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3D Apparel Design Workflow for Puma SE

Metropolia University of Applied Sciences

Bachelor of Fashion and Clothing

Fashion and Clothing

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3D-suunnitteluohjelman tuomista mahdollisuuksista on vaatetusalalla puhuttu paljon. Uuden teknologian implementointi yritykseen kuitenkin vaatii yrityksen sisällä rakenteellisia muutoksia. Vaatetusala kamppailee vielä tämän siirtymisvaiheen kanssa, sillä 3D-vaatesuunnitteluprosessin ns. standardimallia ei ole vielä muotoutunut. Yksi Puman yksiköistä on juuri tässä 3D-suunnitteluprosessin käyttöönoton murrosvaiheessa, ja opinnäytetyön tarkoituksena on tukea yksikköä 3D-ohjelman käyttöönotossa. Opinnäytetyön keskeisenä tavoitteena on määrittää 3D-vaatesuunnitteluprosessiin vaikuttavat avaintekijät ja lopuksi luoda vaihtoehtoinen 3D-vaatesuunnitteluprosessi kyseiselle yksikölle ja käyttöopas Browzwear Lotta -ohjelman käyttäjälle.

Opinnäytetyö on tutkimustehtävä, joka muodostuu kahdesta osasta: tutkimus- eli teoreettisesta osasta ja produktio- eli käytännön osuudesta. Kirjallisen osuuden viitekehys pohjautuu alan ammattikirjallisuuteen sekä asiantuntijahaastatteluihin. Tässä osuudessa perehdytään 3D-vaatesuunnitteluprosessin muodostamiseen vaikuttaviin tekijöihin. Tutkimustuloksista merkittävimmäksi nousi kolme päätekijää: valittu 3D- suunnitteluohjelma, 3D-vaatesuunnittelun vaiheet ja yrityksen suunnitteluprosessin lähtökohdat. Nämä tekijät toimivat opinnäytetyön teoreettisena viitekehyksenä ja työn lopputuloksena syntyi esimerkkikaavio 3D- vaatesuunnitteluprosessille.

Työn produktio- eli käytännön osan lopputuotoksena yhteistyöyritys saa käyttöönsä käyttöoppaan Browzwear Lotta -ohjelmalle. Käyttöoppaan tarkoitus on tukea opinnäytetyön ehdottamaa 3D-vaatesuunnitteluprosessin käyttöönottoa tarjoamalla yritykselle koulutusmateriaalia 3D-ohjelman käyttöönotosta.

Avainsanat	3D vaatesuunnittelu, 3D, vaatesuunnitteluprosessi, 3D CAD, Browzwear, Vstitcher, Lotta

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Transition from the traditional 2D design workflow to the 3D design workflow requires structural changes. Standardizing and optimizing efficiency of the design workflow allows the company to obtain full potential of the 3D program. The aim of this thesis is to support one of Puma SE department in implementing 3D CAD program into their design workflow. The support is provided with a research on the key factors of forming a 3D design workflow. Implementation process is supported also by conducting a training material for Browzwear Lotta.

The thesis consists of two parts: the theoretical and the practical part. The theoretical part concentrates on researching the key factors contributing in a functional 3D design workflow. The research concluded in three major factors: The chosen 3D program, 3D design phases and the company's existing tools. Below this macro level, the secondary factors are: The functions of the 3D program, the company's existing design cycle and the communication platform. Each factor is evaluated and to conclude the theory of the thesis, an example of 3D design workflow is presented. The main benefits of the presented 3D design workflow are: Enhanced communication, more accurate tech pack handover, reduced sunken costs, reduced physical samples and faster lead time.

The second part of the thesis is the practical part. Within the practical part, the design phases explained in theoretical part, are carried out by the author with a help of Browzwear Lotta. A user manual for Lotta is created to support the implementation process with a training material for apparel designers.

Keywords	3D Apparel design, 3D CAD, 3D Design workflow, apparel design workflow, 3D implementation, Browzwear, Vstitcher, Lotta

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1 Objective of Thesis: An Introduction

‘’3D CAD is undoubtedly the next major advance for the sewn product industry’’

Jaenecke and Tait stated this in an article written in 2017 (Jaenecke ja tait 2017). Two years later and the industry agrees. Having major players Nike, Adidas and now Puma to join the sewn products’ 3D design revolution among others. The industry where production costs and speed to market is paramount, has largely relied on the same manual method for the past decades (Papahristou ja Bilalis 2017). 3D design programs have now developed to fit the clothing industry’s needs, it is time to reassess the traditional design workflow and update to the 3D era.

Regardless the hype around 3D design, there is still limited number of researches carried out on the topic of 3D design workflow. Even less on the implementation of 3D design. 3D design has been applied to marketing but to implement it to design, development and production workflow, it is still fairly new.

The purpose of this thesis is to support the department in implementing 3D CAD program, Browzwear Vstitcher and Browzwear Lotta into their design workflow. The thesis consists of both theoretical and practical part. The theory studies the factors contributing to a functional 3D design workflow. The aim is to conclude with an example of the 3D design workflow flowchart. The practical part is to provide the training material for the designers, to support the suggested 3D design workflow. The primary question asked in the thesis is: What are the factors contributing to a functional 3D design workflow?

The research for the functional design workflow concentrates solely on the design, development and production phases. The thesis also introduces 3D apparel design to the reader and maps out 3D design phases, evaluates the functions of the Browzwear software and presents the department’s current 2D design workflow. The results of the research are applied to support the department in standardising the design process and in optimizing the efficiency of the 3D design workflow.

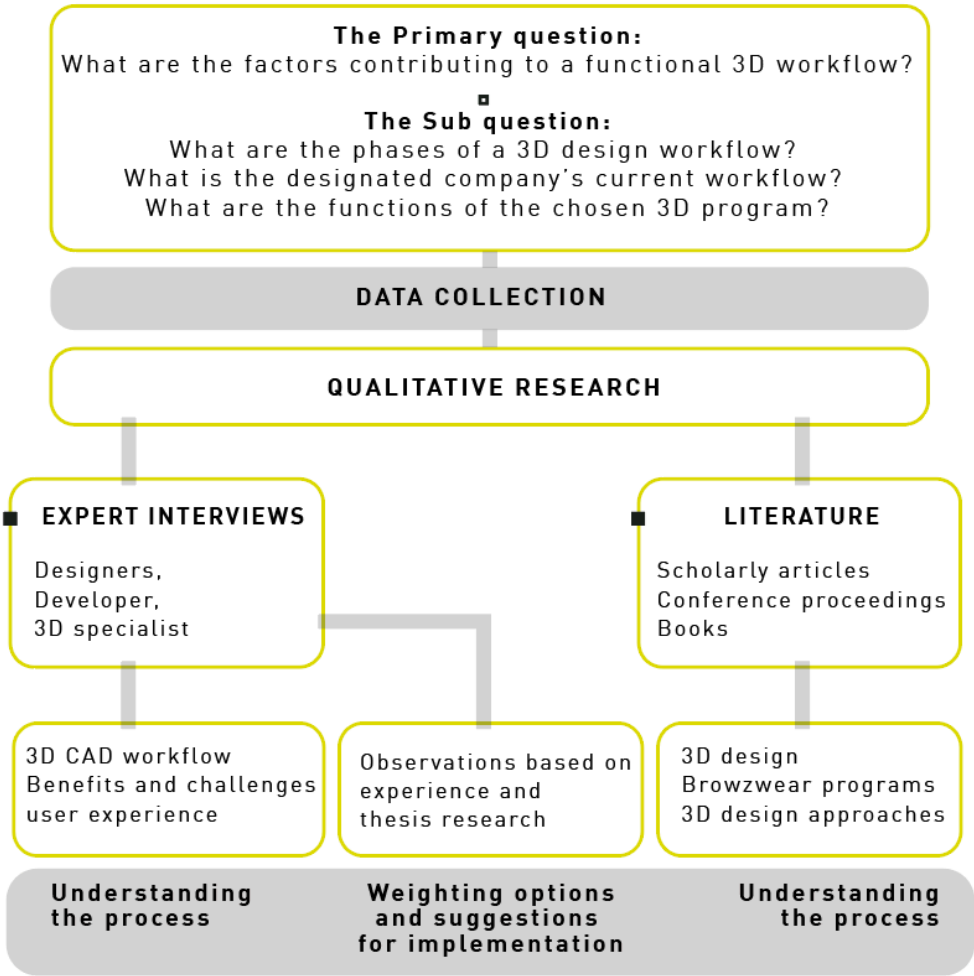
1.1 The Research Methods and Research Questions of the Thesis

The case company has shown interest in shifting from the traditional 2D design workflow to the 3D design workflow with the help of 3D CAD program. The case company has decided which 3D CAD program is used; Browzwear VStitcher and Browzwear Lotta. As one of the case company's department is in the phase of implementing the program into their apparel supply chain; This inspired the idea for the thesis: to study the opportunities of the 3D design program, and to examine the factors affecting 3D design workflow. The aim of the thesis is to study the phases of 3D design workflow, and to evaluate the key aspects of forming a functional 3D design workflow. The outcome is to have an example of 3D design workflow for the company's department, and to support the implementation process by creating a user manual for Browzwear Lotta.

The research for this thesis is based on qualitative research obtained through several methods. As the aim of the thesis is to study a specific topic within the 3D field, qualitative research was a natural choice. The data collection methods are displayed in Table 1 on page 4. Qualitative research is carried out through expert interviews, literature and the author's observations. Observations are based on the information obtained from the research and the author's work experience within the company, and as Browzwear Lotta - program user. The interviews are carried out as semi-structured expert interviews. The benchmark for choosing the interviewees are based on their working experience within the industry, and for their expertise in using Browzwear programs. Five interviews were carried out, and the experts chosen for the interviews are working in different phases of the apparel design workflow: Apparel designers, 3D specialist, developer, project manager and design director. Interview questions are open-end questions as this gives the interviewees the freedom to talk about their experiences, observations and their processes without limiting the amount of information. However, the open-end questions were structured around predetermined themes, to create a framework for the interview. (Bridges et al 2008; according to Frances;Coughlan ja Cronin 2009, 310 .) Literature about the topic are gathered to describe 3D Computer-aided-design (CAD), to study the Browzwear programs, and to back up the authors' observations. Literature are based on scholarly articles, books, conference proceedings, and other variable sources online.

The primary research questions for the thesis is: What are the factors contributing to a functional 3D design workflow? Sub questions for the topic are: What are the phases of a 3D design workflow? What is the designated company's current workflow? What are the functions of the chosen 3D program?

Table 1. Data collection methods.



