

Size wearing: 46

Subject number: 12345

Bust size: 1020

Arm length: 775

Size wearing: 46

Fig. 52 Developed sweater sizes evaluated on 3D scans from CAESAR database

To be able to compare the sizes on different scans, it has been chosen for to select completely different sizes (one small, one large), and pick two different 3D scans to see the difference. The sizes for the 3D scans have been chosen accordingly to the size chart above.

What is noticeable, already for the smaller sizes, is that the sleeves are on the long side. This increases when the garment size gets bigger, as both the shoulder width and the sleeve length increases with each size.

For both garments in size 46, the sleeves are definitely too long, as they completely cover the hand. What can be seen in the graph below, is that there is still a great variation in arm length when looked at the group of people who would fit into one size (40). Using only one sleeve length per garment size is thus not sufficient enough to give everyone something that fits, especially if you are offering customised garments.

Furthermore, with the increase of each size, it is assumed that the body grows linearly. By increasing the width of the garment, the length is also increased. Short, heavy people would thus end up with a sweater that is way too long (as chest circumference is the primary dimension that should be looked at (EN 13402), and long skinny people would have something more similar to a crop top. As the graph below confirms, there is no direct relationship between height and chest circumference, and thus this should also not be the case for clothing. This sizing system is thus not efficient enough for STRIKKS to suggest to their customers. Most people would walk away unsatisfied and there is nothing that suggest that the garment is personalised to their body.

From the fit analysis of the sweater on 3D scans, and the data from CAESAR that supports this, it can be concluded that using only standard sizes will not include most of your target group. Therefore, sizes of the sweater should have at least 3 variables. First, a size will be chosen depending on the chest circumference. For this, the width of the garment can stay the same as had been suggested. Then, a preferred length of the bodice should be chosen, and last but not least, a sleeve length that fits with the arm length of the customers.

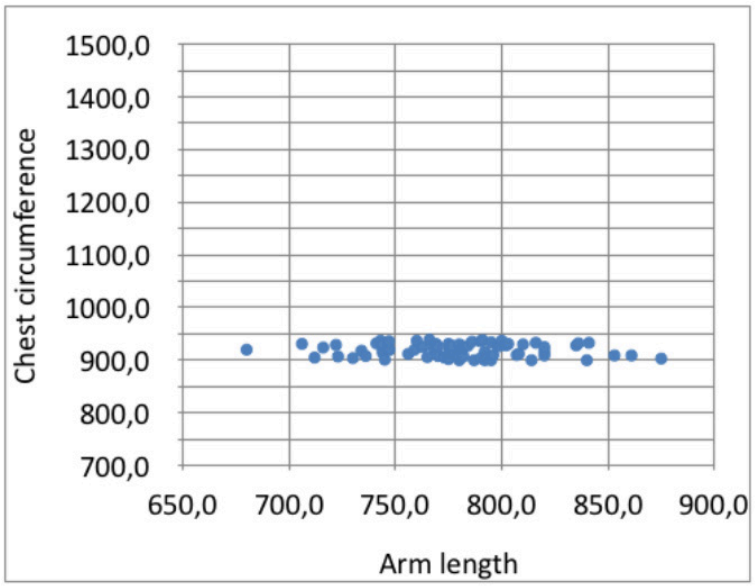


Fig. 53. Range of arm lengths for customers who fit in a size 40

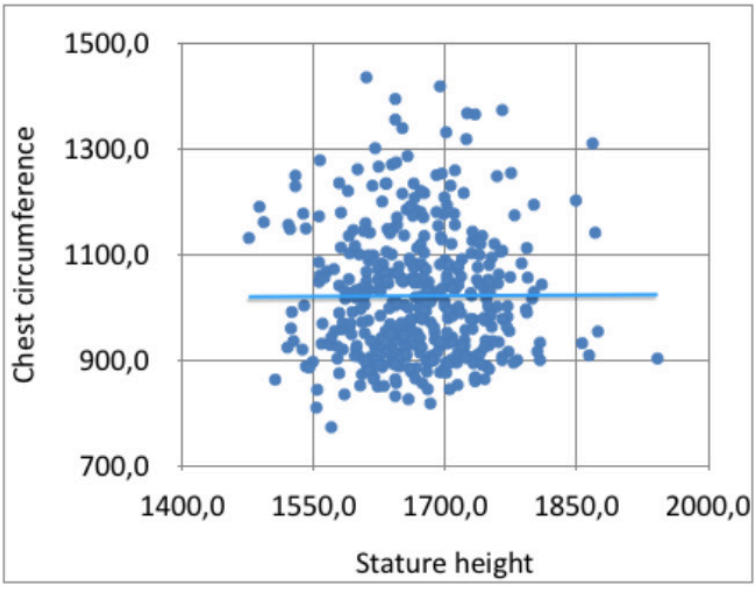


Fig. 54. Scatter plot with the relation between stature height and chest circumference

4.4 Wireframes

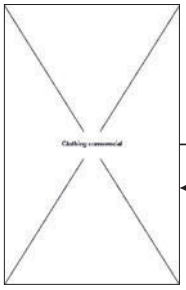
Based on the process tree wireframes have been made that show a possible interaction between the customer and the visualisation screen. In the overview on the next page a flowchart of the interface for the visualisation is shown. Based on the process tree described in the previous section, wireframes are made that show each step the customer can go through. Enlarged visuals of the wireframes can be found in Appendix 7.4.

- The screen, when not in use, might be used to display information such as a commercial or different garment compositions. When the customer wants to start the customisation process, she needs to touch the screen so that the display information will disappear and the home screen appears (02.)
- The home screen appears. If the screen is then not touched for x amount of time, it will go back to its original state: the information display. However, if "Press to start" is clicked, the customer will see the next screen (03.).
- This screen explains how the customisation process will go. This is done to limit the amount of help given by the shop assistants. This is screen also mentions that an account needs to be created to be able to continue. This will create a barrier to prevent people from playing with the system. If the customer does not want to continue, she can press "Nevermind!" and will return to the homescreen. If "Create account" is pressed the next screen will appear (04.).
- From this moment onwards, a home button is displayed in the top right corner. This button will always allow the customer to leave the customisation process. However, once clothing is added to the avatar, and the home button is pressed, a warning screen will appear (23.) asking if the customer really wants to exit.
- During this step some personal information is required. To create the account, a first and last name should be provided as well as an e-mail address that can be used to store information about the customisation process.
- On the next screen information about the body measurements are needed to create the avatar. This should be done with the help of a shop assistant to provide correct measurements. Once these are entered, the shopping can begin.
- At first sight, the avatar will be wearing a neutral sweater (Ecoplanet grey). On the right side 3 buttons have appeared that allow the customer to choose a garment model (07.), a fabric dessin (08.) and colour (09.).
- Once the large button is pressed, several smaller buttons pop up that the customer can choose from. In this case, the interface shows (from top to bottom) a long cardigan, a sweater, a dress and a skirt.
- To choose your next option, you can press the next big button on the list and a new pop up will appear with choices.
- Once all three choices are made, the clothing will be draped onto the avatar (10.).
- Every time the garment composition is updated, the avatar will be looking towards you. With the use of the two arrow buttons on the bottom, the customer can change the view of the avatar (11., 12.) by either rotating clockwise or counterclockwise. The avatar can be viewed from 8 different angles. Furthermore, as mentioned in step 4, if the home button is pressed from this point onwards, a warning screen will pop up.
- Once satisfied with the result, the customer can hit the "save" button at the top of the screen.
- This will store up to three compositions onto the account. At this screen the customer can switch between the compositions to be able to quickly compare. If you are no longer happy with the result, you can hit the trash can button and delete

the composition. By pressing the back arrow the customer will return to the customisation screen (14.).

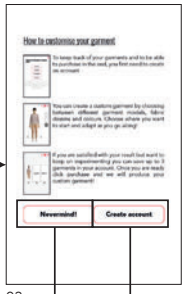
- From this point you can alter the garment by pressing one of the three large buttons. Once a new composition is made (15., 16.) the screen will visualise it (17.).
- For the same garment model, the sweater, a new fabric is chosen.
- Also a new colour is picked.
- This screen shows the new configuration. Again, the arrows can be used to spin the avatar. By clicking multiple times the customer can be seen from different angles (18., 19.).
- The configuration is saved once again. If the customer is satisfied with the result, she can press the shopping cart to start to order the garment (21.).
- If the button is pressed by accident, or for any other reason, but the customer is not ready to purchase yet, you can escape the screen with the "continue shopping" button. If you do want to continue buying you press "Yes!".
- This wil lead to the final screen where you are asked to go to the register to finalise the purchase. At that point the customer has to pay, and receives a print out of the garment she has just composed.

Fig. 55 Proposed interaction with wireframes

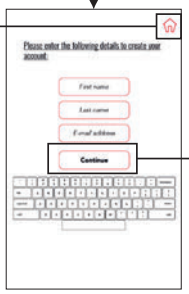


01.

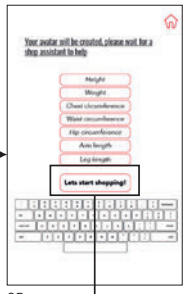
02.



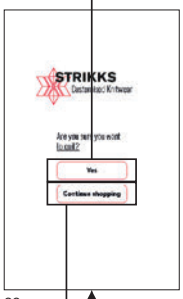
03.



04.

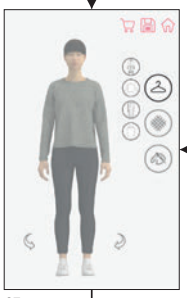


05.

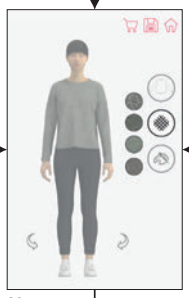


23.

06.

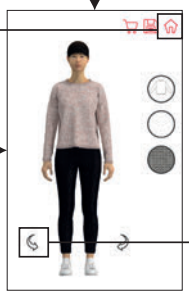


07.



08.

09.



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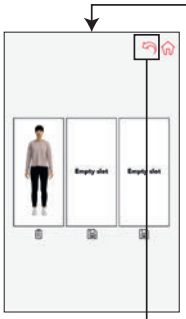
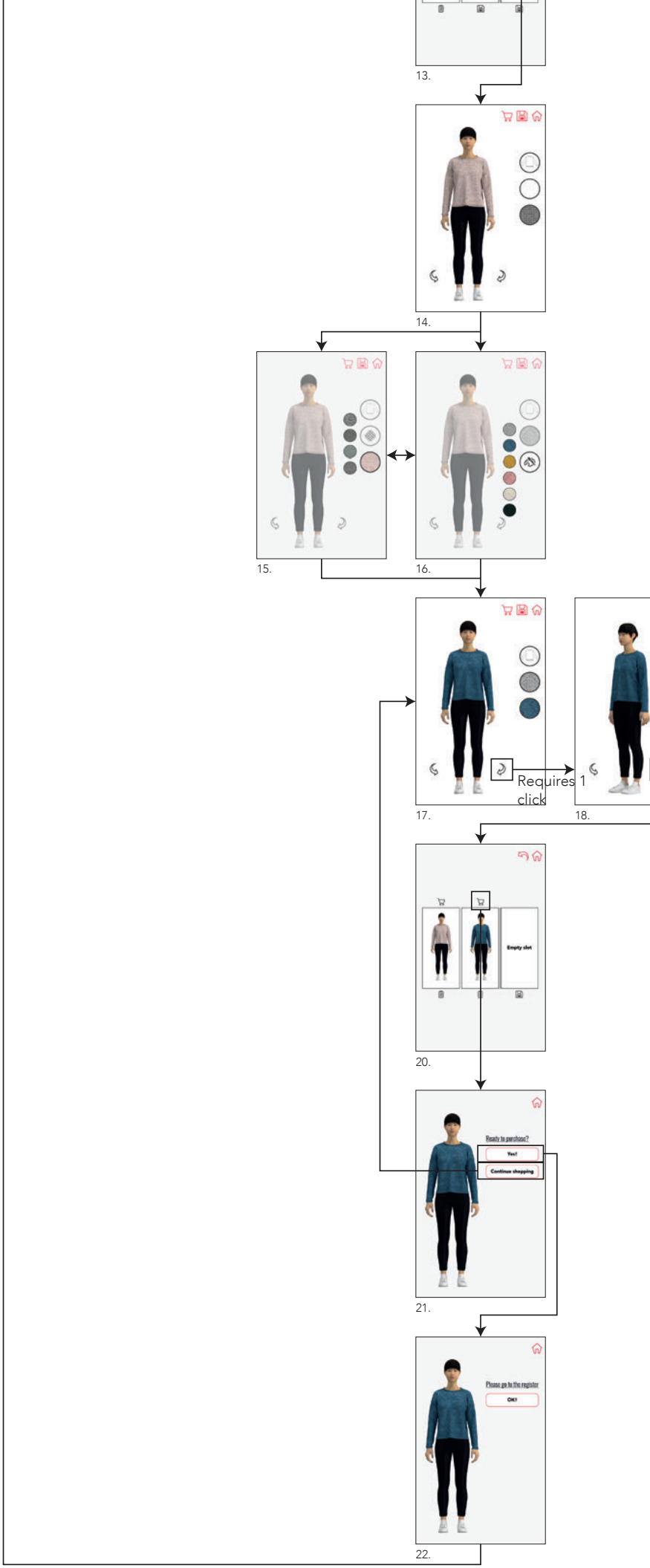


13.

Simulation

Fig. 56 Flowchart wireframes


13.
14.
15.
16.
17.
Requires 1 click
18.
20.
Ready to purchase?
Yes!
Continue shopping
21.
Please go to the register
OK!
22.

Evaluation Wireframes

Making a user friendly interface that the customers can intuitively interact with is important. The design should be able to be used by all ages within the target group of STRIKKS and should be used with minimal help from shop assistants. They can then focus on giving advice about styling and fabric choices.

The current design for the wireframes can only be used to customise the appearance of the fabric by choosing between different dessins and colours. The way the choices are made is similar to the original design of the interactive wall. By showing the dessin and colour options separately it looks like there is less choice available so the customer is less overwhelmed. Furthermore, a digital environment can be easily adapted whenever a fabric is no longer available or new fabrics and colours are added for the new season. Adding the ability to customise the fit of the garments is the next step. This could be done using either touching gestures (for example sliding on the screen) to increase and decrease sizes or by choosing from a selection of sizing options (for example: loose fitting garment, normal fitting or a tight fitting garment).

Unfortunately there is not yet an easy way to incorporate the functionalities and visualisations of Clo3D into another environment. The Benefit by Clo API could be a solution in the future whenever it is further developed as explained in the next chapter. Once this element is included the wireframes should be tested with the target group of STRIKKS to evaluate how the customisation process is evaluated. Especially older people would be interesting to analyse as they have less experience with modern technology.

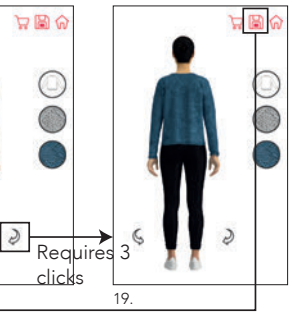


Fig. 56 Flowchart wireframes continued

4.5 Web API

For the visualisation of the clothes on the screen, CLO-SET and Benefit by CLO API's can be used. An API (Application Programming Interface) is a set of functions and procedures allowing the creation of applications that access the features or data of an operating system, application or other service (API, 2019). In the case of this visualisation, the clothing items are made in CLO3D whereafter they can be uploaded to the CLO-SET. The CLO-SET is an online cloud platform where you can share and communicate with your 3D garments. With the use of the API's, information about these garments can be retrieved and used in an application or web interface.

To get information from the server there are two common requests used: the get and post request. These two requests are used to transfer data from the client to server using HTTP (Hyper Text Transfer Protocol) protocol (Paul, 2017). Both get and post can be used to send and receive a response (see figure 57.). However, there are some differences. Using the post method, data is not sent as part of the URL string to the server, but instead the data is sent as part of the message body. This is used for sending sensitive and confidential data such as usernames and passwords. That is also why for both the login of CLOSET and Benefit by CLO a post request is used. Furthermore, using a post request you are able to send larger data that would not fit in the URL of a get request. This is thus used in the API's that sent more information in the body such as the 'Create Benefit Avatar' API.

In the next figure an overview is given of which API's are needed for the visualisation of the knitwear of STRIKKS.

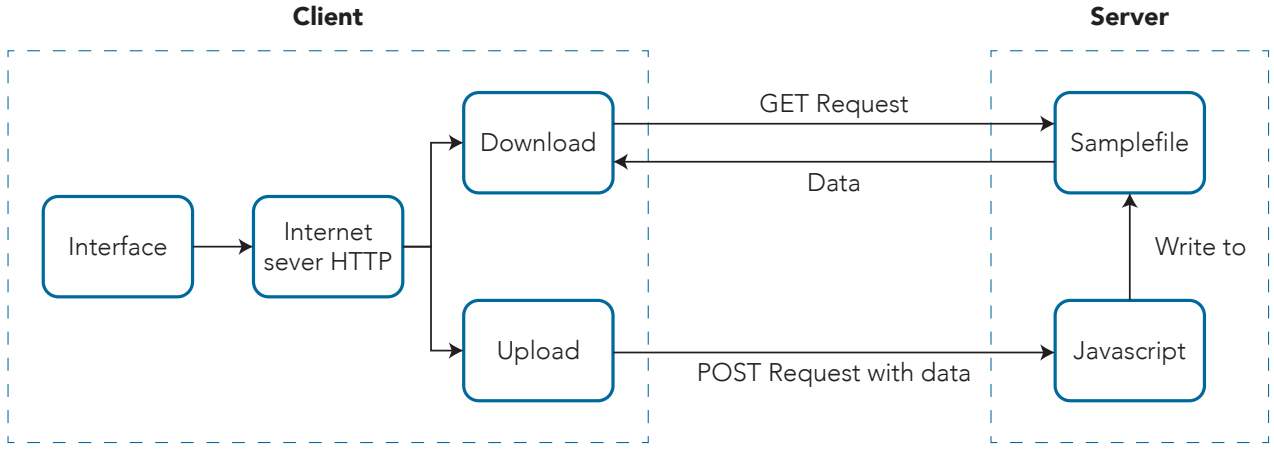


Fig. 57 Difference GET and POST request

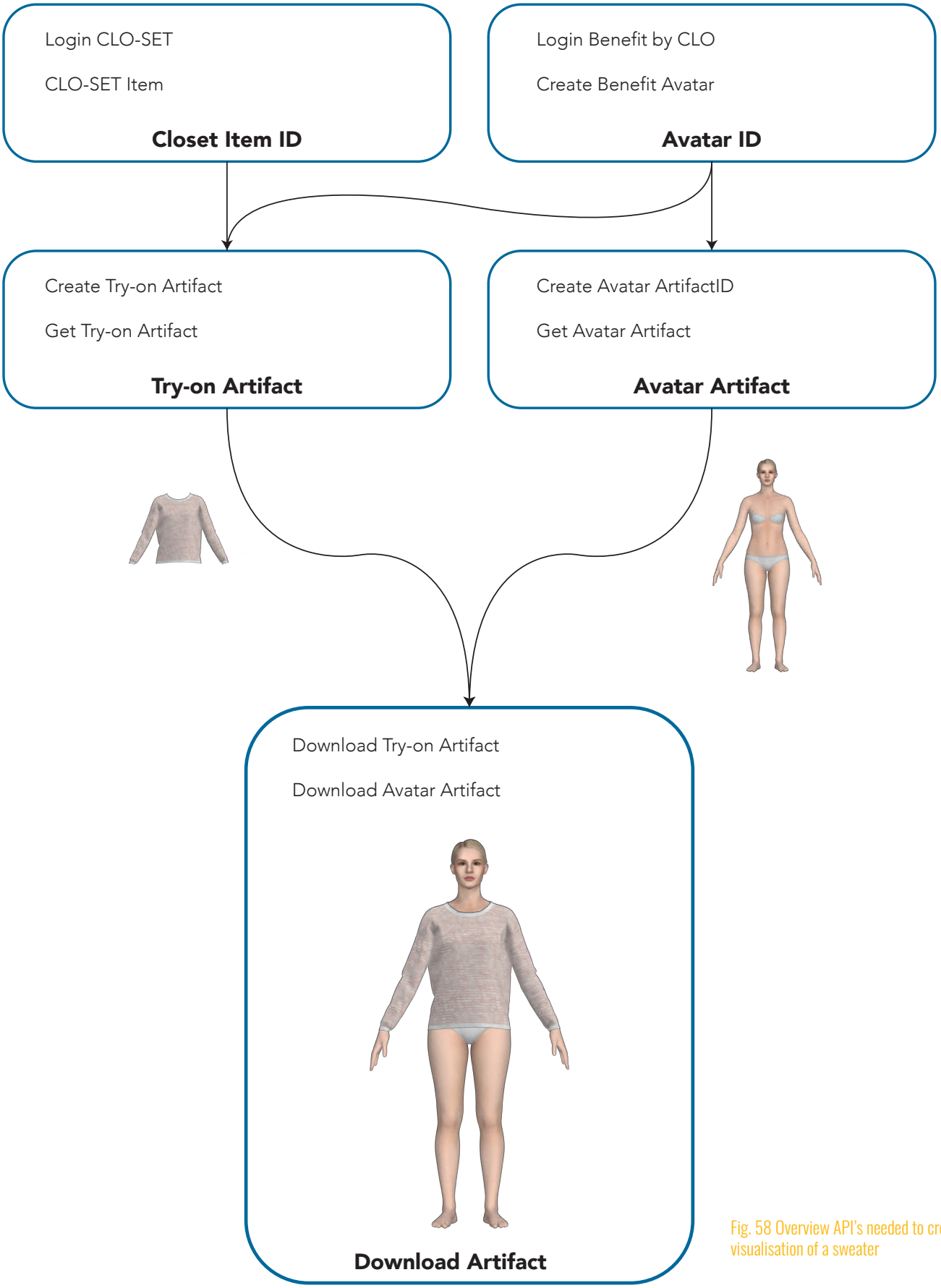


Fig. 58 Overview API's needed to create visualisation of a sweater

To be able to visualise the clothing onto the avatar a sequence of events should happen. These events will take place by calling specific API's from the CLO-SET and Benefit by Clo website. First of all, to get access to all remaining API's you need to log in to both CLO-SET and Benefit by Clo. This can be done using the same log in details for both API's, and this account should be connected to the account with which the garments are made in Clo3D. After an authentication token is given for both API's this information is submitted during the other API's to get access.

Then on the CLO-SET side, an ItemId is needed to retrieve the correct garment from the CLO-SET database. At the same time, an avatar is made using 7 body measurements as input. These measurements are height and weight, but also include bust, waist and hip circumference and arm and leg length to increase the accuracy of the avatar. With both the avatar id and clo-set item id a try-on and avatar artifact can be made. This artifact can be either several png files or an obj file (standard 3D image format). In the last step, these artifacts will be overlapped to create an avatar 'wearing' the garment.

For each API input is required that at least describes which method will be used as well as the URL to which the request should be made. For each request a unique URL is needed that stores the file location. Other input can include parameters for get requests or data in the body of the request of post request, and headers, that allow the client and server to pass additional information with the request or response, such as authentication information.

Then after the request is executed it will deliver a response. This response consists of data which can include an authentication token that needs to be used to call other API's on the same server, a variable that is used as input in other requests (e.g. ItemId) or output such as a png that can be used for the visualisation. In appendix 7.5, a full overview can be seen of what input and output is given for each of the above mentioned API's.

