Virtual tailoring for enhancing product development and sales

Alexandra A.M. Kuijpers

School of Materials, University of Manchester, UK

a.a.m.kuijpers@hva.nl

R. Hugh Gong

School of Materials, University of Manchester, UK

hugh.gong@manchester.ac.uk

Abstract

Purpose

The potential of 3D virtual technology is high for the fashion industry. However, the implementation by the industry is slow. Body proportions and fabric properties contribute to the complex fitting tasks. This paper aims to provide an insight in the benefits 3D virtual technology can have for the fashion and clothing industry, and stimulate interest and application of these digital tools.

Design/methodology/approach

Existing literature is reviewed, focusing on fabric drape and fabric objective measurements used for the simulation of garments, and on how these parameters are translated into a virtual fabric. Moreover, current virtualization processes in industry and education are examined and used to illustrate the way they can be used in the fashion and clothing industry.

Findings

Companies in the fashion and clothing industry, who implemented virtual technology, saw a reduction of prototypes and samples. Students using this technology to realize their designs confirm this benefit. Other advantages are more time for fit and design decisions, clearer communication, more sustainable ways of working, and easier to align with new innovations.

Originality/value

Garment virtualization as illustrated in this paper is applicable in the current fashion and clothing industry, from the highly commercial mass market to luxury brands and independent designers.

Article Classification: Viewpoint / General review

Keywords: Garment-simulation, 3D-product-virtualization, Fabric-properties, Fabric-drape, Change-management.

Introduction

In the last few decades, globalisation has transformed garment manufacturing. High volumes of fabrics and garments are transported all over the world. In most of the cases, this results in longer lead times, higher transport costs and more pollution. Production processes in the fashion and clothing industry are largely driven by cheap labour, thus discouraging innovations in manufacturing. As a consequence limited automation is applied and todays sewing machine operations are similar to those in the 19th-century, (Walter et al., 2009, pp. 1-4).

Nevertheless the fashion and clothing industry innovated in some areas, such as the product development and cutting room where Computer Aided Design and Computer Aided Manufacturing (CAD/CAM), after its advent in the 1970's, slowly emerged and is commonly used today. This enables extensive material reduction and accelerates processes like pattern development, grading, marker making and cutting. However with the implementation of 3-dimensional (3D) CAD, the fashion and clothing industry lags behind compared to other industries. Many industries such as engineering, architecture and automotive started experimenting with this virtual technology more than 15 years ago, enabling them to implement 3D CAD in conceptual development, design, manufacturing and construction phases. At the same time the fashion and clothing industry faces technically challenging aspects such as accurate digital representation of the human body and fabric simulation (Goldstein, 2009, pp. 95-96).

However, the fashion industry can make a headway by implementing 3D virtual technology. Several publications (Luibe and Magnenat Thalmann, 2007; Pandurangan et al. 2008; Goldstein, 2009) have emphasized that virtually simulated garments can contribute to work more accurately and to reduce time and costs. These statements are confirmed by the early adapters in the fashion industry. These companies achieved a considerable reduction of costs and resources in the sampling processes compared with the traditional process. Sportswear brands were the first to implement 3D CAD. This placed them in the forefront of empowering virtualization of the product life cycle. Moreover students, who develop their collections with the use of virtually simulated garments, have shown that they are able to significantly reduce the number of physical garments and enhance their designs.

The reduction of costs and lead times may be an important reason for the fashion industry to implement virtual garment simulation. It can be argued that overproduction and the environmental footprint may be a secondary reason to stress the need to include these new innovations and knowledge based solutions into the fashion cycle.

Some people fear that virtual design may interfere with the creative process. It is our experience that virtual design stimulates creative solutions. Virtual garments could enable companies to undertake the next steps and create virtual catalogues for presentation, sales and e-commerce. This may lead to new business opportunities. Designers will be able to visualize their ideas and present their collections in innovative ways. In combination with body scan data, customized garments could be in the reach of the mass market. Virtual garment simulation can provide educators with new powerful tools to challenge students and help them to improve the insight in translating their ideas into 3D garments.

For virtual garment development a reliable representation and behaviour of the fabric is essential to assess the fit of a garment. Fabric objective properties can be measured and used in 3D virtual software to simulate the fabric. Today the main systems to obtain these properties are KES-F, Kawabata Evolution System for Fabrics (Kawabata, 1980), and FAST, Fabric Analysis by Simple Testing (Boos and Tester, 1994).

Methods

Existing literature is reviewed, focusing on fabric drape and fabric objective measurements used for the simulation of garments, and on how these parameters are translated into a virtual fabric. Moreover, current virtualization processes in industry and education are examined and used to illustrate the way they can be used in the fashion and clothing industry.

Fabric objective measurements and fabric drape

Fabric objective measurements

The simulation of virtual fabrics is based on fabric objective properties. Although those objective properties can be obtained with various individual instruments, the main systems currently used to retrieve these parameters are KES-F and FAST. Both systems retrieve a number of valuable properties, some closely related, although significantly different due to the purpose of the instruments and constructional principles.

For the two systems, KES-F delivers the most precise parameters for the simulation of garments. The comfort of a garment during wear is significantly better represented in virtual garments simulated with KES-F data. This is due to the more elaborated way KES-F measures the tensile and shear properties. The results for bending from both KES-F and FAST are comparable in a virtual environment. FAST is limited with testing stretch materials due to the maximum elongation of 21% (Luible and Magnenat-Thalmann, 2007).

KES-F was developed by Kawabata (1980). In the 1970's Kawabata and Niwa researched methods to quantify the subjective measurement of 'fabric hand'. The fabric hand is an important way to judge the quality of the material. This is mostly done by experts in fabric finishing, but also by consumers. Kawabata set up an expert committee, with whom he defined the commonly used expressions for fabric hand. Kawabata sorted the expressions and divided them in four categories, with a sequence of importance. At the same time the Kawabata Evaluation System, KES-F, was developed. The objective measurements were correlated with the subjective measurements and THV of the committee.

The Kawabata instruments are highly sophisticated. In Europe KES-F is mainly found at a few Universities. Due to its precision, the system is highly appreciated by experts in the field, although it is relative expensive and skilled operators are required. The fabric evaluation system consist of KES-FB1 for testing tensile and shear, KES-FB2 for testing pure bending, KES-FB3 for testing compression and KES-FB4 for testing surface properties. KES-F is unable to test very thick material for bending. but can handle a wide range of fabrics, from very limp to rigid materials, and including highly stretchy knits.

FAST (Fabric Analysis by Simple Testing) is developed in the 1980's by the Australian CSIRO Division of Wool Technology. SiroFAST measures the mechanical and dimensional properties of fabric that can be used to predict performance in garment manufacture and the appearance of the garments in wear (Boos and Tester, 1994).