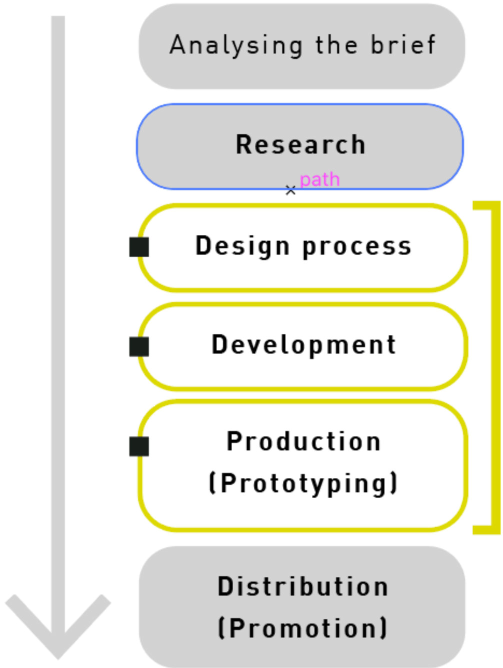
These research questions are approached and analyzed through theory and the manual is formed based on user experience.

1.2 3D CAD workflow and the theoretical framework of the thesis

According to McKelvey and Munslow (2012), the apparel design process varies, but it can be simplified to a 6-phase process: Brief, research, design, development, production, and distribution. A design process with 3D CAD program follows a similar path, but the

implementation of 3D program is mainly situated in design, development and production phase. 3D design is also known to be used as a selling tool and for marketing purposes, but to remain the scope of the topic, this is excluded from the thesis (McGoarty, 2019). The focal point of the thesis is highlighted as yellow boxes in Table 2 below.

Table 2. Traditional workflow and framework of thesis



This thesis focuses on the flowchart of the 3D design workflow, the factors affecting the flowchart, and as a result; creating a functional 3D design workflow for the department. To justify the chosen 3D design workflow, one must consider the potentials of the software, the current design process of the company and the phases of 3D design. To support the understanding of 3D design workflow, thesis will also concentrate on answering sub questions mentioned in chapter 1.1: What are the phases of 3D design workflow? What is the case company's current workflow? What are the functions of the chosen 3D program?

1.3 Glossary of terms

Avatar: Browzwear 3D body

BOM: Bill of Material is a list of components needed to construct a garment (Apparel entrepreneurship 2019).

BW: Newest version of the Browzwear file type for Browzwear August 2019 version or newer version (Support Browzwear 2019).

CAD: Computer-Aided-Design

FAB: Fabric analyzer Browzwear (Support Browzwear 2019).

Flowchart: An illustration to describe a process. The process is presented with various shapes and arrows to show the direction of the process. (Hebb 2019.)

Product group: Describes a group of products that share some or all common features. For example, product group of T-shirts. (Klenk 2019.)

Program feature: Describes a tool to achieve a function. Feature is used to reach the goal of the program, a tool to solve the problem. For example, a pen tool in Browzwear to draw a cut line. (Spacey 2017.)

Program function: Describes a goal or a task of a specified program. The objective is to solve a problem. For example, one of the functions in Browzwear program is to create a cut line on a pattern. (Spacey 2017.)

VSP: Browzwear legacy file before BW file type was created. VSP is a packed file of all the elements needed to create 3D garment (Support Browzwear 2019).

Workflow: Repeatable set of tasks to complete a specific goal. It is something that is performed regularly and in sequence. (Kothari 2019.)

2 3D apparel design

3D apparel design, also known as 3D CAD (computer-aided-design), can be defined as a design process with the help of computer technology. The technology is being used to assist in visualizing the designed garment on a virtual 3D model in real time. The aim of 3D design is to create a realistic perspective of the product in 3-dimension on a virtual body that resembles a realistic human body proportion. (Jokinen, 2010, 1.)

Computer aided design (CAD) in 2D has been part of the clothing industry since the late 80s' with the help of 2D CAD program, such as Adobe Illustrator (Hemphill 2013). It was only in the 90s' that one of the first CAD programs in 3D environment was presented. According to Sayem (2010, 45), Hinds and McCartney were one of the firsts to present an application for a garment simulation in 3D. In this early version of the 3D CAD software, virtual body was modelled based on human body measurements. The measurements were acquired by manually measuring fitting mannequins, or human bodies (Sayem;Kennon;& Clarke, 2010, 47). Due to the growing interest towards 3D CAD, the development of measuring a body is now as far as body scanning. Human body scanning instead of manually measuring the bodies enables a more realistic, and proportionally correct virtual 3D body modelling. (Liu;Zhang;& Yuen, 2010, 576-577.) Nevertheless, according to Papahristou (2017, 2) The Dassault System have stated that the clothing industry is still struggling in finding a process that lives up to the 3D design process' full potential. The challenge is claimed to be the difficulty in mimicking a soft material, and implementing the draping and the stretching properties of different materials into the virtual world (Jaenecke ja tait 2017). The challenges are not only concentrated within the programs but also within the implementation process. One of the disadvantages of implementing 3D into a company's product workflow, is the time spent in training the people. It is also said that implementation of 3D requires much effort, and investment spent on building the base libraries for materials, trims, 3D bodies etc. (Papahristou & Bilalis, 2017, 5.) According to Klenk (2019), one of the challenges in implementing 3D into a company's process is also the lack of commitment from the user's perspective. Learning a new program requires perseverance, interest towards the topic, and consistent practice (Klenk 2019).

However, the potential of 3D CAD programs have been acknowledged, and the industries' major players, Adidas, Nike, Under Armour, and Target have all taken part of the 3D revolution (Papahristou & Bilalis, 2017, 5). The benefits of acquiring the 3D program can be presented as direct and indirect benefits. These benefits can further be divided into three categories: economical, ecological, and communicational. Indirect economic benefit is seen in reduced work time, and costs spent on design process due to better visualization, and faster lead time. A More direct benefit from sustainability and economical standpoint is seen in reduced material usage, packaging and transportation costs as unnecessary samples are eliminated. The 3D CAD is also said to enhance seamless co-operation as communication is made possible within the 3D programs. 3D design programs also enable one to rotate and zoom the 3D render for a full 360 view. This offers a more realistic view of the design, which creates a smaller gap in interpreting the 2D sketch and real product. (Papahristou ja Bilalis 2017, 3-6; Jokinen, 2010, 5.)

3 3D design workflow

Based on the research carried out for this thesis, the author has formed a framework of the key factors in building a 3D design workflow. The flowchart of the 3D design workflow relies on three main factors: The chosen 3D program, the 3D design phases, and the company's existing tools. Figure 1 illustrates the complexity of forming a 3D design workflow within a company. These three factors impact the flowchart of the 3D design workflow, which is displayed in the middle.

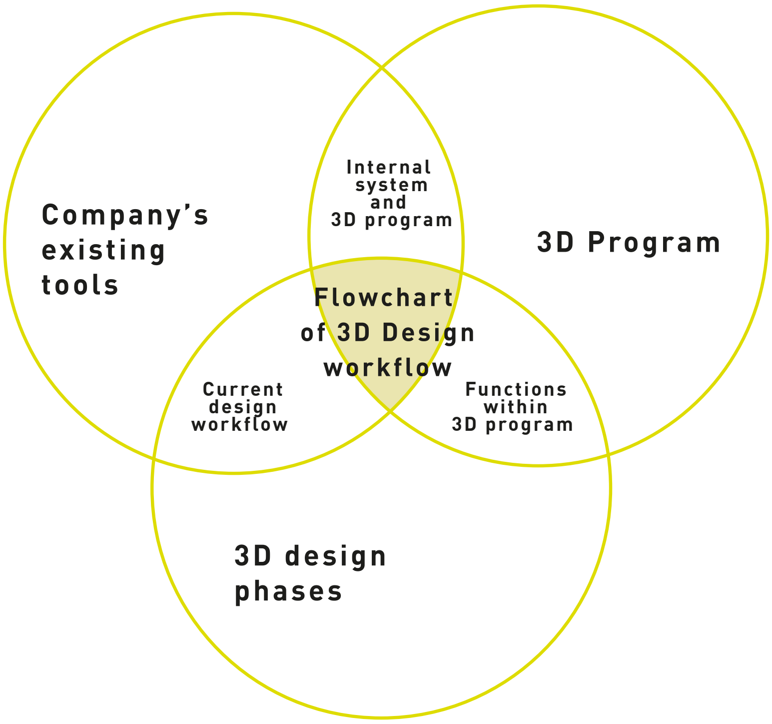


Figure 1. The framework of the thesis.

There are multiple factors that together contribute in forming a functional 3D design workflow. As the Figure 1 above shows a matrix of which factors are considered, when designing a flowchart for the workflow; the company's existing tools, the general phases of 3D design, and the chosen 3D software. Below this macro level, the secondary factors to take into consideration are; the functions of the 3D program, the current design cycle, and the existing internal systems.

3D CAD programs differ from each other in terms of features, which further affects the design phases and the flowchart (Sayem;Kennon ja Clarke 2010, 45-53). To outline the thesis, the 3D design phases will be presented from Browzwear program's perspective.

3.1 3D Design program

Choosing a program, and recognizing its' functions is one the starting points in forming a 3D design workflow. It is one of the key factors in creating the workflow as the completion of each phase is based on the functions, and the features of the program. (Jurica 2019.) In this chapter Browzwear programs and services are presented and the functions of each will be introduced.

3.1.1 Browzwear programs and services

Browzwear is a software company that provides 3D design tools for the fashion industry. The company works with multiple brands, and manufacturers around the world. Browzwear was first presented in early 2000's with a program that enabled virtual dressing room, and 2D to 3D garment simulation. The company continued developing their programs to serve the industry better by providing 3D design programs: VStitcher and Lotta. (Browzwear 2019.) The outlook of the company logo, and the platform for services is visualized in a picture collage below (Figure 2).

