1. Understanding Fashion
– The Future of Fashion

3D Printed Fashion: A Dual Approach

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ABSTRACT

Since the inception of 3D Printing in fashion, the innovators and originators of the medium have come from various disciplines of design. Prototyping was the main use for the first 30 years, being most popular in the areas of engineering, architecture, and product design. The 3D software that was used in these industries to visualize the designs lent itself to 3D printing fashion.

Francis Bitonti, Julian Hakes, Richard Beckett & Neri Oxman all designers whose most notable work is in 3D printed fashion design, yet their backgrounds are in Architecture and they used their 3D skills to create fashion pieces. The most notorious fashion designer who has ventured into 3D printing is Iris van Herpen who often collaborates with designers from other disciplines to create and visualize her intricate 3D printed designs.

In this paper, the researchers from two different of the aforementioned disciplines, who both use 3D printers, offer a unique insight into the pros and cons of 3D printing fashion from each perspective.

Keywords: Fashion, 3D Printing, Engineering, Multidisciplinary, Architecture.

INTRODUCTION

In this comparative study, the authors from multi-disciplinary backgrounds offer an insight into their approaches to the area of 3D printing in Fashion. Still, in its infancy, this area has seen a progression from the maker's market who dominated 3D printing, to professionals in other areas such as architecture and engineering who have moved their skills over into the fashion arena where they have demonstrated their flair for wearable 3D printing. Likening this to other areas in design where two or more disciplines are brought together to complete a project, Z. Ren (2011) et al comments on the area of architecture and notes that due to the fragmented knowledge, no single professional has all the knowledge needed to design a complex 'facility', or in this case item/ product.

1. MOVING OVER INTO FASHION: CASE STUDIES

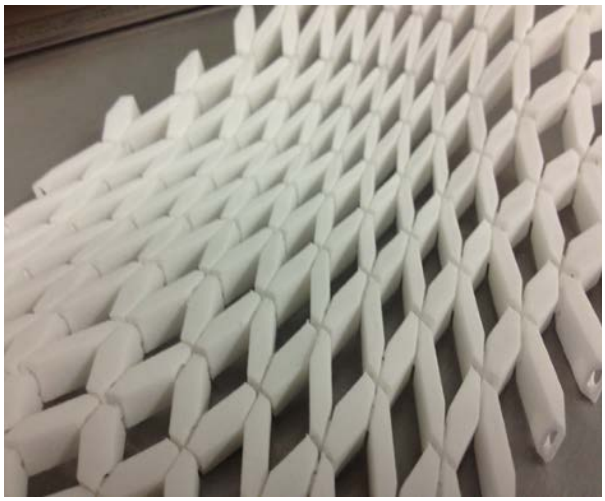
There are certain intrinsic steps in any design process, whether that be in fashion or product and the like, but one thing is constant through all design disciplines and that is the starting point, the concept or brief. How we get to the end of that process could be via a number of paths but it increasingly involves not only more that one person, but more than one discipline.

Through gathering information on 5 of the most notable designers and collaborations operating in the 3D printed fashion industry, we can attempt to establish commonalities within these multidisciplinary approaches.

1.1 FRANCIS BITONTI

An architect turned designer whose most notable 3D printed fashion design was the black dress worn by Dita von Teese made using Selective Laser Sintering and finished with 13,000 Swarovski crystals in a collaboration with Michael Schmidt and Shapeways. Taking over 400 hours to print, the dress was made of 3,000 unique articulated moving components and doesn't rely on a continuous repetitive structure. And unlike a normal dress, that would lie flat, the dress was fully flexible and similar to chain mail.(Wired.co.uk, 2015)

Bitonti's approach isn't admired by everyone and he isn't from a fashion background. He stated "the process between designing the facade of a building isn't dissimilar from building a dress". This statement is questionable unless he has partners from other disciplines to collaborate with, to fill the gaps in the knowledge he may have. To say this is to ignore the body as a canvas and to forget that the body moves, unlike a building that does not. Expertise from the area fashion is needed always to ensure a wearable garment.



www.shapeways.com

1.2 NERI OXMAN

Researcher at the Media Arts and Sciences at the MIT Media Lab and founder of the Mediated Matter research group. Her team conducts research at the intersection of computational design, digital fabrication, materials science and synthetic biology, and applies that knowledge to design across disciplines, media, and scales, from the microscale to the building scale. Her main areas of work and application include architectural design, product design, fashion design, as well as the design of new technologies for digital fabrication and construction.