FAST is originally developed for woven woollen suit fabrics, the output includes a list of recommendations for cutting and sewing. The system is easy in use and relatively inexpensive. The instruments are mainly used in the industry. FAST consists of 3 instruments; FAST-1 for testing compression, FAST-2 for testing the bending length, and FAST-3 for testing extensibility. The properties for shear are derived from the bias extension. FAST-4 is a method to test the dimensional stability of a fabric. FAST- 2 measures the bending length based on a cantilever system. An electronic eye measures the bending curve under an angle of 41.5º. This can cause difficulties when handling very limp or stiff materials as well as knitted fabrics which tend to curl up during testing. FAST-3 is limited with jersey and stretch materials as the maximum extension is restricted under 100 g/cm force.

Fabric drape and its measurements

The measurement of fabric drape started in the first half of the previous century. After the introduction of virtual garment simulation, fabric drape gained interest from various researchers to obtain information for the virtual drape.

For the textile area, Pierce started in the 1930's with the first fabric objective measurements. Pierce (1930) introduced a method to measure the drape quality of fabric, expressed as the bending length.

In the 1950's Chu, Cummings and Teixeira developed the Fabric Research Laboratories (F.R.L.) drape meter to quantify fabric drape. During the 1960's Cusick worked on further development of the F.R.L. drape meter principle, resulting in the "Cusick drape meter" which is still widely used today. A drape meter measures the 3D drape of the fabric and is expressed in the drape coefficient (DC%). The Cusick drape meter uses a support disc and an outer ring, the latter is lowered to enable the fabric to drape. A parabolic mirror transfers the light from a bulb mounted under the disc. Fabric specimen, with a diameter of 24, 30 or 36 cm, are draped on the support disc, which has a diameter of 18 cm. After draping, the shadow of the drape is traced on a paper ring, and the drape coefficient can be calculated with the cut and weight method. Figure 1 represents this principle. With preliminary tests, Cusick (1962, p. 9) found a fabric specimen with a diameter of 30 cm was the most suitable for a range of fabrics, with drape coefficients between 30 % and 90 %. For limp fabrics with drape coefficients lower than 30 %, curves and folds develop under the support disc. Whereas fabrics with a significant difference in warp and weft stiffness have drape coefficients from 80% to 90% and 2 nodes occur. A zero nodes fabric has a drape coefficient of 95 % or higher, although the traced shape is not a precise circle for most fabrics.

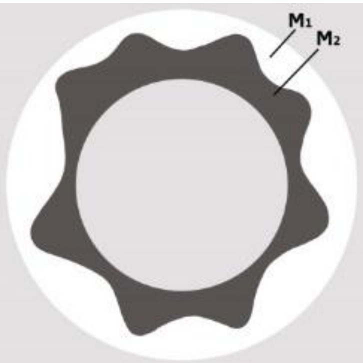

Figure 1. The shadow of the draped sample (M_2) in relation to its original undraped form is represented by the white area (M_1). The light grey area in the centre represents the support disc.

Today the cut and weight method is often replaced by more accurate and faster image analysis methods, as introduced by Vangheluwe and Kiekens in 1993. The principle of testing is equal to the traditional cut and weight method. Instead of tracing the shadow, an image is taken with a digital camera mounted above the drape meter. The calculation of the drape coefficient is based on pixel count. The fastness and the digitally assessable data of this method enable new possibilities to research fabric drape. Due to this development various new drape parameters are developed and more insight in the drape and behaviour of fabric is gained.

Jeong (1998) worked with the same principle, although the drape coefficient was calculated based on boundary selection, which, the author demonstrated, was more accurate than the pixel count method. By testing the same fabric sample multiple times Jeong (1998) found a large variation in drape.
With Adobe Photoshop® Kenkare and Plumlee (2005) retrieved the drape coefficient from digital images taken with a camera mounted above the drape meter. They selected the drape shadow with the magnetic lasso tool based on boundaries, and found good correlation with the cut and weight method.
A digital drape meter based on photovoltaic cells is developed by Collier et al.,(1988, cited in Collier, 1991, p.47). A digital voltmeter registers the amount of light. The same fabric swatch is draped on supports with diameters of 5,0 inch and 3.0 inch (12.7 cm and 7.62 cm). Collier (1991) suggest the effect the different sizes of the support discs have on drape can contribute to more insight in the drape of fabrics.

Al-Gaadi, Göktepe, and Haláz (2012) developed the Sylvie three-dimensional drape tester. The Sylvie 3D drape tester is based on 3D scanning technology and linked to a computer for digital image analysis. Additional rings, with inner diameters of 21, 24 and 27 cm, enable a more dynamical drape measurement. The proportion of the used fabric specimen and support disc are equal to those used with the Cusick's drape tester. Additional rings can be used, the fabric is pushed through the ring and the measurements are taken. The deformation process is registered by 4 cameras, capturing the cross lines projected by four laser transmitters.

An objective method for determining the correlation between a simulated and a physical fabric drape was developed by Kenkare, et al. (2008). They utilized a 3 dimensional body scanner for this purpose. The authors tested a range of fourteen white fabrics with KES-F and Cusick's drape meter. A set-up was made in a white light based 3D body scanner and a fabric specimen draped on a support disc was captured by the scanner. The authors demonstrated there was no significant difference between the drape coefficients obtained with the scanner and the traditional method.

Georgiou et al (2009) introduced a method to replace the slow and expensive process of FAST and KES-F, with the purpose to facilitate the fashion industry and push the implementation of 3D virtual prototyping. With an extension of the Cusick drape meter, image analysis and statistical algorithms, a sample of a new fabric was compared with samples in a data base in order to find the closest match.

Relationships between Fabric properties and fabric drape

Cusick (1965) investigated the influence of bending and shear properties on fabric drape. According to the author the drape coefficient expresses the percentage of the deformation occurring in the loose hanging part, thus indicating the stiffness or limpness of the material. Further Cusick (1965) stated that the shape of the drape is influenced by bending and shearing. To research this relation with the drape coefficient, the author tested the bending length and shear stiffness of 130 fabrics. With simple and multiple regression Cusick (1965) demonstrated that first shear stiffness and next bending length influenced the drape coefficient.

Moorooka and Niwa (1974) found bending rigidity *B* and weight per unit area *W* the most closely related to the drape coefficient. Moreover, they found that the stability and reproducibility of the drape coefficient for fabrics with high hysteresis values in bending and shearing was less.

Collier (1991) found the drape coefficient is inversely related to shear and bending resistance. The author found that drape is most influenced by shear hysteresis at 5^0, followed by bending.

Cloth simulation

In 1994 Breen, House and Wozny delivered a significant contribution to cloth simulation. The researchers applied KES-F data into a particle grid model (mesh). Luible and Magnenat-Thalmann (2007) stressed that the realism of the simulated fabric behaviour depends on both the accuracy of the computational models and the appropriateness of the input fabric objective properties. Pandurangan et al., (2008) stressed the importance of accurate virtual 3D fabric drape for the fashion and textile industry and consequently, the contribution this will have to various processes in that industry. According to Pandurangan et al., (2008) there is limited understanding in how the physical properties of the fabric influence simulation, and this causes inaccurate representation of fabric in a virtual environment. Al-Gaadi, Göktepe, and Haláz (2012) stress that the complexity of cloth simulation is partly due to the effect that fibre, yarn and weave construction have on the performance of fabric. The authors believe that the KES-F is the main system today to retrieve the mechanical properties for fabric simulation. Furthermore they consider that the particle and the finite element models as the two main systems currently used in the textile area for cloth simulation.