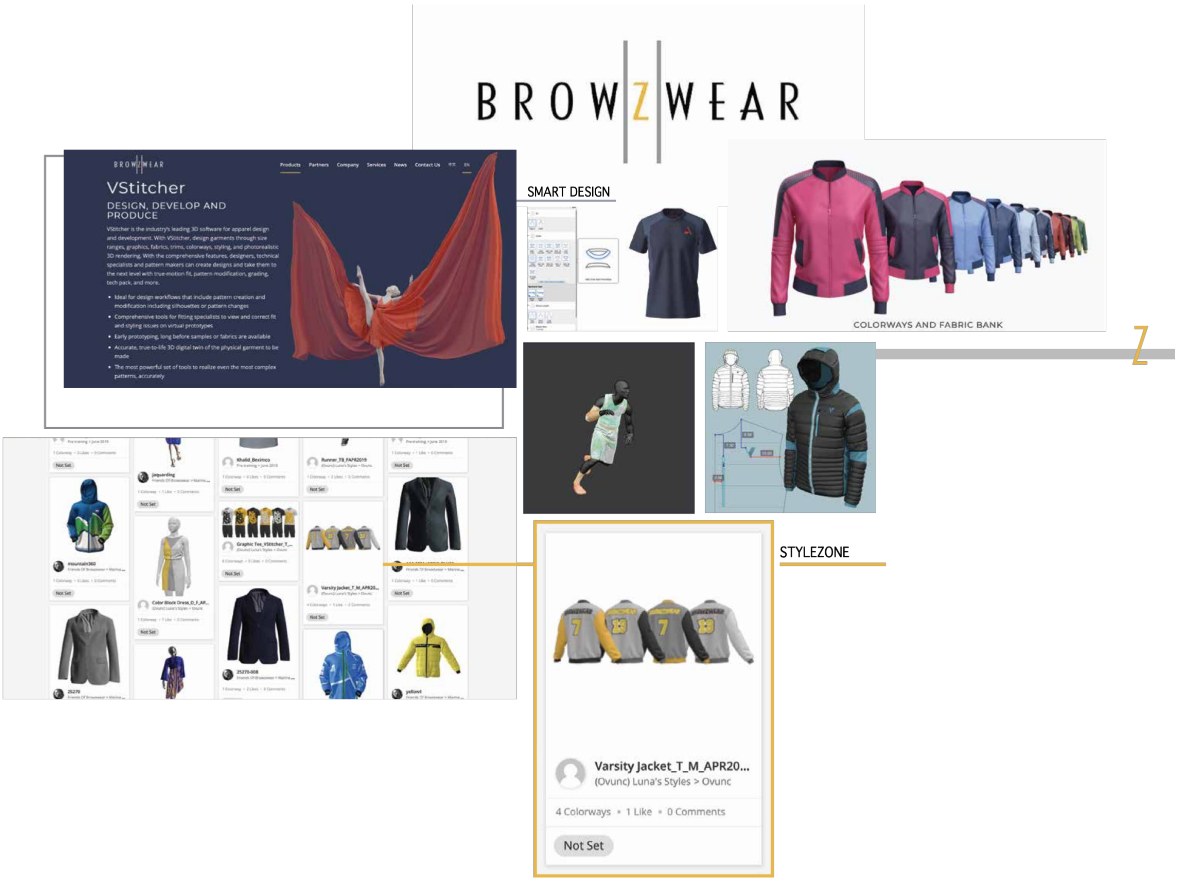


Figure 2. Visual board of Browzwear and its services (Browzwear, 2019; Stylezone Browzwear, 2019).

VStitcher is a 3D program that enables the user to create designs in 3D environment starting from the initial pattern creations, 3D visualization, and virtual prototyping. It is an interactive program for both apparel design and development. This enables the user to visualize the pattern changes in real-time. The functions include pattern creation, modification, grading, tech pack creation, 3D rendering, and garment pressure and tension simulation. Another function is to model an avatar, and to modify its' measurement, posture, and position. VStitcher is an extended version of the Browzwear Lotta as the features available in Lotta are also available in the VStitcher, but not other way around. (Browzwear 2019.)

Lotta is a 3D design program created specifically to serve the fashion designers. The function of the program enables apparel designer to work in 3D and to view the designs in real-time. Lotta is also an interactive program in which one can design in both 2D and 3D windows. However, one cannot modify patterns in Lotta. The program allows users to recolour fabrics, to apply and modify graphics, to render the designs, create tech packs and design cut lines. However, the cut lines are not translated automatically to the initial patterns. The pattern changes need to be applied manually in the VStitcher. As there are no feature for pattern modification in Lotta, pattern skills are not necessary. Nevertheless, this limits the designer to work only within the validated blocks. (Browzwear 2019.)

The features of both programs are described more in-depth in the chapter 3.2 together with the design phases.

In addition to the 3D design programs, the company provides supporting services and platforms for their 3D design users. The services provided are Stylezone, SmartDesign and Fabric analyser. (Browzwear 2019.).

Style zone is an online platform for commenting and sharing the 3D garment renders. The platform is built to ease the communication between the suppliers, the company, and the market. (Browzwear 2019.) Having a ready-made platform also speeds up the process of implementing the 3D program into a company's workflow (Klenk, 2019). Stylezone provides a secure space to share inter-active designs and as a cloud service, the platform can be viewed on all devices. The platform allows users to import 3D renders in multiple colourways where one can view the virtual garment in full screen. The access to view certain styles or collections can be modified. The Figure 3 below showcases the Stylezone layout and the view of each style. The style view provides the garment's VSP file, enables turning and zooming the render. Within both programs, there is a function to share the garment design directly from the 3D program to Stylezone. (Stylezone Browzwear 2019.)

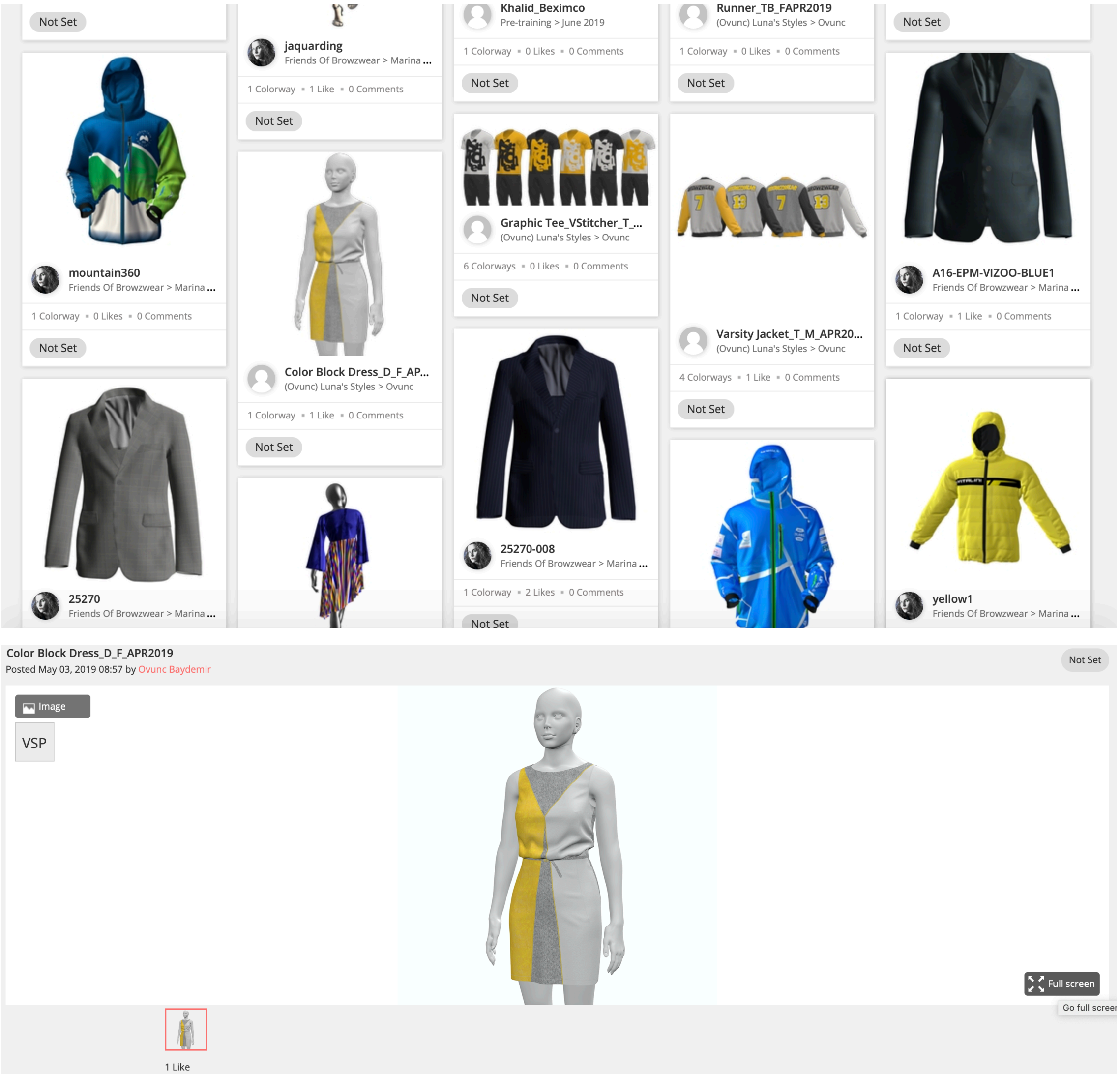


Figure 3. Screenshot of Stylezone layout. (Stylezone Browzwear 2019)

Smart design is an additional function that supports the 3D design users. Smart design enables 3D apparel designers to modify and create styles by choosing each part of the garment from desired neckline or a collar, to sleeve and garment lengths, and pocket option. The designer can build their own designs by choosing each garment's pattern piece and the desired fit. To enable this function, the company or Browzwear sets up the SmartDesign templates based on the company's own pattern blocks. The aim of smart design is to save time and offer Lotta users the freedom to build the designed product piece by piece. (Browzwear 2019.)

Fabric analyzer by Browzwear (FAB) is both a technology and a machine that tests fabric properties, and translates it into the digital fabric. The more precise testing results, the more accurately the digital fabric will drape in the 3D design program. FAB analyses the mass, the thickness, the bending and the stretching properties of the fabric. Linearity, and the transparency of the fabric is also assessed. Testing results are translated into a digital fabric for VStitcher and Lotta. (Support Browzwear 2019.)

3.1.2 Browzwear groundwork

According to the experts within the field, to fully obtain the benefits of implementing the 3D CAD program into a product workflow, it is recommended to collect, and create a library for features that is often needed in the process. Fabric, trimming, basic pattern block, rendered 3D body, and core colour –libraries are one of the key traits for a faster and smoother 3D design process. This gives the designers a base to start designing and to have more accuracy in design, development, and production. (Kumar 2019; McGoarty 2019; Schaffarth 2019.) The libraries are often project managers' responsibility, and the methods in collecting the information for each library is out of scope of this thesis (Papahristou ja Bilalis 2017, 5).

Virtual material library is set up with materials that the company is using. It is recommended to create a library with the most commonly used materials, and their codes indicated by the company. This speed up the process of virtual fitting and supports the tech pack creation with accurate information. (Kumar 2019.) To have a realistic virtual fabric with correct draping and stretching properties, the fabric needs to be tested, and the information is added into the program. Once the virtual fabrics are created, and the library is embedded into the program, the material is available for download, and ready for use. The fabric library and the view of fabric properties are shown in Figure 4 below. (Support Browzwear 2019.)

