RAE2026

Creation of 3D Printed Fashion Prototype with Multi-Coloured Texture: A Practice-Based Approach

Prof. Sau-Chuen Joe AU

UoA38

11.2025

Contents

Title: Creation of 3D Printed Fashion Prototype with Multi-Coloured Texture: A Practice-Based Approach

Descriptor

This study was funded by ITF-HKRITA (ZRAR, HK$2,591,734; Project Co-Investigator) and conducted from December 2018 to June 2021. To date, few structured theoretical design process models have been specifically developed for creating 3D-printed fashion garments with multi-coloured surface textures. The selection of 3D printing materials and printing methods for producing such textures, as well as the consideration of ergonomic factors in the development of 3D-printed garments, remain underexplored.

In this research, adopting a practice-based research methodology, an extensive literature review was conducted on (i) relevant design process models, (ii) the latest 3D printing technologies and 3D-printed products featuring coloured or textured surfaces, (iii) colouring methods for 3D objects, and (iv) ergonomic factors to be considered in designing 3D-printed fashion garments. Based on this review, a distinctive design process model for 3D-printed fashion garments was developed, and a prototype featuring a multi-coloured surface texture was produced. The research outcomes were disseminated through a refereed journal publication and a seminar presentation.

The findings contribute both theoretically and practically to the fields of high fashion, education, and research related to 3D-printed fashion products with multi-coloured surface textures. The design process model developed in this study provides a structural framework to assist designers, engineers, and design students in addressing related design challenges. Furthermore, the ergonomic solutions proposed in this research can help improve body movement and comfort when wearing 3D-printed garments. Since the size specifications of 3D models can be easily modified in CAD to achieve a precise custom fit, fashion and textile designers are encouraged to adopt 3D printing technologies with multi-coloured surface textures as a new creative design tool.

Personal Profile: Prof. Sau-Chuen Joe AU

Associate Professor Joe Au's research focuses on developing fashion design process models for 3D digital printing and exploring their practical applications in various fashion products. He has a particular interest in multi-colour 3D surface printing and the challenges of achieving colour fidelity in 3D printing technologies. As both a researcher and practitioner, he adopts a practice-based research methodology to address design problems.

Joe serves as the Co-Investigator of two ITF-HKRITA projects: "Stretchable 3D Printing Looping Stitches" (ZRAR) and "Cellulosic 3D Printing Flexible Material for Apparel" (ZR2L). He led the development of the methodology, application, and dissemination work for creating 3D-printed fashion prototypes with multi-coloured textures and directed the study on colour fidelity in multi-colour 3D printing for fashion and textile design .

Before joining PolyU, Joe was trained as a haute couture designer at F.I.T.,in New York, earned his MDes from UNSW, and obtained his PhD from PolyU. He is a tenured research faculty member and has received the Gold Award at the Special Edition 2022 Inventions Geneva Evaluation Days in 2022 (Appendix I) and the Red Dot Design Award (Design Concept category) in 2024 (Appendix II).

Research Questions

The research aims to investigate the following questions:

1. What is the distinctive design process model that can describe the development of 3D-printed fashion garments with multi-coloured surface textures?
2. As most 3D-printed objects are monochromatic, what 3D printing materials and technologies are most suitable for producing fashion garments with multi-coloured surface textures?
3. To improve garment fit in 3D-printed fashion garments, what ergonomic factors should be considered in the development of garments with multi-coloured surface textures?

Research Outputs

The multi-component outputs comprise the following:

1. A distinctive theoretical design process model for 3D-printed fashion garments with multi-coloured textures was formulated.
2. A 3D-printed fashion prototype with a multi-coloured texture was created based on the developed theoretical design process model.
3. A refereed journal paper, titled “Creation of 3D Printed Fashion Prototype with Multi-Coloured Texture: A Practice-Based Approach”, was published in December 2020.
4. A seminar presentation, titled “Innovative Fashion: Creation Process of a 3D Multi-Coloured Printed Fashion Prototype with PolyJet Technology”, was delivered at the University Research Facility in 3D Printing Open Day Seminar, PolyU, in August 2021.

Research Field & Key References

Background of 3D Printing Technology

- 3D printing technologies have enhanced design and manufacturing processes across industries by streamlining various operations. These include replacing traditional assembly-line production with single-step processes to minimize complex manufacturing stages, digitalising designs to eliminate the need for converting information into physical materials, and customizing products of different types and sizes to reduce additional costs and labour requirements [1].

- In particular, 3D printing has revolutionized the design process. Traditionally, design and manufacturing were clearly separated stages; however, with the advent of 3D printing, designers are now directly involved in determining how to transform two-dimensional concepts (through computer-aided design (CAD) and computer-aided manufacturing (CAM) processes) into 3D objects and real products [2].

- Recently, in the fashion and textile industries, 3D printing has emerged as a creative tool for producing fabrics as well as fashion lifestyle products and accessories. This practice-based research study applied 3D printing theories and technologies to develop an innovative fashion prototype based on a newly formulated theoretical design process model specifically designed for 3D-printed fashion garments with multi-coloured textures. The technologies and their applications were thoroughly examined to identify and evaluate suitable methods for creating fashion garments featuring innovative multi-coloured surface textures.