Table 9. Comparison possibilities with Clo3D, the Benefit by Clo website and their Web API's

	Clo3D	Benefit by Clo Website	Web API's
Different fabric options	Yes	Yes	No
Sizing options	Multiple grading options & manual grading	Single grading options	No grading
Quality images	High (depending on time)	Poor	Poor
Fabric texture	Visible	Not visible	Not visible
Measurements avatar	Many	7	7
Adjust skin/hair colour	No	Yes	Yes

Evaluation CLO-SET & Benefit by CLO API's
Although the API's of Clo3D seem like a perfect and easy way to make your own web interface, this is unfortunately not the case. As makers of Clo3D, CLO-SET and Benefit by CLO are still developing their own virtual fitting room, a lot of features from Clo3D are not available yet. As part of their development, they allow the users of Clo3D to beta test their Benefit by CLO website, where you can virtually try on your clothing created in Clo3D. However, as of the 24th of May, the BeneFit Team has put a restriction on number of POST calls and restricts you from commercial use of the service before the service is officially launched.

At this point, there are still some significant differences present between Clo3D, the Benefit by CLO website and the web API's. Table 9 gives an overview of the differences between the three.

- The most important differences are that the web API's do not allow you to choose between different colour options or different sizes from your garment grading. These are two of the main options for customising your garment, and without, the whole concept cannot be conveyed. The colour and sizing options, however are available in the website of Benefit by Clo as can be seen in figure 59. This would suggest that this could be an option for future API's but is not yet implemented as they are still beta testing.
- However, using standard graded garments is still not an ideal option. As was noticed with the garments that were graded by Sandra, even with multiple sizes you would not be able to find a fitting garment for everyone. Using Clo3D, you are able to choose different grading systems for each pattern component, allowing you to scale the sleeves and bodice separately already increases the number of correct fits. However, being able to adjust all dimensions of the garment pattern individually is still preferred over this work around.
- The quality of the visualisation is poor on the website and api compared to the visuals created in Clo3D. As the website wants to have quick response times, image quality is decreased and file uploads are limited. This makes it hard to see the texture of the fabrics. In Clo3D, when zoomed in the texture is clearly visible (as seen in the image on page 81).
- Furthermore, for all mediums it is possible to upload a 3D scan. However, when using the avatar editor in the programmes themselves, the quality is also quite different. On the website and web API's you are able to adjust up to 7 dimensions of the body. In Clo3D on the other hand, you are able to adjust 30 measurements creating a more accurate result.
- One of the advantages of using Benefit by Clo compared to Clo3D is that you can easily switch between different skin colours, also including darker skin tones that are not standardly available in Clo3D.

Fig. 59. Colour and sizing options available on the Benefit by Clo website [24].

4.6 Store Design

Although the visualisation might be the most important aspect of the design of the future store of STRIKKS, there is more to think about to complete the whole experience. The front of the store should attract its customers and lure them in. Once inside, the overall look of the store should engage you in shopping and make you want to purchase something.
As a first step in designing the store a collage is made with memetic references (see fig. 60). This collage shows the look and feel of the shop with memes such as forms, colours, materials and textures.

I think the store should have a feminine look to attract their customers but at the same time be minimalistic to let the clothes be the hero of the store and to have space to explain the concept.

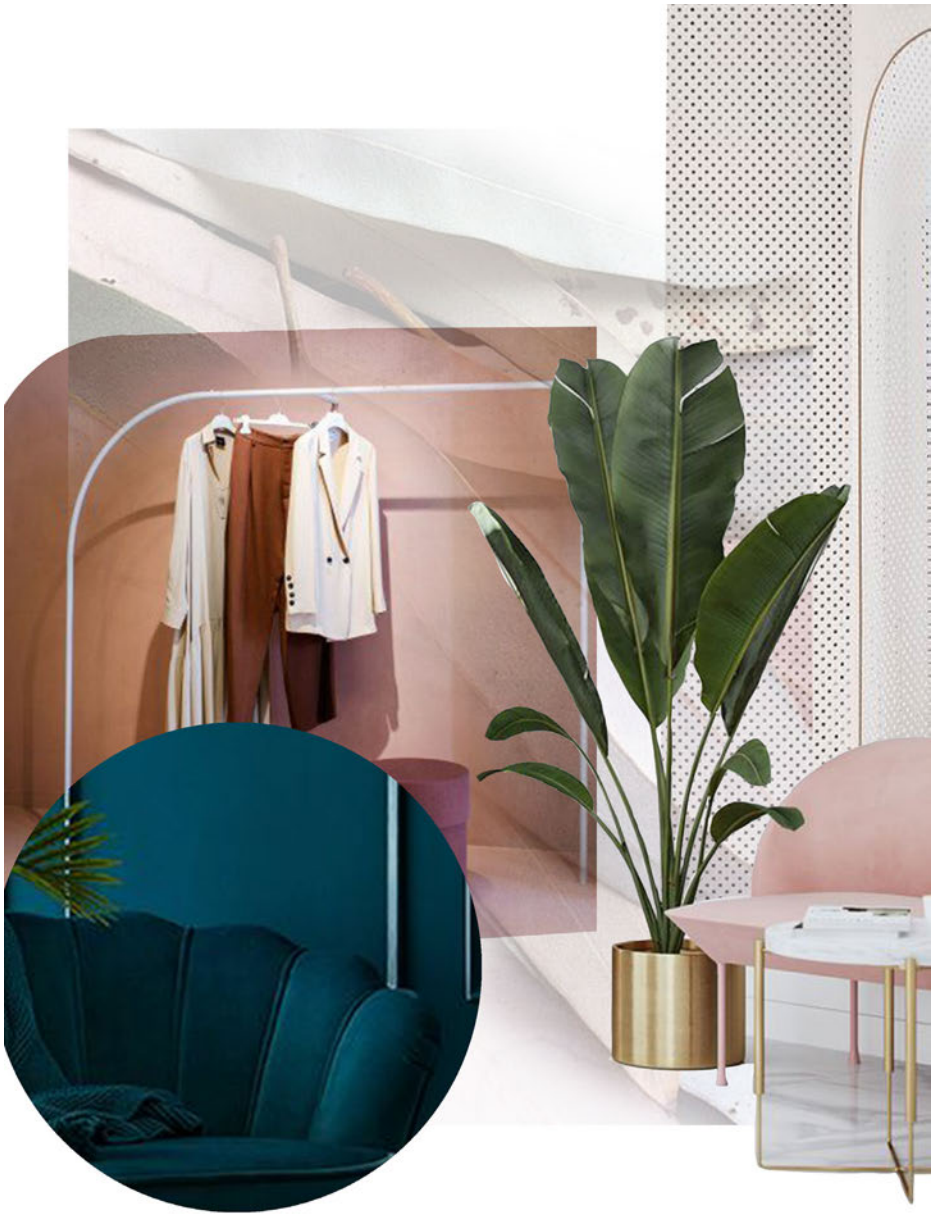


Fig. 60. Memetic collage for potential STRIKKS shop

As STRIKKS won't be the first one to open up a store, there are some guidelines to help you become successful (Khan, 2018)(Brophy, 2019)(Kizer & Bender 2007). These guidelines include: the entrance, the power wall, store layout and check out.

As soon as the shop front windows have persuaded you to come inside, you enter the decompression zone. The decompression zone is the area in the shop just located right behind the entrance. It is the space where your customers transition between outside and inside. It is the area where they can take a glance at what your shop has to offer and estimate if your items fit with their taste and budget. As customers are in their transition mode, they are more likely to miss any items inside that decompression zone (Kizer & Bender, 2007)(Underhill, 2009).

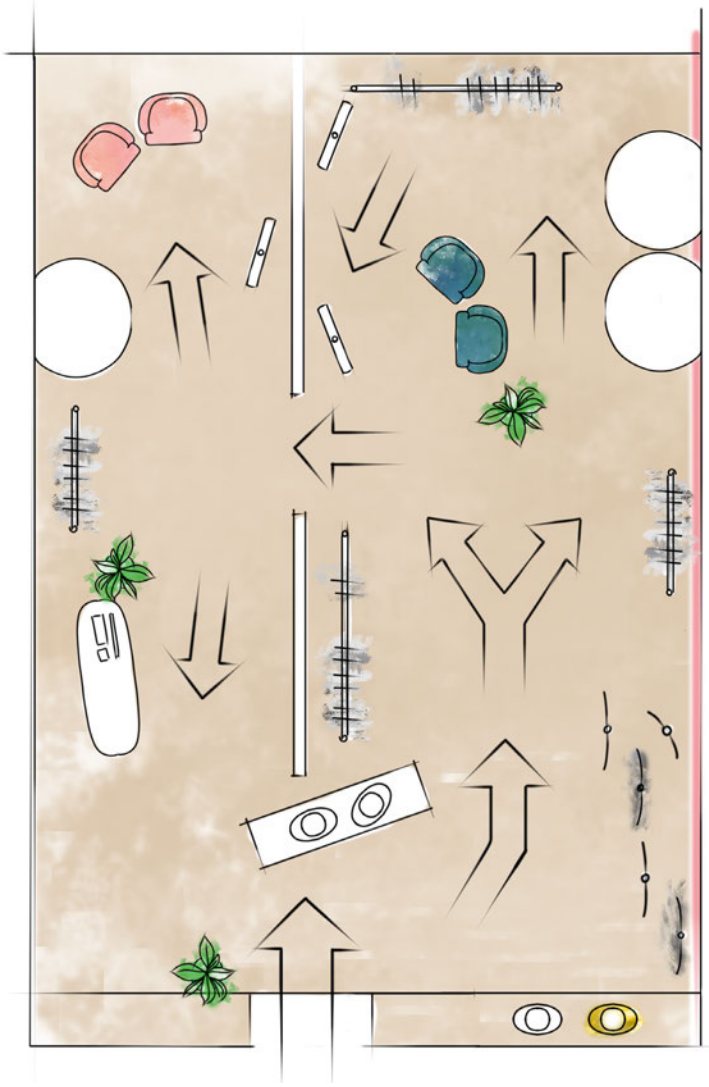


Fig. 61. Floorplan store including guided loop walking flow

After you have decided that you would like to browse in the shop the question is where you go. Depending on what kind of floor plan your store has (grid floor plan, loop floor plan or free flow floor plan) you can guide your customers differently. For the apparel industry, a loop or free flow floor plan is recommended (Brophy, 2019). For STRIKKS I have chosen for a loop floor plan (see fig. 61). This creates a guided shopping experience where a defined pathway can tell a story to the customer. In STRIKKS case this could be valuable as a customer can browse the different garment models in the beginning of the store, then get introduced to the different fabrics, create their customised garment and ending their route at the register. According to Khan (2018), Brophy (2019) and Kizer and Bender (2007) most people, in a country where you drive your car on the right side of the road, tend to turn right just after they have entered the store. This decision can also be enhanced by placing your register at the front left area of your store. As the register is often the last place you visit at the store it would make it more logical to start your shopping journey at the other side of the store.

After turning right, you face the so called "Power Wall". It is one of the first areas where customers will be looking for items to buy. That is why this is a perfect place to display important items such as the new and seasonal items, or items that are highly on demand. Furthermore, this would be a perfect place for STRIKKS to introduce its customers to the customisation concept.

Fig. 62. Front window and power wall.

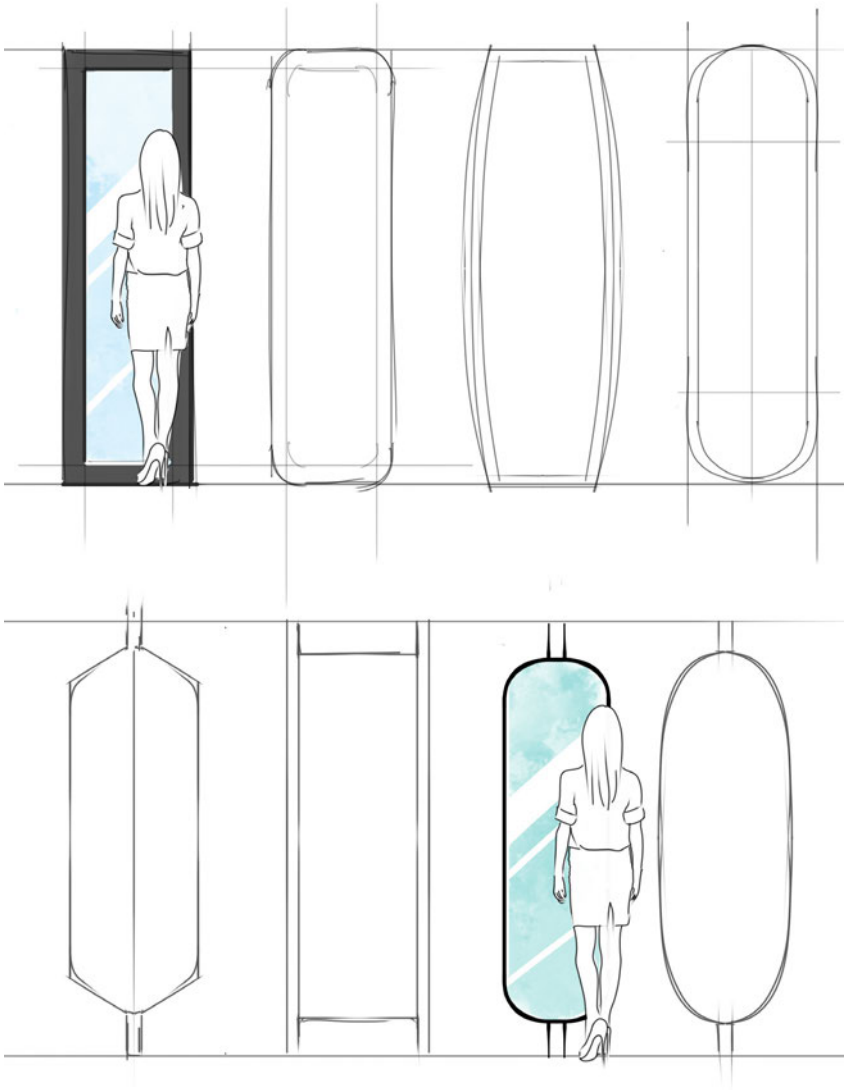


Fig. 63. Design sketches of visualisation mirror

After turning left again, the customer will be surrounded by clothing racks displaying samples of STRIKKS' clothes. The different garment models can each have a few different fabric and colour combinations to inspire the customer.

Walking even further there are the customisation areas. These areas include a mirror-like display, seating area's and changing rooms. From the different mirror sketches the third one on the bottom row is chosen as this fits with the memetic collage and because it would be connected to the floor and ceiling it could have a dual function. One side of the display could be used as a regular mirror for the customers who might not yet be interested in customising their own garment, while the other side of the mirror includes the screen that is necessary for the customisation process. The mirror will then be able to spin around its axes. While the customer will be either trying on a garment in the changing room or get her measurement taken in a more private area, their friends or family can take a seat in the sitting area. The changing booths can even be converted into 3D scanning booths at a later stadium of the store.

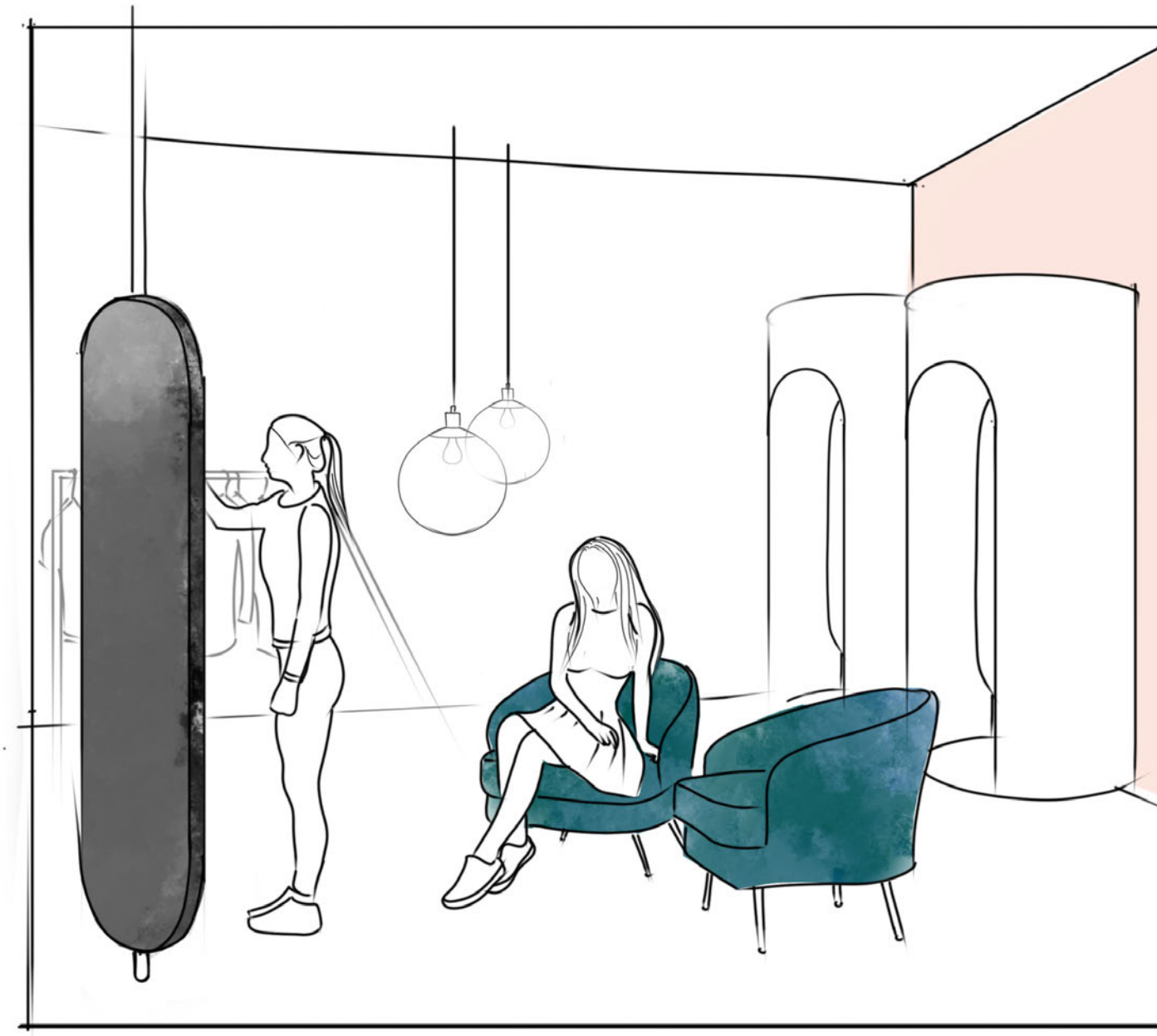


Fig. 64. Customisation area including changing booths, a seating area and visualisation mirrors

In this potential shop of STRIKKS at least 2 or 3 employees should be present. One shop assistant should have the skills to take correct measurements of the body and use them as input for the visualisation. Whenever he or she is not busy they can help people with understanding the concept or help the customer through the personalisation process. Another shop assistant could then also be helping at the other customisation area while also managing the register. Making sure they have multiple jobs to do could give the customer also some alone time with friends or family to try some things out that they might otherwise feel uncomfortable with.

5 Evaluation

5.1 Validation Visualisation

The product-service system that has been developed will be evaluated. This will be done in terms of customisation experience and whether the produced garment is comparable with the visualisation made during the customisation process.

Comparing a knitted garment to the visualisation shown is a key part of this process. If this visualisation is supposed to convince the customer of buying a garment that she is looking at, but receives something completely different, then the visualisation is not helping the customer. To show what is meant, a visualisation of the garment that has been customised earlier this year has been visualised in the Clo3D software. The pattern that STRIKKS has used to knit the garment has been copied to the software and then shown on an avatar with the same dimensions as the participant. When compared to the photographs taken with the participant actually wearing the garment, some differences are noticable. The fabric on the visualisation seems more rigid and therefore facing forward instead of hanging alongside the body as shown in the photograph. Furthermore, the sleeves seem much larger in the visualisation compared to the sleeves on the real cardigan.

What is important to find out, is where these irregularities come from. Therefore a test has been set up that will be used to see whether these differences are a one-off or whether there is a fault in the visualisation process and/or knitting process. 6 Sweaters, with a simple pattern, will be produced from the patterns generated from the visualisation of Clo3D.

Fig. 65. Comparison visualisation long cardigan and photographs of knitted garment

5.1.1 User testing visualisation Clo3D

Purpose of this research

The purpose of this research is to analyse the effectiveness of the visualisation that is being used. Visualising the avatar and the garment will both be evaluated. This visualisation will be used for informing the customer about how the garment will drape on their specific body and how the combination of different colours and dessins will look like.

For this research, it is chosen to only use one type of garment: the sweater. This is done to see if any defects in the sweater are present multiple times indicating that there is an error in the procedure. To evaluate the adequacy, a comparison will be made between the garment that is being visualised and the produced garment. The visualised garment will be rendered from different viewing angles and from the same viewing angles pictures will be taken from the participants wearing the sweater. This research will take place in two sessions: the first where the garment is customised and the second session (4 weeks later) where the garment will be tried on and evaluated.

Research question

- How effective is the visualisation in conveying the appearance and behaviour of the knitted garment on the customers body once produced?

Sub questions

- Does the user feel that the avatar resembles herself?
- To which extend does the knitted garment differ from the visualisation with regard to the fit of the garment?
- How well are the colours of the fabric represented on the screen compared to the real life samples?

Methodology

During this user test, participants are asked to customise their own sweater. They can do this by adjusting the length of the sleeves and the total garment as well as choosing a combination of dessin and colour

Participants

For this research study 6 female participants were invited that were able to create their own garment. These women are from the Faculty of Industrial Design Engineering of the Technical University of Delft. They have voluntarily indicated that they were willing to participate and were chosen from a larger group of students because of their different struggles with shopping for clothes (e.g. broad shoulders, long and slim figure, larger breasts). After participants consent was given, data was collected of specific body measurements.

Most struggles were related to two or more body measurements as clothes would fit one measurement but not the other. To confirm the issues the participants had with shopping, their body measurements were compared to the measurements in the DINED anthropometric database of Dutch adults in 2004 (female 20-30 years old)(Molenbroek, 2017). In the table below the issues mentioned are shown in both measurement and to which percentile of the population this would belong.

Equipment
The visualisation was made with Clo3D software on a Macbook and run on a 55 inch screen by CTouch via an HDMI cable. This screen shows the whole avatar as large as possible. Furthermore, the body measurements were taken using a flexible tape measure. The body measurements that are taken can be found in appendix 7.6.

To show what fabrics can be applied to the sweater, of each knitted fabric a sample is present of 25 by 25 cm. Furthermore the labels on these fabrics state of what material they are made. Besides, there are also 3 example sweaters present of each the same size but made from different fabrics to show how this will influence the garment as a whole (one in white honey dessin, one in binary pink dessin and one in a grid dessin similar to mohair grid but the fabric is not available anymore for choosing). These examples however are NOT available to try on as this might give wrong impressions, and the visualisation itself should show how the garment will fit.

Participant	Issue	Measurement (mm)	Percentile
1	Large bust circumference	1020	77,1
	Large hip circumference	1125	80,92
2	Large bust circumference	990	66,75
	Small waist circumference	765	41,01
3	Short sleeves because of tall stature	1880	99,8
	Small waist circumference	755	37,52
4	Broad shoulders	390	8,21
	Large bicep circumference	365	Unknown
5	Short sleeves because of tall stature	1820	97,64
6	Small waist circumference	840	13,28
	Large hip circumference	1020	41,34

Table 10. Body dimensions that could cause issues during shopping

Procedure Session 1
The participants will have about 45 minutes to go through the customisation process.