Oxman fuses science and technology together in her research and practice and coined the term Material Ecology, which considers computation, fabrication, and the material itself as inseparable dimensions of design. In this approach, products and buildings are biologically informed and digitally engineered by, with and for, Nature. This multi-faceted approach allows for many outcomes and considers things from all angles and because of her multiple skills she is a collaboration in herself.

In 2012 Oxman collaborated with Iris Van Herpen for a 3D printed fashion project resulting in the Anthozoa cape and skirt debuting at the Spring 2013 Paris Fashion Week. Iris van Herpen was the first fashion designer to employ 3D printing in her collections and she is known for collaborating with various designers and architects to help her get the results she wants. This collaboration of Oxman's architectural background and skills in structural design together with Van Herpen's knowledge of fashion and the body make for a striking combination.


Neri Oxman Anthozoa Cape & Dress collab with Iris Van Herpen

1.2 RICHARD BECKET

A British designer who was educated in Physiology, Biochemistry, and Architecture and has worked as an architect for many years before setting up his own design practice in 2013 and Lecturing at UCL alongside. Most notably Beckett is known for his work with Pringle of Scotland's Autumn/Winter14 and Spring/SummerS15 collections in both men's and womenswear.

Each of the fabrics was digitally designed and made up of over 1000 individual 3d printed geometries that interweave together to create bespoke three-dimensional materials. These materials were then seamlessly integrated into the collection using traditional knitwear techniques. Each fabric was designed and engineered to exhibit the required movement, behavior and aesthetic in order to work on the body and as part of the seasonal collection.

Becket most recently co-founded Syn.De.Bio (Synthetic Design Biotopes) with Marcos Cruz. The website was set up to disseminate new bio-digital work that is emerging in the crossroad of design, biology, and engineering. (Becket. R 2016) This is another step towards multi-disciplinary working stemming from Becket's own multi-faceted background in science and design.


Pringle Paris A/W 2014

1.3 JULIAN HAKES

Julian Hakes is an architect with an established background, designing buildings and bridges around the world since 2000. In 2006 with one breakthrough moment of experimentation, he designed a shoe (The Mojito) where the idea emerged from the thought that footwear "designs had stopped evolving and had reached a point in their own tradition where they became repeats of things that had been before rather that innovate.

He used an Ultimaker desktop printer machine to prototype the shoe and his shoe designs ever since, simply for its speed and ease and its ability to produce a concept in 3D much quicker than traditional methods. In 2015 video for Ultimaker Hakes talks about his process:

"The key difference starting from and architectural approach it that I started with the foot and the body and the biomechanics of how you walk and how the load comes, then I looked at the material and the process and the design kind of comes from those two things together. I didn't start by wanting to make a twisty shape The way it looks is a result of the process" Ultimaker 2015