Two distinct areas for the modelling and simulation of cloth

Breen, House and Wozny (1994) recognize two different areas for the modelling of cloth. One area is computer animation, where the purpose to have a visual realistic result is leading. This result is based on the visual behaviour of the physical material. Figure 2 represents a game figure wearing a Prada outfit

Figure 2. Computer graphics: Virtual copy (left) of Prada outfit (right). Source: Final fantasy and Prada, posted by Adrian on gaming, 2012.

The second area is the engineering and Computer Aided Design (CAD). The purpose in this area is to achieve reliable copies, respecting the mechanical properties and behaviour of the physical material. Figure 3 represents virtual fitting, to access comfort by movement, based on simulations with KES-F and FAST properties.

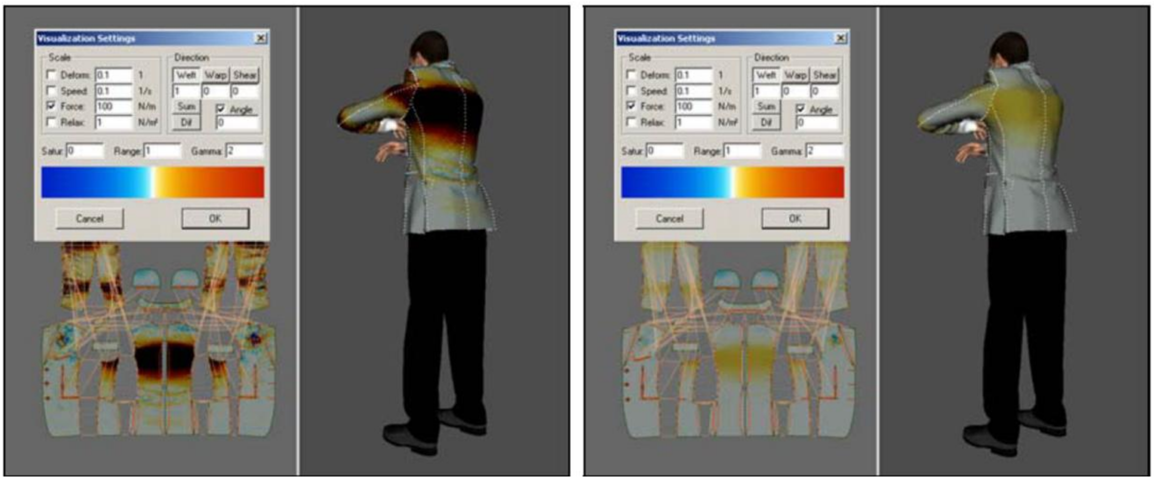

Figure 3. Simulation respecting the mechanical measurements, Virtual measurement of tensile property; left based on KES-F and right on FAST data. Source: Luible and Magnenat-Thalmann, 2007.

Methods for cloth simulation

Although simulations with finite element methods are very precise, they are not commonly used for cloth simulation. This is mainly due to long computation time and the handling of collisions. The latter mismatches with the complex buckling and wrinkling of cloth. Mainly, simple circles or

rectangles are used for simulation (Volino and Magnenat-Thalmann, 2000, pp. 50-51; Hu, 2004, p. 16).
Breen, House and Wozny (1994) stress the complexity of textile materials which are compounds of fibres with their own characteristics and intricate connections: ‘Significantly, all of these components are held together, not by molecular bonds or welds, but simply by friction”. The authors build their model respecting the mechanical parameters. The model consists of a particle spring system, where the particles represent the intersection points of the warp and weft yarns, as illustrated in figure 4.

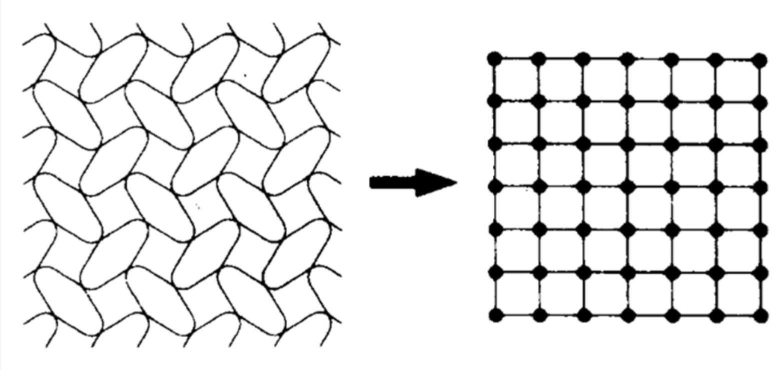

Figure 4. Thread crossing map into particles, Left plane weave, right particle grid translation. Source: Breen, House and Wozny, 1994.

Several authors found the bending the most dominant parameter for garment simulation (Breen, House and Wozny, 1994, Parandugan et al. 2008).

Examples form industry

KappAhl is a Swedish company who develops male, female and children collections for their own stores in the northern part of Europe. They use 3D virtual prototyping for product development. An important benefit of working with 3D virtual prototyping is the reduction of prototypes and samples. With virtual fits they sized down the amount of physical samples from multiple to one sample per style. Additionally the communication and decision making improved by discussing the virtual styles within the design and buying team for input and approval (Silow, 2011). In 2009 KappAhl started using 3D virtual prototyping. Lotta Silow (2014) points out the benefits of the implementation in the company’s work process. Apart from the sample reduction and easy improvement of fit, it enables them to visualize quickly multiple options with slight pattern or print variations. These variations are presented to and discussed within the design and buying team, enabling them to choose the best options to build the collection, without making any physical sample or prototype. Complete size ranges are virtually fitted, the software shows the Avatars positioned next to each other in the ordered size range. With these checks it is easy to improve fit and proportion in all sizes. Avatars lined up next to each other in different skirt lengths easily communicates the season’s skirt lengths within the different teams.

Adidas started implementing 3D virtual products in an early stage. In 2004 a small team started researching the possibilities by firstly looking at industries, such as architecture and automotive, who had implemented this technology already. They started the vitalization process in the footwear area. Pushed by the confines of the current system, virtualization is a key strategy for the company (Eder, 2013). Since the launch of the virtualization program, in 2010, the use of virtual textile samples is increasing significantly throughout the various departments. They easily go around without high cost and time investment compared to physical samples. The gained time can be set in for fit and design decisions (Mueller, 2012).