1. Participants were informed about the purpose of the research and the procedure.

2. A consent form was signed to continue with the study (see appendix 7.7).

3. The concept of customised knitwear and the benefits that go along are explained. The participant is then told what different kind of options are available to customise the sweater.

4. Measurements of the participants body will be taken using the tape measure by Maartje Boer. These measurements are then used as input for editing the avatar in Clo3D. The measurements will be written down with pen.

5. The avatar will be adjusted on the computer without the participant viewing this process. Once the avatar is finished, it will be shown to the participant.

6. The jeans and sweater size will be adjusted to the participants body, and a neutral grey fabric (Ecoplanet Grey) will be applied to the sweater. This process will again not be shown to the participant. Once finished, the avatar will be shown to the participant in a 360 degrees view.

7. The next step is to choose a dessin and colour for the fabric. The participant is allowed to touch and feel the fabrics, compare them side by side and thus ask to see the fabrics on the sweater in Clo3D. The participant can choose different fabrics for each of the pattern components (so each part of the sweater that is knitted separately can have a different fabric). During this process, Maartje Boer will give advice if certain combinations are not ideal to match or whenever asked.

8. The participant is asked to which extend she thinks this avatar represents her body.

9. The participant is then asked what she thinks about the length of the garment and sleeves and whether she likes the fit of the sweater. These parameters will be adjusted if the participant is not satisfied. This process will be visualised on the screen so that changes can be made quickly.

10. After a final decision is made about which fabrics are wanted, the size of the sweater is checked, as different fabric properties could influence this.

11. The final result will be rendered and emailed to the participants. Furthermore, they will receive a card from STRIKKS that illustrates their design.

12. After the 'purchase' is made, a few questions will be asked.

After all participants have successfully created their own unique sweater, STRIKKS will start production of these sweaters. The patterns that are created using the Clo3D software will be used.

Interview

- How would you describe your body?
- How would you describe the body of the avatar?
    - Why is this different?
- Does it bother you that the avatar does not have the same skin/hair colour that you have?
- Do you feel the avatar resembles you the way you see yourself in the mirror?
- Did this make you feel any way?
- Did you make fabric choices based upon the visualisation shown or the fabric samples available? (in terms of physical properties)
    - Why?
- Did you make colour choices based upon the visualisation shown or the fabric samples available?
    - Why?

On a scale from 1 to 5 (1 very low, 5 very high)

- What are your expectations towards the quality of the knitted garment?
    - How high are your expectations towards the quality?
- What are your expectations towards the fit of the knitted garment?
    - How high are your expectations towards the fit?
- What are things you will be critical about once trying it on?
- If you were really purchasing this garment in a shop environment, would you have made the same purchase?
- If you were buying this online, would you have made the same purchase?

Procedure Session 2

1. Participants are welcomed back and a few questions were asked about what has been going on in their mind since the first session (see interview questions).

2. The participants are asked to open the gift bag with their name on it. They are asked what their initial thoughts are on the sweater.

3. The participants are asked to put the sweater on and can take a look in the mirror.

4. They are asked to express their opinion about the sweater.

5. The original visualisation is shown and asked to compare the knitted sweater with the virtual avatar.

6. Afterwards another few questions are asked to evaluate the garment.

7. At the end the participant is given a gift card to thank them for their participation.

Interview

- If you think back to the first session where we have customised your garment, would you have taken the chance and purchased the garment?
    - Why or why not?
    - What else do you need to take this step?
- What have you done with the visualisations that I have send to you? Did you show them to anyone?
    - What were their opinions?
    - Did this change your expectations about the sweater?
    - If yes, what are your expectations now on a scale of 1 to 5?
- What are your initial thoughts about the sweater?
    - What do you like and dislike about the sweater?
- Does the sweater fit as you expected?
    - Why, why not?
- Is the fabric the way as you expected?
    - Why, why not?
- On a scale of 1-5 how content are you with the sweater? Both in terms of the overall sweater as well as the fitting of the garment?
- To which extent is this better or worse than you expected? (much worse, worse, neutral, better or much better)
- How would you compare the knitted sweater with the visualisation?
    - What is the biggest difference?
    - What do you think needs to improve?

Roles

Facilitator

Maartje Boer will lead the customisation session as if she was an employee of one of STRIKKS' shops. She would be assisting the customer through the process and has the knowledge every assistant should have. This knowledge includes, what options are available to customise and which are not. How different fabrics have different properties and how these influence the behaviour of the fabric and thus also the draping.

Data processor

I will be the data processor and thus not influence any choices that will be made by the customer. I will be behind the computer adapting the visualisation to all the changes that are made by the customer as if this would be an automated process.

Visualisations created garments

At the end of the first session, each participant had created their own unique garment. The result of these garments are shown in the next figures 66 through 71.

Fig. 66. Visualisation participant 1 in front view and zoomed in 3/4 view

Fig. 67. Visualisation participant 2

Fig. 68 Visualisation participant 3

Fig. 69. Visualisation participant 4

Fig. 70. Visualisation participant 5

As the garments were adjusted in real time in Clo3D, the patterns can be directly used to start knitting. A comparison has been made between the garment and the body dimensions of the user to check for potential fitting problems. For the first, and second particpant, it seemed that the fit around the bust area would become too tight, as for the first participant the measurement for the chest circumference was equal and for the second participant only a centimetre difference was present. The positive ease between the garment and the body measurment was increased to 4 centimetres.

Fig. 71. Visualisation participant 6

Patterns used for knitting

On the next pages the knitting patterns with different dimensions can be found. Each participant, because of their unique body has a unique pattern. The back and front panel are the same width and have the same seam lengths on the side. The center of the front or back, however, can differ in length to create a visual horizontal line at the bottom of the sweater when it is being worn.

Furthermore, the neckline and finishes are the same for every sweater, except the plisse sweater for participant 5 where the finishes at the bottom have been removed to let the plisse flow better.

The sleeve lengths are ideally not adjusted. Only for participant 3 we had to increase the width otherwise her arm would not fit into the sleeve (this was one of the issues of this participant). The left and right sleeve have been made to the same measurements.

All patterns have been created on a scale of 1:10.

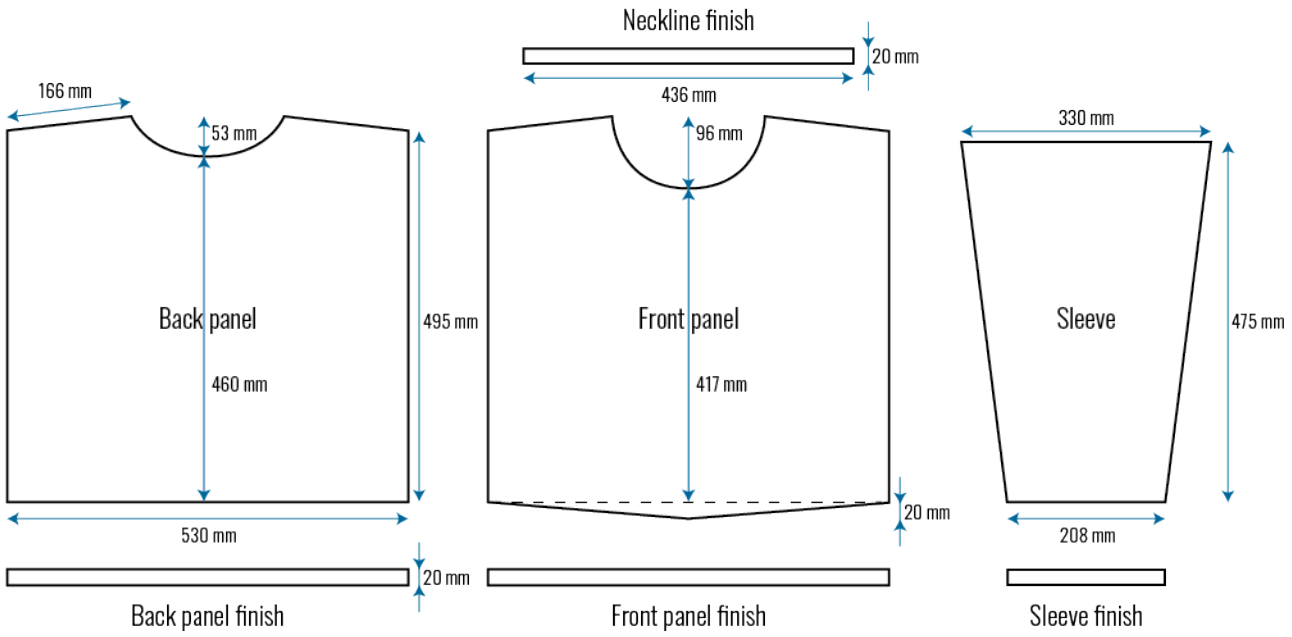


Fig. 72. Knitting pattern for the sweater of participant 1

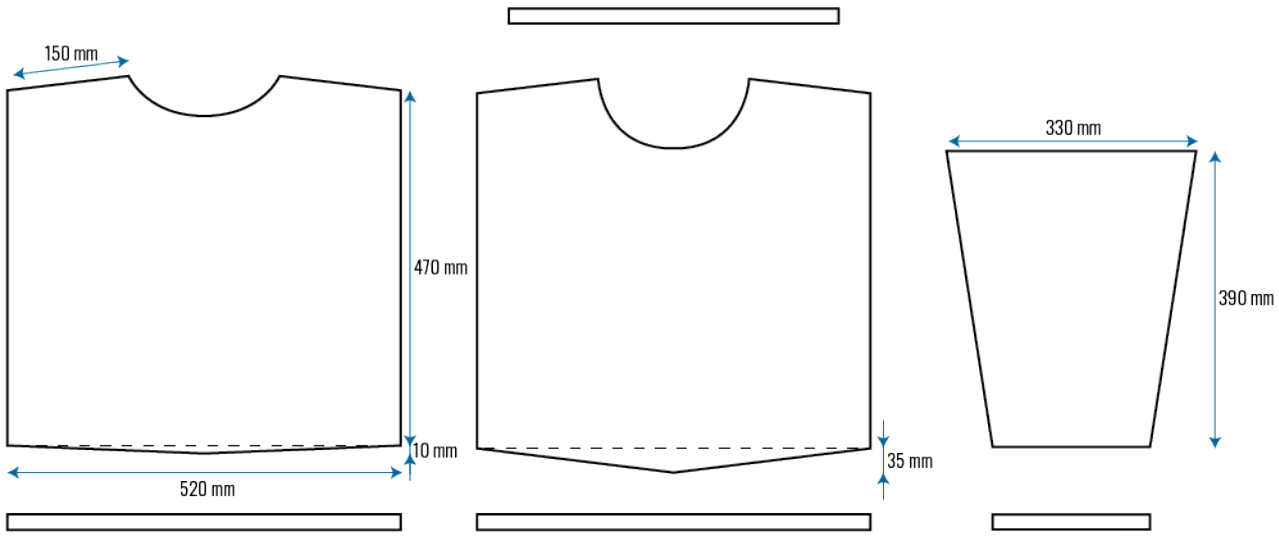


Fig. 73. Knitting pattern for the sweater of participant 2

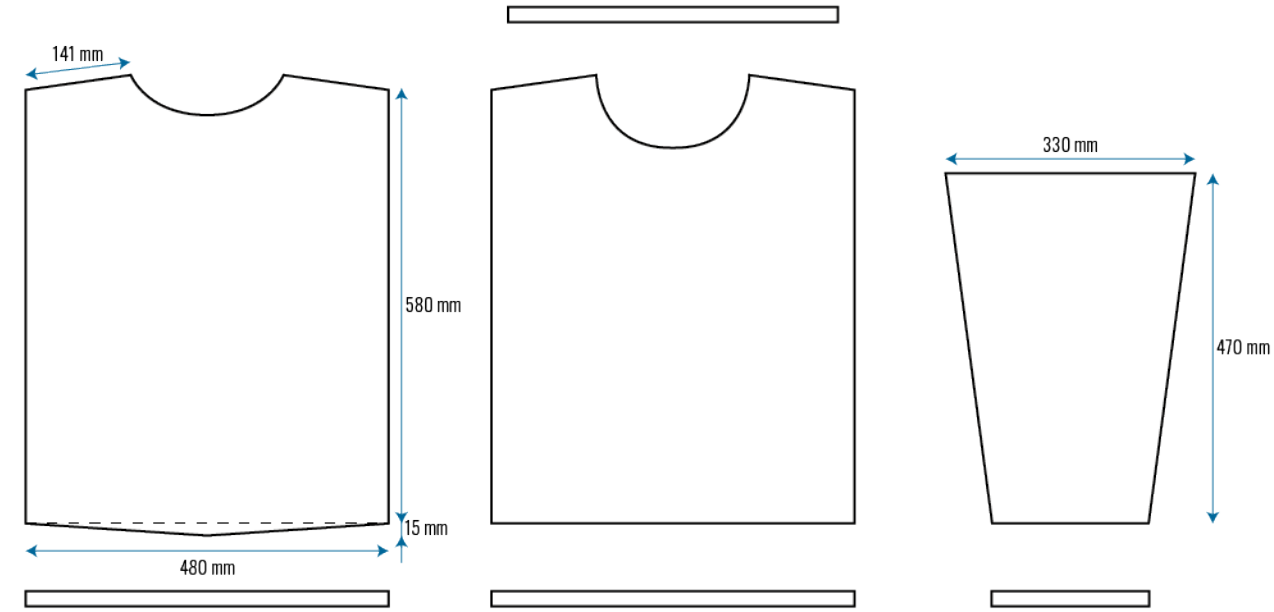


Fig. 74. Knitting pattern for the sweater of participant 3

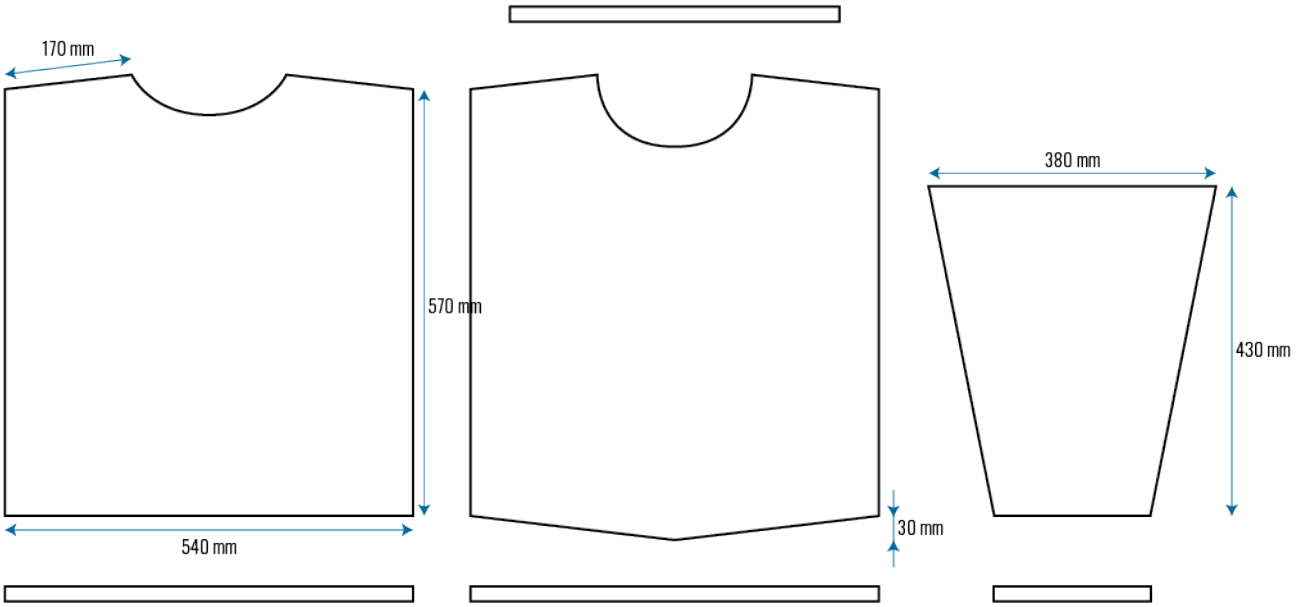


Fig. 75. Knitting pattern for the sweater of participant 4

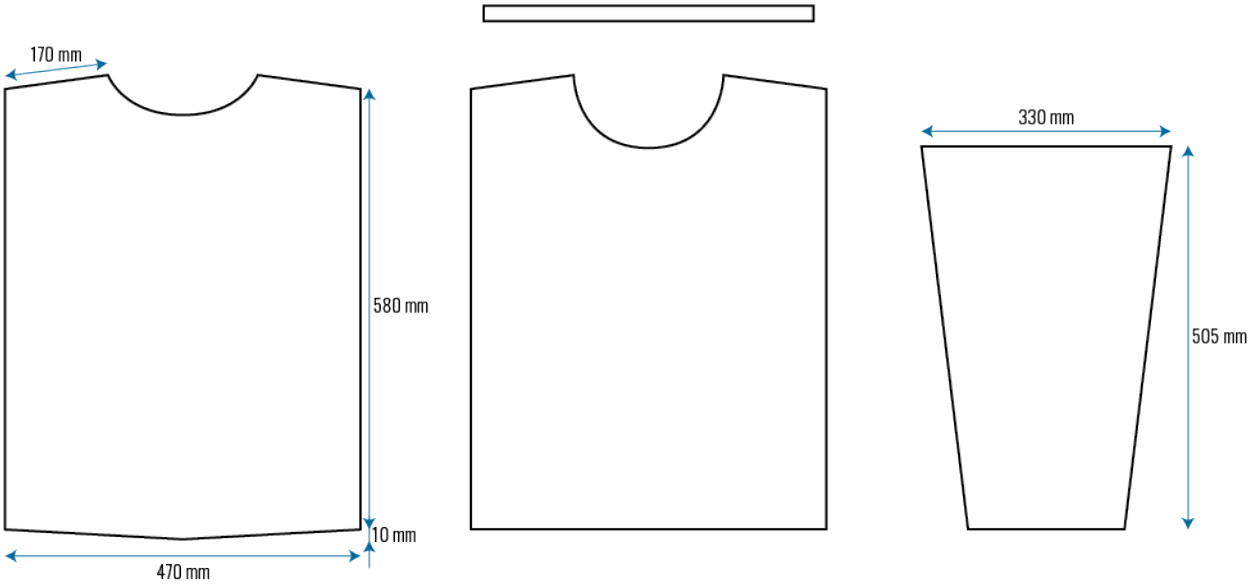


Fig. 76. Knitting pattern for the sweater of participant 5

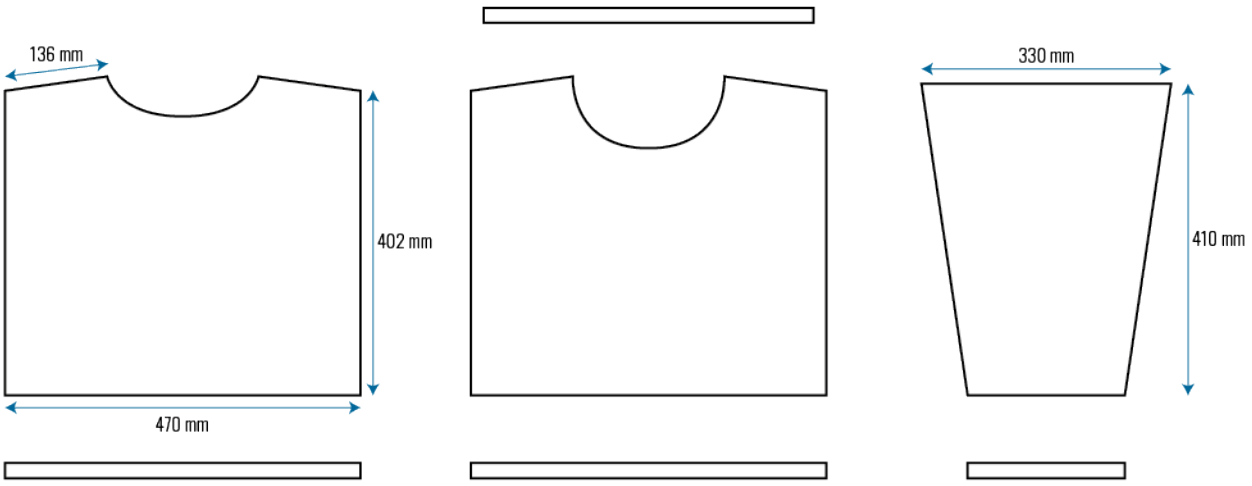


Fig. 77. Knitting pattern for the sweater of participant 6

5.1.2. Results user test

The results of this research consists of a three different elements. First of all, how did the participants experience the customisation process and what observations were made that could influence the effectiveness of this customisation experience. Secondly, the visualisation and the knitted garment will be compared. And lastly, it will be analysed whether or not the expectations that were formed during the first session are met and what could have caused this.

Observations and potential problems

Sweater

- The way the sweater is designed, it has a straight underside of the garment when laid flat. However, when the garment is draped over the body the sweater never looks straight. The sides of the garment look longer than the front and back. This was experienced as unpleasant as this could reveal the belly or back of the customer. It was desired to lower the front and back of the sweater to create a visually straight line at the bottom of the garment as it would be worn. To achieve this, the pattern had to be adapted which created a challenge for knitting the sweater.
- The pattern of the sweater for the plisse fabric is different from the other fabrics. Because the plisse fabric has the tendency to unfold it becomes wider at the bottom than at the top where it is stitched in place. To keep this characteristic of the fabric it is unwanted to create a border at the bottom of the sweater and sleeves as is done with the other fabrics to create a neat finish. This widening at the bottom also creates a zigzag effect at the bottom which is hard to visualise. This can be done in Clo3D, however it requires a totally different pattern than all the other fabrics.
- During the customisation of the fitting of the sweater the width of the sweater could not be adjusted without changing the length of the sleeves at the same time. As the width of the garment increases the width of the shoulders increases as well which then again affects the total sleeve length. If the sleeve length was determined but the customer wanted to adapt the width of the garment, we should have decreased the sleeve length with the same amount as the increase of the width of the sweater. The exact amount was often forgotten and the sleeve length had to be readjusted visually which could have led to an undesired result.

Clo3D

- Clo3D has the option to select and move the garment pieces in the 3D environment without adjusting the pattern in the 2D environment. You could compare this to pulling and adjusting a garment in real life. With this tool a garment can be draped slightly different on the body of the avatar to adjust faults of the simulation (e.g. fabric being stuck in the avatar). The danger with pulling the garment too much is that it could end up being in an unnatural position and would thus let the customer make different choices based on the visualisation. As an example, if the garment is pulled forward it might look as if the bottom of the sweater is a horizontal line around the body, while if the garment was in its natural position, the garment at the front would be shorter than at the back resulting in different decisions (e.g. lowering the front while in the other position this was not necessary).

- Probably from the same reason, a fault in the initial simulation, the length of the left and right sleeve did not look the same. The question was then, on what sleeve do you determine the length?

- Most participants did not identify themselves with the avatar in terms of appearance. They did recognise that the avatar had their measurements and body shape, but the shape of the head and hair and skin colour were something that distracted the customers from their customisation process. 4 Participants even asked if the head could not be shown. Furthermore, the posture of the avatar was not always natural (see figure 78.). The avatars head and shoulders would lean forward resulting in showing a less pronounced breast. Another issue was the shape of the torso of the avatar. Whenever the waist circumference was much larger than expected by the software, a bump around the waist area would be visible (see figure 78 (left)). The silhouette of the avatar's torso was not natural. For a loose fitting garment, like the sweater, this was not visible for the customers, but for a more tight fitting garment showing the shape of the body, this would have been a problem.