Ultimaker 2015

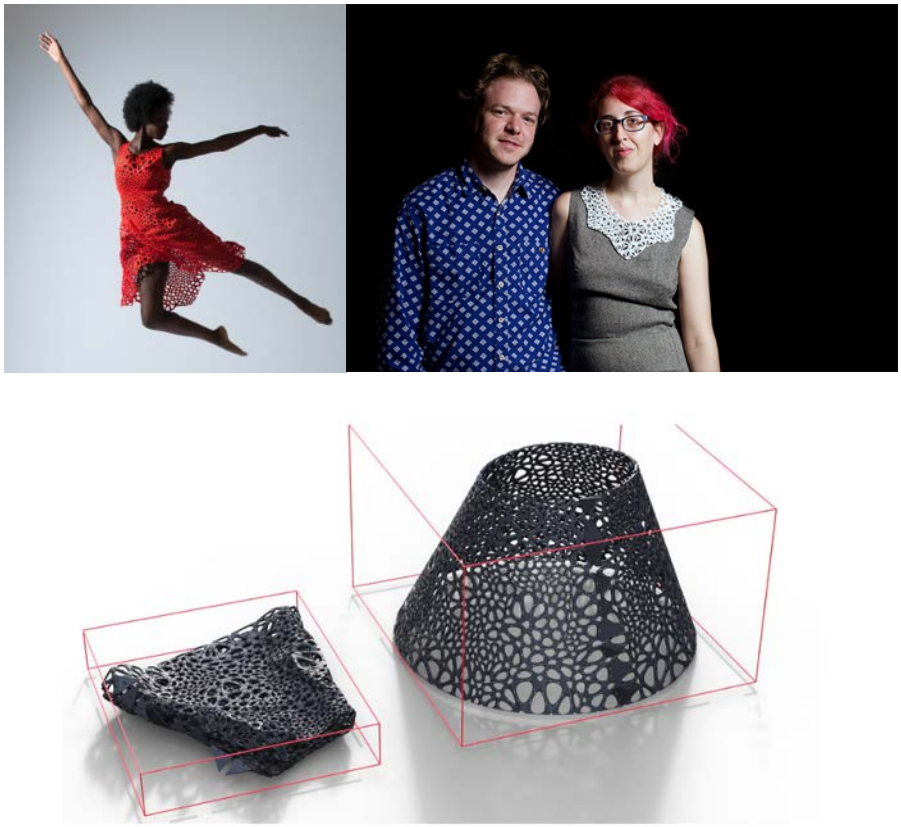
This recognition of a different approach by the designer is key and points out a striking difference from a fashion/ shoe designers approach. More often than not a fashion designer will start with a concept, the shape, the colour the effect they want to achieve and then apply it to the body with the aid of existing blocks. With Hakes process, he first starts with the body and allows that to create the final design itself offering maximum functionality resulting in form following function. Though this is not always the case as many fashion designers with strengths in pattern cutting also start with the body then create the design through cut.

1.5 NERVOUS SYSTEMS

Co-founders, Jessica Rosenkrantz and Jesse Louis-Rosenberg started Nervous Systems the in 2007 after graduating from MIT a few years earlier, Rosenkrantz in architecture and biology and Rosenberg in mathematics.

Their most notable fashion piece to date is the Kinematics dress, which is made up from 100's of hinged pieces which allow the dress to flow in a fabric like manner. Nervous systems said. Bodies are 3D but clothing is traditionally made from a flat material that is cut and painstakingly pieced together. In contrast, Kinematics garments are created in 3D, directly from body scans and require absolutely no assembly. (Nervous System, 2013)

With their unique backgrounds, they are able to work in a very distinctive way. Using their skills from architecture to design the 3D structures element, their knowledge from biology clearly influencing the biomimicry used in many of their designs and finally the mathematical formulas to generate the algorithms that allow the customers customize their own products online via their generative design systems.



Kinematics Dress, Co-founders, Jessica Rosenkrantz and Jesse Louis-Rosenberg, Hinged 3D Print

Greiger .D stated that:
As of now, most 3-D clothing is made with hard plastic or nylon that is meant to mimic actual fabric but is still uncomfortably rigid. For the Kinematics dress, Ms. Rosenkrantz and her co-designer spent a year coming up with its 2,279 triangular panels interconnected by 3,316 hinges, printed as a single piece in nylon. (Greiger.D 2015)

1.6 STUDIO XO

Whilst teaching at the RCA in 2011 Benjamin Males and Nancy Tilbury met and founded Studio XO in London. It brings together fashion and technology to produce wearable technologies and designs, most famously for Lady Gaga and the Black Eyed Peas.

Males studied mechanical engineering at Imperial College, he also had an interest in fashion which ultimately had a more powerful pull. Tilbury studied fashion at the RCA before moving to the research lab of the Dutch technology giant Philips where she pioneered wearable technology. She also worked with the Media Lab at MIT and set up the MA fashion futures program at Kingston University.

Their truly multidisciplinary studio in London is a step ahead of a traditional fashion studio and appears more like a workshop. There are 3D printers and soldering irons but also scissors, paper patterns and rolls of fabric. The pair has around 10 staff who work as hybrid designers, coders, and engineers who share their passion for fusing fashion design and technology together. In an interview with the Guardian Males points out that:

"There has always been this problem with this over-the-wall approach, Scientists solve something and they hand it over the wall to the designers. We want to break down those walls." (Compton. N 2014)

Tilbury said that it is "Design Engineering that happens to be dressed up as fashion!" (AEG 2014). Her unique fusing of areas has generated new terminology that will need to be adopted going forward in the fashion industry and fashion education if we are to keep advancing with this multidisciplinary way of working.