This strategy has led to a reduction of 1.5 million physical textile samples between 2011 and 2013,thus reducing costs and lead times, and allowing faster decision making within the company. Next to this they contributed to a more sustainable approach by saving material and resources. Furthermore by transporting less material and samples around the globe, they reduce their carbon footprint. These virtual samples are easily available and replace time consuming photo shoots of the real samples. The company uses these virtual samples to replace the real ones in e-catalogues, sell-in, e-commerce and brand marketing. At the end of 2013 Adidas used 500 virtual samples on the website and in web shops. The company aims to close 2014 with a reduction of 2.5 million physical samples (Adidas Group, 2014, p.p. 23-24). Another goal is to virtualize the design process, therefore, Adidas introduced a new 3D design tool in 2013 (Adidas Group, 2013a, p.p. 30-31).

The Adidas group uses these virtual 3D products in novel inventories for selling their products and obtaining information about their customers. Inventories such as virtual sell-in for retail or in the end consumer market footwear walls and window shopping. With easy to use scanning technology for customers, the virtual garment can be fitted on the individual body of the end user.

Adidas launched in Western Europe a new way to present their collection to the retail buyers. Instead of having sales samples in every colour and putting whole collection ranges on the floor, they shifted to a sophisticated sell in process. On large digital touch screens virtual samples of the collection ranges are presented. The buyer can browse through the entire range, rotate the virtual products and generate product specific information and drag the items they want to sell-in for their own shops in a separate area. Accordingly, they can swipe the final selection into a specific area to generate the orders automatically and finally retrieve a digital or printed copy from the orders. Figure 5 illustrates this process (Adidas Group, 2013, p. 30).

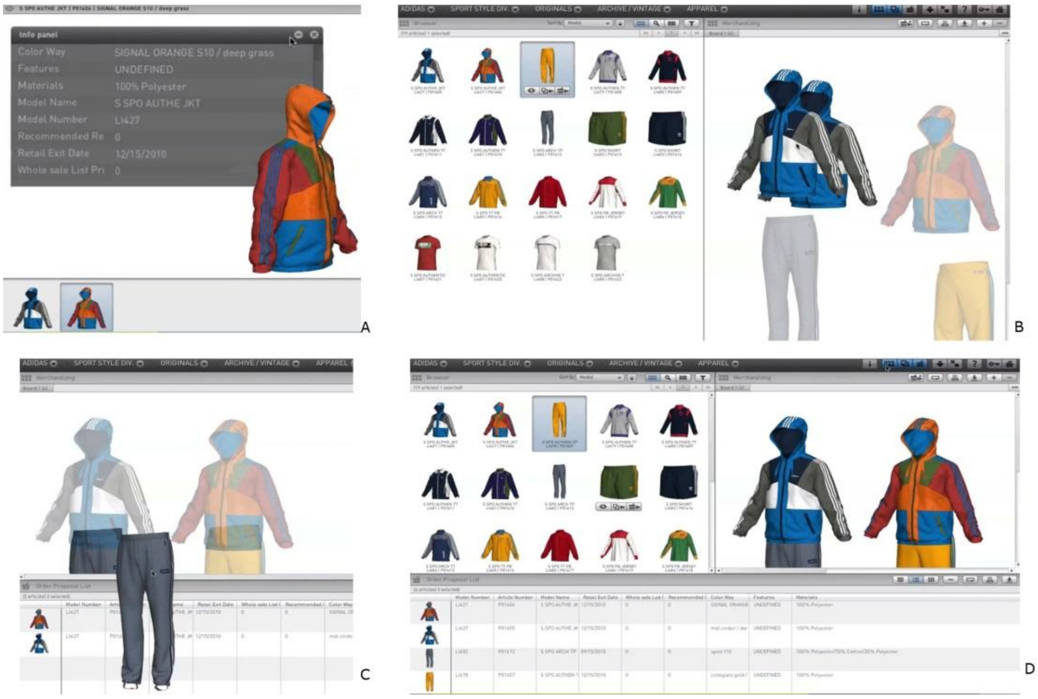

Figure 5. Virtual sell-in tools Source: RTT Marketing Solutions (2013)

The footwear wall (figure 6) is a novel customer experience. The idea for the digital footwear wall dates from the Olympics in Beijing in 2008, when the square meters of the shops didn't allow to show the entire Olympic range. Cooperating with Intel, Adidas developed an interactive virtual shelf, displaying virtual products, able to trigger the costumers and to push products. The Virtual footwear wall works with a similar principle as the Sell-in device. By touching and swiping customers can also select and rotate the 3D real-time rendered products. Additional they are able to obtain product specific information, interact real time with social media and buy the product on a connected tablet. Video analytics recognize gender, patterns, demographics, preferences and most viewed items. Apart from virtually enlarging the shop's square meters, for Adidas the benefits are significant. It enables the company to give tailored advise, push products and attract the customer with games and video (Aubrey, 2014).

Figure 6. Adidas footwear wall. Source: Start JG

A comparable project is set up in cooperation with retailer Foot Locker, resulting in the 'the A standard', an interactive digital shelf with 3D virtual products. This digital shelf is based on the same principle as the footwear wall. It provides customers with product information and performance of the apparel and shoes, which are available in store and also on-line. For the retailer 'the A standard' is an ultimate opportunity to collect data and align their sell-in. In the United States, 28 selected Foot Locker stores will be equipped with this interactive experience (Cunningham, 2014).

At the next level the shop window is transformed into a virtual touchscreen (figure 7), thus opening the shop after closing time, letting customers browse through the range and letting them interact with their mobile phone.

Figure 7. Window shopping. Source: Adidas Group, 2013c

Figure 8 summarizes the benefits the fashion and clothing industry can gain by virtualizing their products.