Fig. 78. Problems of avatar of participant 3
Left: Bump around the waist area
Right: Forward leaning neck and shoulders

Clo3D Continued

- Participants were also not satisfied with the bottom garment the avatar was wearing (black tight jeans). As the participants were customising their sweater, they had already a bottom garment in mind that they owned that they would have liked to see on the visualisation. The garment in their mind was used as a reference point for how long or short the garment should be.

- As the screen the visualisation was shown on, was not big enough to show the avatar life size, it was chosen to show the whole avatar on a smaller scale. This resulted to the inability to show the fabric details and structure. As a solution, the visualisation would be zoomed in once a while to show how the fabric is different from any other fabric. This thus conforms the need for a life size avatar as was mentioned in the list of requirements.

- Lastly, during the customisation of the size of the sweater, 2 participants continuously asked to make the front and back panel narrower to show their waist. At a certain point, the measurements of the garment would be less than their own body measurements resulting in a garment with negative ease. However, the opposite is demanded by the design of this sweater; positive ease, a larger garment measurement than body measurement. As a result, the garment width had to be increased again although the customers did not choose for this.

Fig. 79. Close up of the six knitted sweaters

Comparison visualisation and reality

For each participant a comparison is made between the visualisation that was made beforehand, the pictures that were made afterwards and any additional visualisation. This additional visualisation is used when the measurements of the knitted sweater do not match the original pattern. For example, In the case of participant 1 and 6, which both had the mohair grid fabric, the fabric turned out much wider (+10 cm) than was intended, and thus a new visualisation was made. With this new visualisation we can still examine whether or not the fabric in Clo3D drapes in the same way that the knitted sweater does. For each sweater the differences and similarities will be indicated.

Fig. 80. Knitted sweater for the six participants

Participant 1

Differences compared to first visualisation

- As mentioned previously, the width of the front and back panel was much wider than anticipated. The panels were 66 cm wide instead of the 51 cm it should have been.
- This resulted in the sides of the sweater draping lower than was expected, creating a curve at the front and back of the sweater.
- This also caused the sleeves to start at a lower point along the arm (halfway upper arm) instead of near the shoulder. Which then also resulted in sleeves that were too long.
- From the neckline up the grid pattern is not present but replaced with a solid dark blue panel. This is due to the technical limitation of the knitting machine. This could have been told to the customers beforehand, or even tried to be visualised for the participants as this significantly changes the appearance of the sweater.
- The colour of the sweater is slightly different from the visualisation. The knitted fabric has a more saturated colour compared to the visualisation.
- The sleeves seem wider than the visualisation shows.

Differences compared to second visualisation

- The fabric is less stiff dan it looks in the visualisation. As can be seen from the sideview, the fabric sticks outwards from the bust down, which it does not in real life. The same accounts for the back of the sweater.

Similarities compared to second visualisation

- The length of the garment looks comparable, both at the front and back as the sides of the garment, creating a rounded effect.
- The sleeves start at almost the same position on the arm. Resulting in also similar length that both reach just over the widest part of the hand.
- The visualisation and knitted sweater both show similar folds in the sweater. At the front there are two folds from the bust down and also two folds from the back to the side of the garment.

Participant 2

Differences compared to visualisation

- The sleeves in the visualisation start slightly higher up the arm, however, the total length of the sleeves is the same.
- The width of sleeves seems a bit larger than shown on the avatar.
- The border of the sweater, knitted with different stitches, seems larger than in the visualisation. This can be seen at the end of the sleeves, and the bottom of the sweater and the neckline.
- The sweater drapes slightly different from the visualisation. It seems that the sweater flows more outward and the folds are softer/larger.
- The seams are visually present in the knitted sweater as they are sewn together on the outside of the sweater (normally on the inside so they are not visible). The seams in the visualisation are almost not present.

Similarities compared to visualisation

- Overall the knitted sweater looks very similar to the one in the visualisation, only small details are different as mentioned above.
- Length of the garment is the same as in the visualisation. As shown in both pictures, the front of the sweater is a little raised and outwards. In real life it is even more outwards than in the visualisation.

Participant 3

Differences compared to visualisation

- The creases and folds are accentuated in the visualisation compared to the real sweater, especially in the front where they are more pronounced. The knitted sweater is more flexible and thus takes on the contours of the body better. However, the position and direction of the folds are similar
- The length of the sleeves of the knitted sweater seem a little bit longer than in the visualisation.

Similarities compared to visualisation

- All in all the sweater looks really similar to the visualisation.
- The sleeve starts at the same position on the upper arm in both the visualisation and the photo.

Participant 4

As this sweater is very similar to the sweater of participant 2, similar differences between the visualisation and real knitted sweater can be found.

Differences compared to visualisation

- The sweater drapes slightly different from the visualisation. It seems that the sweater flows more outward and the folds are softer/larger.
- The border of the sweater, knitted with different stitches, seems larger than in the visualisation. This can be seen at the end of the sleeves, and the bottom of the sweater and the neckline.
- The seams are visually present in the knitted sweater as they are sewn together on the outside of the sweater (normally on the inside so they are not visible). The seams in the visualisation are almost not present.
- The avatars shoulders are more leaned forward showing smaller breasts. The participant only noticed this during the second session, as during customisation it all looked normal and she thought the avatar really represented her body type and size.

Similarities compared to visualisation

- Overall the knitted sweater looks very similar to the one in the visualisation, only small details are different as mentioned above.
- Length of the garment is the same as in the visualisation. As shown in both pictures, the front of the sweater is a little raised and outwards. In real life it is even more outwards than in the visualisation.
- The top of the sleeves starts at the same position in the photograph and in the visualisation. The sleeves are also the same length.






Participant 5

Differences compared to visualisation

- As was already noticed and communicated to the participants during the first session when the sweater was being customised, the plisse fabric could not be visualised the way it should. This is now the biggest difference and has the most influence on the look as a whole. The characteristic of the plisse, folded at the top and stitched together to keep the same shape and flare out at the bottom, could not be shown. In stead, the plisse was shown as a vertical striped pattern. This influences the width of the fabric as well as the bottom finish of the product.
- As was seen with the other sweaters, if the garment becomes wider it creates a raised arch in the front and back of the sweater in stead of the straight finish as the visualisation shows.
- Furthermore, the participant pointed out that the fit of the sleeves was uncomfortable. In the photograph and the second visualisation from the front view, it shows that the sleeves are tighter around the armpit. This could be because of two reasons. First of all, the fabric at the shoulder seam was sewn together with the correct measurement in mind (distance between shoulder and neck in the front and back panel), limiting the amount of stretch in that particular area. In Clo3D, however, the seams are stretchable which allows the fabric to widen resulting in a difference between the pattern measurement and the stretched measurement in the 3D environment. The fabric at the shoulder seam had stretched almost 7 centimetres (204-136 mm). The second reason, could be an extra piece of fabric that was attached underneath the armpit due to the size limitations of the knitting machine. The machine was not able to create the front panel at once due to the width of the garment. To overcome this problem 2 extra pieces of fabric were attached as shown in figure 81.
- Because the stretch at the shoulder seam was restricted in the knitted sweater but not in Clo3D, the sleeves ended up being too short as the seam pulled the fabric towards the shoulder.

Similarities compared to visualisation

- Overall the dimensions and shape of the knitted sweater compared to the visualisation seem to be correct, but because the fabric drapes so different from the visualisation it looks like a completely different sweater. It could have just as easily been the Ecoplanet fabric.

Fig. 81. Solution for width limitations knitting machine: extra panel underneith arms






Participant 6

The sweater of participant is 6 is also very similar to the one of participant 1. They are made from the same fabric although with a different board colour.

Differences compared to first visualisation

- The width of the front and back panel were much wider than anticipated. The panels were 10 cm wider than it should have been.
- This resulted in the sides of the sweater draping lower than was expected, creating a curve at the front and back of the sweater.
- This also caused the sleeves to start at a lower point along the arm (halfway upper arm) instead of near the shoulder. Which then also resulted in sleeves that were too long.
- The sleeves seem wider than the visualisation shows.
- The avatars shoulders are more leaned forward showing smaller breasts. This also affects the draping of the sweater in the front.
- From the neckline up the grid pattern is not present but replaced with a solid dark blue panel. This is due to the technical limitation of the knitting machine. This could have been told to the customers beforehand, or even tried to be visualised for the participants as this significantly changes the appearance of the sweater.

Differences compared to second visualisation

- The fabric is less stiff dan it looks in the visualisation. As can be seen from the sideview, the fabric sticks more outwards at the back, which it does not in real life. The same accounts for the back of the sweater.
- The neckline of the sweater is larger, probably also because of the widening of the sweater in general.
- The sleeves still look too long compared to the visualisation, because the sleeves also start at a lower position.

Similarities compared to second visualisation

- The length of the garment looks comparable, both at the front and back as the sides of the garment, creating a rounded effect.
- The visualisation and knitted sweater both show similar folds in the sweater. At the front there are two folds from the bust down and also two folds from the back to the side of the garment.

Satisfactory result and expectations met?

During the first session of the user test participants were asked what their expectation was of the knitted sweater. The expectations were mostly based upon the visualisation that had just been made in combination with the fabrics and Maartje Boers input about the personalisation process. In the next paragraph the expectations per participant are described together with a score indication. This score indicates how high their expectations are: 1 very low, 2 low, 3 neutral, 4 high and 5 very high.

Expectations Participants

1. Expectations are low (2) as she is expecting the sweater to be different from the visualisation. The visualisation is just an image and the end product will probably not look and feel the same.

2. Expectations are high (4) as it is a custom designed piece. But is worried she made the wrong decisions and will regret that once she tries on the sweater.

3. Expectations are really high (5). She thinks that the sweater will fit perfectly, especially since Maartje Boer (designer and expert) is taking her measurements. She has more trust in Maartje and the measurements that are taken than what she sees on the avatar. Thinks that although the visualisation shows the pattern, Maartje will double check all measurements.

4. Expectations are low (2). Has had lots of experiences with online shopping where the size chart claims it should fit, but in the end it doesn't. Feels like this shopping experience is similar, and is thus reluctant to the end result.

5. Expectations are really high (5) for the fitting of the garment. She expects especially that the sleeves will be the correct length as that would be the reason she would be buying this garment. In terms of fabric, the expectations are lower, but still high. She recognises that these are just sample fabrics and that the fabric for her sweater could be slightly different.

6. Expectations are high (5). She expects the sweater to look exactly like the visualisation: tight sleeves and looser around the waist. The length of the garment and sweater should be correct as that would give her the best shape. She expects that fabric to be just as the samples, and relies more on them than on the visualisation.

Furthermore, when asked if the participants would purchase the garment, when imagining that this was a real situation, none of them said yes. The participants were too insecure about their choices and the result and would have liked to try on a similar sweater first. One of them said that it would be more helpful to see some 'success stories' where both the visualisation and knitted sweater would be shown.

During the second session, the participants were shown the sweater and were able to try it on. They were asked to give their opinion about the sweater and to which extend the result met their expectations.

1. The appearance and feel of the garment was awarded a 4 out of 5 as the sweater and fabric felt really nice, the fitting however, was awarded a 3 out of 5 . The sweater was "a little different" than expected, not necessarily better or worse than expected as she already expected the sweater to be slightly different from the visualisation.

2. The result of the sweater was awarded a 4 out 5 by the second participant. She really liked the dessin and colour of the fabric as well as the feel of it. However, she felt the sweater was wide (even though according to the design of the sweater it could not be any smaller) and not accentuating her small waist. Furthermore, even though the length of the sleeves was the same as the visualisation, the length felt weird and she would have liked them to be longer. Therefore, she gave the fit of the sweater

a 3. In the end, the sweater was the same as could be expected from the visualisation, but she would have liked to have made different choices during the customisation process of the fitting.a 3. In the end, the sweater was the same as could be expected from the visualisation, but she would have liked to have made different choices during the customisation process of the fitting.

3. The participant was thus also really pleased with the end result and gave a result of 5 out of 5 to the sweater. Both the fitting and the fabric were exactly as aspected if not better. The length of the sweater is great and the fabrics draped the way she thought it would do. She was pleasantly surprised with the result as she had secretly expected that the sleeves would be too short anyway, but it turned out to be the correct length.
4. Participant 4 gave the overall sweater a 4 out of 5 and the fitting between a 3 and 4 out of 5. She really liked the sweater and thought the fabric was nice and soft and the colour fitted her skin colour. The fitting is however not as she thought. Although the comparison between the visualisation and the knitted sweater is very similar, the image in her head looked different from the visualisation. She expected a baggier sweater that was a bit longer in general and also had longer sleeves.
5. Although the fit was not how the participant had expected, she awarded a 3 out of 5 for the fit. She really wanted the sleeves of the garment to be the correct size as that would be the reason she would have bought a custom garment. However, the overall appearance was given a 4 out of 5 as she really liked the fabric style and colour. All in all she liked the garment and would have probably bought the sweater if it was like this in the store, but since the garment was custom made for her it did not satisfy her expectations.
6. Participant 6 was the unhappiest participant with the end result of the sweater and it was much worse than her expectations. She awarded the fitting of the sweater a 1 out of 5. The reason for this is that she initially didn't like the design of the sweater at all. She wanted something that would accentuate her waist and together we came up with a crop top sweater. The knitted sweater however, turned out much too wide resulting in hiding her waist completely and besides, the sleeves were also too long. The fabric on the other hand got more appreciation and was assigned a 4 out of 5 as this was similar to her expectations.

5.1.3 Conclusions user test

So how effective was the visualisation in the end in conveying the appearance of the knitted garment?

The effectiveness of the visualisation depends on three things. First of all, does the customer feel the avatar resembles themselves and is she then willing to make decisions based on how the sweater fits the avatar. Second, is the visualisation of the sweater itself appealing enough? Are the colours represented well and does the fabric drape the way it does in real life? And last, but definitely not least, how well do the measurements of the sweater compare to the pattern generated by Clo3D?

Avatar resemblance

Before the participants were able to customise their own sweater, an avatar was made with the same body measurements as the participants. The avatar was shown to the participants and all of them acknowledged that the avatar had their measurements but still felt distant towards the avatar. It felt weird as normally when shopping on the web, you are used to seeing skinny models wearing clothes and not yourself. Furthermore, it was hard to identify themselves, as the avatar did not have their particular skin, eye or hair colour, and the avatar was wearing skinny (almost legging like) jeans and none of the participants would be wearing such pants with this sweater. Lastly, the posture of the avatar was unnatural. As the shoulders and neck leaned forward the avatar did not show as much of the breast area as could be, resulting in a different arrangement of the fabric around that area.

Appearance sweater

The appearance of the sweater is very similar to the real knitted sweaters although not quite there yet. The fabrics in Clo3D have been composed using the Clo3D emulator and bending and tensile testing of the fabrics. This was done using relatively small samples (12 by 5 centimetres) compared to the garments. Some extra test could be done using larger samples to improve the draping appearance. Furthermore, the colour of the fabric looks less saturated than in real life. The appearance of the fabric can be slightly adjusted with the lighting conditions of the renders but not during the customisation process as it was done during this test. Furthermore, the photograph of the fabric itself can be taken under different lighting conditions and edited with software afterwards to create a more realistic effect.

Comparison measurement sweater and Clo3D pattern

As the visualisation of the sweater is based on 2D patterns, it simultaneously creates a pattern that can be used for the knitwear production. But before production can start, the measurements have to be converted to number of stitches and number of rows that have to be knitted. This conversion is an important step in making sure that the knitted sweater will have the correct measurements. To do this, samples of each fabric have been made and the number of stitches and rows have been measured over a certain length.

What has been noticed during this test is that the conversion of the pattern to the knitted mohair grid fabric was not optimal. Each sweater was washed, and then dried on a flat drying platform in the correct dimensions. However, once the sweater had dried and taken from the drying platform, the dimensions changed in a slightly shorter but much wider sweater. This resulted in a sweater that did not match the measurements of the pattern. This could have been due to the fact that during preparations wrong measurements were taken from the knit samples to achieve the right amount of stitches and rows to be knitted. Thus, the fabric sample was not a good representation of the whole garment.

To conclude, if the conversion between the pattern and the knitted sweater is good (as was with the sweaters of participant 2,3 and 4) the visualisation is effective in conveying the appearance of the knitted garment. However, although the visualisation showed a good representation, the participants were not always satisfied with the result. From the six sweaters that were

produced one fitted exactly as was expected (from participant 3), two did not fit at all and the participants found it worse than expected (dark blue mohair grid sweaters) and the other three thought it resembled the visualisation well, but the end result still did not satisfy their needs.

The reason for this dissatisfactory result is not only due to the visualisation. The two sweaters made with the mohair grid dessin turned out much wider after washing and drying the garment. The measurements of the knitted garment were not equal to the pattern that was created in Clo3D and thus it was expected that the participant did not see the resemblance in the visualisation and that it did not meet their expectations.

Another reason for this dissatisfaction is that the participants had a rough time deciding what shape and size of the sweater would look best on them. Participants found it hard to make decisions on details of the sweater that you would normally not have to make any decisions about. People do not care if their sleeve length is 40 or 50 centimetres long, as long as it has their desired length. During the customisation phase participants often asked for Maartje Boers opinion on what she thought would look nice. It is similar to going to the hairdresser with a great idea in mind, and you trust that the they will create a hairstyle that will fit you. The help of an expert who knows what styles will accentuate the good parts of your body and hide others might be needed to convince the customer of buying something she will love in the end and want to keep on wearing.

5.2 Recommendations

The visualisation has already proven to be a valuable in the customisation process, but could be improved to make the experience even more pleasant. These adjustments include changing the avatar, doing more research about the knitted fabrics, adjusting the interaction between the customer and the screen and looking for ways to take Clo3D to the next level.

The avatar at the moment is not perceived as an attractive representation of the customer. The hair, eye and skin colour cannot be adjusted and the posture is often unnatural. To make the avatar exactly look like the customer a 3D scan can be made. However, there are also other options than this expensive alternative (as some investments need to be made). There are other companies developing avatars for the computer aided fashion industry. Including them is Alvanon (2019) which has a large database of 6000 AlvaForms that represent the body shapes and sizes of customers all over the world (Wrigth, 2019). These AlvaForms have no particular hairdo or skin colour.

A second recommendation is to do some further textile research. The visualisation in Clo3D shows the fabrics quite well but it could definitely be improved. Especially the plisse fabric needs some special attention to make sure that it represent the characteristics of the fabric and does not look like a striped dessin. According to Mageean (2017) creating a digital material is a manual and tedious process. "Digitizing a material sample is not as easy as simply taking one picture and dropping it into your 3D application." As she explains, the human brain is able to interpret the shape of material sample by just looking at how the highlights and shadows behave. To replicate the fabric sample in a 3D environment the software needs more input than just a single image. That is why Vizoo has developed a fabric scanner xTex (Vizoo, 2019) that uses up to 8 different lighting set ups to create so called texture maps which include information about textures for colour, structure, reflectivity, transparency and more. These texture maps can then be imported into your 3D software to create super realistic fabrics.

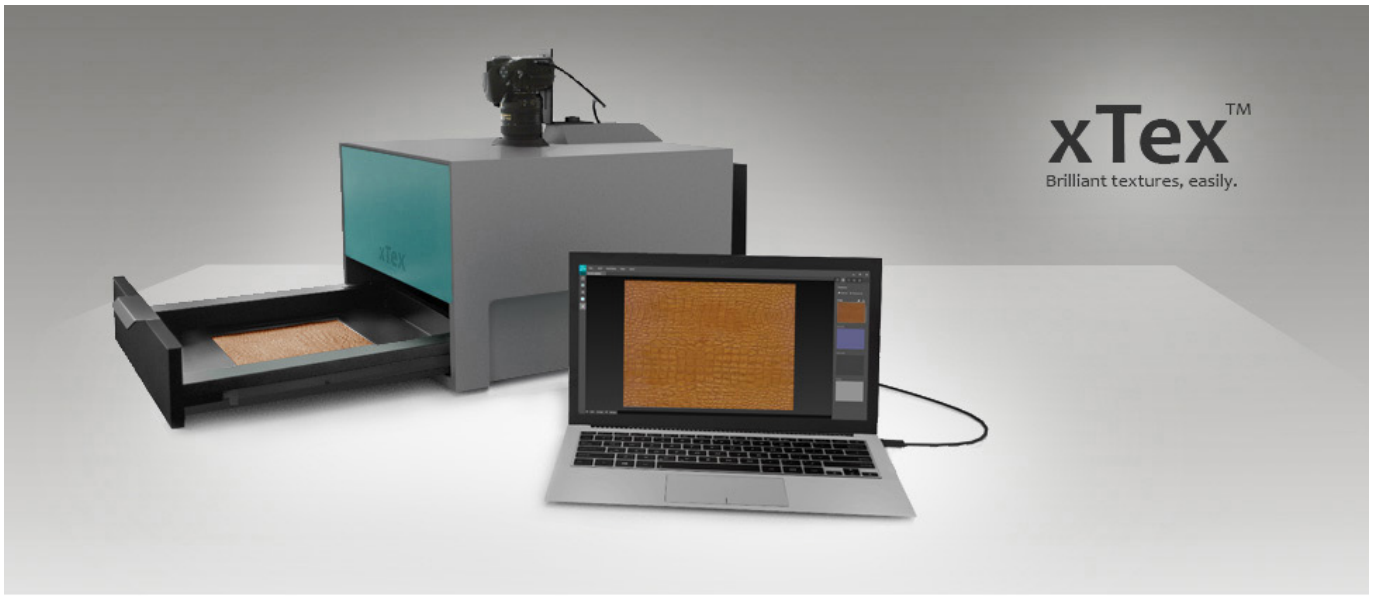
Furthermore, the behaviour of the fabrics itself should be analysed with more detail. Larger fabric samples could be measured and evaluated during the knitting process. What dimensions does the fabric have just when it is just taken from the knitting machine. What influences does washing and drying have and how does the fabric change over time when it is being worn?

What needs to be further investigated is the way customers make their decisions. What could be concluded from the user test is that customers have to make choices about details that they are not familiar with. Whenever asked about your chest circumference most people can make a guess, but who knows how long their arms are or what circumference their biceps are. Making decisions based on these numbers is experienced as difficult by the customer and this is where the customer needs advice. What is a regular length and fit for a sleeve and what could be different. Furthermore, customers are afraid to make wrong choices and then do not want to commit to buying. Some experiences of previous buyers could maybe persuade them. Another solution could be to create an interface with two different settings. A beginner mode where the size of the customer is predicted by the system but she can still choose for a loose, normal or tight fitting. This would prevent the customer from making decisions she has not enough knowledge for. The customisation experience would then be focused on finding the right dessin and colour that fits your style. The other setting would be the expert mode, where there are more parameters to adjust the shape and size of the garment. This setting would allow more creativity and create different kind of sweaters.