Studio XO Fashion Lab http://www.xoxemotionaltech.com

Nancy Tilbury & Benjamin Males

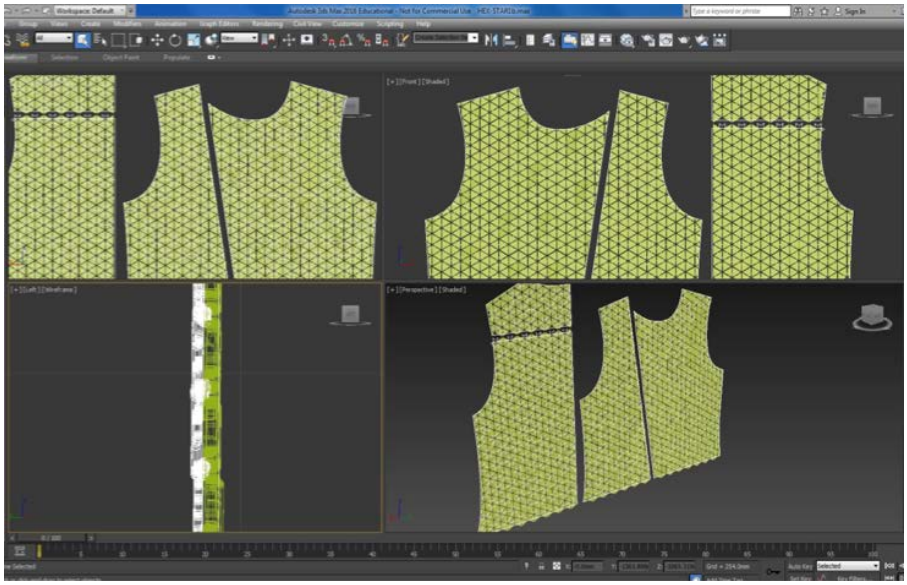
2. THE FASHION DESIGNERS APPROACH

The Fashion designer has 10 years' experience in industry designing and making clothing for retailers and brands mainly in the menswear market. The move into 3D printing in fashion came from a passion for technology and innovation and she has taken up research in this area as a Ma by research.

2.1 STRENGTHS

2.1.1 KNOWLEDGE OF THE BODY & FASHION DESIGN PROCESS

Long term menswear design experience and fitting 100s of garments to different shaped bodies in order to create the best fit, the fashion designer knows where garments need to fit and where they may need more room to allow movement. Applying this to 3D printing fashion means that the designs are adapted using the same tacit knowledge as when pattern cutting. In traditional fashion design, seams and darts are applied to the pattern/ design in order for the garment to fit around the curves of the body. In 3D design, this process is translated into the patterns of the textile structures designed and placed in the right areas to allow the equivalent movement. Links or structures can be made smaller in areas that need more movement and larger in areas that may need less. The image below shows some of the initial development on 3Ds max



Grain. E 3D CAD textile structures for Huddersfield University Pattern Cutting Conference 2016