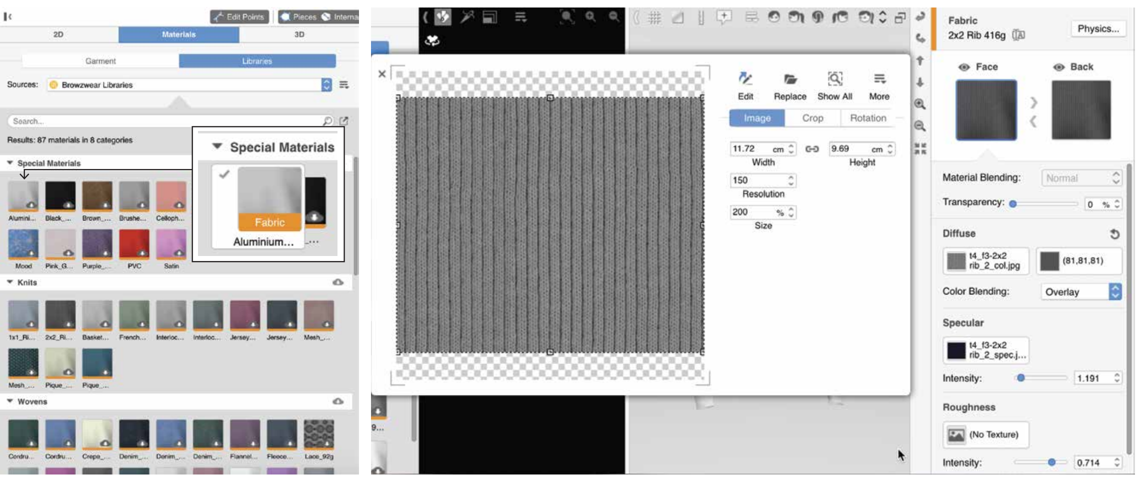


Figure 4. An example of material library in Browzwear Lotta.

The trimming library serves the same purpose as the material library. The aim is to have a correct draping for virtual fabric modelling, and to have a correct information later in the tech pack. Having most commonly used trims imported into the program with the trim codes, the designers can drag and drop the trims onto the garment while designing. This speed up the 3D design process and gives more freedom in trying out different trims while designing. (McGoarty 2019.) The trim library is shown below in Figure 5.

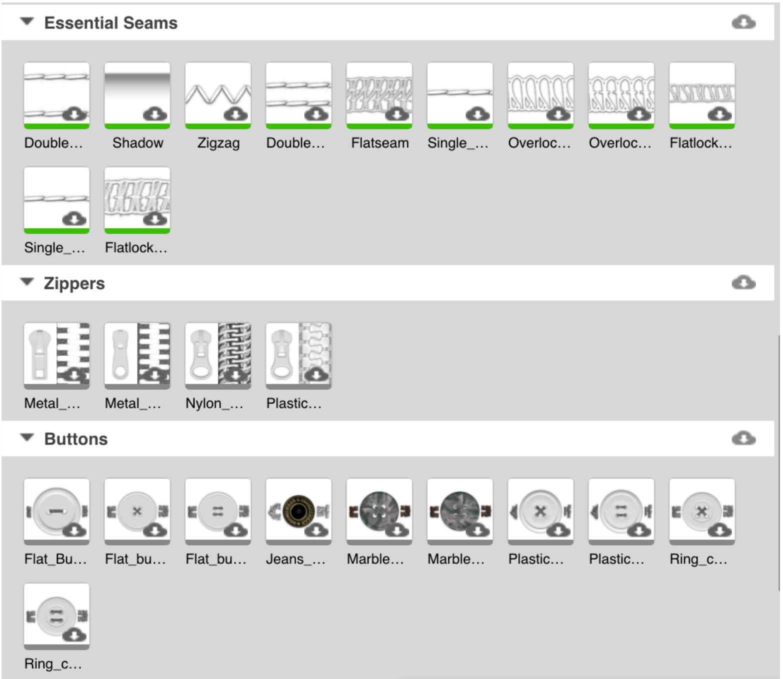
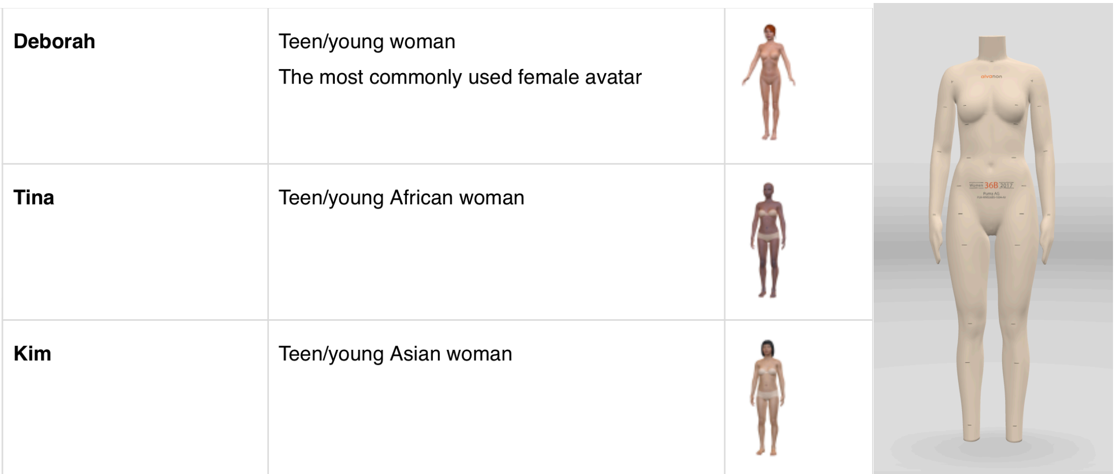


Figure 5. An example of trim library in Browzwear Lotta.

One of the most crucial libraries regarding creativity and speed, is the basic pattern block –library. The ideal pattern library consists of the patterns for all basic silhouettes that the company uses from season to season. This could for example be the basic T-shirt, pants, and hoodie patterns. The aim of having the basic pattern library is also to speed up the 3D design process. Once the pattern is done, the design phase can start right away without having to create the pattern from the scratch. (Klenk 2019; Schaffrath 2019.)

The base for the design phase in Browzwear VStitcher is the 3D virtual body, which is renamed in Browzwear programs as an avatar. The program enables the users to modify an avatar's measurements and proportions to fit the company's standard measures. It is crucial to have an avatar as close as possible to the company's standard measurements, as this is the base for the virtual fitting. (Kumar 2019.) Browzwear VStitcher also allows the user to choose an avatar with preferred ethnicity, skin and hair colour, preferred pose and gender. Once the look, size, and pose have been chosen, one can save the 3D model as the standard 3D avatar. The library of the standard sized avatar is created also to support design and development for speed and accuracy. Companies can decide whether to choose the avatars available within VStitcher or to import their own avatar. The variety of the Browzwear avatars includes a young woman, ayoung African woman, ayoung Asian woman, a woman, a plus-sized woman, a 6-14-year-old girl and a female mannequin. For men there are a man, a young man and a 6-14-year-old boy. In addition to the avatars mentioned above, there is also an option for a 0-4-year-old baby avatar. An example of the available avatars is screenshotted below in Figure 6. (Support Browzwear 2019.)



Deborah	Teen/young woman The most commonly used female avatar	
Tina	Teen/young African woman	
Kim	Teen/young Asian woman	

Figure 6. A screenshot of Browzwear female avatars (Support Browzwear 2019).

Based on the user experience with the Browzwear Lotta, it is preferred to also have the company's core and seasonal colour palette created in the colour library. The company's core and seasonal colours saved and named with correct codes adds more value to the program. Within both programs, it is possible to import colours for example from Pantone and Coloro colour libraries, but it is also possible to create a separate colour library. The user can also hand pick the shade with a dropper tool. Having the colour palette set up ready for the design phase, the colouring process speeds up and ensures a more accurate tech pack creation. (Klenk 2019.)

3.2 3D design phases

The second key factor in forming the workflow for 3D design are the design phases. The actions within each phase is indicated based on the features of the 3D CAD program. The phases of the 3D design in Browzwear can roughly be divided into five key stages:

Pattern creation, preparation and stitching; Virtual fitting; Design in 3D; Tech pack creation; 3D render (Jurica, 2019; Klenk, 2019; Kumar, 2019; McGoarty, 2019; Schaffrath, 2019). The 3D design phases within Browzwear program alone does not form the workflow, but the phases play a crucial part in indicating which phase must be part of the 3D design workflow. The steps of the design phases are explained more in-depth in the chapters below. The description is written and illustrated based on the expert interviews, the Browzwear Support website and the author's analysis while using the Lotta program.

3.2.1 Pattern creation, preparation and stitching

Pattern preparation with VStitcher begins from importing the basic pattern block from the library. The base pattern is chosen based on the desired product group and based on silhouettes closest to the desired design. In case of a new silhouette, a new pattern can be created from the scratch. This can be carried out either in Browzwear VStitcher or in another pattern creation program. Patterns are then modified to have desired silhouettes including the sleeve length, the product length, the neckline etc. Once the base patterns are as preferred, the patterns are prepared for the virtual fitting. Within VStither the patterns need to be arranged on the avatar, marked on which layer the pieces should be sewn and virtually sew the pattern pieces on the 3D body. (Kumar 2019; Support Browzwear 2019.)

The aim of the 'arrangement' is to assign, for which part of the body each pattern pieces belongs to. This is illustrated in Figure 7 below. The patterns should also be marked with numbers to indicate the relative layering order for each pattern piece. The pattern piece closest to the wearer's skin is marked as 0, and the number grows according to the amount of the layers. This is also a way to assign garment layers when creating an outfit. An example of the layering is as followed: Bra pattern group is 0, Tee pattern group is 1 and outer jacket pattern group is number 2.