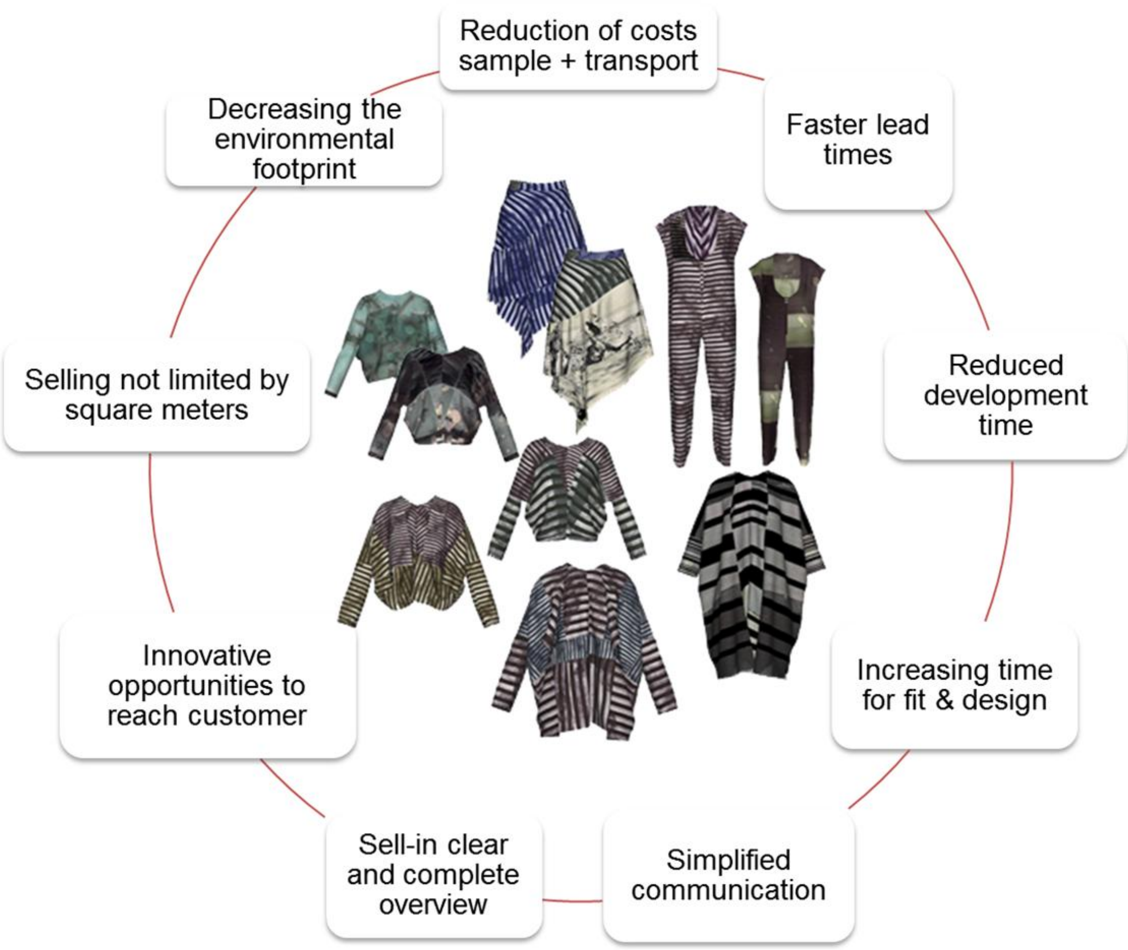

Figure 8. Benefits of virtualization for the fashion and clothing industry

3D Body scan and virtual garment

With body scan technology, a virtual replica can be made of the human body. Users of garment simulation software have mostly the choice between a parametric avatar, with adjustable sizes or importing a body scan. Whereas the parametric avatar has benefits for fitting a complete size range or the measurements can be adjusted to the average of the target group. The body scan represents an individual person, on which a virtual garment can be draped in a digital environment. This prompts the opportunity for fashion and clothing companies, as well as for independent designers to create customized garments. They can develop the first customized fits in the virtual environment, without producing toiles and reduce the presence of the customer for fitting the toiles.

Virtual garments simulated on 3D body scans may be used to optimize garment fit (Daanen et al. ,2014). In the Dutch army each soldier has a personal shopping chart to select the right size military garment, the chart is based on measurements retrieved from individual body scans. The aim of this system is to obtain the best fitting garment in minimum time. The accuracy of this system was tested for 35 male soldiers. The best fitting combat jacket and pants were compared to the predicted sizes. The fits were repeated in a virtual environment using a selection of the population. The original patterns used for the garments were virtually stitched and draped on the body scans of the soldiers. The authors found virtual fitting a promising tool, since it is not biased by personal preferences.

To select the correct size Adidas experimented with an easy to use scanner, based on Microsoft Kinect®: the "BodyKinectizer". On digital screen, operating on body movements, a garment can be selected. Next, a system is able to make a rough body scan from a dressed person. The virtual garment is draped around the body, with gesture the right size selected, fitted and finally bought. Figure 9 illustrates this process. The company is aiming to have the system used at home and in the shop (Adidas group 2013b).

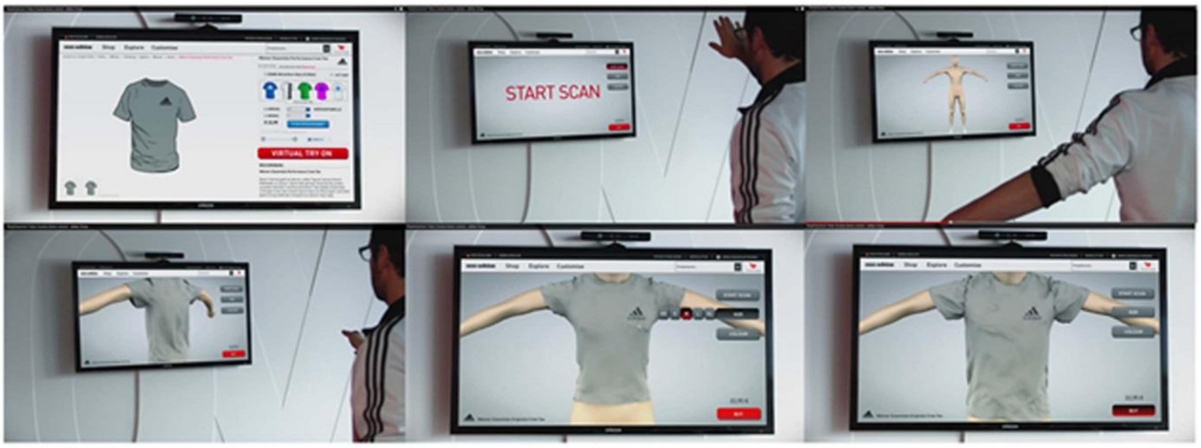

Figure 9. BodyKinectizer, source: Adidas Group, 2013b

Education

Next to brands, who could gain from virtualization, independent and starting designers, willing to work beyond the traditional borders, will also benefit from this technology (Kuijpers, 2012). The visualization possibilities for print design and the immediate feedback on the virtual garment when working with virtual 3D technology are far beyond traditional possibilities and give a lead in the product development process.

The Amsterdam Fashion Institute – AMFI have been working with 3D virtual technology since 2009. The commercial Lectra Modaris® software has been used for 2D pattern drawing and 3D virtual simulation, whereas 3D CAD is mainly set in for students after the second year. Before the software was implemented, sportswear brands like Adidas and Nike who already implemented this technology were examined.

The bachelor level has three directions, namely Fashion & Branding, F&B, Fashion & Design, F&D and Fashion & Management, F&M. In the first and second years, there is a direction specific general program. In the third and fourth years, students are able to tailor their own education with the large variety of 6 months programs in the flexible program. In between the second year and graduation, they do their internship and have to follow a specialism and minor. The specialisms are department driven, whereas in the minors students from all three directions are allowed to join. In the first and second years, 2D digital pattern drawing is offered to management and design students. Designers learn first manual pattern drawing, and in the end of the second year a sneak preview of 3D CAD is offered. Managers learn basic pattern drawing when working with 2D CAD. In the flexible program we offer 3D CAD in a few minors and specialisms, such as specialism Make and Buy, minor Denim, minor Individuals and minor Hypercraft. In the latter students are challenged to work on a high level combining digital and traditional craftsmanship The program pushes the boundaries of virtual possibilities. Students choose to design an experimental or a technical collection, the latter is always in cooperation with a company. In this minor students use the 3D virtual technology intensively to develop their collection.