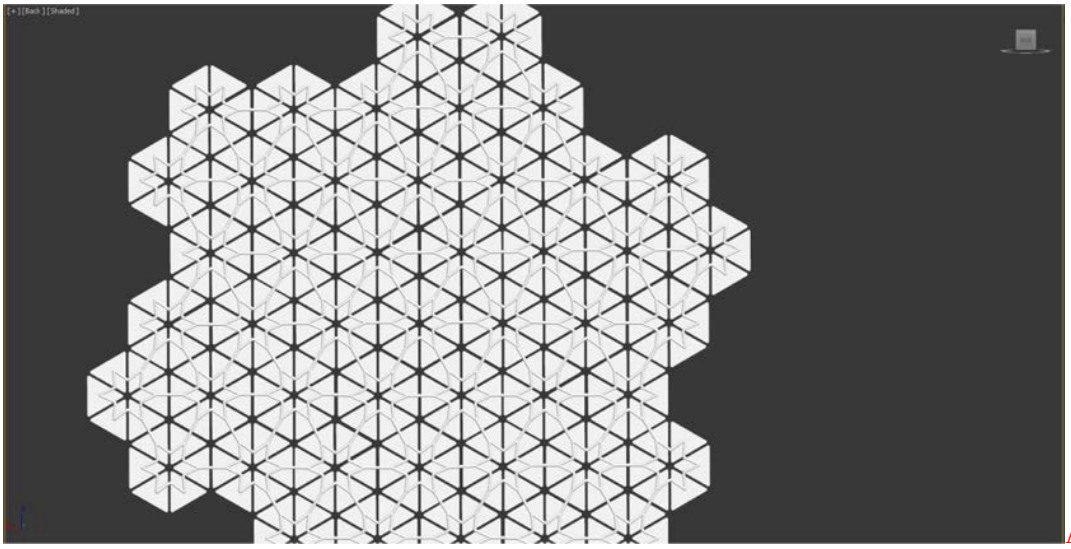
2.1.2 KNOWLEDGE OF TEXTILE STRUCTURES

Having worked with many materials in fashion both knit and woven, the fashion designer knows whether a particular design needs a stretch fabric or a woven/structured fabric and can alter the design according to this. Although the materials and structures in 3D printing are not the same as in fashion, the fashion designer knows that an equivalent textile structure needs to be designed in order for it to work on the body. A traditional knit or woven structure cannot be mimicked in 3D printing materials as it will not react the same, but new structures need to be designed to enable similar properties.

2.2 WEAKNESSES

2.2.1 3D CAD (3dsMAX)

As well as designing the 3D garment/textile the researcher had to learn how to use the software in which the garment was designed. Coming from a menswear background the researcher designed using Adobe illustrator a CAD program use in fashion to draw up flat designs to send them off to the factory to have them made up by the manufacturer. This, however, was not an easy transition and somewhat of an obstacle, which alongside the research itself the 3D software had to be mastered to a point where sufficient designs could be drawn up.
3ds Max was used to draw up the 3D designed textile structures and although there were some similarities in the functionality of the program, the commands were ultimately different and it felt like learning a new language.