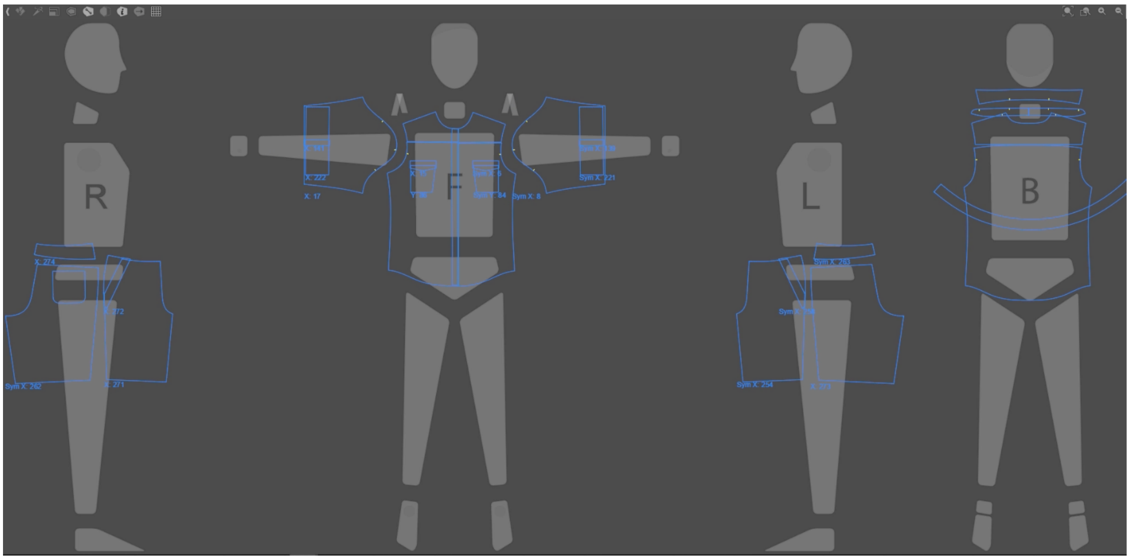


Figure 7. Screenshot of pattern arrangement in VStitcher. (Support Browzwear 2019)

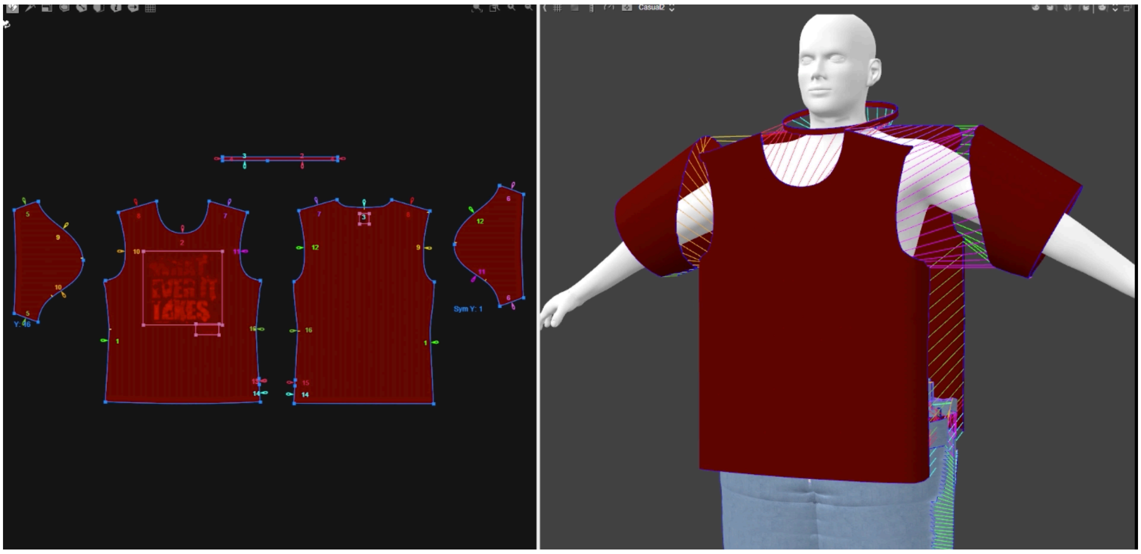


Figure 8. Screenshot of virtual stitching process in VStitcher. (Support Browzwear 2019)

The pieces then need to be virtually sewn by indicating which cut lines are sewn together, and in which direction they should be sewn. (Schaffrath 2019; Support Browzwear 2019.) Therefore, whomever oversees the pattern piece preparation, and virtual sewing, should have the required technical skills to understand how the garment is conducted (McGoarty 2019). An illustration of the virtual stitching process is screenshotted in Figure 8 above.

3.2.2 Virtual fitting

Virtual fitting, also known as dressing an avatar, is one of the main benefits of the 3D design. It is to visualize how the designed garment looks on the avatar, how the patterns fit, and to check the proportions and the positions of the cut lines on the avatar. As Browzwear programs are an interactive software, the changes made in 2D patterns can be simulated and visualised on the avatar automatically and vice versa. (Klenk 2019.)

The position and the movement of the avatar can be changed which enables the developer and the designer to see how the garment and the fabric reacts to the movements. The tension and the pressure of the garment can also be revised with a feature called ‘pressure map’ and ‘tension map’. The maps demonstrate which area is highly stretched and pressured. This is illustrated by colour coding the garment on the avatar: Red is the area with the most tension, yellow with medium tension, turquoise with slight tension and white in areas where the fabric is not stretched or pressured (Figure 9).

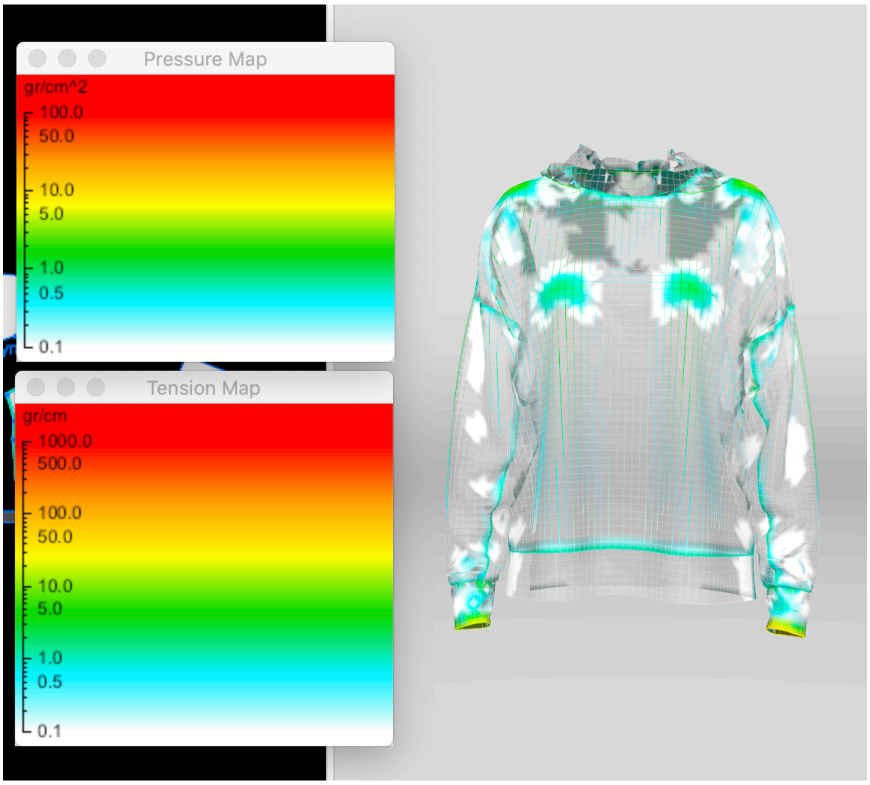


Figure 9. Srcreenshot of pressure map & tension map in Browzwear Lotta.

This function can be applied to check the fit, to ensure the comfort and to indicate which area needs more fabric. The patterns can still be modified at this stage to ease the tension and to improve the fit. The pattern pieces are modified in the 2D window or the 3D model, for as long as the fit, and the end look is as desired. Once the patterns are ready, the pattern pieces, the avatar and the 3D design are packed into a file, file type as VSP or BW. This is then be uploaded on the desired platform ready for the next phase. (Kumar 2019; Support Browzwear 2019.)

3.2.3 Design in 3D

The design phase in 3D covers the colouring process, embellishment and the cut line modification. This phase can be executed either in Browzwear VStitcher or Browzwear Lotta. When designing in Browzwear Lotta, the VSP or BW file is imported to open the basic pattern pieces and the correct avatar. Here also, the file containing the patterns should be chosen based on the style closest to the desired design. Lotta program enables the user to create cut lines and to request changes in the pattern by commenting on the garment. (Kumar 2019; McGoarty 2019.)

Commenting tool called 3D annotation allows the user to comment and to pin it on the garment for more efficient communication. Figure 10 shows the comment on the left and on the right side of the screenshot, the annotation is marked on the garment. This is ideal to use when there are multiple people working on the same design. (Klenk 2019.) It should be mentioned, even though it is possible to create cut lines and to modify them in Lotta program, the cut lines are not applied to the initial patterns automatically. As stated above in the chapter 3.1, in case of changes in pattern pieces, the changes must be applied manually in VStitcher. When designing in VStitcher, the changes in the patterns are automatically applied in real time. (Support Browzwear 2019.)

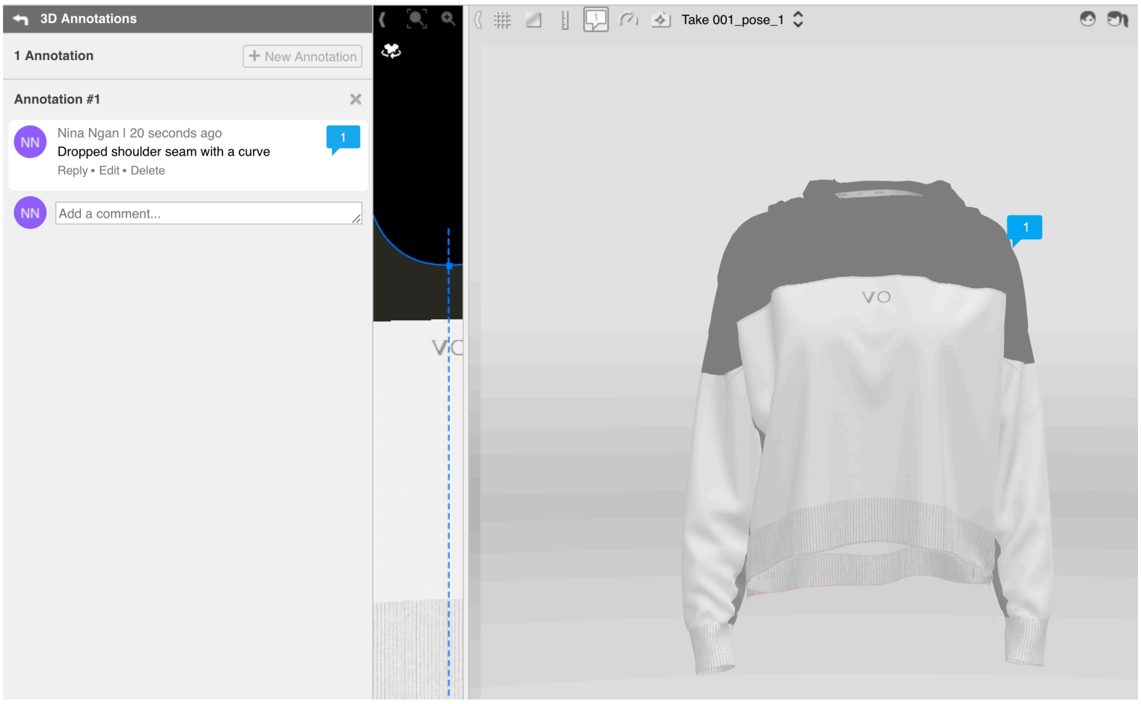


Figure 10. Screenshot of 3D annotation tool with Browzwear Lotta.

Once the base design is chosen, the embellishment can start. Both programs support multiple file types in terms of importing pictures and graphics. Therefore, the desired graphic can be imported and modified in Browzwear programs. Graphic modification includes scaling, rotating and recolouring properties. The position and the size of the graphic is visualised in both 2D and 3D window. This speed up the process of indicating the desired graphic size and to indicate the measurements for the graphic positioning (Figure 11).