Research Field & Key References

3D Printing Technology

- 3D printing is an additive manufacturing technique used to create solid objects. During the manufacturing process, materials are successively deposited layer by layer, with the final product comprising multiple cross-sectional layers [1].
- The process begins with a 3D digital model generated on a computer using various 3D design software programs, collectively referred to as CAD. A software program then slices the model into layers and converts them into a file format readable by a 3D printer. Subsequently, the printer deposits materials layer by layer to form the physical 3D object.
- 3D virtual objects are created through a combination of 3D modelling, texturing, and rendering in CAD design. In the 3D modelling process, polygon meshes and polygons are assembled to form shapes. Texture mapping is used to apply surface textures to 3D virtual objects, which may include images or hand-painted designs. During the rendering process, the texture meshes are unwrapped into a flat image, and the texture is projected onto the 3D model [3, 4].
- The PolyJet 3D printer was selected in this study because it can:

  - create high-resolution and smooth surface colour 3D printing with translucent materials [5, 6].
  - mix rigid and flexible materials simultaneously to produce a 3D printed product.
  - print pixels with different materials, and materials can be combined or blended to obtain a product with a specific colour or flex gradient [5, 7].

Research Field & Key References

Various 3D Printing Methods

3D printing methods	Typical techniques	Materials form	Mechanism	Description
Photo-polymerization	Stereolithography	Liquid (photosensitiv e polymer)	Light or radiation Solidification	Photopolymers are exposed to radiation or light to trigger a chemical reaction, which then cures liquid materials to form the required solid product.
Extrusion deposition	Fused deposition modelling	Liquid (melted thermoplastic)	Cooling Melting and solidification	The materials used are melted thermoplastics and the thermoplastic material is hardened to form layers.
Material jetting	Multi-jet modelling, PolyJet Drop-on-demand, Nano-particle Jetting	Liquid (liquid photopolymer)	Cooling or chemical changes Solidification	Layers with specific patterns are formed by a liquid photopolymer that undergoes cooling or chemical changes. The printing process requires a supporting material.
Granular materials binding	Selective laser sintering, Selective heat sintering, Selective laser melting, Electron beam melting, Multi-jet fusion	Powder	Laser or other energy sources Fusing and solidification	The powdered materials are energized and melted, and they coalesce or fuse and consequently harden to form a solid.
Binder jetting	3D Printing	Powder	Liquid binder Fusing and solidification	Droplets of the liquid binder, which acts as glue, are deposited on the powder for fusing the powder together to form the final object.
Directed energy deposition	Laser metal deposition, Laser engineered net shaping, Electron beam melting	Powder (metal)	Laser or other energy sources Fusing and solidification	Thermal energy is used to melt powder materials and fuse them together.
Sheet lamination	Laminated object manufacturing	Paper or plastic sheets	CO_2 laser for selective cutting and bonding	Paper or plastic sheets are originally bonded together with glue or a binder. The adhesive density is high in the main object part, whereas unwanted materials are selectively removed according to the density level.
3D printing pen	None	Liquid (melted plastic)	Cooling	The pen releases melted plastic materials from its heated tip, and the released materials cool immediately to assume the desired shape or angle.

Research Field & Key References

Current 3D Printed Fashion Products with Coloured or Texturized Surfaces

Products	Author	Picture	Description
Black Drape Dress	Jiri Evenhuis and Janne Kyttänen		It is regarded as the first wearable piece created by industrial engineers. The technology used was SLS technology, in which fine powder is melted and used to form 3D shapes with the aid of lasers.
N12 Bikini	Jenna Fizel and Mary Haung		The N12 bikini was the world's first 3D printed ready-to-wear, and it was formed layer wise using solid nylon through the SLS printing process.
Stained Glass Corset	Michaella Janse van Vuure		It is combined with rigid and flexible materials, which comprised three types of digital materials with transparent and coloured panels.
Dita's Gown	Michael Schmidt and Francis Bitonti		The dress comprised over 3,000 articulated movable parts for linkage and over 12,000 Swarovski crystals for decoration. It is regarded as the first fully articulated 3D printed dress.

Research Field & Key References

Current 3D Printed Fashion Products with Coloured or Texturized Surfaces

Products	Author	Picture	Description
Three-dimensional printed swimwear	Zhang Hongyu		The swimwear was printed using silicon polymer, and therefore, it was soft and thin.
Hard copy	Noa Raviv		The 3D printed parts were built on textile fabrics and created confusing illusions, making it difficult to distinguish between the 3D printed objects and the textile garment's shell.
3D printed collection	Iris van Herpen		Iris van Herpen brought 3D printing technologies to the fashion runway in 2010. She was the first fashion designer to use 3D printing technologies on the runway.
Wearable skins	Ner Oxman		Multiple materials of different densities and plastic materials were used. The garments of the collection varied in opacity, colour, and materials.

Research Field & Key References

Need for a theoretical design process model for 3D printed fashion garments with multi-coloured textures and the corresponding practical application

- It has been observed that no specific theoretical design process model has been developed for 3D printed fashion garments with multi-coloured textures.
- Due to the limitations of 3D printers, 3D modelling methods, and available 3D printing materials in the market, the coloured texture mapping used in 3D printing methods on fashion products has not been fully explored. The current 3D printed products are either monochromatic or short of multi-coloured surface textures, which do not fully meet customers' expectations.
- The ergonomic aspect of current 3D printed fashion garments, which increases the comfort of the wearable 3D printed garments, has not been fully investigated. A new set of garment ease allowances and a specific joint and interlock design for joining various garment panels together were developed to address the aforementioned shortcomings of the current 3D printed fashion garments.

Research Methods, Prototypes & Materials

Methodology

- A practice-based methodology was adopted in this study, and the main focus was the design practice. The practice-based research was an original investigation that could generate new knowledge in terms of practice, and together with new concepts and methods [8].

(a) Development of a theoretical design process model for 3D printed fashion with multi-coloured surface texture

- A design process involves creative activity and the process of finding specific problems and their best solutions [9, 10]. The aim of designing is to simplify a complicated concept or object, and hence, a systematic design approach is required [11].