The past five years there have been multiple examples of how students gained more overall insight and enhanced their products by working with 3D virtual technology. The perception of how the 2D pattern and 3D garment interact with each other increases. It is easy to try and investigate, creative students can easily test and experiment with shape, print, colour and fabric, thus pushing their collection to a higher level and raise the quality of their work.

The learning aspects are on various levels from beginning to advanced and also in connection to other courses. At beginners level students are able to develop complex patterns, with the immediate feedback on the avatar and the clear connection between 3D garment and 2D pattern, they can easily correct mistakes (figure 10). The relation between 3D garment and 2D pattern is most often more difficult to obtain by physical fits.

Figure 10. Fit and design process, visualize ease and adjust patterns, AMFI Hypercraft 2014 technical design, Isabelle Schuijt & Alicia de Groot.

Designers, who have a higher level pattern drawing skills by entry to the programs, adjust their fit very efficiently with the seamless interaction between 2D pattern and 3D garment (figure 11,12). The amount of physical toiles is in most cases reduced to one. Although not preferable, fashion & management students sometimes skip the physical toiles with relative good results. Next to this more insight is obtained with specific tools in the program such as the automatic transfer from lines, drawn on the 3D Garment, to the 2D pattern and the possibility to visualize the ease of a garment. Designer Sebastian Pleus (Pleus, 2014) points out the benefits of Hypercraft, reducing the amount of toiles and seeing the pattern alterations immediately. Another benefit for him is the ease to place prints. Figure 11.

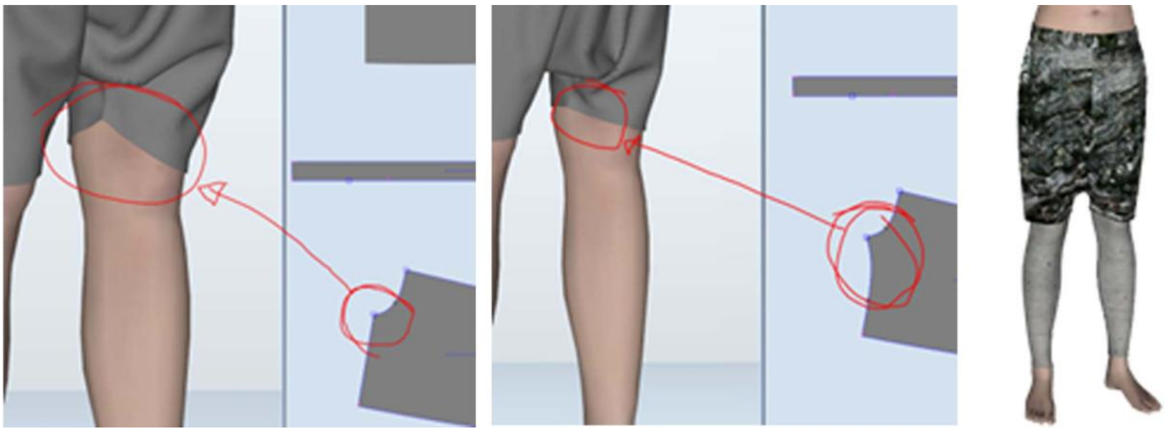

Figure 11 Fit and design process, AMFI Hypercraft Experimental Design, Sebastian Pleus, 2014

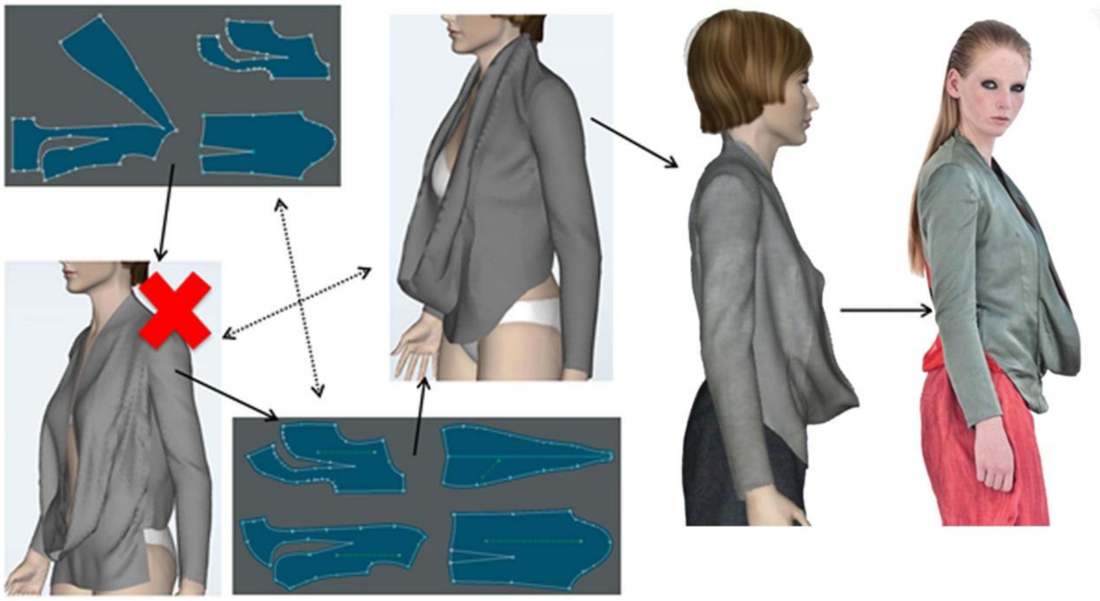

Figure 12. Virtual fit and design process, AMFI Hypercraft Experimental Design, Laura Kirchner, 2010

Accurate material representation is required when fitting a garment virtually, and checking the ease and the drape of the material. Beforehand, students test their designs with different draping fabrics in order to decide what works the best (figure 13). The students test their materials with FAST and input the parameters into the 3D CAD program to simulate the fabrics. By doing this they gain more knowledge of material properties and the behaviour of textile material. There is a more coherent interconnection and insight between the textile classes and design process.

Figure 13. Make design decisions based on fabric drape, AMFI Hypercraft 2014, Experimental Design, Marijn Rikken.

The unlimited option for print design is another strong point when working with 3D CAD application. In real life, it is often hard to see how the print can be scaled or placed the best. By placing prints on the virtual garment, days of work are reduced to a few hours. To gain ideas before hand, students use other garments to make decisions about how the print can be placed most optimum (Kuijpers, 2012).