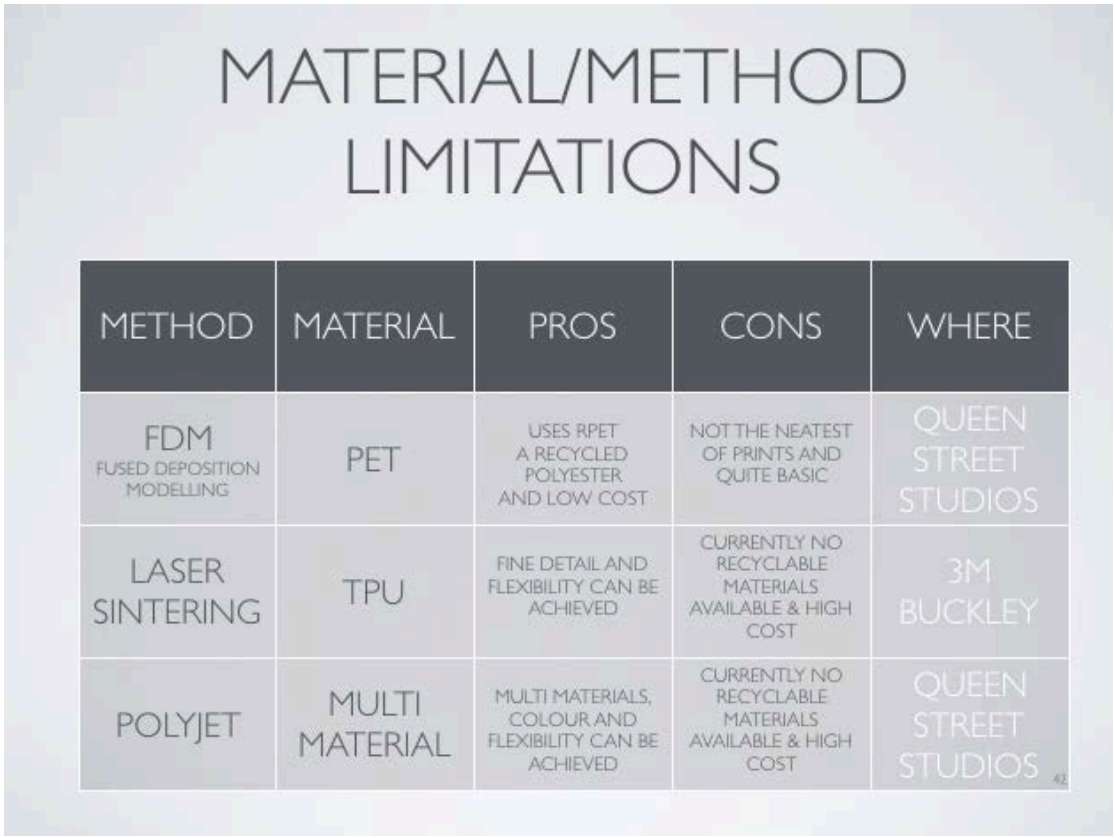


ADD

Skinspiration 3D Textile CAD design Grain. E 2016

2.2.2 MATERIAL KNOWLEDGE

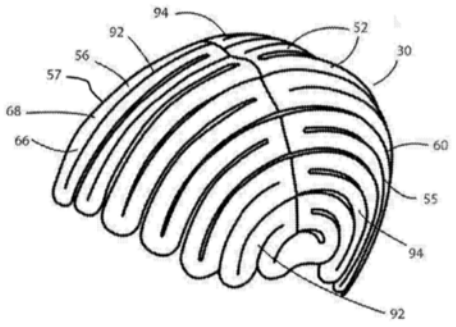
There is no prerequisite of how the 3D printing materials they are designing with move or react as it would be in traditional fashion. The 3D printing materials are new and this knowledge must be built by testing alongside designing in 3D, only then can the designs work to their greatest efficiency, otherwise it is designing blind. Not knowing how a material reacts to movement or certain shapes and structures is a design faux pas as it would most likely result in an unsuccessful print. In this research an initial in-depth evaluation of materials and manufacturing method was undertaken. In the below image, FDM, laser sintering and polyject 3D printing manufacturing methods were evaluated



Research into Material & manufacturing pros and cons Grain.E 2016

3. THE ENGINEER/PRODUCT DESIGNER'S APPROACH

The Product designer has been using 3D studio max since 1994, AutoCAD drawings since 1989 and Solid works since 1996 so has an abundance of knowledge in 3D CAD systems. He has used 3D printing in both teaching and research for a number of years and has invented new patented products with 3D printing being the process of manufacture. Below is a cooling cap made from a 3D printed mold, molds are another way product designers use 3D printing to create products.



Dr. Unver. E & Paxman Coolers (2016). Heat exchanger: Scalp Cooling Cap

2.1 STRENGTHS

The 3D printing and 3D CAD skills are the greatest assets when it comes to working towards a 3D printed design project as a Product designer. Knowing how to create any structure on 3ds Max is such an advantage and working together with a fashion designer this partnership can be strong to create structure both suitable for the body and realistic to 3D print. The knowledge of the 3D printing materials and their properties and the machinery in which to print it with is invaluable and together with the ideas of what structure to create from the fashion designer, the product designer can suggest the right setting on the printer and the appropriate materials in which to make it.

The majority of the time the product designer used for design evaluation and model making and checking the design fit and function. Seen in the graphic below plastic and metal 3D printing has been used for a number of projects and potential applications for design and manufacturing has been investigated and applied.

Type	Technologies	Materials
Extrusion	Fused deposition modeling (FDM)	Thermoplastics (e.g. PLA, ABS),HDPE , eutectic metals, edible materials
Granular (Powder based)	Direct metal laser sintering (DMLS)	Almost any metal alloy
	Electron beam melting (EBM)	Titanium alloys
	Selective heat sintering (SHS)	Thermoplastic powder
	Selective laser sintering (SLS)	Thermoplastics, metal powders, ceramic powders
	Powder bed and inkjet head 3d printing, Plaster-based 3D printing (PP)	Plaster
Light polymerised	Stereolithography (SLA) or Digital Light Processing (DLP)	photopolymer
Laminated	Laminated object manufacturing (LOM)	Paper, metal foil, plastic film
Wire	Electron Beam Freeform Fabrication	Almost any metal alloy