- According to the literature [12, 13] on the design process models in the fields of fashion and textile design, the theoretical design process model for 3D digital printed fashion was proposed based on the concept of 'analysis – synthesis – evaluation', with three main stages. The analysis stage involved defining and considering the problem process and setting the objectives; synthesis involved a feasible solution generation process; and evaluation involved the critical assessment of the solutions. The proposed design process model is summarized in Figure 1, with further elaboration on the development of 3D fashion prototypes presented.

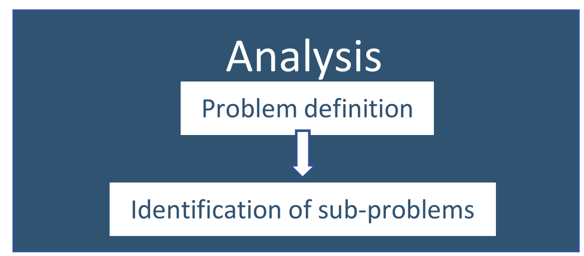
Research Methods, Prototypes & Materials

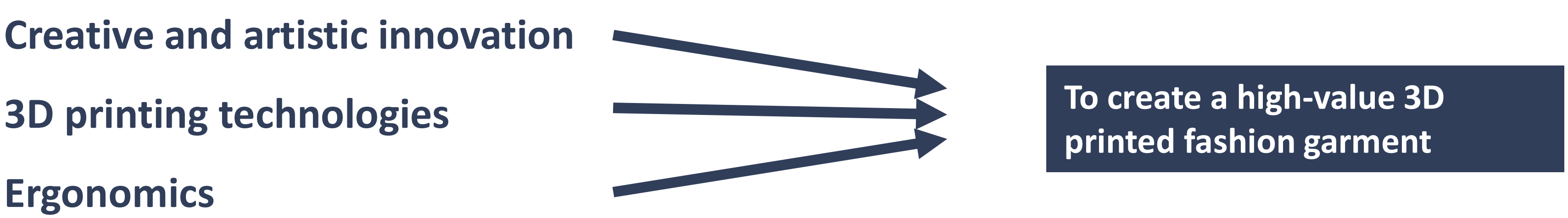
(i) Analysis Stage

- ***Problem definition***. The first step was to identify the specific design problem. In the definition process, objectives were established, and feasible resources and design boundaries were reviewed [14]. **In this study, the research aim was to create a 3D printed fashion prototype with multi-coloured texture, and the objective was to combine artistic innovation, ergonomics, and 3D printing technologies to create a 3D printed fashion prototype that was appropriate for wearing in terms of fitting and ergonomics.**

- ***Identification of sub-problems***. A review of recent colour 3D printed products in various markets, including the product design, fashion design, and textile design, **showed that the sub-problems involved 3D printing technologies, materials that could be used in fashion garments, and multi-coloured 3D printing methods appropriate for producing the texturized 3D printed garment**.

- Specific design problems were identified in this stage. In the current study, the research objective was to:





Research Methods, Prototypes & Materials

(ii) Synthesis Stage

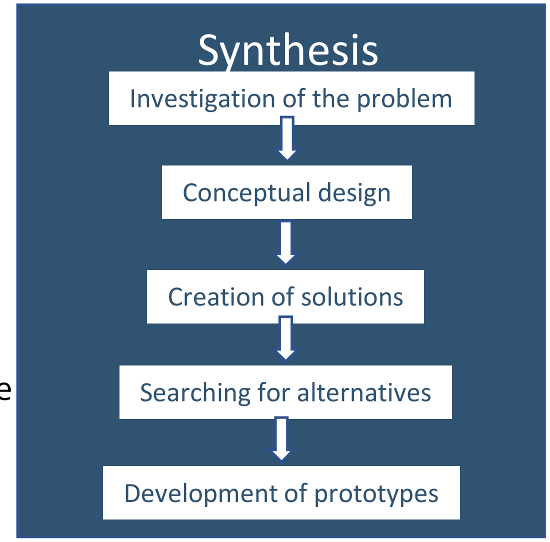
- ***Investigation of problems***. The problems were investigated before conceptual solutions were generated through a literature review, which helped to identify the design needs. Evaluation of the information in the objectives, design constraints, and design criteria was required, and a feedback loop connection was established between the generation and evaluation processes [15].

- ***Conceptual design***. By investigating the design problem, preliminary ideas were generated. **The main factors, on which ideas were generated, include (i) types of 3D printers, (ii) 3D printing materials, (iii) texture patterns, (iv) colour printed texture, and (v) ergonomics.** In this stage, designers were required to use their imagination for idea generation for improvements [16].

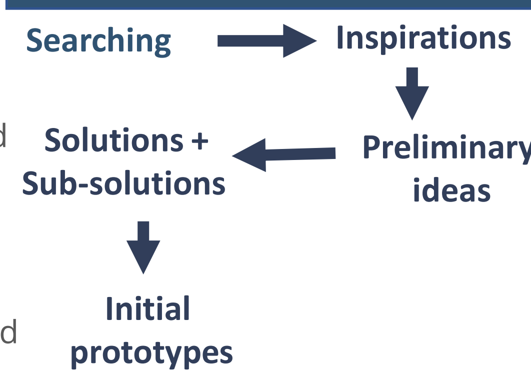
- ***Determination of solutions***. The solutions were abstract, and they did not describe details and small activities involved in obtaining solutions [17]. In this study, **solutions were proposed based on (i) PolyJet 3D printers, (ii) 3D printing materials of rigid resins, (iii) different types of texture patterns created by software 3ds max, (iv) colour printed texture, and (v) ergonomics, including the placement of style lines and the addition of ease allowances to the garment.**

- ***Searching for alternatives***. The fashion prototype should be visually appealing, and the alternative design sub-solutions could be generated **by considering aesthetic requirements regarding the printing materials, texture patterns, colouring methods, and placements of style lines.**

- ***Development of prototypes***. Feedback on the conceptual design stage was reviewed to create various initial prototypes, and after experimental sampling, the final solution was decided.