Creating variations on a just finished collection is often a threshold for students, with 3D virtual CAD they can cross this border. To reach this next level is often an eye-opener for the student. Sebastian Pleus started with a complete black collection. With the virtual outfits he was able to experiment how his designs worked with other colours; Figure 14. After this Sebastian imported the virtual outfits in Adobe Photoshop ® to give the Avatars a personal look, with this he obtained a more 3D look for his presentation.

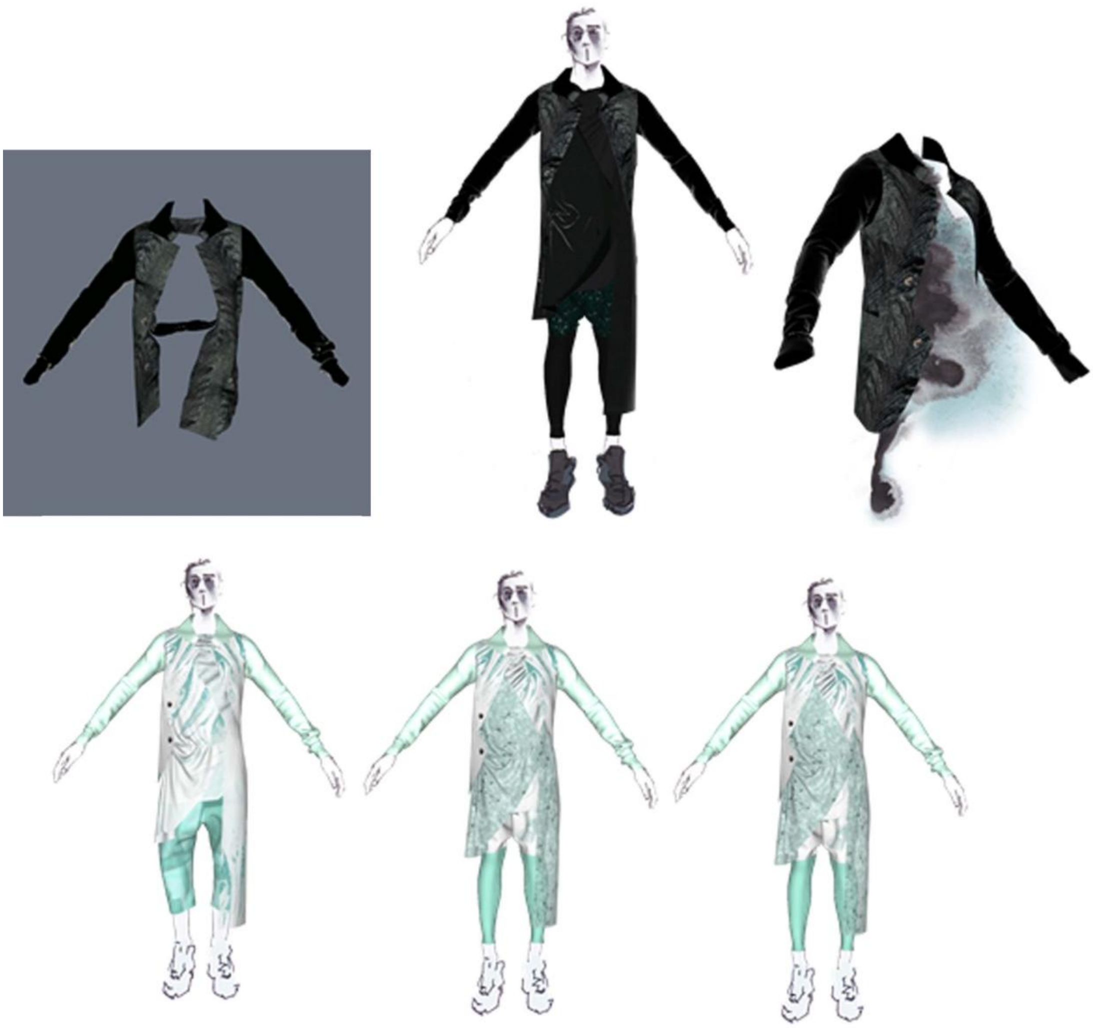

Figure 14. Some of the virtual varitions, AMFI Hypercraft 2014, Experimental Design, Sebastian Pleus

Another example is from designer Marijn Rikken, who challenged herself to transform her designs with colourfull prints (figure 15). Learning these skills prepares students better for a position in the industry.

Figure 15. Virtual print variations, AMFI Hypercraft 2014, Experimental Design, Marijn Rikken

Digital printing of textile material contributes to this way of working. A combination of digital printed fabric swatches, a physical outfit and unlimited virtual variations create new business models for designers and mangers of the future. Virtual designs combined with 3D body scanning technology enable customized tailoring.

Learning these digital tailoring skills requires time investment, open mind for new technology, and perseverance to go through the technical part. Mistakes made at a certain point in the digital work process, often cause errors not clearly visible and may demotivate students. Students who passed this phase work independent, with less interference from teachers. For Designers, unrealistic avatars and fabric texture visualization might be a threshold, some interact with other programs to adjust the virtual outfits to their own preferences.

Some people fear that virtual design may interfere with the creative process. It is our experience that virtual design stimulates creative solutions; it opens new ways to look at a product and allows experiments to be done more freely.
Figure 16 summarizes the benefits education can gain by virtualization.

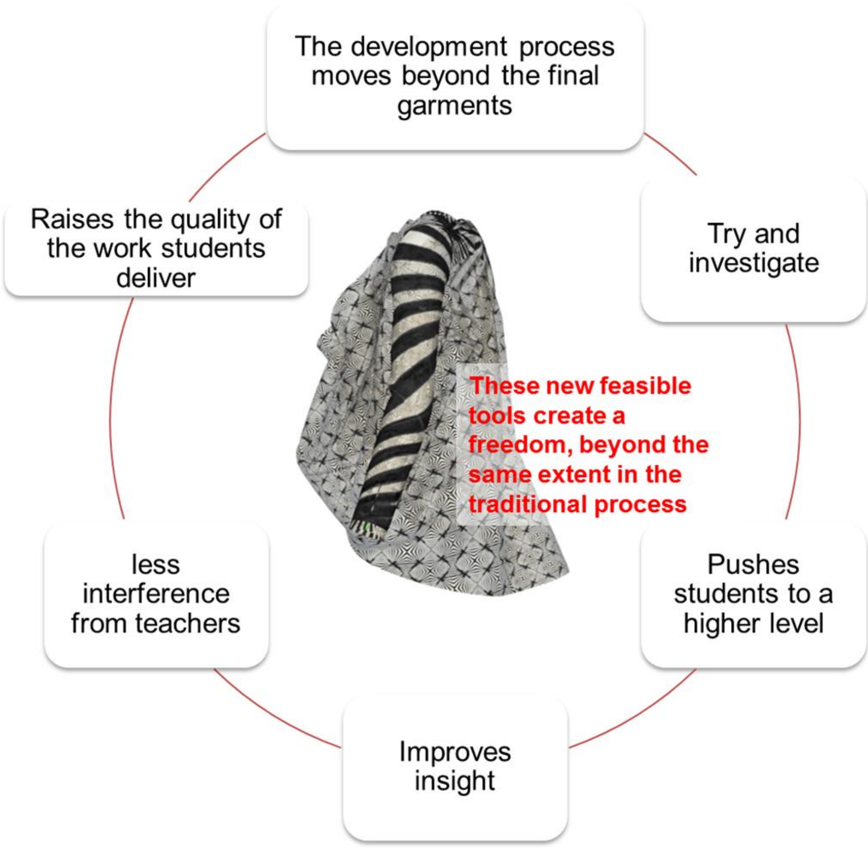

Figure16. Benefits of virtualization for education

Conclusions

It has been shown by examples from industry and academia, using virtual technology can bring significant benefits in various ways.