Figure 11. Screenshot of graphic positioning in Browzwear Lotta.

The design phase also includes assigning the correct stitches to the seams and attaching the 3D trims onto the garment. 3D trims can be applied in both Browzwear programs and each parts of the trim can be modified to the desired colour and size. (Support Browzwear 2019.)

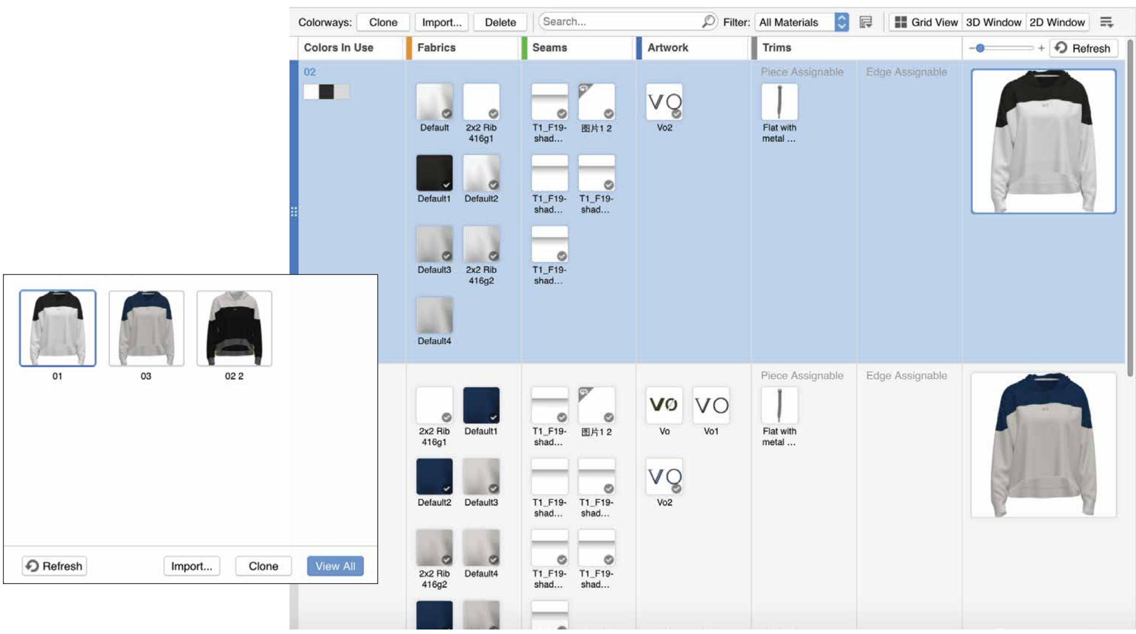


Figure 12. Picture collage of colourway view examples in Browzwear Lotta.

The programs also give an opportunity to create multiple colourways. The designed garment can be cloned and recoloured as desired. Cloning a colourway means that the colourway is copied including seams, trims and the artwork. However, the artwork can change between the colourways. The colourway view within both programs enables the designer to oversee the colourways of a style all next to each other. A screenshot of the colourway view is shown in Figure 12 above. (Support Browzwear 2019.)

3.2.4 Tech pack creation

According to Klenk (2019), the Browzwear 3D specialist, tech pack creation is one of the core functions of both programs. The tech pack function creates an informative document for the 3D design. Browzwear tech pack includes all specifications, bill of material (BOM) including fabric, artwork, seam and trim details and their indicated codes. The annotations can also be included into the tech pack. The function also provides 3D rendered images, patterns are in correct sizes and the specifications for the artwork placement is specified. The information is packed in a file that can be distributed either via html link or a pdf file. (Support Browzwear 2019.)

The traditional way of creating a tech pack is to draw black and white flat drawings of the design. The flat drawing is accompanied by specifications such as measurements for a certain cut line and the position for an artwork. BOM is provided with trim, material and colour codes. The position of the cut lines and the placement of an artwork is usually obtained by demonstrating cut lines on a reference garment. The graphic size is printed in multiple sizes and placed on the reference style to visualize where the graphic is preferred to be placed. The information of the placement is marked and measured. As tech pack is created manually, it can be time consuming and there is more room for inaccuracy. The tech pack feature, when used correctly, significantly speeds up the process. (Schaffrath 2019.)

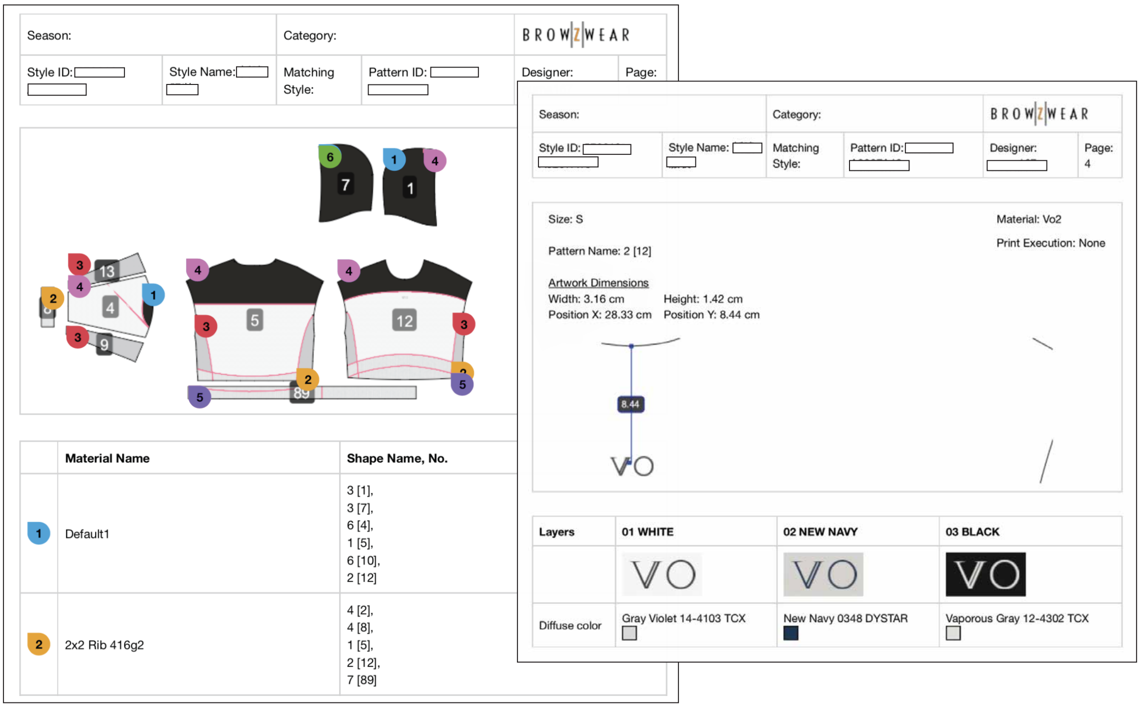


Figure 13. Picture collage of tech pack sheet created with Browzwear Lotta.

Above in Figure 13 is an example of the tech pack sheet created with Browzwear Lotta. The figure is a screenshot of the tech pack sheet including the pattern pieces and the fabric specified for the certain piece. The screenshot also includes a sheet of the artwork, its' position and colouring for each colourway. The information of the style and the pattern ID, as well as the name of the style, and the designer is removed.

3.2.5 3D Rendering

3D Rendering is a computer-generated image of the designed garment. This phase includes both 3D styling and 3D rendering. The styling tool in Browzwear programs allows the user to adjust the garment on the avatar. It has seven different functions: Pinch, brush, erase, radius, hold, flatten and retouch. Pinch and brush are the tools to fix a part of the garment. Hold, flatten and retouch indicates the way of using the chosen tool. Pinch can be chosen to move the selected point or area. Brush paints the area that needs to be moved. Erase is for erasing the previous styling. Hold function keeps the chosen area as indicated. Flatten smoothens the area as if it is being ironed. Retouch can set the shrinkage or stretching values for the chosen area. (Support Browzwear 2019.)

Within both Browzwear programs, the render type and the render output can be chosen as desired. The type is to determine in what way the render is built, and the output is to specify, how the render is viewed. There are three render types within the programs: Normal, Ray trace and schematic. Normal render has the same quality as the 3D window while designing. The size of the render is small, and it is quickly drawn based on the design. V-Ray Ray trace is a higher quality picture of the garment. It mimics more of a realistic look and it takes more time to be created. Schematic is a black and white image of the design. It resembles the technical sketches, and this is usually used when the design silhouette is shown. (Support Browzwear 2019.) In figures 14-15, the same garment is rendered as a normal render and as V-Ray Ray Trace render. This is to demonstrate the quality difference.

Figure 14. V-Ray Ray Trace Rendered image created in Browzwear Lotta.

Figure 15. Normal image render created in Browzwear Lotta.

The output of the 3D render is also divided into three types: Image, turntable and V-ray Real-Time Ray Trace Rendering. Image is a 2D picture of the 3D design. Turntable is an interactive 3D render which is created from a series of renderings. As the turntable is an animation produced in HTML file or GIF, the 360 view of the garment is also viewable for non-Browzwear users. V-ray Real-Time Ray Trace Rendering provides a ray trace rendering in real time and allows the user to adjust the design simultaneously. (Support Browzwear 2019.)

3.3 Company's existing tools

The thesis concentrates on constructing a functional 3D design workflow for one of Puma SE's departments. As mentioned above in chapter 3, the tertiary key factor in forming the 3D design workflow is the existing tools of the company. In this case, the existing tools of the department. It is important to understand the department's current design workflow, to be able to recognize the operators for each workflow phases, and to understand the current execution for each phase, and how the communication is currently done. This lays out the information of the operators and positions within the department, the systems and programs available, and the current communication platform.

3.3.1 Puma SE

Puma SE is a sports apparel company founded in 1948. It is a German owned (Puma SE 2019) company which is ranked as the 4th biggest sportswear company. In 2018, the company reached global sales of over 4,6 billion euros. (O'Connell 2019.) The company logo is a puma which is shown in the visual board (Figure 16) below and their trademark is the ''Formstrip''. Their sports products consists of team sport, golf, running and training, basketball, motorsport and sportstyle department.