Initial prototypes were developed with experimental sampling to arrive at final solutions.



Research Methods, Prototypes & Materials

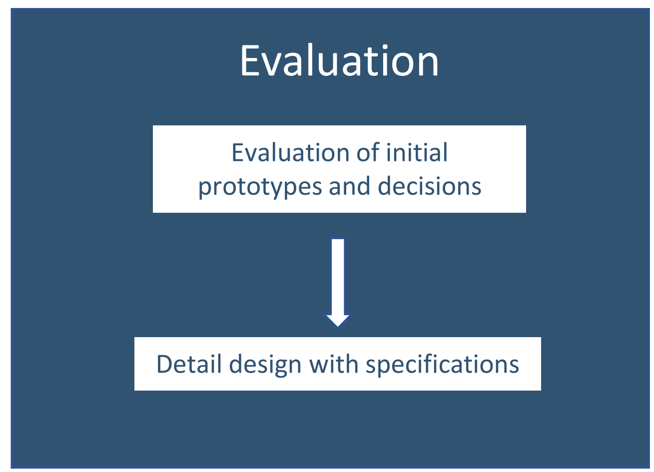
(iii) Evaluation Stage

- ***Evaluation of initial prototypes and decisions*. The initial prototypes were evaluated according to the aesthetic and technological characteristics of the 3D printing materials, colour, texture performance, and comfort that could be applied to fashion garments.** A feedback loop was established between the synthesis stage and evaluation stage for designers to redesign and improve an unsatisfactory design.

- ***Detailed design with specifications***. The final stage provided the detailed design with specifications for the final prototype. **The materials, printing method, colour, and texture of the pattern were identified with the integration of ergonomics.** All illustrations and specification documents were produced.

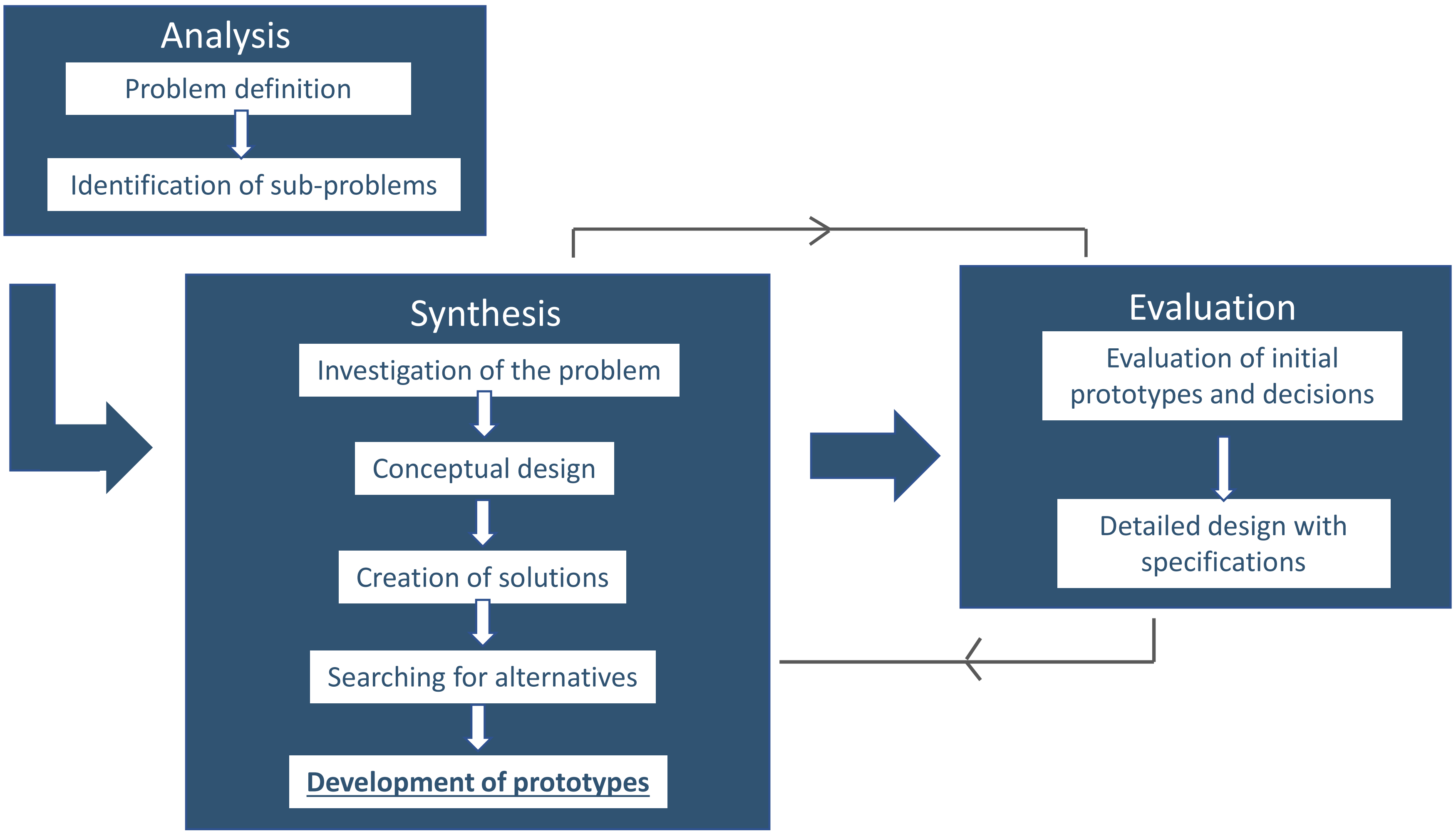
The final stage provides the detailed design with specifications for the final prototype.