During this project the limitations of the software that was used, Clo3D, have been found. As this software was not developed to be used for customising clothing a few features are not present that would make the whole customisation process much easier. As an example, being able to create a link between different pattern pieces would be a much needed feature. This is an option that the Lectra software does have. The linkage will adapt certain measurements based on what you adjust to the pattern. This would especially be handy when adjusting the width of the sweater. As increasing the width of the sweater also increases the length of the sleeves a link should be made that could counteract the increase in the sleeves to maintain the same dimension. This linkage would be especially valuable in more complex garments, for example with garments that have sleeve heads. Furthermore, another valued feature would be an error message once the garment becomes too small. Clo3D has already implement fit maps but those have to be manually triggered. In STRIKKS' case there will always be positive ease in the garment. If the software could then detect whenever there is not enough positive ease anymore it would eliminate the chance of the garment being too snug. Perhaps these features could be suggested to the Clo development team, or otherwise could be realised by making a plug in for the existing software.

At this point in the development process I would suggest STRIKKS to further develop the visualisation screen and interface. Whenever the visualisation is effective enough and helps customers to make better decisions, a pop-up store could be opened to show the concept to the people. Until that moment the garments can still be produced using the visualisation in the studio of STRIKKS.

Fig. 82. xTex fabric scanner from Vizoo 3D [25]



5.3 Concept Evaluation

Although the visualisation has been tested by itself, a closer look should be taken at the whole concept to make sure it is feasible, desirable and viable. First of all, the concept will be evaluated with regard to the design goal set at the beginning of this project. Did the end result reach the design goal, or what could have been done to achieve it? Then, the concept will be evaluated based on the requirements set after the analysis stage and in what way the critical design elements have been applied to the design of the store. Can these design elements be implemented within a reasonable time? Lastly, how will this concept influence the stakeholders and is it a desirable concept for all of them?

Based on Design Goals

The original design goal of this project was to

"design an interactive experience that will sell personalised knitwear in a retail environment. In this experience an accurate display of the garment should give the customer insights into how the garment will look on their body and will enable them to make decisions that will lead to a satisfied result. The experience should convince the customer of purchasing the garment but should also avoid disappointment after trying the garment on the first time."

From the evaluation of the visualisation it can be concluded that an accurate display of a garment is definitely possible with the Clo3D software. A few improvements could be made to make the experience more pleasurable. Furthermore, the way the garments have now been adjusted is not ideal for a store environment. An expert would be needed that is able to use the Clo3D software and also have the knowledge about the production process to make sure the garments can actually be produced. This would be a time consuming operation and not cost effectively. The experience of the customisation process could still be developed further by developing a working interface and testing this with the intended target group.

Based on Stakeholders

STRIKKS

This concept could absolutely contribute to the sales of customised knitwear. As it is a fairly new concept, an no store is currently carrying out this process, it is hard to convince people of the result of the knitted garments. Showing them the visualisation can already give them a good idea about what to expect. What is important for STRIKKS is that their concept keeps evolving to keep their customers interested in buying more than a single piece. STRIKKS could have some basic pieces and fabrics that are timeless and can be worn for many years, but also develop some interesting patterns that are maybe only produced for a certain amount of time. This exclusiveness could trigger the customers to come back and buy another piece for their wardrobe.

Customer

STRIKKS has developed a concept that is applicable to many different users. Whether those customers are people who need customised clothing because their body type is not suitable for off the rack clothing, or customers who want some unique knitwear, or customers who care about the environment and want to invest in clothing that can last a lifetime, there is something for everyone.

However, for the customer to be able to benefit from this concept it needs to be certain that the result will be good a hundred percent of the time. One faulty garment and STRIKKS might lose her reputation and thus customers. It is therefore of the uttermost importance that STRIKKS will launch their concept only if the result can be guaranteed every single time.

Shop assistant

The shop assistant is an important part of this concept. A good or bad shop assistant can make or break this concept. Someone should be there to guide the customer through the process, especially when it has just been launched. The new concept could be confusing to customer and might need to be explained. Furthermore, measurements should be taken of the customers body dimensions. Taking wrong measurements will result in a badly fitting garment so getting someone with the needed experience is crucial.

Based on Requirements

The proposed design is being evaluated using the list of requirements that has been developed since the analysis phase. This list is primarily focused on the visualisation as that is the biggest part of the concept. In the next section the "Must have" criteria will be analysed and furthermore it will be evaluated how easily the "Should have" and "Could have" requirements can be implemented into the design.

As mentioned in chapter 3, the "Must have" criteria are features that are critical for the concept and need to be implemented to have a successful product. Criteria concerning the visualisation itself (1.2, 1.3, 1.4 and 1.6) have been implemented in the visualisation of the garments. Although the avatar was not always shown at a 1:1 scale during the user test, it was clear that customers needed the visualisation to be of a significant size to be able to see the details of the fabric and to see the draping more clearly. The need for this requirement was thus confirmed.

As the interface was not developed as far as I would have liked to, it is hard to evaluate whether or not they will meet the criteria. At this point the garment could be adjusted in terms of fabric dessin and colour but not by the customer herself (requirement 1.1). Furthermore because of the time limitation in this project, only the sweater was used. The customer did not have the ability to choose between different garments.

The visual representation of the colours and dessins could be optimised (req. 1.5). The visualisation was able to show each dessin and colour combination, but the colour of the visualisation was not as close to the real life situation as it could be. The visualisation itself now heavily depends on the quality of the picture taken, but could probably be improved by editing the photograph itself or adjusting the lighting conditions that are being used in Clo3D.

Criteria 1.7 has not been implemented into the design of the customisation process. The size of the garments during the test has been solely determined by adjusting the size visually. Does the clothing look like the right size, or do I need to adjust something? Afterwards, the size was double checked and we noticed some pattern dimensions that could potentially cause some problems.

As the interaction has not been developed far enough, no user test have been done with the target group of STRIKKS. Therefore, a statement about how well the concept meets the last must have criteria (1.8) cannot be made.

Although not all "Must have" criteria have been met yet, the "Should have" criteria did make it into the concept design. During the user test, participants were able to change the proportions of the sweater to meet their own fit preference. Furthermore, each different dessin had its own physical properties. However, no distinction has been made between the different colour options. Some minor differences could be present between yarn colours as to create the different colours the same yarn goes through different production processes.

Requirements 3.1 and 3.3 have not been implemented in the design yet, but participants did suggest to add these features to the customisation process to take some doubts away. Most participants had already a certain bottom piece in mind when customising their garment and would have liked to see that garment on the avatar to use as guidance for making decisions. Furthermore, some changes in garment size were so small that they were hard to compare. A comparison of two or more garments next to each other could make this comparison easier and help you choose for which size to go.

Fig. 83. List of Requirements from chapter 3

1. Must Have

1.1. The customer must have the ability to change the garment model, fabric dessin and fabric colour during the use of interface.

1.2. Changes made to the garment must be visible as quickly as possible, but it should take no longer than 10 seconds as customers get impatient and stop the customisation process if it takes too long. (Nielsen, 2009)

1.3. The whole garment must be visualised in full size (scale 1:1) to give the customer the idea that she is looking in the mirror and to show enough details of the fabric.

1.4. The garment must be able to be viewed from at least 8 different angles (e.g. front, back and side), but preferably more. This will give the customer more insight into how the garment will fit their body.

1.5. Visual representation of the colours and dessins must be realistic and close to real life (adapted to different store environments) to avoid disappointment from the customer after purchase. This visualisation is based upon woven textiles.

1.6. Corresponding measurements between avatar and customer give the customer the possibility to evaluate the fit of the garment.

1.7. The size of the garment must be predicted by the system according to STRIKKS' vision of how the clothing should look on a customer.

1.8. The interaction with the visualisation must be intuitive and easy to use, so that no help is needed from a shop assistant. The design should take advantages of prior experiences with the physical and cultural environment (Mortensen, 2019). The customer should be able to perform actions without considering them.

2. Should Have

2.1. The ability to increase and decrease garment size (positive/neutral or negative ease) to allow the customer to change the fit preference in case the customer is not satisfied with the fit provided by STRIKKS.

2.2. Each knitted fabric (different dessins), still shown as woven fabric, should have its own fabric properties to give the customer more insight in the behaviour of the different fabrics. As knitted fabrics, using the same yarn, have different properties depending on what stitches are used, every dessin should get its own properties.

3. Could Have

3.1. The garment could be combined with other pieces of clothing (e.g. pants and shirt).

3.2. The avatar could be placed in different environments (e.g. outside, work, party).

3.3. Could show comparison of garments side by side to let the customer choose between two compositions that are equally liked.

4. Would like but won't get

4.1. As the final shape of a particular stitch depends on the types of stitches around it, constructing realistic knitted clothing requires a simulation at yarn level (Yuksel et al., 2012). Stitches can be formed using various knitting operations, leading to a rich variety of possible knitting patterns with drastically different appearances and behaviours, therefore it is important to simulate each fabric individually to get the most accurate result.

4.2. The avatar mirrors customers movement to give a better illusion of looking in the mirror.

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7 Appendix

7.1 Project Brief

DESIGN FOR our future

2980

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name
initials
student number
street & no.
zipcode & city
country
phone
email

[redacted]

Your master programme (only select the options that apply to you):

IDE master(s): ★ IPD ( ) DfI ( ) SPD

2nd non-IDE master:

individual programme: - - (give date of approval)

honours programme: ( ) Honours Programme Master

specialisation / annotation: ( ) Medisign
( ) Tech. in Sustainable Design
( ) Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair Dr. T. Huysmans dept. / section: ID/AED

** mentor A.H. Jellema, MSc dept. / section: ID/AED

2nd mentor

organisation: Fieldlab UPPS TU Delft

city: Delft country: Nederland

comments (optional) Both chair en mentor are from the AED section, however Anton has more focus on user centered design and the ergonomics involved, while Toon will be able to help with the 3D anthropometry and technical part of the project.

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Dr. T. Huysmans date 26 - 11 - 2018 signature Toon Huysmans Digitally signed by Toon Huysmans Date: 2018.11.26 12:18:59 +01'00'

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 31 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 31 EC

List of electives obtained before the third semester without approval of the BoE

☒ YES all 1st year master courses passed

☐ NO missing 1st year master courses are:

name date 10-12-2018 signature CB

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ☑ APPROVED ☐ NOT APPROVED

Procedure: ☑ APPROVED ☐ NOT APPROVED

comments

name A Huwae date 8 - 1 - 2019 signature

Initials & Name M. van der Bie Student number 4296575

Title of Project Designing a user experience to sell personalized knitwear in-store

Personal Project Brief - IDE Master Graduation

TU Delft

Designing a user experience to sell personalized knitwear in-store — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 16 - 11 - 2018 — 03 - 05 - 2019 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

STRIKKS is a design studio that has a fascination for and develops knitted fabrics and products. They are continuously searching for innovative possibilities and applications for knitting. Research has been done on "Personalisation in knitwear, a contribution towards a sustainable wardrobe" (Boer, 2018) and with this research STRIKKS combines the change in the fashion industry and the demand for personalisation to create a profitable business. As consumers are more aware of how clothing is manufactured and consumed, they want to be more conscious of their behaviour and thereby contribute to society. STRIKKS has made this possible by creating a collection of knitted garments that can be personalised by the customer.

A concept is developed where the customer can configure her own garment in a retail environment by choosing a garment model, a colour and a knitted fabric. In this way a personal and unique garment is created that fits to the body and style of the customer. After the garment is altered to personal likings, the correct dimensions of the clothing are determined by taking measurements of the body with a measuring tape and using Designaknit software to translate this into the correct pattern. Then, the personalised garment will be produced by STRIKKS in their own studio. For this they use their own knitting machines that have an easy programming language, are quick and able to make on demand clothing. These machines are able to create different knitted panels that are sewn together, whereafter the garment will be delivered to the customer.

Unfortunately, the risk is present that the customer may be disappointed with the way the garment fits and looks after the purchase as the visualisation of the end product beforehand is limited. Therefore, together with Fieldlab UPPS (Ultra Personalized Products and Services), the current situation needs to be improved to convince the customer to purchase a personalized garment which will meet their expectations. Fieldlab UPPS, an initiative of Smart Industries, is a collaboration between ten institutions of whom TU Delft is one, that stimulates the development of personalized products through their knowledge, facilities and subsidies.

Boer, M. (2018). "Personalisatie in knitwear, een bijdrage aan een duuzame garderobe". Master thesis, Willem de Kooning Academie Rotterdam.

Website Designaknit software: https://www.softbyte.co.uk/designaknit.htm

Website Fieldlab UPPS: www.upps.nl

space available for images / figures on next page

introduction (continued): space for images

image / figure 1: The personalised knitwear interactive wall

TO PLACE YOUR IMAGE IN THIS AREA:

- **SAVE THIS DOCUMENT TO YOUR COMPUTER AND OPEN IT IN ADOBE READER**
- **CLICK AREA TO PLACE IMAGE / FIGURE**

PLEASE NOTE:

- **IMAGE WILL SCALE TO FIT AUTOMATICALLY**
- **NATIVE IMAGE RATIO IS 16:10**
- **IF YOU EXPERIENCE PROBLEMS IN UPLOADING, COVERT IMAGE TO PDF AND TRY AGAIN**

Personal Project Brief - IDE Master Graduation

TU Delft

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The current interactive system (an interactive wall) that has been developed, is supposed to be stationed in a retail or department store. This wall shows the different options that the customer can interactively choose from (garment model, colour and knitted fabric), and during that process the end result is projected onto a mannequin. This visualisation should show the customer how the garment that she has composed will look like once fabricated. Depending on how this looks like, the customer can adapt the garment and/or place an order, or decide to discard the composition and come to the conclusion not to buy the personalised garment.

Changes that are made in this process should be directly visible, so that when something changes, for example the pattern, the effects are immediately visible and will give you confirmation on whether or not you want to apply that change. However, as it is now (the mannequin is wearing white clothes on which the garments are projected) it is not very clear. Lighting conditions are not optimal, and the customer has no idea of how the clothing will look on their own body. Certain clothes might look great on a mannequin but end up looking completely different once you are wearing it. This makes it difficult to convince the customer to buy such a garment and to avoid disappointment at the time of fitting the produced garment.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

The goal of this project is to design an experience to sell personalized knitwear in a retail environment, which clearly envisions how the garment, that is not yet produced, will look on the customer. This will help to convince the customer to purchase the garment but also avoid disappointment after trying it on the first time.

The result will be a shopping experience that is able to convince the shopper of buying personalized knitwear that they will be satisfied with once produced. In this experience an accurate display of the garment should give the customer insights into how the garment will look on their body and will enable them to make decisions that will lead to a satisfied result. To show the garment, different methods of visualizing fashion will be explored and adapted to the knitwear designed by STRIKKS. A number of factors will be taken into consideration when choosing a suitable visualization solution: what is most convincing for the customer, what can change quickly during the personalization process, what is realistic to produce in a relatively short amount of time and which is most cost effective.

The outcome can be a visualization that photo-realistically shows the clothes in certain positions, that shows the knitwear non photo-realistic but represents how the garment will fit the body of the customer or a simulation that shows how the fabric will behave during movement or any combination of the three. To show how the garment will fit on the body of the customer, measurements are taken and reproduced in the visualization. This process should be pleasant for the customer, and could for example involve a person taking measurements or the use of a 3D scan. After a configuration of the garment is made, the measurements that are taken will be converted into a pattern. Depending on how these were taken and how many will be taken, a different approach is needed to convert it into a pattern. One option that will be explored is the use of existing software, like Designaknit, or developing a system that is able to use a 3D scan to create a pattern that might be better fitting because of the detailed measurements.

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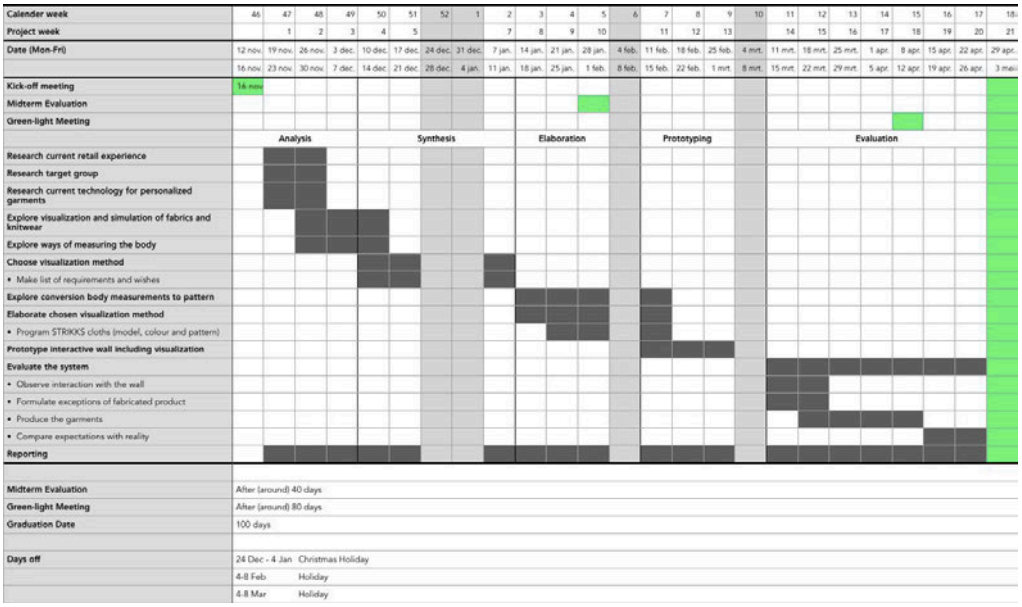
PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 16 - 11 - 2018 3 - 5 - 2019 end date



Initially, the graduation project will start with general search into the current retail environment and how experiences are evoked in these situations, together with defining the target group of personalized knitwear. Then, the technology that is already available for personalized garments will be analyzed along side exploring what ways fabric can be visualized and simulated in general and how knitwear in particular can be shown. It is important to quickly get to know the differences between these fabrics, in order to be able to adapt a visualization of a fabric to one of knitwear. This will be done with both literature research as well as talking to professionals in this field.

At the same time, it needs to be investigated how the size and shape of the customer will affect the visualization/simulation, and how these measurements will be determined. These measurements will also be used to create the pattern that will be sent to the knitting machines. Therefore, a method needs to be found that can both be used for visualizing and creating the pattern, that works as well for both situations. In the next step, all the different options and combinations will be compared. Together with the customer a list of requirements and wishes will be made to see what is most important for the visualization and what will persuade the customer to buy such clothing.

Then the chosen visualization method needs to be elaborated. To do so, the clothing designed by STRIKKS needs to be developed in the software. The models, the colours and the different patterns need to be programmed separately, as well as the possibility to combine the different options. Besides, the digital model, a physical prototype needs to be made that is able to show the experience that has been designed. This prototype should show the visualization, but also be able to translate the chosen options (from the physical buttons) to the visualization. Then the product-service system will be evaluated with potential customers, and recommendations will be made.

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MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

This project "The optimal visualization and conversion technique for personalized knitwear" combines my personal interests with competences I have and want to learn.

As a young kid my mother learned me to make stuffed animals, scarfs, pillowcases and other handicrafts using different types of needlework (knitting, crochet and embroidery) and this made this particular project interesting to me. Especially, as it is on a more industrial level and using computer aided techniques to come to the end result. Using computer aided design is also something I like to do, and I think I am able to learn new computer programs relatively quick. However, for this project it becomes more difficult and complex as fabrics are introduced in the system. Most often, when products are designed, they are made from materials that are not able to move, flow and change shape the way fabrics can. And just like every type of plastic behaves different, so does each type of fabric, which makes it a challenge to try to find a way to visualize these fabrics. What makes it even more challenging is that the human body itself moves, and thus inlfuences the way the fabrics stretch and deform.

At last, the graduation project is not only a space to develop my professional competences, but also personal skills. In my case, I want to work on my project management and planning abilities. I will need to plan my activities well, stick to them and deal with uncertainties and unforeseen circumstances effectively and efficiently to make sure the project will be finished on time. Furthermore, I am eager to take more initiative to really make the project my own, and take it to the next level.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

7.2 Transcript try out session January

Transcript audio opname

Het idee is dat dit concept in een winkel of shop-in-shop plaats zal vinden. Daar moet je je dan een etalage of iets bij voorstellen. Wat zijn dan normaal als je door een stad loopt "triggers" (oorzaken) om een winkel in te gaan?
Ik denk voornamelijk dat ik het zie aan de kleren die hangen in de etalage. Iets wat dan natuurlijk opvalt is de kleur. En daarna de algemene vorm van de kleding. Dus als ik zeg maar veel zie met een ronde hals, dan denk ik ze hebben niks voor mij dus loop ik even door. Het moet iets zijn wat past bij wat ik zelf graag draag. Als ik daar dan wat van zie in de winkel dan gaat ik kijken.

Zijn dat dan dingen die je meteen in de etalage moet zien? Want stel je voor dat je dus alleen maar dingen met een ronde hals ziet, denk je dan niet van misschien hebben ze wat anders in de winkel?
Misschien als de algemene stijl past bij wat ik graag wil dragen. Ik vind het wel moeilijk om mijn stijl te definiëren. Het is een combinatie van soorten stoffen, kleuren en uitstraling. Als ik dat zie dan ben ik benieuwd wat ze nog meer hebben.

Is het prijskaartje dan meteen iets waar je naar kijkt?
Ik kijk er pas naar als ik binnen ben. Het prijskaartje is uiteraard belangrijk maar het is niet alleen het enige wat bepalend is. Als je natuurlijk geen cent te makken hebt dan houdt het op. Maar ik denk dat het genoemd moet worden in combinatie met de kwaliteit van de kledingstukken en hoe lang je denkt deze te kunnen dragen. Deze bijvoorbeeld (wijst naar trui die ze aan heeft) - ik weet even niet meer hoeveel ik ervoor betaald heb - maar ik weet dat het een tijdloos stuk is, en als ik hem goed bescherm en goed was dan kan ik het jaren dragen. Dan mag het dus wel 300-400 euro kosten. Dat is dan niet relevant. Het is een natuurlijk materiaal, en in die zin dus goed voor het milieu, en ik kan het jaren dragen. Dus het valt wel te verantwoorden.

Het is voor STRIKKS wel het doel om - ook al hebben de kledingstukken wel een behoorlijk prijskaartje - mensen daarmee niet af te schrikken. Ze moeten aan de etalage dan natuurlijk wel kunnen zien dat het te personaliseren valt. Ik kan me voorstellen dat je misschien voor een "off-the-rack" trui €300 neerlegt, maar dat als je weet dat je het kunt personaliseren dat je dan inziet dat het wel meer waard is.
Ik denk dat er in Nederland wel meer mensen zijn zoals ik, die een beetje een afwijkend figuur hebben, die het wel op prijs zullen stellen om dingen op maat gemaakt te hebben. Of er tenminste zeker van willen zijn dat het ook goed staat. Het kost me normaal gesproken best veel tijd om iets te vinden wat bij mijn figuur past. Dus als je een adres weet te vinden waarvan je zegt daar kan ik naar toe en we kijken samen wat er perfect past dan is dat ideaal. Het is zeker een genot om dat voor te stellen.

Je hebt nu voor de stof gekozen die ook al op het vest zit. Is daar een reden voor? Want je zei eerst dat je het breisel met de honinggraat structuur ook heel mooi vond. Ik heb je niet zien twijfelen of je dan die structuur op het vest zou willen doen.
Je wordt beïnvloed door wat je ziet. Ik denk dat het daarop neerkomt. Bij een model wat aanwezig is kun je zien wat het gaat worden en het is moeilijker om van iets anders een idee te vormen van hetzelfde model met een andere stof. Als dat model er met die andere stof ook is zou dat bepalend kunnen zijn.