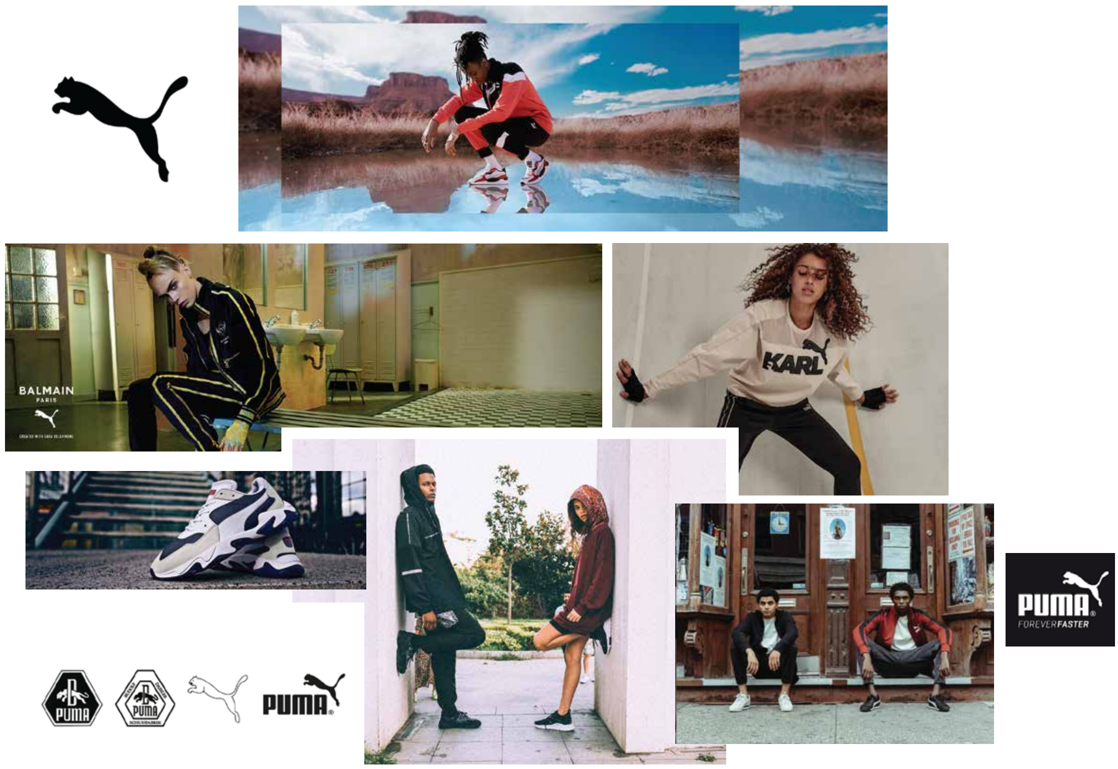


Figure 16. Visual board of Puma Sportstyle (Puma SE 2016, Puma SE 2019, Puma Sportstyle 2019).

The thesis concentrates on the department that works mainly with the sportstyle wear. The products targets the consumers who are passionate about sports, who thinks of sports as a lifestyle and this is reflected in their everyday wear. (Puma SE 2019.) Visual board above (Figure 16) showcases the products, the projects and the overall feeling of Puma Sportstyle products. The pictures are acquired from Puma Sportstyle Instagram page, their Europe web page, and from Puma Catch up -the Puma employee magazine webpage.

3.3.2 Current design workflow

The department's current 2D design workflow is presented in Table 3 below. The information acquired for this chapter is based on the conversation with two apparel designers within the department, senior designer Deiniger-Handrick and designer Schaffrath. It is also based on author's experience for working within the department. The table also points out the operators for each phase and the program relevant to the design, the production and the development stage. The table is colour coded as followed: Grey as non-relevant to the thesis and yellow as a relevant to the thesis.

Table 3. Puma SE department's current 2D design workflow.

Operator	Flowchart of design workflow	Program used
Market	Brief	
Designer	2D design Confirmation	Adobe Illustrator
Designer & Developer	Techpack	Adobe Illustrator
Suppliers	Pattern creation	
Designer & Developer	1-3 Physical sample fitting	
	Production	
	Dictribution	

The current design workflow begins with a briefing from the market. The briefing is an outline for the project or the collection. It includes information of the product group, the amount of styles, the target group and the suggested timeline for the project. The amount of the information and the preciseness of the briefing varies.

The secondary stage is the design phase. The design phase includes research and mood board creation if needed. This is executed by the designer and currently it is done through Adobe Illustrator. This is also the stage for sketching, colouring, defining the style, and choosing the storyline and the silhouette for the project/collection. The sketching is executed in 2D either by hand drawn, or with the assistance of the 2D design program, Adobe Illustrator. The designs are presented to the relevant parties. This is the phase where the designs are confirmed, or sent back for revision based on the feedback. It is a cycle that continues for as long as the final style is confirmed. On an average, the product creation workflow, 5% of the creation timeline is the design phase.

After the designs are confirmed, the tech pack is created. The current tech pack phase on its own takes up to 5% of the timeline, and it is executed mainly by the designer, and partially by the developer. The flat drawing, the measurements, the colourways, and the materials are chosen. This information is collected into the tech pack and uploaded on the internal system.

Once the tech pack is available in the internal system, it is communicated to the developers via email. The developers then continue by adding information of the garment in the internal system. The developer also communicates with suppliers for sample production. The suppliers create patterns based on the tech pack, and the physical sample is sent to the designer for the first fitting.

The fittings are organized to check the fit, the visual look, the measurements of the physical sample, the quality of the workmanship and the price of the production. The fitting is executed by the designer, the developer and the product line manager. The designer is in charge of the visual aspects of the garment. The developer oversees the measurements and the workmanship. The product line managers manage the costs of the production. The changes made for the product development, are applied on the tech pack if needed, and the developer communicates the changes to the supplier. The revised tech pack is once again uploaded in the internal platform. The changes are applied in the next sample, and the revised sample is requested if needed. The decision for requesting a revised sample depends on the complexity of the changes. This rotation of fitting, tech pack update and sample creation can be cycled up to 3 rounds. This naturally lengthens the product creation timeline and exposes to more errors. Files are distributed to the relevant parties via the internal system, and email is the main communication platform.

Once the fit and the design is confirmed, the production can start. The time from the approval to product distribution takes up to 60% of the workflow.

4 3D design workflow

The following chapter concludes the theory part of the thesis. In these chapters an example of 3D design workflow is presented, illustrated and explained. The thinking process behind the 3D design workflow example, is argued with the research findings. As the primary research method for the 3D design workflow creation was the expert interviews, the interviewees are presented in chapter 4.2. The interview method is explained more in-depth and the findings of the interviews is also concluded in this chapter.

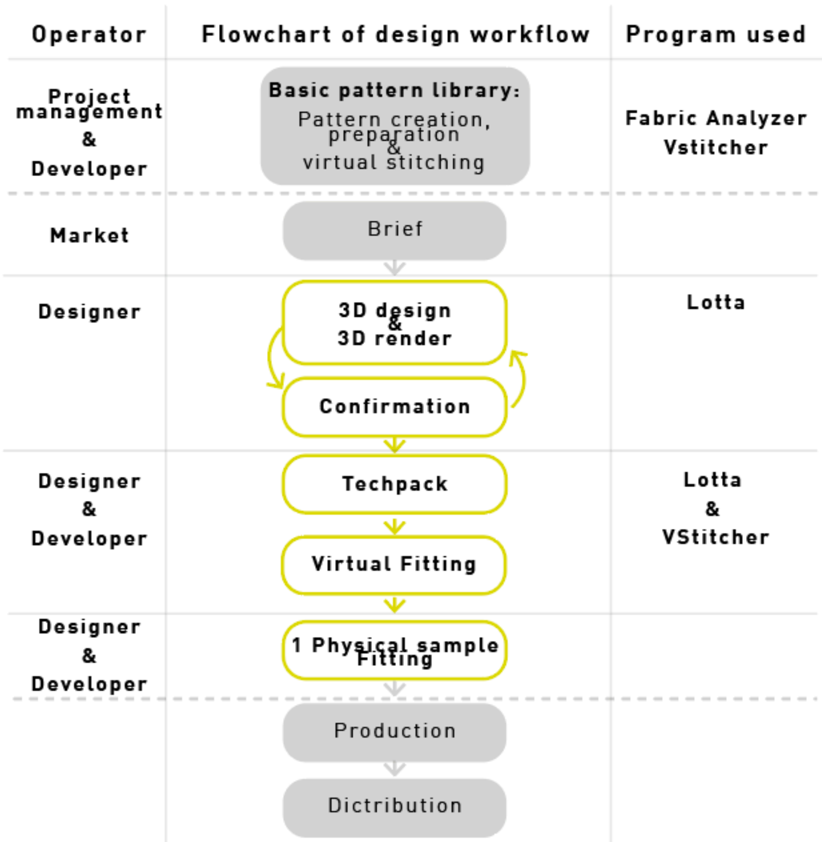
4.1 An example of 3D design workflow

Based on the research, an example of 3D design workflow for the department is created. The flowchart of the workflow illustrates a process where the implementation phase is taken into consideration. The implementation phase includes training all individuals involved and fusing the internal system with the 3D design program. In an ideal scenario, the designs can be uploaded directly from the 3D program to the internal system. And to have the designs updated automatically in the internal system when the changes are made in 3D design program (Kumar 2019, McGoarty 2019). The example workflow below is formed based on the two assumptions; The internal system is not yet interacting with the 3D program, and the suppliers are working with 3D program.

Table 4 below is to visualize the ideal 3D design process within the department. Colour coding is applied the same as in chapter 3.3: Grey as non-relevant to the thesis, and yellow as a relevant part of the thesis. In this workflow, the programs chosen are both

Lotta and VStitcher: Lotta for the designers and VStitcher for the developers. The argument is based on the product groups the department is currently working with, the affordability of Lotta, and the functionalities of each program. Puma SE has been in the industry for significant amount of time, therefore the library for produced styles is extensive. The new styles created in this department are mainly based on the reference silhouettes from previous seasons, which doesn't require drastic changes considering the patterns. Thus, the function for pattern modification is not crucial for the designers. It should also be considered that not all designers have a background in understanding the technical part of the pattern creation. However, as the implementation process evolves, the need of each program is recommended to be re-evaluated.

Table 4. An example 3D design workflow.



The main functions of Browzwear programs are the possibility to create default libraries, pattern creation and modification, cut mark and silhouette design, colourway creation, graphic scaling and positioning, tech pack function and 3D rendering. The functions of the program describe what one can do within the program (Spacey 2017). This information alone gives an overview of the phases which further shapes the flowchart of the 3D design workflow. According to the user experience interviews, it is mentioned that the libraries for basic components support the design workflow in terms of speed, accuracy and fluency. This is recommended to be the primary phase for implementing the 3D program into the 3D design workflow. (Jurica, 2019; Kumar, 2019; McGoarty, 2019.) Pattern creation, preparation and virtual stitching is mainly involved in the basic pattern block creation process.

Similar to the department's current design workflow, the workflow begins with a briefing. The research is executed, the mood board created, and the sketching is executed in 3D program. This gives the designer more room to explore different cut lines and materials (McGoarty 2019). Designing in 3D also allows the designers to recognize, which cut lines works and which doesn't (McGoarty 2019, Schaffrath 2019). The silhouettes, colourways, trims and artworks are indicated in the 3D program. Final design will virtually be fitted, styled and rendered into the 3D render. The designs are presented with the 3D renders, and the designs are revised if needed. The circle of the design and confirmation continues for as long as both parties are pleased with the result. Once the design is confirmed, the design is virtually fitted, comments are made through the 3D annotation tool, and the tech pack is created.