- Materials
- 3D printing method
- Colour
- Texture of the pattern



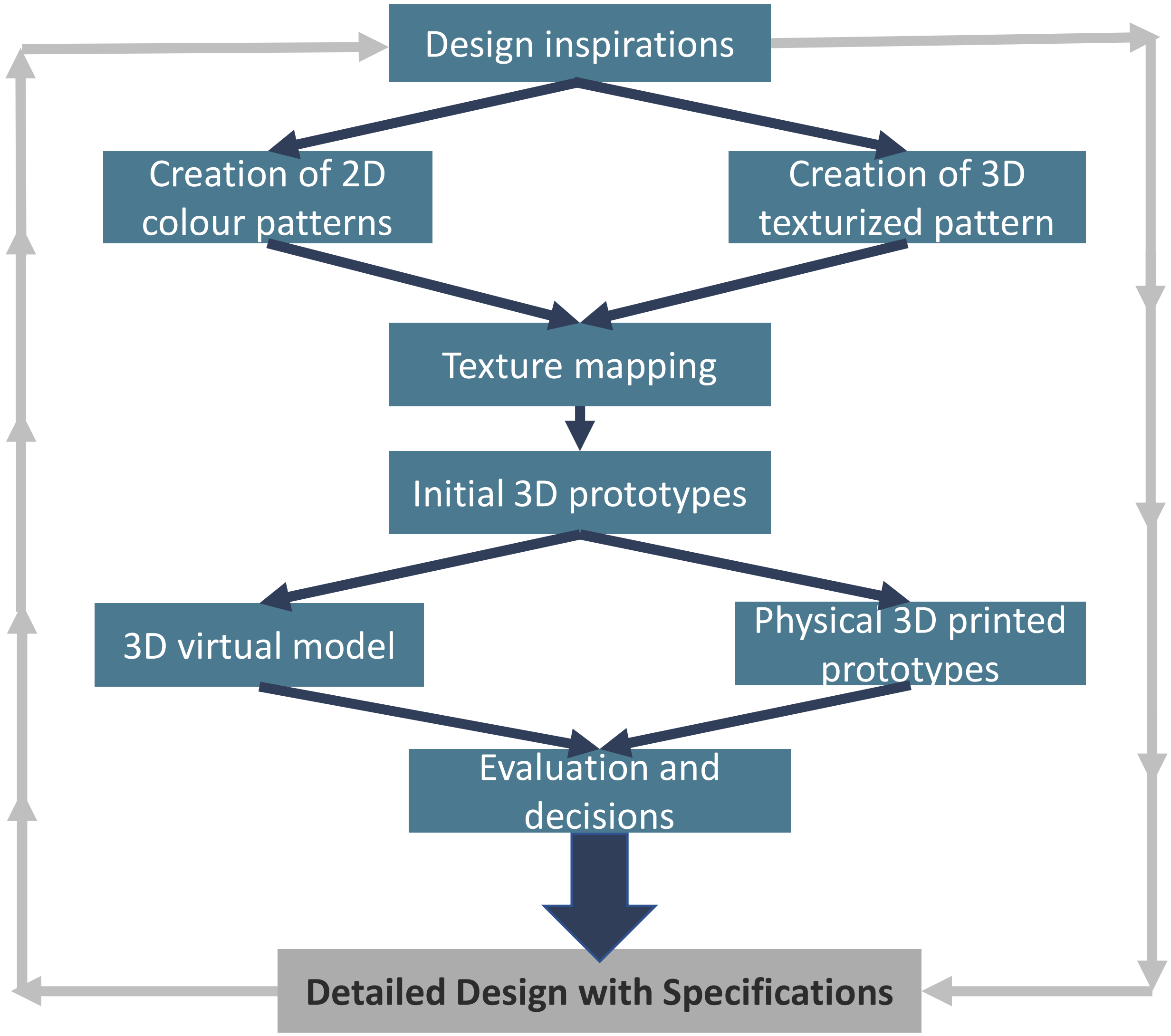
Research Methods, Prototypes & Materials

Figure 1. A theoretical design process model for 3D printed fashion with multi-coloured surface texture.



Research Methods, Prototypes & Materials

Development of 3D fashion prototypes.



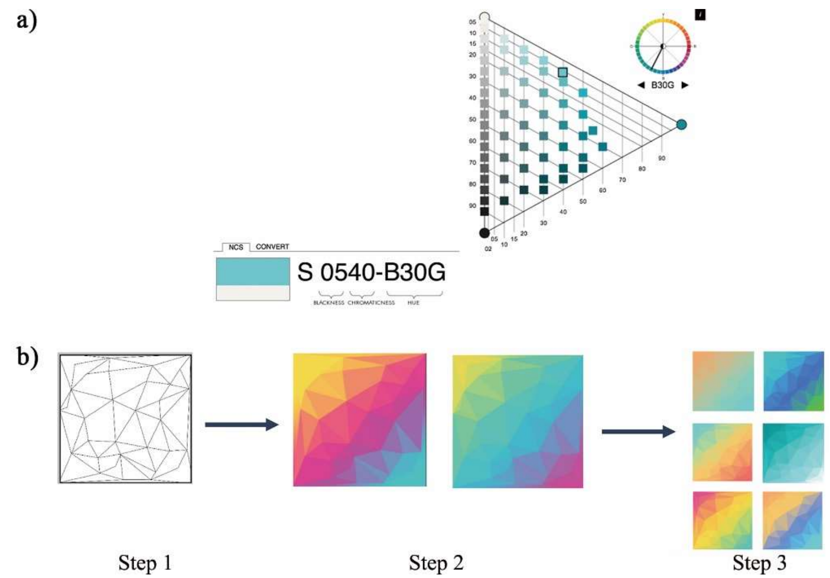
Research Methods, Prototypes & Materials