Unver, Ertu Dr (2013) 3D Printing Process Chart

2.2 WEAKNESSES

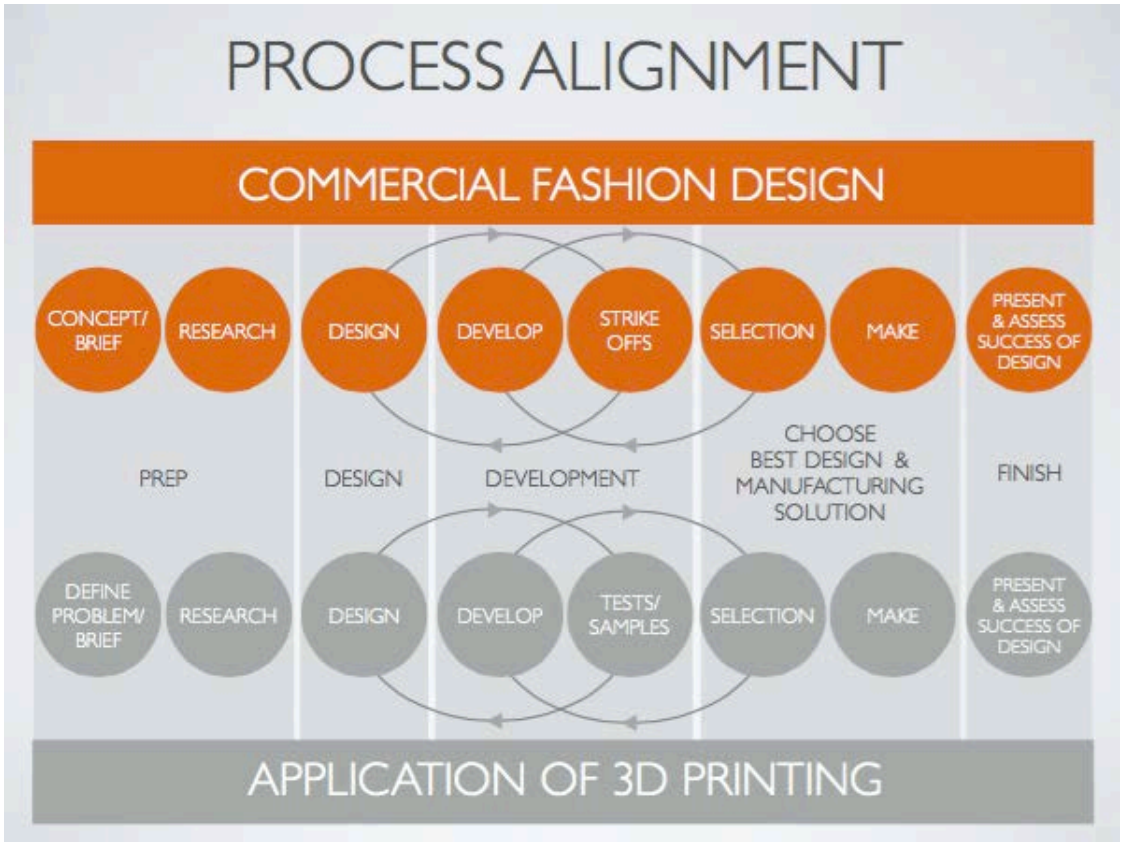
Directly opposite to the Fashion designer, the Product designer has no or little fashion knowledge in terms of design and what may fit etc., however, they have designed things in the past that fit the body such as caps but may not have necessarily designed products that need movement like clothing does. Also knowing what suits a person fashion wise and what details may work to be aesthetically pleasing isn't key when designing product.