The tech pack is uploaded on Stylezone with BW file for the development and the suppliers. The suppliers will make the changes in the patterns based on the tech pack, and the comments made through the 3D annotation tool. The developers will check the BOM and communicates with the suppliers regarding the costs and the production details. After the suppliers have applied the pattern changes, the 3D design is updated on Stylezone. The designer either confirms or comment for changes after assessing the updated 3D design. The comments are made in Stylezone and in Lotta. The physical sample is ordered check the style, the fit, the workmanship and the fabric (Jurica 2019, Klenk 2019, McGoarty 2019, Schaffrath 2019). In case of changes needed after the samples are fitted, the tech pack is revised. However, one of benefits of 3D design is the possibility for virtual fitting at the early stage. This is also the phase where one can already see how the fabric drapes, how the patterns fit and whether the design is visually pleasing or not. The design or the developer can react to the errors already before the physical sampling. Therefore, the changes required after the physical sample should not be too drastic and the revised sample is not needed. After the sample is approved, the production can start. All communication with the suppliers is done through Stylezone or by email.

The aim is to implement the 3D design process within all the product groups. However, as Klenk (2019) stated in the interview, it is more efficient to start the implementation process step by step from one product group to another. This means, that the department is recommended to start with one simple product group, such as T-shirts, and continue to another product group.

4.2 Interview results

One of the main sources of information for the thesis is expert interviews. The interviewees are chosen based on their experience working within the clothing industry, but most importantly based on their experience working with 3D program. There were 5 interviewees, and their field of specialty varies. The interviewees are following: Browzwear 3D Specialist Marylina Klenk, Puma SE Development manager Saschi Kumar, Puma SE Apparel designer Hannah Lin Schaffrath, Adidas Apparel designer Matthew McGoarty and Adidas Design director Lotta Jurica. One of the key factors in choosing the mentioned interviewees are based on their field of specialty. This is to have a wider view of the process by interviewing experts working in different 3D design phases.

The interview was carried out as a semi-structured interview. According to Frances, Coughlan and Cronin (2009) Bridges et al (2008) described semi-structured interview as a more flexible type of interview. The open-end questions allow the interviewees to have more control over the interview process. However, the interviews were partially controlled by pre-determed themes to outline the topic. The chosen themes for the expert interviews were 3D design workflow with Browzwear program, 3D CAD implementation and Browzwear program functions. The themes of the interview were the same for all interviewees, but the questions depended on the answers of each interviewee.

The questions regarding the 3D design workflow are mainly about describing the 3D design workflow they are working with. The aim of this theme was to have each phases of the workflow explained, and to understand the communication methods between the different operators within the process. It is also to understand the full 3D design workflow, to map out the design phases and to understand the process is like. The challenging part of dismantling the answers for this theme lies within the fact that all the interviewees pointed out, how new 3D still is, and how there is no standard 3D design workflow formed yet. However, the answers the interviewees described had similarities. The described phases of the 3D design are described in chronological order: Pattern preparation, virtual stitching, design in 3D, virtual fitting, tech pack creation and 3D rendering. All interviewees point out that there is still a need for at least one physical sample by the end of the workflow. This is to check the fabric and the trim quality and to check the workmanship of the garment. The communication regarding the styles is mainly done via Stylezone as the platform is available for use right away. However, the designers and developer stated in the interview that it is ideal to have the 3D program linked to the internal system. Ideally the commenting can be done with the 3D annotation tool, and the changes made in 3D is automatically updated in the BW file in the internal system.

The second theme is the functions of the Browzwear program. This is mainly to describe the 3D design phases more in-depth, and to discuss about the benefits, opportunities and challenges using the program. One of the main benefits pointed out by the interviewees is the visual aspect of the program. The benefit of seeing the design in 3D, to be able to modify the changes in real time, and to see the fit while designing. It is also mentioned by one of the interviewees that the program gives more freedom in exploring cut lines, colourways, and materials. The challenges of the program concerned the quality of the 3D renders, and the limitations to work only within the basic pattern blocks. The 3D render image quality is criticized for not being realistic enough. According to few of the interviewees, the potential of the program is limited by the pattern making skills the user has.

The third interview theme was 3D program implementation. The questions regarding this topic mainly circled around the process of forming the 3D design workflow. It is often mentioned that the topic is challenging as there are no standard 3D design workflow yet. The structure of the workflow also varies between the companies depending on the capacity of the resources and the team structure of the company. The resources of the company indicate the time invested in training the operators. The team structure indicates the tasks of each operators within the workflow. Jurica states in the interview that the starting point for the 3D design workflow creation is based on the functions of the program. Other interviewees also mention that the company's existing workflow is a good base to start. However, the 2D design workflow shouldn't limit the 3D design workflow creation. The argument for this statement is because 3D program has many functions that 2D programs doesn't. It is not ideal to replace the 3D program only in the phases where the 2D program used to be.

5 Conclusion

Standardizing and optimizing the efficiency of the design workflow allows the department to obtain the full potential of the 3D program. The aim of the thesis is to support the department in implementing the 3D CAD program into their design workflow and to conclude the research with an example of the 3D design workflow. Despite the technological advances happening with 3D design, the topic for implementing 3D into the design, the development and the production process -is still alien. As Klenk stated in the interview, there is no standardized 3D design workflow yet. The workflow varies from company to company depending on the factors stated below.

The research questions were formed around the goal to help smoother and faster transition from 2D to 3D design workflow. As there are no standardized 3D design workflow yet, the aim of the thesis was to study the factors involved in creating a functional workflow. The goal of the thesis is to provide an example of a 3D design workflow and to support the implementation phase by providing training material for Browzwear Lotta users. The research questions were formed, having the thesis goal in mind. Primary question of the thesis is: What factors are contributing to a functional 3D design workflow? The sub questions being: What are the phases of 3D design workflow? What is the designated company's current workflow? What are the functions of the chosen 3D program?

The topic was approached by examining the literature written about 3D design workflow. As the topic is precisely about 3D design workflow and its's creation process, the qualitative research method was chosen. Literature was mainly used to acquire the base information for 3D apparel design in general. There are multiple researches and conference proceedings written around the topic: 3D design, but literature on design workflow was limited. Primary research method for workflow creation was carried out with expert interviews. The interviewees were chosen based on their field of expertise, and for their experience working with the Browzwear 3D programs. The experts chosen, are specialized in development, apparel design and Browzwear programs. All interviewees have been or are currently part of the 3D implementation process. Five interviews were carried out and the interview method was semi-structured. The themes guiding the interviews were following: 3D design workflow, 3D CAD implementation and Browzwear program functions.

Based on the findings from literature and information obtained from interviews, the research concluded in three major factors contributing to a functional workflow creation process: The chosen 3D program, 3D design phases and the company's existing tools. Below this macro level, the secondary factors are; the functions of the 3D program, company's existing design cycle and the communication platform. This is illustrated in Figure 3 on page 8. The illustration acts as a framework for the thesis.

Each factor is evaluated and presented in the thesis. The department had chosen Borwzwear Vstitcher and Lotta as the designated 3D programs. The 3D design phases comprise of five key stages: Pattern creation, preparation and stitching; Virtual fitting; Design in 3D; Tech pack creation; 3D render. The department's 2D design workflow was presented and the crucial operators for each phase was named: The Designer, the developer and the supplier. Primary communication tool for the department is via email and the company's internal system. The Internal system is utilized to share files regarding the designs.

Example of 3D design workflow comprises of eight repetitive stages from which 4 stages are influencing the design, the development and the production processes. The main benefits of the presented 3D design workflow are: Enhanced communication, more accurate tech pack handover, reduced sunken costs, reduced physical samples and faster lead time. Communication and tech pack accuracy is enhanced with 3D renders and commenting tool available within the program. The 3D annotation tool enables users to comment and drag it to the designated area which gives less room to misinterpret. Reduced sunken are avoided by recognizing the commercial styles at early stage and by recognizing the errors regarding the garment fit. The opportunity to carry out virtual fitting reduces the needs for multiple physical sample rounds. As for now, sample rounds within the department can spike up to 3 rounds and the goal of 3D design workflow, is to have only one round of physical samples. The fit, the draping and proportions can be visualized already at the design and virtual fitting stage. This will further conclude in faster lead time.

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Jurica, Lotta 2019. Design director. Adidas. Personal interview: 30th October 2019

User manual – Browzwear Lotta

User manual consists of 18 pages. To protect sensitive information of the company, the user manual is only partially attached to the published version.

Browzwear Lotta user manual.

(August 2019 edition)

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i = Information
H = How to's

BROWZWEAR

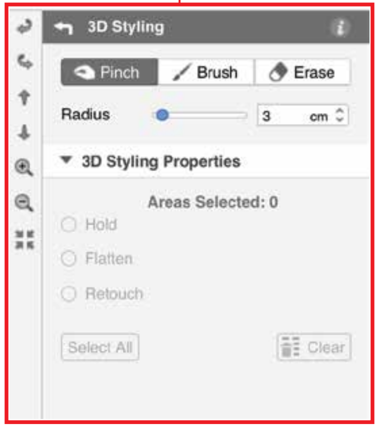
Software company that specializes in 3D simulation.
The company offers three products: VStitcher, Lotta, and Stylezone.

	Vstitcher	Lotta	Stylezone
To whom?	Suppliers Developers Designers	Designers Marketers	Suppliers Developers Designers Marketers
What for? Main functions	Product creation from pattern creation to physical product. - Pattern creation & modification, - Design with cut lines, artworks, trims, - Tech pack creation, - 3D photorealistic rendering	Product creation starting from design with existing pattern blocks. - Design with lines, artworks, trims, - Tech pack creation, - 3D photorealistic rendering	Secured platform to share 3D designs, to view and to comment on the designs. Ease communication.

Main toolbar

Start/End 3D Simulation

	Home: displayes a menu **Colorways:** displays colorway workspace	Texture	**Move and scale texture within pattern piece.**
	Open files: Navigate to file or recent files	Assign	**Apply materials to the garment pieces or internal lines**
	Save file	Insert	**Add shapes rectangle or ellipse shape** **Symmetry:** Shape added symmetry to mirrored piece **Cross:** Shape crosses between pattern pieces
	Undo, history, redo	Pen	**Draw line or shapes** **Symmetry:** Shape added symmetry to mirrored piece **Cross:** Shape crosses between pattern pieces
	Render, Create tech pack, Print to file	Size: M	**View and mange the size range on graded garment**
	Upload on Stylezone	Snapshots	**View and choose snapshots**
Select	**Select piece, line or point**	01	**View, create (clone) and import colorways**



Styling: Pinch, Brush, Erase