Development of 3D Fashion Prototypes

(a) Creation of 2D Colour Patterns

- To ensure colour harmony, colour patterns were developed based on six colour schemes: monochromatic, analogous, complementary, split complementary, triadic, and tetradic. Among these, blue and blue-green colour groups are the most preferred across different cultures [18].
- First, the primary colour was selected from the blue-green range of the Natural Colour System (NCS) colour wheel. A soft cyan tone (S0540-B30G; hex code #74d1d7) was chosen because it could be accurately reproduced using CMYK colourants (Figure 2a).
- Next, a series of colour groups corresponding to the six colour schemes and their respective hex codes were created. The selected colours were printed using CMYK colourants. Patterns were drawn on a segmented square and filled with colours according to the defined colour variation groups using Adobe Photoshop CS6 (Figure 2b). In this process, the colour sequence was the only variable, while the pattern segmentation, gradient direction, and texture of the 3D virtual object were kept constant.

Figure 2.
(a) The primary colour selected in NCS colour wheel;
(b) Colour pattern creation process: Step 1: segmenting the square; Step 2: filling in with colours; Step 3: creating colour variations.



Research Methods, Prototypes & Materials

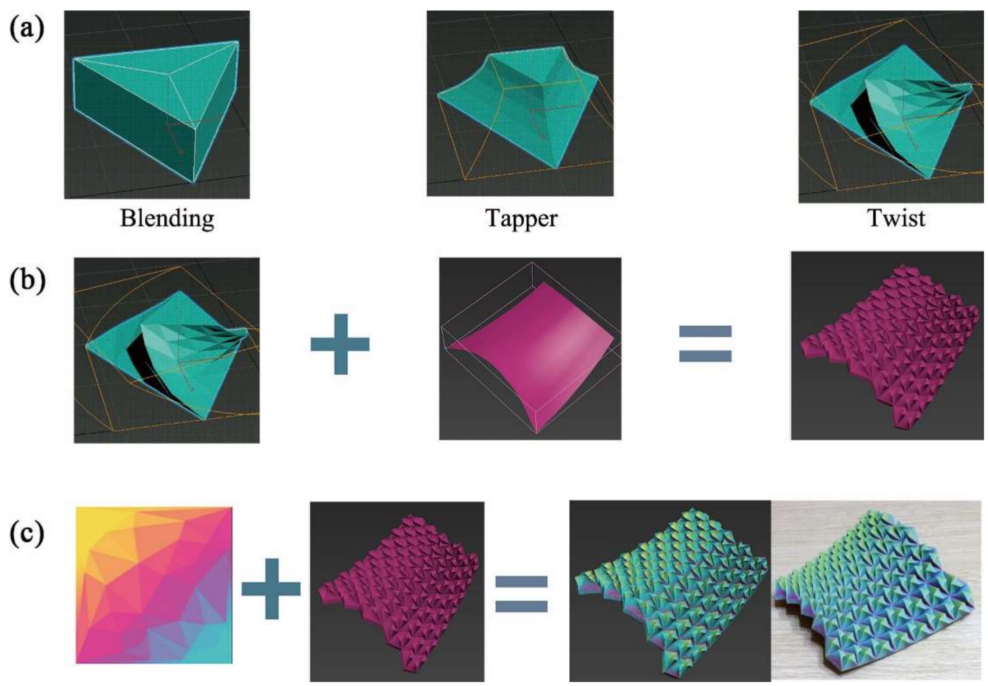
(b) Creation of 3D Texturized Patterns

- The 3D virtual modelling process was performed in 3ds Max with a Para 3D plugin. A basic 3D object was created through polygonal modelling, with three modifiers (blending, tapper and twist) involved in the process (Figure 3a).
- The basic 3D object was then calculated automatically by the Para 3D plugin and laid out on a curved plane (Figure 3b).

(c) Colour Texture Mapping on Meshes

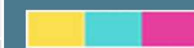
- After creating the 3D virtual design, colour patterns were texture-mapped (projecting colour patterns onto the 3D object) (Figure 3c).
- Based on the six colour schemes, colour pattern variations with different sequences developed in Photoshop CS6 and various textures were wrapped onto the 3D virtual object.

Figure 3.
(a) Basic 3D object creation process, Step 1: modelling the basic object by blending modifier; Step 2: using tapper modifier to create the desired shape; Step 3: a final basic object was created by twist modifier;
(b) The basic object laid out on a curved plane;
(c) Texture mapping (projecting colour patterns) onto the meshes and the 3D printed physical prototypes.