3. THE COMPARISON

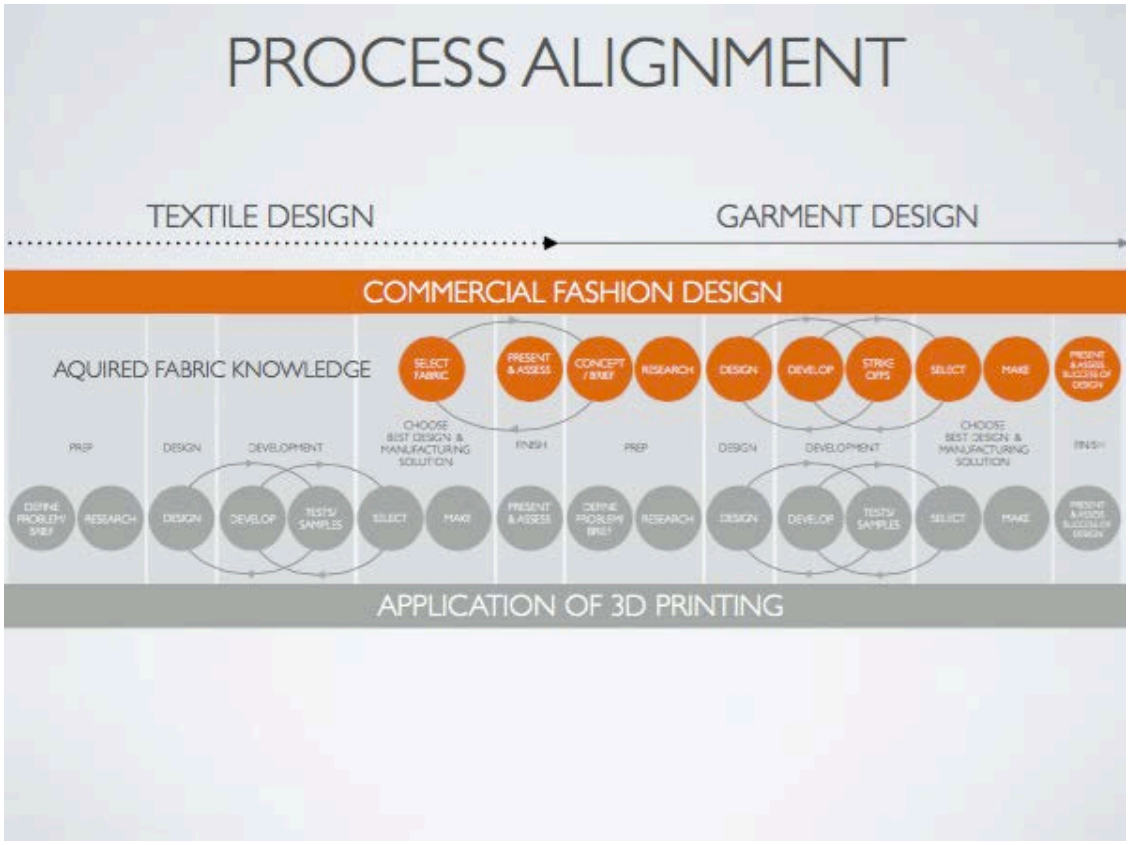
The two diagrams represent the process alignment between commercial fashion design and fashion design when using a 3D printer. The first diagram is what was planned to take place and drawn up before any of the 3D work had started, then the second diagram is what actually took place.

The difference is huge due to the fact that with traditional fashion design, the designer would know the materials they were working with and how to design for those materials but did not have to first design the textile material itself. With the actual process, because of its infancy, not enough pre-existing 3D printing textiles exist to design from, therefore the project started at the point of textile design and not of garment design as it would traditionally.

More research and innovation in this area over the next few years will increase the availability of pre-existing textiles to print out into the shapes of wearable designs, but until then the researchers must start from scratch and design new structures for the materials we have to work within this area and work with their properties and constraints as this is not fabric anymore.



Original process alignment proposal. Grain.E 2016



Amended process alignment proposal. Grain.E 2016

3.CONCLUSIONS & FURTHER STUDIES

To generate and encourage more cross-disciplinary work and research to create more, creative outcomes and solutions to briefs.

To work towards a hybrid workspace, a fashion workshop/ fashion lab much like Studio XO has where they split off the work area into 4. A traditional pattern cutting and sewing machines area, a coding and programming, area, a CAD and 3D printing area and finally a workshop with tools to allow designers to mix hard and soft materials together with ease in the same space as the traditional methods. This kind of space will work hand in hand with cross-disciplinary working and collaborations between 2 or more sectors. A final suggestion would be to add a science lab type area with a view to developing biomaterials which are gaining popularity from both an innovation and sustainability perspective.

The strengths and weaknesses of both the designers are directly matched to compliment each other in such a project. The need for multidisciplinary work is a necessity because of the different skills needed to complete the task. Although both approached require technical ability in each area, Product designs main objective a marketable product is function and Fashion designs main objective is form and combining both where form and function is key it is.

The designers will eventually evolve to integrate more technical skills into the design process, because of the quicker design ideation of 3D design the creativity will be dramatically increased and there will be less need for collaboration as there will be hybrid designers.

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