KappAhl uses virtual technology in the design and product development phase, enabling them to reduce the amount of prototypes significantly. By working in this way KappAhl gains, in a very early stage, immediate benefits and feedback with the first fit and design decisions. They improve the fit for all sizes, with the way they set in the virtual technology to fit the size ranges, ensuring a better end product in the shops.

Although Adidas started at the other end, the sales and branding area, they reduced the amount of physical textile samples with 1.5 million in three year’s time. They are now implementing virtual design applications in the design and product development phase. Virtualization of their products has

enabled the company to shift to digital sales, the virtual products can easily be used in this environment. The real time rendering in combination with touch devices allows seamless rotation.
For education, students were able to work independently and being self-correcting after an intensive training. They pushed their creativity with new options and possibilities that are missing in the traditional process. They were able to improve their fit and design and at the same time reducing their prototypes and samples to a minimum.

Fabric is a highly anisotropic material. Its drape behaviour is influenced by many factors. Instruments like KES-F and FAST are developed for other purposes, but are suitable for obtaining properties to simulate fabric. Simulation of textile material is intricate and complex, depending on suitable objective measurement systems, simulation models and computer capacity. Current simulation models are built on today’s technologies. They facilitate a workable situation, as shown with the investigated examples. These examples are a pledge for the future of the fashion and clothing industry and stress the relevance for researching accurate fabric simulation. The success of virtual garment development is based on 3 key elements: virtual human, 2D pattern and virtual fabric. They need to interact seamlessly with each other to obtain a reliable fit (figure 17). For the virtual fabric this consists, in the fit phase, of accurate representation of the mechanical properties, plus for the design phase, of reliable representation of the texture. For the virtual human, this consist, in the fit phase, of accurate and reliable representation of the target group, plus for the design phase, of visual alikeness with the target group. Next to accurate representation of the 2D pattern, alterations in the pattern need to be exactly executed in the virtual garment.

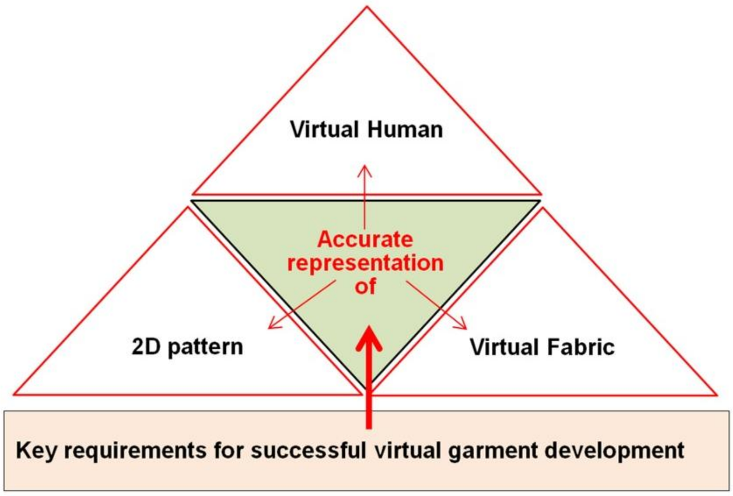

Figure 17 Accurate and seamless interaction between key elements for virtual garment development
In spite of the imperfections, the examples show the benefits of 3D virtual technology for the fashion and clothing industry. Current configurations are already suitable for implementation into a virtual product life cycle. ‘A mindset is necessary to virtualize the traditional process from prototyping,

sampling and sales' (Kuijpers, 2012). In various departments, people have to adapt a new way of working, figure 18 summarizes the benefits.

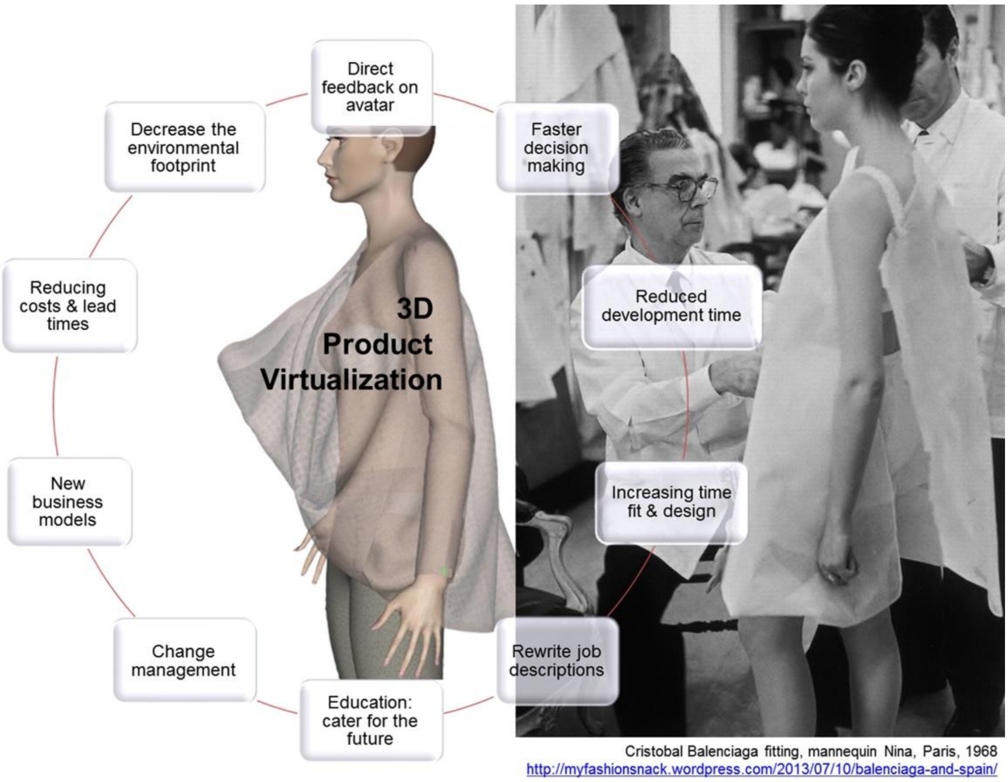

Figure 18 Benefits for the fashion and clothing industry, to obtain with the current virtualization possibilities.

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