Wij willen dus een visualisatie maken waarbij dat wel mogelijk is. Denk je dat dat dan zou helpen?
Zeker. Ja want dan kun je beide modellen even aanvoelen, welke het gaat worden. Ik heb ook verschillende stijlen dus ik kies niet alleen maar dit en laat de rest zitten. Dus het is even kiezen welke combinatie. De blauwe vanwege de soort stof is een mogelijkheid, maar deze was ook mogelijk geweest. Ik weet alleen niet waarom ik er niet voor gekozen heb. Waarschijnlijk omdat dat andere model er al was en die combi van de beetje ruwe stof met dat speelse van de plissé aantrekkelijk was.

Je hebt nu gekozen voor de donker blauwe kleur met het grijze. Is dat iets wat je nog niet in je kast hebt hangen?

Ja. Ik heb geloof ik maar 1 trui die daar op lijkt. Een donker blauwe met van dat melé. En die had ik gekocht omdat het zo'n traditioneel patroon heeft aan de voorkant van ruiten met licht beige en crème kleur. Daarbij had ik vanwege dat traditionele patroon en de lichte kleuren het blauw voor lief genomen.

Je zei zelf dat je rood wel miste als kleur. Waren er nog andere kleuren waarvan je zou zeggen daar had ik ook wel uit willen kiezen?
Mijn eigen kleuren zijn meer felle kleuren. Misschien iets meer van rood, fuchsia, oranje. De warmere kleuren. Misschien paar. Aan de ander kant weet ik ook dat als je een garderobe samenstelt je een aantal dingen moet hebben in de basis kleuren en meer accessoire achtige kleuren waarmee je om die basis heen kunt bouwen. Dit blauw enzo valt dan meer onder de basis achtige kleuren. Dus ik heb daar geen moeite mee.

Maar het liefst toch wel rood gehad?
Ja, en zo eindig ik helemaal in het rood (had al rode trui en broek aan die dag). Er zijn van die impulsen die niet perse redelijk zijn. En er zijn keuzes zodat ik niet als een parkiet rond zal lopen en ben daarom voor die kleur gegaan.

Wat vond je ervan dat je op dit moment niet verschillende maten kon passen? Had je graag een kleiner vest van hetzelfde model willen passen?
Ik vind het wel fijn om niet na te hoeven denken over zal het een S of een M worden. En zal het bij de buurwinkel weer een andere schaal zijn. Ik heb het niet gemist eerlijk gezegd. Maar misschien heeft het ook met het model te maken. Dit is niet echt een nauwsluitend model. Ik hoef niet te weten wat voor maat het is. Het past, punt. Als je uit gaat van personalisatie dan valt dat een beetje weg naar de achtergrond.

Had je voordat je hierheen kwam al bedacht van ik wil heel graag een trui of een vest?
Nee, helemaal niet. Ik ben toevallig wel fan van gebreide kleren. Iets wat een beetje meebeweegt vind ik fijner dan een strak hemd, omdat mijn figuur daar niet bij past. Dat voelt niet prettig. Alles wat gebreid is, is voor mij prima. De enige voorkeur is dat het mijn figuur mooi naar voren brengt. Iets wat mij langer en slanker maakt dan klein en rechthoekig.

De maten worden nu opgenomen met een meetlint. We zitten ook te kijken naar andere opties zoals een 3D scanner. Weet je wat het is?
Ik heb het nooit echt mee gemaakt, en ik kan me er eigenlijk ook niks bij voorstellen.

Je hebt verschillende soorten 3D scanners, maar het principe is dat de afstand van het licht of de laser gemeten wordt tot de persoon. Dan komt er een zogenoemde point cloud, allemaal puntjes met die afstand informatie, die een 3D figuur vormen. Is dat iets waarvan je zegt dat zou ik wel/niet willen doen? Het heeft natuurlijk voordelen en nadelen. Aan de ene kant zou je juist strak zittende kleding aan moeten doen, maar anderzijds hoeft er niemand aan je te zitten.
Dat er iemand aan me zit heb ik opzicht niet zo heel veel moeite mee, als dat professioneel is. Je voelt natuurlijk wel het verschil tussen iemand die de maten opneemt en iemand die iets doet wat niet de bedoeling is. Dus daar heb ik geen problemen mee. Dat iemand die bekwaam is en goed omgaat met het meetlint is wat mij betreft ook geloofwaardig. Het is wel zo dat als je een beetje nauwsluitende kleren wilt hebben en je een beetje afwijkend figuur hebt is zo'n meting met van die punten ideaal (3D scanner). Dan weet je dat het goed is. Ik sta daar ook wel open voor. Ik veronderstel dat dat niet kanker verwekkend is ofzo.

Vond je het vervelend dat er iemand mee stond te kijken? In een winkel omgeving kunnen dat natuurlijk meer mensen zijn. Zou je dat dan nog steeds in de winkel willen doen of liever in een aparte ruimte?
Ik had daar geen moeite mee. Ik heb het gesprek als zeer vrij ervaren. Ik had niet het idee dat iemand mij wat probeert aan te smeren. Dus het is prima. Als iemand anders mee kijkt kan diegene misschien ook ideeën opdoen en doorgeven.

Heb je bepaalde verwachtingen voor dit kledingstuk wanneer je het krijgt?

Dat het mij goed staat. Dat ik er mooi mee uit zie. Dat ik die jaren kan dragen. Dat het een paar keer gewassen mag worden zonder dat het de vorm/kleur verliest.

Als je het kledingstuk terug krijgt wat denk je dan dat het ergste is dat er mis mee kan zijn?
Ik zou zo 1, 2, 3 niet weten. Het personaliseren hebben we vrij grondig aangepakt. Ik vind het wel spannend om te zien hoe die grijze boord eruit ziet, omdat ik dat nu nog niet heb kunnen zien. Ik vertrouw er wel op dat het goed past. Als het echt niet had gekund had ik het hopelijk wel gehoord van iemand die meer verstand van heeft van de combinaties. Ik denk misschien dat als het proces (het maken van de kleding) heel lang duurt je bloot gesteld wordt aan andere trends en dat je smaak dan misschien veranderd. Dat je het daarom niet zo aantrekkelijk meer vindt. In mijn geval zal dat denk ik niet zo zijn, want ik ben vrij trouw aan de stijl die ik kies. Voor de rest zou ik het niet weten. Ik denk dat het juist fijn is dat je de stoffen kunt zien en voelen. Je hebt verschillende modellen dus met een klein beetje verbeeldingskracht denk ik dat het gepersonaliseerde model wel bevalt.

Vind je dat er te veel/te weinig keus is kwa stoffen.
Nee, ik heb niet het idee gehad van oeps waar moet ik beginnen. Ik vind het wel oke. Je kunt ook wel wat geks bedenken. Maar als je een basis kledingstuk aanbiedt wat jarenlang mee gaat dan vind ik het wel goed. Je wordt natuurlijk ook beperkt doordat het breiwerk is. Kwa afwerkingen kun je misschien wat uitbreiden. Je kunt daarmee spelen met de modetrend ofzo. Ik zit te denken aan het breien van wat meer etnische motieven of traditionele ruiten. En traditionele afwerking die ik zelf heel mooi vindt zijn kabel truien. Het heeft een verlengde werking. Maar ja je kunt ook niet alle mogelijke breisels aanbieden. Wat stoffen betreft vind ik het prima.

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
0.00	Ik ben aan het kijken naar de modellen kwa vorm en die het best bij mijn figuur passen		
0.20			Pascale pakt de kleding stukken vast en gaat als een klant door het rek “shoppen”
0.26	Ik heb eigenlijk niet zo lang geleden voor het eerst een vest zonder knoop gekocht, en dat vond ik opzich wel te dragen. Ik heb het altijd wel een beetje raar gevonden dat er geen knoop was. Hoe moet ik het dan dicht doen? Maar het viel eigenlijk wel mee		Pascale pakt lang blauw vest met zakken
0.45	Het is een model die ik eventueel wel zou kunnen overwegen maar die is wel erg lang		Ze hangt het kledingstuk weer terug
0.55	Ik denk dat het mij wat kleiner zou maken, ik moet voor iets korters gaan		
			Pascale kijkt verder door de kledingstukken
1.13	Dit is een beetje te grof		Voelt aan grijs vest met dikke garen
1.22	De trui is een beetje kort		Ze houdt de roze trui voor zich en kijkt in de spiegel
1.36	Doen jullie iets met V-hals? Of is die ronde hals gewoon…	Dit is het model zoals wij het voorstellen, maar als jij liever een V-hals hebt en je aangeeft tot waar die moet komen: hoog, laag of heel laag, dan meet ik dat op en maken we een V-hals	
1:56	Oké dus dat behoort tot de mogelijkheden. Het is voor een klein figuur zoals ik handiger om het een beetje langer te maken	En de onderkant dan gewoon recht maken denk ik. (trui heeft nu een gebogen voorkant waarbij het midden hoger is dan de zijkanten)	
2:13	Ja, ik weet niet, hoort het bij de heup te komen?	De voorkant hoort net op de broekriem en achter is dan net langer	
2:30	Ik denk niet dat ik zo … ben. Ik zou dat constant oprekken	Maar dat is wel iets wat we op maat kunnen maken he. Als je zegt hij moet langer of korter dan kan dat gewoon	
2:40	Het is toch leuk gedurft, en grappig dat dat kan		Pascale hangt de trui terug

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
2.49		Je ziet het al bij die witte trui, die is langer.	
2.53	Even kijken hoe dat eruit ziet		Pascale pakt witte trui en bekijkt het in de spiegel
3:00	Oh en die heeft, oh ja net zoals bij die ander, een ander soort afwerking bij de mouw		
3.13	Het is een mooi, wat verfijndere stof. Zou een interessante kandidaat kunnen zijn kwa breisel		Pascale kijkt nog eens goed naar de trui, maar hangt hem dan toch weer terug in het rek
3.31	Deze is mij te kwetsbaar en zou binnen de kortste tijd beschadigen. Dus is niet iets voor mij. Maar vind het wel een heel sierlijk model		Pascale kijkt naar het groene vest met dunne garen
3.52		En in een andere stof?	
4:05	Het is toch een beetje te breed		Pascale houdt het vest nu voor zich voor de spiegel
4.10		Wil je het niet eens aanpassen?	
4.15	Oh even eraf halen?	Ja	Pascale trekt de trui die ze nu aan heeft uit, en probeert het vest
4.30	Ja omdat ik vrij klein en breed ben, heb ik kleren nodig die mij langer maken.		
5:00	Ja zo zit ie wel een beetje laag	Dan zou ik het model korter maken, en de mouwen zijn te lang.	Pascale slaat haar mouwen om om te zien hoe het zou staan met kortere mouwen
5:25		Ik denk dat het model jou te breed maakt	
5:30	Ja, het doet mij een beetje aan een ochtendjas denken. Dit is misschien net niet iets voor mij		Pascale trekt het vest weer uit
5:42		Dan denk ik toch dat je dat andere vest eens aan moet doen, ook al is het te lang. Dat blauwe vest	
5:49	Oh oke, even kijken.	Die kleed meer af	Pascale pakt het blauwe vest en probeert het
6:05		Het is een heel ander model	

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
6.08			Pascale doet een “sassy” loopje naar de spiegel
6:20	Je kan zo een beetje dansen/ er mee spelen met de onderkant (ander stofje met plooien)		
6.29	Dit is wel een model dat…	Ja staat je heel goed, en het heeft dubbele zakken, waar je net niet bij kan, dus die moeten hoger	Pascale bekijkt zichzelf vanuit meerdere kanten in de spiegel
6.45			Pascale pakt het vest in het midden vast en slaat het om om te zien hoe de lengte dan zou zijn, Maartje assisteert
6.54	Hoe hoog denk je dat dat zou moeten zijn? Want ik vind dat als de zakken juist richting de heupen gaan ze deze gaan onderstrepen	Ik denk dat we deze lengte (ander stof onderkant) zelfs weg kunnen laten	
7:11	En dan is het natuurlijk handig als ik een presentatie van de mogelijke modellen kan zien. Ik heb wel een beetje verbeeldingsgraat maar…	Nee dat is inderdaad moeilijk	
7:26		In jouw geval zou ik het onderste deel weglaten	
7:32	Hoe heet dit ook alweer	De plissé	
7:35	De plissé zou weg moeten dan?	Ja dat is natuurlijk wel zonde. Hm dit is een uitdaging	Pascale klinkt teleurgesteld
7:48	De verhouding zullen anders moeten om toch een beetje de verhouding van het model te bewaren maar wel zo dat het bij mij past	We zouden de lengte tussen de zak en de onderkant kunnen inkorten, maar niet veel	
8:06		Dat is wel moeilijk in dit geval	
8:13	Ik ken nog niet zo veel van inkorten van kleding…		
8:23		Even kijken of de zakken toch iets omhoog kunnen	
8:28	Ik heb ooit een buikdanskostuum ontworpen en heb daarbij een beetje geleerd van hoe is je figuur en wat wil je onderstrepen en wat wil je juist wegmoffelen		

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
8:41		Nu worden je heupen wel weggemoffeld (bij het model zoals het is) Alleen zijn de zakken dan wel net iets te laag, maar het is ook decoratief	
8:49	Ik denk niet dat ik het zo ga gebruiken. Het ziet er niet uit van die zakken die volgepropt zijn met van alles. Dat kan zwaar zijn en het elastiek met de druk van trekken veranderen. Ik denk dat ze gewoon een sierfunctie zullen vervullen		
9:15		We zouden ook het vest juist langer kunnen maken. Wat vind je daarvan?	
9:22	Ik weet het eerlijk gezegd niet. Nee, ik denk dat dat geen goed idee is, want - naja misschien verbeeld ik het me wel - ik ben bang dat ik dan op het vest ga lopen en struikel		
9:45		Oke, dus meer puur uit functionaliteit, om die reden.	
9:50	Ja ik ben heel gewild op functionele kleren, en als ze mooi zijn is dat mooi meegenomen		
10:04	Ja ik moet zeggen, ik vond deze interessant vanwege de breisel (wijst naar witte trui) en dat vond ik hier ook (wijst naar gele jurk), en ik vind deze kleur ook niet verkeerd, en zo'n lang stuk ook niet, hoewel het wel dicht is (zijkant van de jurk onderaan). Maar dit model opent wel nieuwe perspectieven (lange blauwe jurk die ze al de hele tijd aan heeft)	Dat is leuk om te horen	
10:36	Dat is wat je hebt als je kleren gaat passen met andere mensen. Ze komen altijd met andere suggesties, en dat is dan ook een verassing.		

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
10:46	De afwerking van de kraag vind ik ook mooi	Wat ik me kan voorstellen is dat we bij jou de voorpanden nog net een beetje langer maken, breder, dat je ook echt het gevoel hebt dat je hem dicht kan doen. Hij kan niet dicht want er zitten geen knopen op, maar het kan wel ietsjes (breder)	
11:08	Ja ik weet niet wat de oorspronkelijke bedoeling was		Pascale speelt met de voorpanden van het vest. wel of niet dicht/ gewoon laten hangen
11:14		Als je zegt ik vind het mooi zo, dan laten we het zo	
11:18	Ja, hij zit nu eigenlijk zo dicht dat ik bij de heupen moet trekken. Dus als ie zo dicht bij elkaar kan zonder te trekken dan zou dat denk ik ook fijn zijn. Ja dat lijkt me een goed idee.		
11:40	Oke, dan kunnen we voor dit model gaan.	Je hebt je keuze al gemaakt?	
11:44	Ja, ik vind het een speels model. Het voelt comfortabel aan. Dus ja, ik zie het wel zitten.		
12:00		En nu mag je nog kiezen voor kleuren en stoffen. Heb je daar al een idee over?	
12:08			Pascale kijkt bedenkelijk richting de stoffen
12:10		Wat je nu hebt is deze en deze stof. (Maartje haalt de proefstoffen uit het rijtje). Dit is je combinatie	
12:25		Het kan dus ook in een andere kleur en een ander materiaal. We hebben biologisch katoen, dat zijn deze. Dit is mohair, dat is wat transparanter.	
12:50	Dat is mezelf niet proof, dus ik zou dat niet gebruiken, dat is te kwetsbaar.		
12:56		Dan hebben we merino wol, de stof is niet dik maar wel los en comfortabel.	
13:10	Ook vrij kwetsbaar, voor mezelf dan he. Ik weet niet hoe ik het doe, maar ik trek altijd draden eruit.		

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
13:17		En wat je nu aan hebt - en wat deze stof ook is, maar dan andere kleur - is gemaakt van gerecycled textiel. Dus het zijn restanten uit textiel fabrieken die niet verkocht zijn en dus opnieuw vervezeld worden om er draad van te maken.	
13:32	Oh, wat interessant.	Die heb ik ook in het grijs, en in het wit.	
13:40	Wat ik bij die blauwe interessant vind en bij die witten en grijze niet zo is, is dat het een beetje melé is. De verschillende tinten. Dat vind ik wel een interessant element.	Ja, deze heeft dat heel duidelijk	
14:10	Dat zou wel bepalend kunnen zijn, ook al weet ik niet of ik zo gek op blauw ben. Het is niet de kleur waar ik in eerste instantie meteen naar toe zou grijpen in de winkel.		
14:40	Dit is op zich interessant.	Dit is ietsjes lichter dan wat je nu hebt (lichtblauwe melé stof van gerecycled textiel)	Maartje houdt het lapje stof over het vest voor de spiegel zodat Pascale het verschil kan zien.
14:50	Ik moet ook rekening houden met mijn huids en haar kleur.		
15:04	Dit is dezelfde stof maar dan een stuk donkerder. Een beetje donker is op zich voor mij goed.	Ik denk dat ze allebei mooi zijn.	
15:20	Normaal heb ik alleen maar grijs in m'n kast.		
15:30			Je ziet dat Pascale erg twijfelt over de stofkeuze
15:45	Het zijn niet echt knallende kleuren (zoals zij veel draagt) en grijs moet ik nog erg aan wennen bij wijze van spreken.		
16:06	Ik denk niet dat ik het zou durven om iets in het grijs van zo'n groot oppervlak te nemen. Misschien wel als een t-shirt eronder.		

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
16:13		En als we die stap even overslaan en we kijken naar de onderkant - dit gedeelte (wijst naar plissé) - daar heb je natuurlijk ook keuze uit al die stoffen en ook dus uit de kleuren. Zou je dan daar de kleur willen toevoegen?	Pascale bladert nog eens door de stoffen.
16:30	De neiging is groot ja, want ik hou van bonte kleuren.		
16:45		Kijken wat je hiervan vindt	Maartje pakt gele plissé stof en houdt het voor de onderkant van het vest voor de spiegel
16:55		Het valt wel op bij die rode broek, dat zou ik niet doen.	
17:00	Daar heb ik niet zo veel moeite mee, maar het is een beetje te licht.		
17:16		O dit is mooi, bij die rode broek	Maartje houdt een andere stof voor het vest (roze)
17:28	Hm ik weet niet. Dan zou ik toch eerder die gele doen	Ik heb ook nog donker groen	
17:50	Nee dat is mij een beetje te koud(e kleur)		
17:55		Wit en grijs hebben we dan nog	
18:06	Verven jullie de stoffen zelf?	Nee, wij kopen de garens in, en die hebben al een kleur.	
18:18	En zijn dat natuurlijke kleuren?	Nee helaas niet. Dat zou wel fantastisch zijn. Dus wat we wel belangrijk vinden is dat het duurzame materialen zijn. En op een gegeven moment willen we ook naar diervriendelijke wol.	
18:40	Wat dat betreft geen verkeerd ideaal.		
18:46			Maartje houdt de witte plissé stof voor.
18:55	Hm nee		
19:06	Dat is beter		Maartje houdt de grijze plissé stof voor
19:12	Ja	Ja deze is te wit he? Dat kan ik me voorstellen	
19:18	Dat is geen kleur die ik zou kiezen. Licht roze trekt mij niet aan. Ik ben meer van de fellere kleuren.	Ik vind roze ook heel mooi, maar jij zei van niet he?	

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
19:45	Ja, dat past goed bij elkaar. Dit is wat donkerder en intenser, en dat is wat lichter en vrouwelijk. Dat is ook mooi bij elkaar. Dat zou meer een zomer variant zijn.	Dit is de lichtere variant	Maartje houdt nu de combinatie van lichtblauw gerecycled stof en grijze onderkant voor Pascale.
20:14		En jij vindt het mooi dat de stof zo lekker wijdt valt (de plissé stof). Zodat je zo met je been kunt schoppen (iets wat Pascale deed toen ze het vest net aan had)	
20:20		Je kan natuurlijk elke stof kiezen he! Maar dan heeft ie dus niet dat wijde effect	
20:26	Die plissé maakt het op de juiste manier af. En dat maakt er iets vrouwelijks van.		
20:39	Ik zit mij af te vragen of het misschien mogelijk zou zijn - ik weet niet hoe dat eruit zou zien - om deze band (rondom de opening van het vest) in de donker blauwe plissé kleur te doen?		
20:57		Je wilt deze kleur voor het hele vest toch? (licht blauwe kleur)	
21:03	Achteraf gezien kies ik toch liever deze (donker blauwe variant van de gerecyclede stof)		
21:13		Oké dus dan hebben we dit toch?	Pascale controleert of de stof die ze aanheeft hetzelfde is als het proeflapje dat Maartje vasthoudt.
21:17		Hij wordt zachter en vezeliger (de stof) doordat je hem draagt en gebruikt, en deze heeft wat meer beweging gehad, en deze dus nog wat stugger (proeflapje)	
21:36		Ik denk dat je te veel kleuren krijgt. Maar jij mag natuurlijk kiezen.	Pascale houdt nu ook de onderkant van het vest bij de rest van de lapjes om de combinatie te bekijken
21:45	Het is natuurlijk nu maar twee kleuren. Dan zal het dus handig zijn om dat inderdaad te kunnen zien.		

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
22:10		Ik zou het niet doen omdat er zo'n kader ineens om je lichaam komt in een donkere tint en dat is heel dwingend/aanwezig.	
22:20	Het was het idee om die verticale lijn te onderstrepen, maar misschien kan ik dan beter voor die lichtgrijs gaan? Zodat het nog steeds onderstreept maar op een subtielere manier. Het is een idee.		
22:47		Het moet dan wel in hetzelfde materiaal (voor steekgrootte zodat alles uitkomt bij het aan elkaar naaien), dus dat zou dan deze grijze zijn (grijs van gerecycled textiel). Dan krijg je zo'n randje erlangs.	
23:10	Ja. Dan is het grijs iets meer in verhouding tot het blauw. Ik denk dat ik dat wel aankan. Zou wel een toevoeging kunnen zijn. Je moet ook niet te veel willen veranderen, dan wordt je een soort papegaai.		
23:49	Dan wordt dat het.		
23:51		Zal ik dan nog even kijken hoe we de maten kunnen aanpassen. Dus ik schrijf even wat dingen op, en meet hier en daar wat maten van jou.	
24:00	Zal ik dat uittrekken?	Nee laat maar even aan. Ik wil gewoon de verhouding zien waar het kledingstuk kleiner of korter moet.	
24:10		Ik ga de lengte van deze plissé ietsjes korter maken.	
24:20		Niet veel korter, ik denk zo'n 3 cm.	Maartje houdt het meetlint bij het kledingstuk en kijkt wat er eventueel af kan.
24:30	Je zou met verhoudingen van het kledingstuk moeten werken.	Ja, maar omdat je het uiteindelijk moet vertalen naar het patroon en je het in cm's moet breien doe ik het zo. Maar ik kijk wel naar de verhoudingen.	
24:48		Hier zou ik dus 3cm vanaf halen. Want als je te veel doet dan heeft het niet meer dat effect wat jij met je been deed, dat sierlijke.	