Research Methods, Prototypes & Materials

(d) 3D Printing Materials

	Colours involved	Colour Pattern	3D Printing information	Colours involved	Colour Pattern	3D Printing information
			Printer: Zprinter310 Method: 3DP Materials: Plaster			Printer: ObJet J750 Method: PolyJet Materials: Resin
Plaster Prototype Outcomes				Resin Prototype Outcomes		

	Plaster	Resin
Weight (g)	49.95	31.57
Tensile strength (MPa)	14.2	50-65
Elongation at break (%)	0.23	10-25
Flexural strength (MPa)	31.1	60-110
Flexural modulus (MPa)	7163	1900-3200

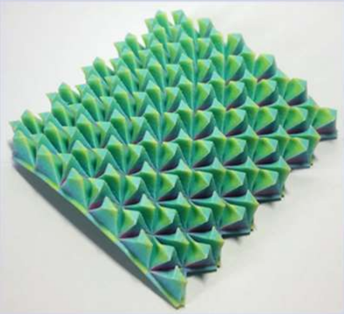
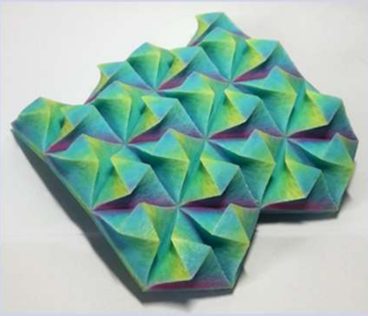
Research Methods, Prototypes & Materials

(d) 3D Printing Materials

	Plaster	Resin
Colour performance	Excellent but some vision deviation due to light reflection on rough surfaces.	Excellent. Colour patterns were shown in detail.
Sensation of touch	Rough surface and may cause itchy when in touch.	Smooth surface texture.
Rigidity and flexibility	Stiff but brittle.	Rigid with low flexibility.
Weight	Heavy.	Heavy but lighter than plaster.
Summary	**The properties and performance of the resin prototype were found to be considerably better than those of the plaster one. Thus, resin was selected as the 3D printing material for further development in this study.**	

Research Methods, Prototypes & Materials

(e) Pattern Density Design

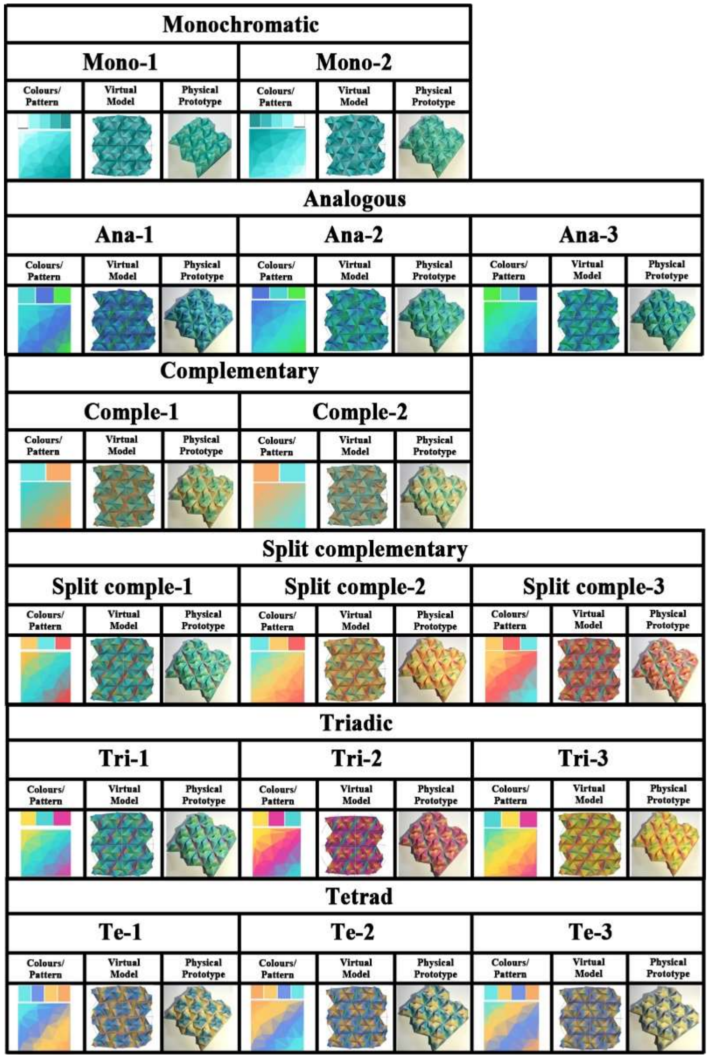
	High pattern density prototype	Low pattern density prototype
Side length (cm)/ arrangement of triangle pattern	0.9/ 10 x 12	2/ 4 x 6
Weight of 3D object (g)	21.86 (lower, but more supporting materials were consumed)	31.68 (higher, fewer supporting materials were consumed)
Weight of supporting materials (g)	62.31	45.95
Rendering time in 3ds max (s)	13 (longer time for rendering because of high-density meshes)	5 (shorter time for rendering)
Colour performance	Better with an interesting chameleon effect. The resolution of the mapped-mesh pattern texture was higher 	Good with sharp colour performance 
Summary	**It has not been recommended to use high pattern density for creating 3D printed garments.**	

Research Methods, Prototypes & Materials

(f) Physical 3D Printed Prototypes

- After creating the initial 3D virtual design with texture pattern mapping, the required files were exported using 3ds Max.
- The 3D printer software received the files and processed the slicing of the 3D object. The software then sent instructions to the 3D printer to control and process the 3D printing.
- Stratasys J750 PolyJet printers were available for multicolour printing, and the files used the texture mapping colouring method during the 3D modelling process.
- In total, 16 physical prototypes with a size of 7.5 × 7 × 2 cm were grouped into six colour schemes (Figure 4).

Figure 4. Summary of the initial 3D printed prototypes.