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
24:59		Ik ga hier een klein stukje uithalen (tussen de zak en einde stof. Want het effect van die zakken moet op dezelfde plaats blijven. Alleen hier en daar dus een stukje eraf. Dan hangt de plissé precies tussen je enkel en je knie, dus op het midden van je kuit.	
25:44		Ik meet dan vanaf het hoogste punt van de schouder tot aan de knie. Het blauwe gedeelte is dan 1 meter.	
26:31	Ik vind van wel.	Ik meet ook jou lengte van hoogste punt schouder tot aan de bovenkant van de zak. Want de plaatsing is goed toch?	
26:45	Zouden de zakken dan misschien ietsje pietsje kleiner moeten? Om de verhouding met de rest van het vest te bewaren	Nee. Ik denk dat dat te weinig effect zal hebben. Als de zakken dan ook te kort worden hebben ze niet meer dat …. - het is zo leuk dat het losse zakken zijn. Als ze te kort worden is dat niet meer zo.	
27:45	Ik vind het jammer dat jullie helemaal niks van rood hebben.	Geen rood, nee. Wel grappig want het wordt wel vaker gevraagd.	
27:52	Is dat een keus of toevallig zo?	Dat is wel een keuze ja. Rood past eigenlijk niet in onze stijl. Maar ik denk dat we het misschien wel toe moeten voegen.	
28:03	Wat is jullie stijl dan?	Ja eigenlijk de kleuren range die je hier ziet, maar ook wel wat je aan de andere dingen en producten ziet. Rood is gewoon niet onze kleur. Maar het is goed dat je het vraagt, want als meer mensen het vragen betekend het dus dat het op de een of andere manier in het palet moet.	
28:18	Ja rood is echt mijn kleur.		
28:55		Ik ga even verder met (het opmeten) …	Maartje probeert verder te gaan met opmeten maar het gesprek blijft doorgaan waadt dat lastig is.
28:57	Ik kan me ook voorstellen dat de kleuren veranderen van seizoen tot seizoen	Maar dat is ook het idee. We gaan wel steeds kleuren vernieuwen, of stoffen toevoegen/vervangen.	

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
29:12	Aan de andere kant, ik kan me voorstellen dat jullie duurzame kleren maken want als je als je iets op maat laat maken verander stel ik dat je dat niet na een jaar in de prullenbak gooit en iets nieuws koopt. En dat de insteek meer is dat je kiest voor iets wat echt bij jou stijl past los van de mode ipv de allernieuwste hypermoderne kleuren.	Je hebt helemaal gelijk.	
29:40	Dan vind ik het assortiment wel heel rustig. Het is een basis die je met veel andere tinten kan combineren.		
30:00		Nog even over de mouwen, en dan de lengte vooral	
30:05	Ik ben voorstander van wat kortere mouwen, eerder driekwart.		Pascale stroopt de mouw op om het resultaat te zien.
30:15		We maken dan dit stuk ook iets korter (afwerking einde van de mouw dat omgeslagen is). Maar die omslag is wel mooi.	
30:20	Ja, dat zou ik niet weg willen. Die moet minstens 4 van mijn vingers lang zijn.	En dan komt hier het dubbelgevouwen stuk(wijst naar stuk waar afwerking begint), of ga je het dan nog dubbelvouwen?	Maartje meet op hoe lang dat dan ongeveer zou zijn.
30:42	Even kijken		Pascale speelt met de mouw voor de spiegel om de juiste lengte te vinden
30:49	Zo vind ik het goed. Het uiteinde hoeft niet perse korter. Even spelen ermee als dat wel zo zou zijn. Zou ook wel kunnen.		
31:17	Nee dit is een normale mouw dan. Ik denk dat driekwart toch een beetje raar zou zijn.	Maar niet driekwart dan?	Ze stroop de mouw op tot driekwart.
31:30	Ja, tot de pols is prima. Als het zo zit is het goed.	Ik zou het gewoon tot de pols doen. Maar waar jij het wilt hebben	
31:40		Totale mouwlengte is 40 cm.	Maartje gaat de mouw opmeten. Uiteindelijk niet het verkorte (omgeslagen) uiteinde opgeschreven.

Tijd	Wat zegt Pascale	Wat zegt Maartje Boer	Notities
32:10			Terwijl Maartje de gegevens opschrijft, speelt Pascale nog even met de mouw.
32:28		Ja. Dan hebben we alle maten opgenomen. Dan maak ik voor jou een afbeelding met wat je krijgt.	Pascale trekt ondertussen het vest weer uit en hangt het op.

7.3 Physical Properties Fabric

Mohair Grid

Bending test results

	weft	warp
contact distance (A)	8 mm	18 mm
length (B)	46 mm	47 mm

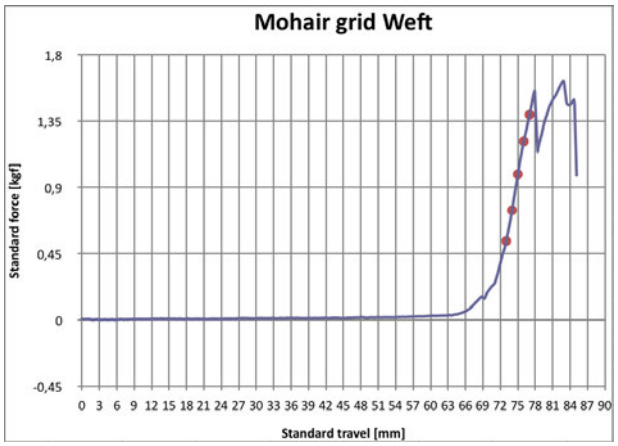
Weight & Thickness

	120x30 mm
Weight	0,84 g
Thickness	1,36 mm

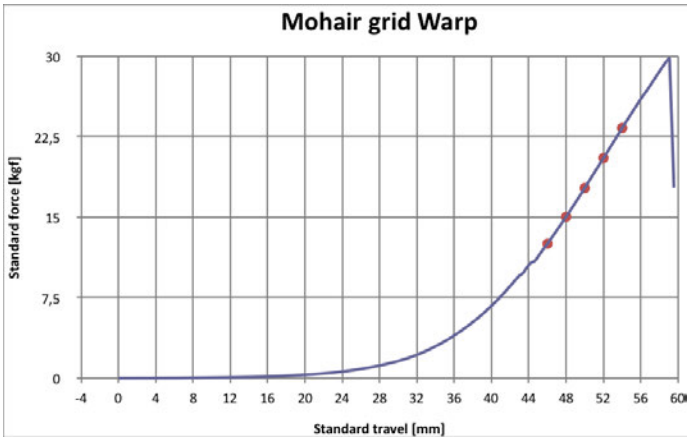
Results Tensile test

	Weft		Warp	
	Length (mm)	**Force (kgf)**	**Length (mm)**	**Force (kgf)**
1	73,0	0,54	46,0	12,53
2	74,0	0,74	48,0	15,04
3	75,0	0,99	50,0	17,73
4	76,0	1,21	52,0	20,51
5	77,0	1,39	54,0	23,33

Graph tensile test in weft direction



Graph tensile test in warp direction



Plisse

Bending test results

	weft	warp
contact distance (A)	6 mm	34 mm
length (B)	39 mm	51 mm

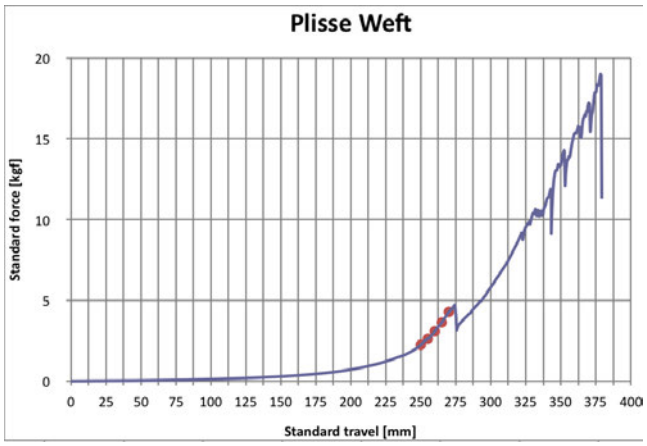
Weight & Thickness

	120x30 mm
Weight	1,76 g
Thickness	3,90 mm

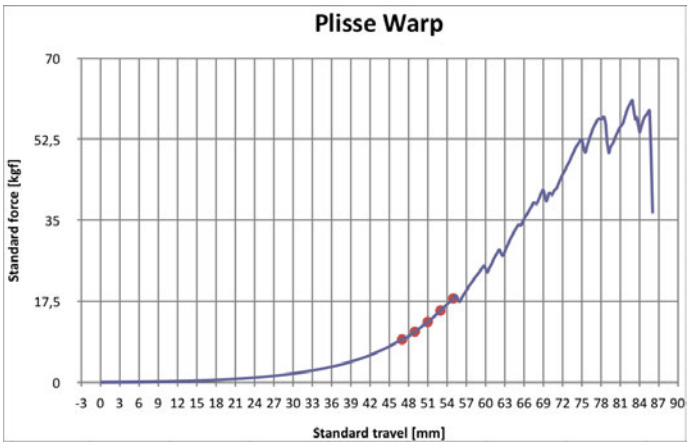
Results Tensile test

	Weft		Warp	
	Length (mm)	**Force (kgf)**	**Length (mm)**	**Force (kgf)**
1	250,0	2,25	47,0	9,22
2	255,0	2,63	49,0	10,95
3	260,0	3,09	51,0	13,06
4	265,0	3,64	53,0	15,45
5	270,0	4,28	55,0	18,09

Graph tensile test in weft direction



Graph tensile test in warp direction



Honey

Bending test results

	weft	warp
contact distance (A)	21 mm	19 mm
length (B)	46 mm	46 mm

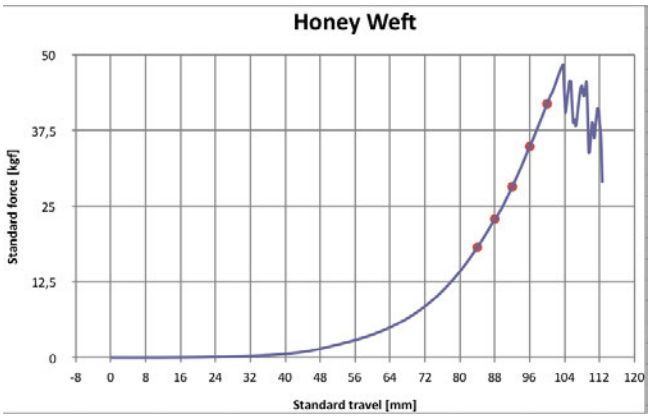
Weight & Thickness

	120x30 mm
Weight	1,56 g
Thickness	2,10 mm

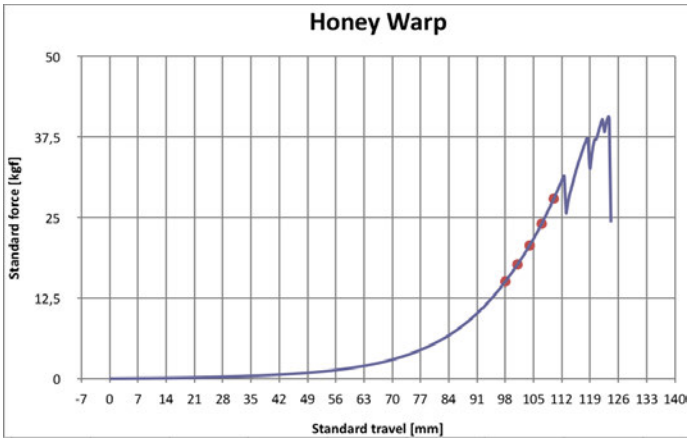
Results Tensile test

	Weft		Warp	
	Length (mm)	**Force (kgf)**	**Length (mm)**	**Force (kgf)**
1	84,0	18,22	98,0	15,07
2	88,0	22,89	101,0	17,70
3	92,0	28,23	104,0	20,66
4	96,0	34,85	107,0	24,0
5	100,0	41,88	110,0	27,90

Graph tensile test in weft direction



Graph tensile test in warp direction



Ecoplanet

Bending test results

	weft	warp
contact distance (A)	29 mm	36 mm
length (B)	49 mm	52 mm

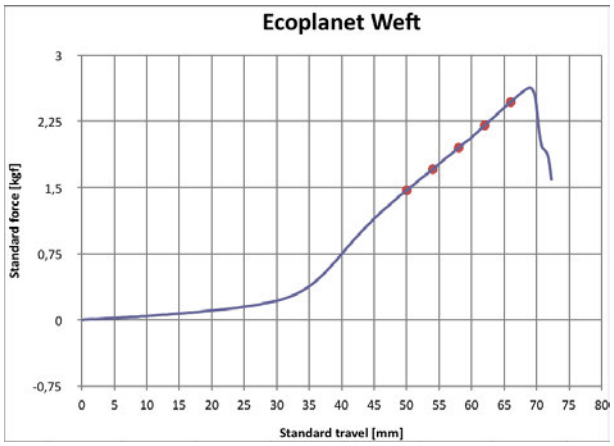
Weight & Thickness

	120x30 mm
Weight	1,55 g
Thickness	2,24 mm

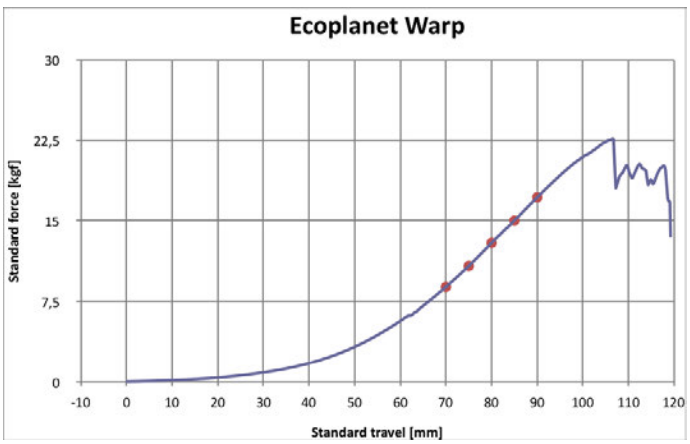
Results Tensile test

	Weft		Warp	
	Length (mm)	**Force (kgf)**	**Length (mm)**	**Force (kgf)**
1	50,0	1,47	70,0	8,84
2	54,0	1,70	75,0	10,78
3	58,0	1,95	80,0	12,93
4	62,0	2,20	85,0	15,02
5	66,0	2,47	90,0	17,20

Graph tensile test in weft direction



Graph tensile test in warp direction



V-dessin Tuck

Bending test results

	weft	warp
contact distance (A)	33 mm	39 mm
length (B)	52 mm	60 mm

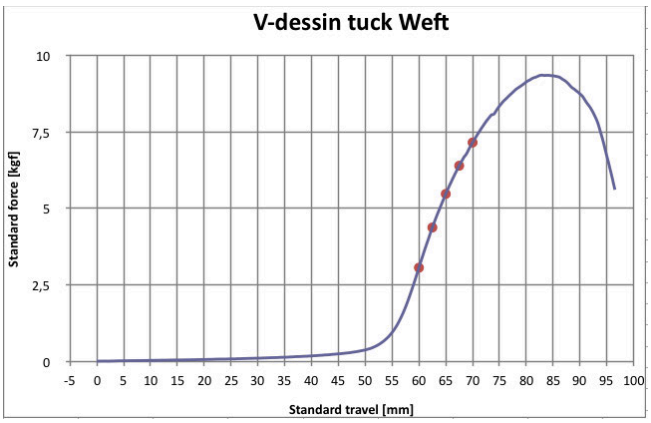
Weight & Thickness

	120x30 mm
Weight	2,17 g
Thickness	3,37 mm

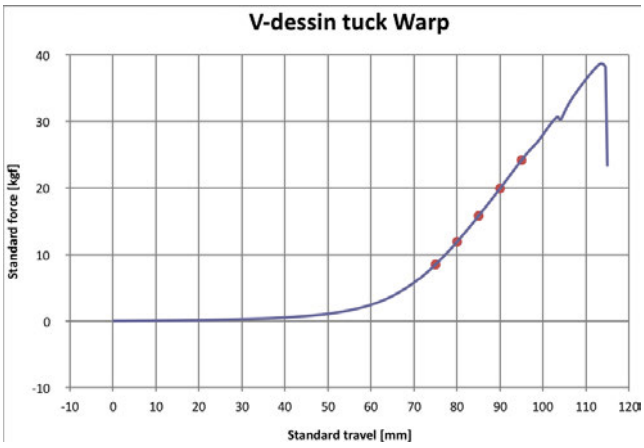
Results Tensile test

	Weft		Warp	
	Length (mm)	**Force (kgf)**	**Length (mm)**	**Force (kgf)**
1	60,0	3,06	75,0	8,49
2	62,5	4,38	80,0	11,90
3	65,0	5,47	85,0	15,79
4	67,5	6,39	90,0	19,93
5	70,0	7,15	95,0	24,20

Graph tensile test in weft direction



Graph tensile test in warp direction



7.4 Close Up Wireframes

Clothing commercial

How to customise your garment

To keep track of your garments and to be able to purchase in the end, you first need to create an account.

You can create a custom garment by choosing between different garment models, fabric dessins and colours. Choose where you want to start and adapt as you go along!

If you are satisfied with your result but want to keep on experimenting you can save up to 3 garments in your account. Once you are ready click purchase and we will produce your custom garment!

Nevermind! **Create account**

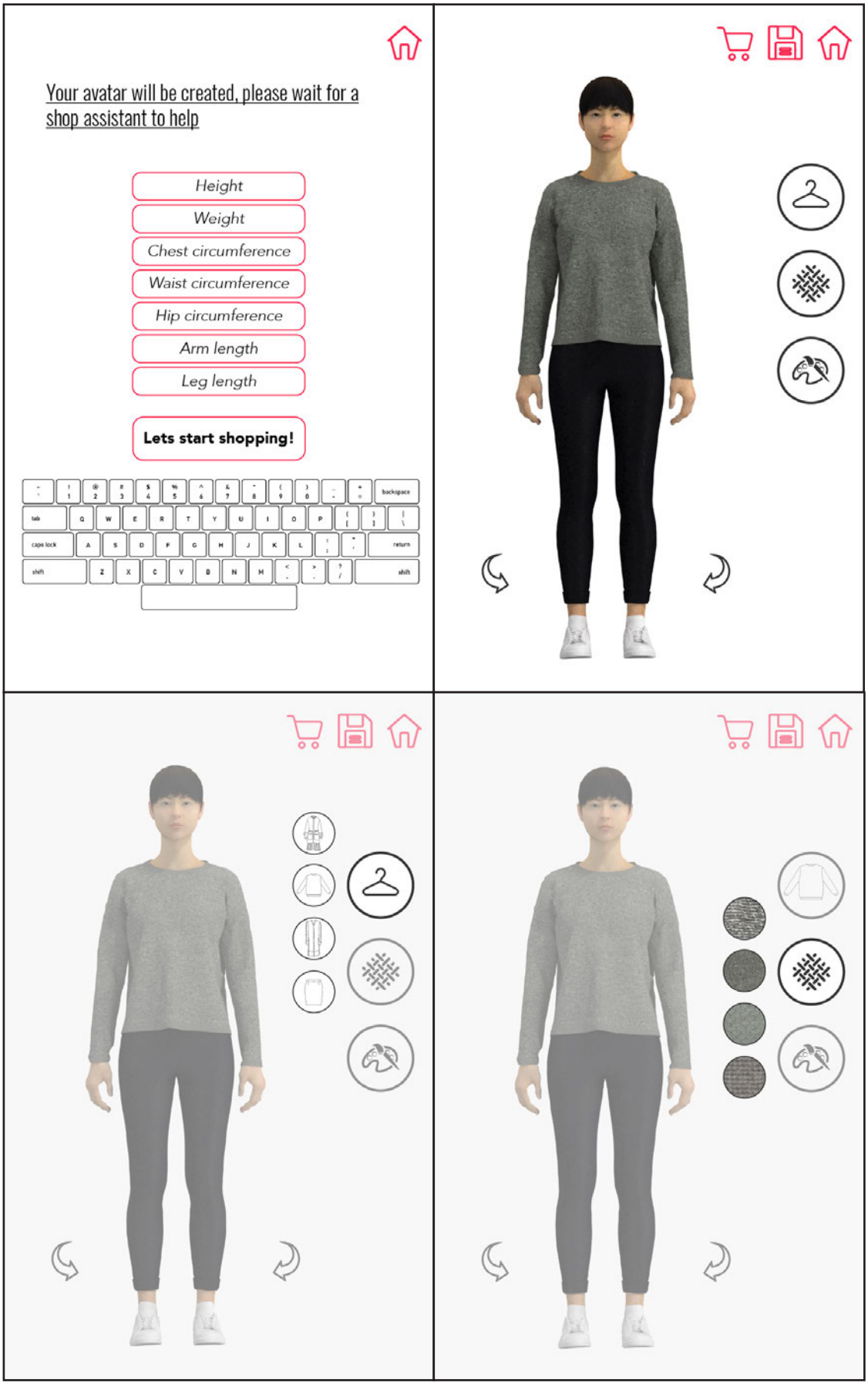
Please enter the following details to create your account:

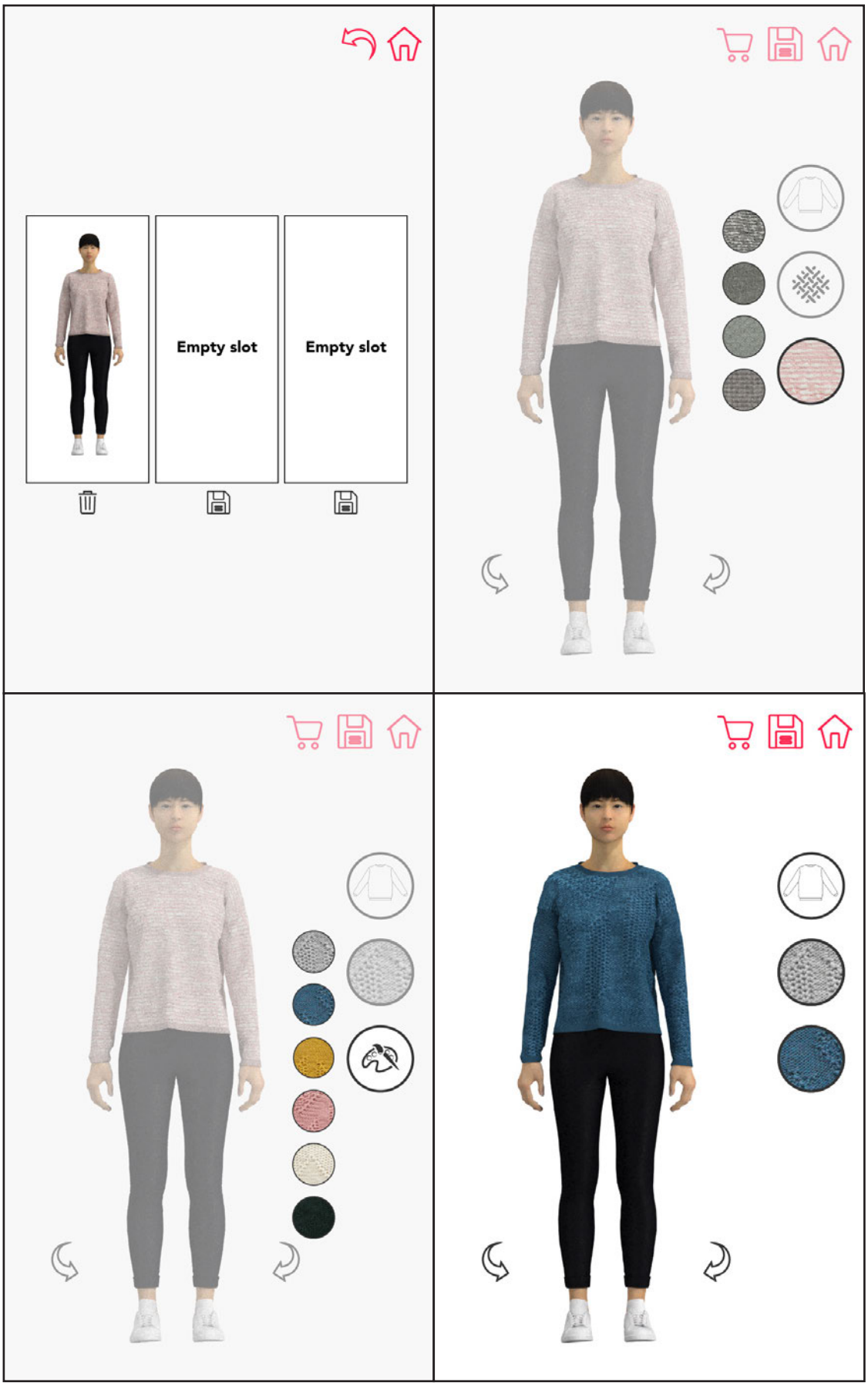
First name

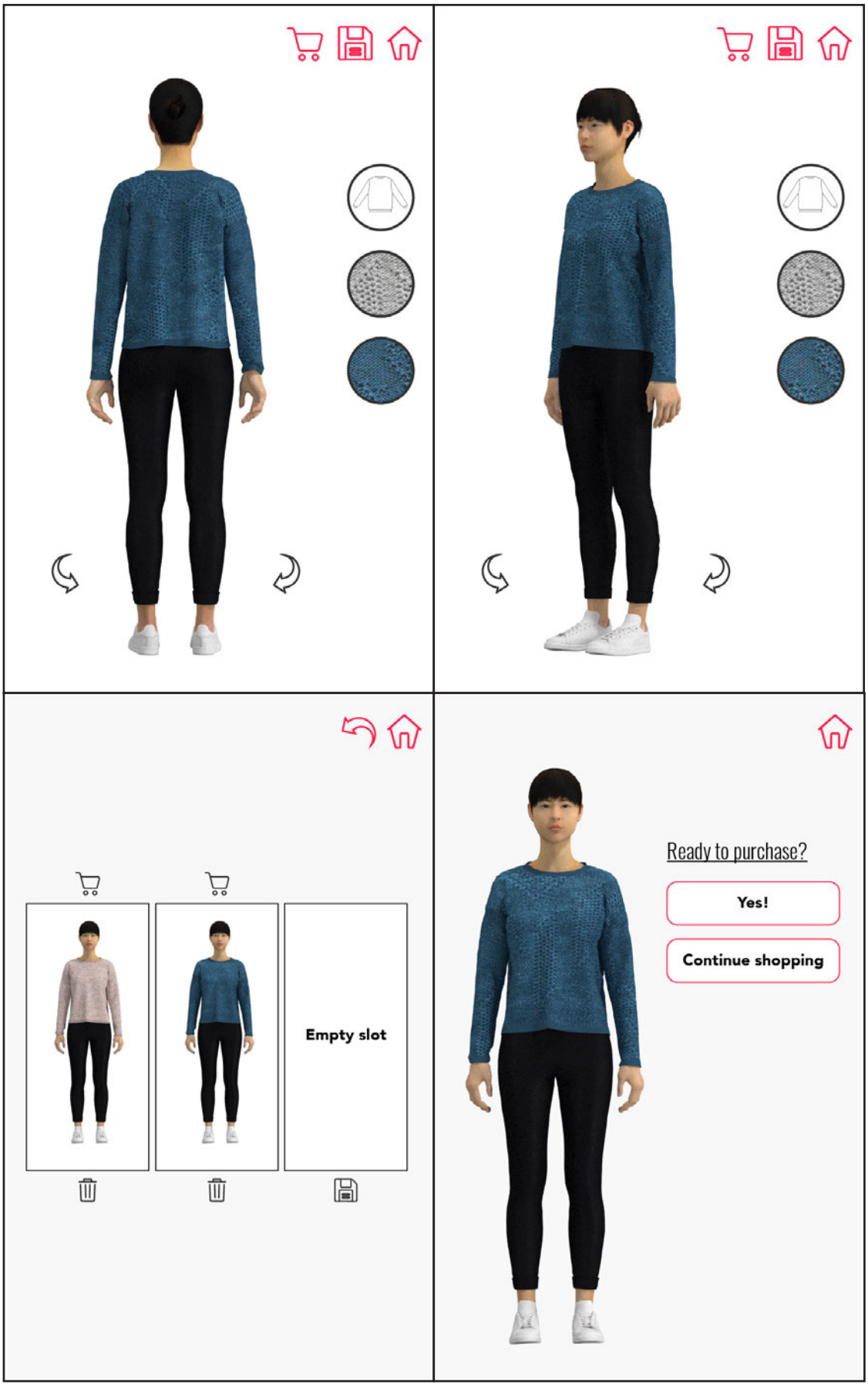
Last name

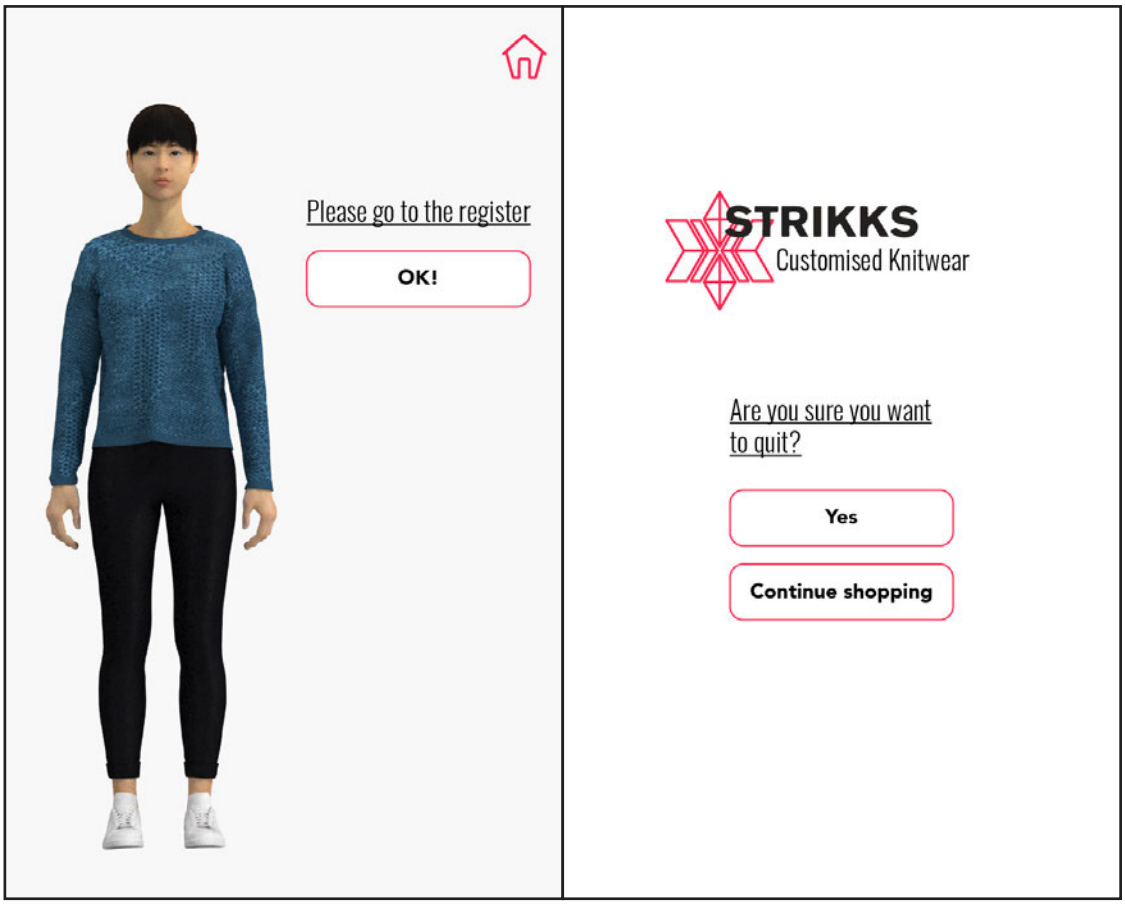
E-mail address

Continue


Your avatar will be created, please wait for a shop assistant to help
Height
Weight
Chest circumference
Waist circumference
Hip circumference
Arm length
Leg length
Lets start shopping!


Empty slot
Empty slot


Empty slot
Ready to purchase?
Yes!
Continue shopping


Please go to the register
OK!
STRIKKS
Customised Knitwear
Are you sure you want to quit?
Yes
Continue shopping

7.5 Web API's

Login CLO-SET
Type of method: POST
URL: https://www.clo-set.com/api/Account/Login
Input:
Headers:
Content-Type = application/json
Accept = application/json
Body:

```
{
        “Email”:”maartje.vanderbie@gmail.com“,
        “Password”:”******”
}
```

* Password is concealed as this is confidential information

Output:


```
{
   "Code": 1,
   "Data": {
      "Email": "maartje.vanderbie@gmail.com",
      "Token": "d7b3f7ea548d440dbf10b82c77523296",
      "BasicAuth": "Basic
bWFhcnRqZS52YW5kZXJiaWVAZ21haWwuY29tOmQ3YjNmN2VhNTQ4ZDQ0MGRiZjEwYjgyYzc3
NTIzMjk2"
   }
}
```


* Token & BasicAuth is different every time the request is made, so these cannot be used anymore. The ones shown are just an example.

CLO-SET Item
Type of method: GET
URL: https://www.clo-set.com/api/Item
Input:
Headers:
Content-Type = application/json
Accept = application/json
Authorization = BasicAuth from Login CLO-SET API

Output:


```
[
   {
      "ItemId": "5b1e6d37fc66488cbf9b66fb0fc5df67",
      "Version": 1,
      "StyleNumber": "Basistrui Grading & Colorway",
      "FileType": 1,
      "FileSize": 206014624,
      "FileName": "Basistrui Grading & Colorway.zpac",
      "FilePath": "https://files.clo-set.com/private/201904/5b1e6d37fc66488cbf9b66fb0fc5df67/1/
Basistrui+Grading+%26+Colorway.zpac?verify=1554325388-
t%2b86XnayVEhnYl3SFMeKEHJUx4f4wBnFKQv%2fDgV6UUY%3d",
      "IsNew": false,
      "ThumbnailPath": "https://files.clo-set.com/private/
201904/5b1e6d37fc66488cbf9b66fb0fc5df67/1/thumbnail.png?verify=1554325388-
%2fVzV6yEb8cU7R3B%2fOunlpotd6cNTYUrZHiV1wzehUkw%3d",
      "ThumbnailName": "thumbnail.png",
      "IsS3ImagePath": false,
      "CreatorName": "maartje.vanderbie",
      "CreatorEmail": "maartje.vanderbie@gmail.com",
      "CreatorId": 0,
      "UpdateDate": "2019-04-03T19:51:15.92",
```

```
        "FavoriteSeq": 0,
        "IsCreator": true,
        "Processing": false,
        "ColorCode": null,
        "WorkflowName": "Draft",
        "WorkflowNum": 1
    },
]
```


* This is one example of an item that was uploaded to the CLO-SET at that time. For each item the same information is shown but then applied to that particular item.

Login Benefit by CLO
Type of method: POST
URL: https://apisite.benefitbyclo.com/api/accounts/login
Input:
Headers:
Content-Type = application/json
Accept = application/json
Body:


```
{
        "closetAccount":"maartje.vanderbie@gmail.com",
        "closetPassword":"myPassword"
}
```


* Password is concealed as this is confidential information

Output:

“eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJ1bmlxdWVfbmFtZSI6Im1hYXJ0amUudmFuZGVyYmllQGdtYWlsLmNvbSIsIm5iZiI6MTU1NDMzMTc2NCwiZXhwIjoxNTU0MzM3NzY0LCJpYXQiOjE1NTQzMzE3NjR9.ObWADq29sTn0Ud5nyWIbSWb3q9IZ3wxw4FjGR2FEiww"

* Same as the CLO-SET Login, this code is different every time the request is made, so this cannot be used anymore. The one shown is just an example.

Create Benefit Avatar
Type of method: POST
URL: https://apisite.benefitbyclo.com/api/benefitavatar
Input:
Headers:
Content-Type = application/json
Accept = application/json
Authorization = Code from Login Benefit by CLO
Body:


```
{
        "gender":"female",
        "height":172,
        "weight":61,
        "type":2,
        "shape":0,
        "pose":0,
        "chest":90,
        "waist":72,
        "hip":100,
        "arm":60,
        "leg":-1
}
```


Output:


```
{
    "avatarId": "rs5ca538d652046944c09633a7",
    "fileType": "fbx",
```

```
    "status": "ready",
    "createdAt": "2019-04-03T22:51:02.743Z"
}
```


Create Avatar ArtifactID
Type of method: POST
URL: https://apisite.benefitbyclo.com/api/artifact
Input:
Headers:
Content-Type = application/json
Accept = application/json
Authorization = Code from Login Benefit by CLO
Body:


```
{
    "input" : {
      "requestType" : "AVATAR",
      "avatar": {
        "avatarId":"{{avatarId}}",
      }
    },
    "output" : {
      "fileType" : "PNG"
    },
    "option" : {
      "overwrite" : false
    }
 }
```


Output:


```
{
    "artifactId": "5ca53a5d52046944c09633a8",
    "status": "completed",
    "input": {
        "requestType": "AVATAR",
        "avatar": {
            "avatarId": "rs5ca538d652046944c09633a7"
        },
        "garment": null
    },
    "output": {
        "fileType": "PNG"
    },
    "createdAt": "2019-04-03T22:57:33.7268419Z"
}
```


Get Avatar Artifact
Type of method: GET
URL: https://apisite.benefitbyclo.com/api/artifact/:artifactId
Input:
Headers:
Content-Type = application/json
Accept = application/json
Authorization = Code from Login Benefit by CLO
Parameters:
artifactid = artifactid from Create Avatar ArtifactID API

Output:


```
{
    “artifactId":"5ca53a5d52046944c09633a8",
```

```
   “status":"completed",
   “input": {
      “requestType":"AVATAR",
      “avatar": {
         “avatarId":"rs5ca538d652046944c09633a7"
         },
      “garment":null
   },
   “output": {
      “fileType":"PNG"
      },
   “finishedAt":"2019-04-03T22:57:33.122Z",
   “elaspedTimeinSec":0.0,
   “errorType":0,
   “createdAt":"2019-04-03T22:57:33.122Z",
   “errorMsg":"ERROR_NO",
   “thumbnail":null,
   “fileList":null
}
```


Download Avatar Artifact
Type of method: GET
URL: https://apisite.benefitbyclo.com/api/artifact/:artifactId?includeFileList=true
Input:
Headers:
Content-Type = application/json
Accept = application/json
Authorization = Code from Login Benefit by CLO
Parameters:
artifactid = artifactid from Create Avatar ArtifactID API
includeFileList = true

Output:


```
{
   “artifactId":"5ca53a5d52046944c09633a8",
   “status":"completed",
   “input": {
      “requestType”:"AVATAR",
      “avatar": {
         “avatarId":"rs5ca538d652046944c09633a7"
         },
      “garment":null
   },
   “output": {
      “fileType":"PNG"
   },
   “finishedAt":"2019-04-03T22:57:33.122Z",
   “elaspedTimeinSec":0.0,
   “errorType":0,
   “createdAt":"2019-04-03T22:57:33.122Z",
   “errorMsg":"ERROR_NO",
   “thumbnail":"",
   “fileList":["https://cf.benefitbyclo.com/Avatar/RealtimeRenderImage/720x1280/Type2/Female/
Pose0/172/61/90_72_100_60_82/Type2_Female_Pose0_172_61_90_72_100_60_82_000.png?
Expires=1556924711&Signature=T03J7QDO-bM-
WYx076LeVKtfvjS5iwicYgXhKGdhYMd3cB9yfQr-
CCnBgopHO2eyp3p79f8IlTa7PSfeGWERl4YghxdkZPTycrgBl0bKes5OpwxapLN7IkyJAaTYT-
rxHd6APkre9wh0bh6UkHNIymWSBiPOHeB0oCKzUO8p90fF4OqyQRows6Bq2l5b2gweG1vTedxt
ufozOiTZAYDjUywQxb101Vk-
EVpDV0GRBPpUG68ZwsM8dwzTesOS1VzJEaxSfoyeb086q~ltgbEBDltunTRKRCHaPRfKycz4-
```

ezYnnXtzc70bz~T6MWatlPFL72r0Ua6f-TUQhCzd3THug__&Key-Pair-Id=APKAIMVQ7DWGDTQ2KI6Q"
}
* This fileList url is one of 8 artifacts that is produced by this GET request.

Create Try-on ArtifactID
Type of method: POST
URL: https://apisite.benefitbyclo.com/api/artifact
Input:
Headers:
Content-Type = application/json
Accept = application/json
Authorization = Code from Login Benefit by CLO
Body:

```
{
   "input" : {
     "requestType" : "TRYON",
     "avatar": {
        "avatarId":"{{avatarId}}",
     },
     "garment" : {
        "closetItemid" : "{{ItemId}}",
        "grading" : -1,
        "simulation" : 1
     },
   },
   "output" : {
      "fileType" : "PNG"
   },
   "option" : {
      "overwrite" : false
   }
 }
```

Output:

```
{
   "artifactId": "5ca53d5652046944c09633a9",
   "status": "pending",
   "input": {
      "requestType": "TRYON",
      "avatar": {
         "avatarId": "rs5ca538d652046944c09633a7"
      },
      "garment": {
         "closetItemId": "5b1e6d37fc66488cbf9b66fb0fc5df67",
         "grading": -1,
         "layer": 0
      }
   },
   "output": {
      "fileType": "PNG"
   },
   "createdAt": "2019-04-03T23:10:15.6390337Z"
}
```

Get Try-on Artifact
Type of method: GET
URL: https://apisite.benefitbyclo.com/api/artifact/:artifactId
Input:
Headers:

Content-Type = application/json
Accept = application/json
Authorization = Code from Login Benefit by CLO
Parameters:
artifactid = tryon artifact from Get Tryon Artifact API

Output:


```
{
   "artifactId": "5ca5407852046944c09633b2",
   "status": "ready",
   "input": {
      "requestType": "TRYON",
      "avatar": {
         "avatarId": "rs5ca538d652046944c09633a7"
      },
      "garment": {
         "closetItemId": "a636a03c176742498455e6bfed1e88d0",
         "grading": 0,
         "layer": 0
      }
   },
   "output": {
      "fileType": "PNG"
   },
   "finishedAt": "2019-04-03T23:23:43.204Z",
   "elaspedTimeinSec": 6.377,
   "errorType": 0,
   "createdAt": "2019-04-03T23:23:36.827Z",
   "errorMsg": "ERROR_NO",
   "thumbnail": null,
   "fileList": null
}
```


Download Try-on Artifact
Type of method: GET
URL: https://apisite.benefitbyclo.com/api/artifact/:artifactId/filelist/0
Input:
Headers:
Content-Type = application/json
Accept = application/json
Authorization = Code from Login Benefit by CLO
Parameters:
artifactid = tryon artifact from Get Tryon Artifact API

Output:


```
{
   "fileList": [
      “https://cf.benefitbyclo.com/Garment/RealtimeRenderImage/720x1280/
a636a03c176742498455e6bfed1e88d0/V1/G0/Female_Pose0_172_61_90_72_100_60_82/
a636a03c176742498455e6bfed1e88d0_V1_G0_Female_Pose0_172_61_90_72_100_60_82_C0_0
00.png?Expires=1556925890&Signature=Q~GRSQNzABzKpOR-
mU~e5VadabXalwCW9csPcqQxN7EYtfeTZwXpaQ1UMUvj5IVxn1QOunX5yQipZGSiHwnS7qSS7F
kyd4A2cvFsatvHbO2ZjJrSkV-
X1mgFAIOHHsKbBtRTi1zIg0lQLa3eEpGS2ArCXECV417jqcGEH3oIRXFgPwzwhLtpIfH-9EaKFVsjU
SMkIvmqujEI9jSEUiocsAy~lwxWEBHtI10nNQp~3qvLbmhKckEiHU6bUUYoK4h5jLC9E4rGf-
gBCApVdO4J-
E~P0UqeMIEPf2L7WajrTt9RQ9cX4z2e~BgMj3huMIZOiQFYzlUB9SaqFPUXtqXw5Q__&Key-Pair-
Id=APKAIMVQ7DWGDTQ2KI6Q"
   ],
}* This fileList url is one of 8 artifacts that is produced by this GET request.
```

7.6 Measurements avatar Clo3D

Standard measurements

- Height
- Bust circumference

Basic details

- Neck base circumference (optioneel?)
- Across shoulder (curvilinear)
- Waist circumference
- High hip circumference
- Low hip circumference (over breedste gedeelte heup)
- Inseam leg height
- Thigh circumference
- Arm length
- Bicep circumference

Intermediate details

- Under bust circumference
- HPS to Apex
- Waist height

7.7 Consent Form User Test

Information Sheet for User test visualisation concept

Purpose of the research

The purpose of this research is to analyse the effectiveness of the visualisation that is being used. For this, a comparison will be made between the garment that is being visualised and the produced garment.

Benefits for participating

As a compensation and thank you for participating in this study, you will receive a gift card of €15,-.

Personal information

During this study body measurements will be taken. These measurement will be used for dimensioning an avatar that represents your body, as well as used as a reference for the production of the garments.

This study will includes a video-recorded session. This video will be transcribed in text and images may be captured. This video will remain off the internet and will be deleted after this graduation project. This footage will not be shared beyond the study team.

This study will also includes an audio recorded interview. This interview will be transcribed in text and can be used as quotes in research outputs. This audio recording will remain off the internet and will be deleted after this graduation project.

The second session (June) will involve pictures being taken of you wearing the knitted garments. These images will be used as a comparison to the visualisation made during the first session.

Usage of data

The data that is being collected during the research will be de-identified (anonymised) for use in the graduation report. Only the study team will be able to link your name to the corresponding data.

07/05/2019

Consent Form for User test visualisation concept

Please tick the appropriate boxes	Yes	No
Taking part in the study		
I have read and understood the study information dated 07/05/2019. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	□	□
I understand that taking part in the study involves a video-recorded session and an audio-recorded interview.	□	□
I understand that taking part in this study involves pictures taken of you wearing the knitted garment.	□	□
Use of the information in the study		
I understand that information I provide will be used for the graduation report and the production of the knitted garments by Maartje Boer (STRIKKS).	□	□
I understand that personal information collected about me that can identify me, such as e.g. my name or body measurements, will not be shared beyond the study team.	□	□
I agree that my information can be quoted in research outputs.	□	□
Permission for further contact by Maartje Boer		
I agree that Maartje Boer is allowed to contact me after this study for further questions.	□	□

If yes, please provide email address _____

Signatures

_____	_____	_____
Name of participant [printed]	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Maartje van der Bie	Signature	Date

Study contact details for further information:

Maartje van der Bie

+31657584240

M.vanderbie@student.tudelft.nl


TU Delft
STRIKKS
designer knits