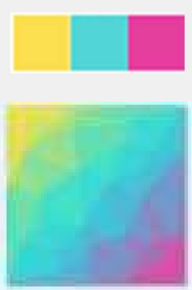
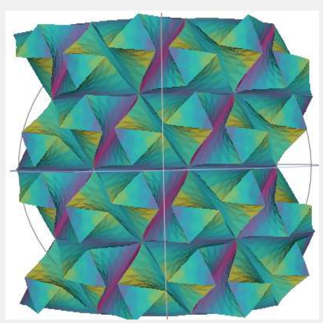
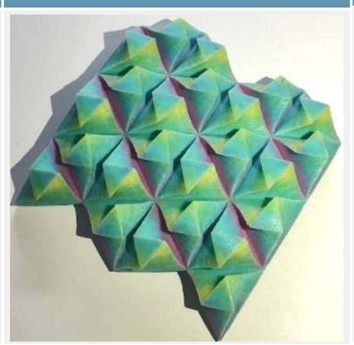
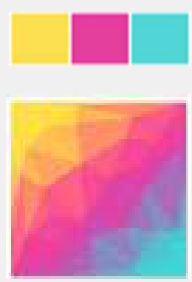
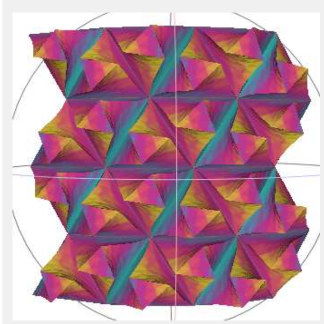
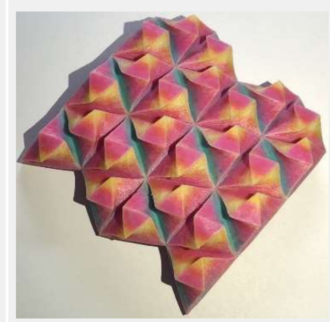
Research Methods, Prototypes & Materials

(g) Colour

- Although the 3D printer Stratasys J750 could achieve nearly full-colour printing in both CMYK and RBG, with more than 360,000 colours, it still had technical limitations in terms of colour accuracy (Stratasys, 2018). Physical prototypes with serious colour fidelity problems were eliminated from the study.

- These problems included (i) fading on the Ana-1, Ana-2, Ana-3, Comple-1, Comple-2, Split Comple-2, Split Comple-3, Te-1, Te-2, and Te-3 prototypes; (ii) colour switching on the Ana-2, Te-1, Te-2, and Te-3 prototypes; (iii) colour pattern image blurring on the Mono-1, Mono-2, Comple-1, Comple-2, Split Comple-2, Tri-3, and Te-3 prototypes; and (iv) serious colour fidelity defeats on light and soft colour on the prototypes of analogous, complementary, split complementary, and tetrad schemes.

- In summary, following the assessment of 16 physical prototypes and comparison with virtual rendering models, the Tri-1 and Tri-2 prototypes showed satisfactory performance. Moreover, blue was the preferred hue in most studies of colour perceptions and associated meanings. Therefore, the Tri-1 prototype was selected for further examination in this study.

Tri-1			Tri-2		
Colours /Pattern	Virtual Model	Physical Prototype	Colours /Pattern	Virtual Model	Physical Prototype
					

Research Methods, Prototypes & Materials

(h) Designing Joints and Interlocks

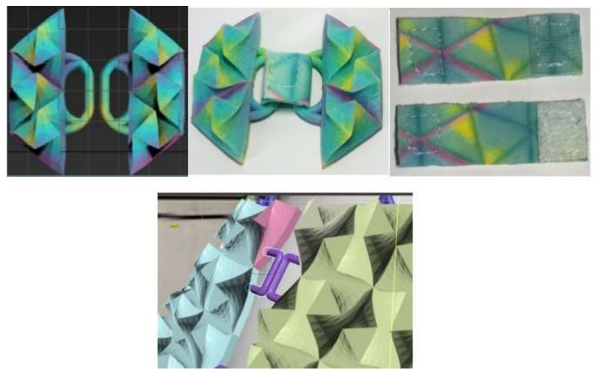
Joint was designed with a 6-mm slit distance between panels as a precondition. The joint thickness was unified to 3 mm. The prototypes were printed on resin materials using the Stratasys J750 printer. A pair of joints and interlock is shown in Figure 5a. All the joints were evenly distributed in pairs (Figure 5b). A texture rendering process was performed to unwrap the meshes and create a UV map.

(i) Materials Used in the 3D Printing Process

- Resin was the 3D printing material used in the final stage of developing the 3D printed garment. All the required files were imported into the 3D printer software PolyJet Studio. The software sliced the 3D model and automatically calculated the amount of 3D materials required. The matte resin materials and soluble supporting materials were involved in the 3D printing process.

- The total printing time was approximately 309 hours. After the post-processing washing, all the panels were joined by using the interlocks, and the final 3D printed fashion prototype with an innovative surface texture was complete.

Figure 5.
(a) Left: A 3D model of joint; Middle: A physical 3D printed joint; Right: Neoprene fabric interlocks;
(b) Position of joints on the final prototype.

(a)
(b)


Research Methods, Prototypes & Materials

(j) Detailed Design with Specifications

(i) Preparation for 3D Modelling of the Final Prototype

- A 3D virtual dummy was required as a template for the 3D modelling of the virtual garment and for mapping the virtual fabric mesh.
- A TC2 3D body scanner was used to generate the 3D virtual model and obtain accurate measurement data for a standard size 10 dummy (Figure 6).
- The resulting 3D model was then imported into 3ds Max as the base template for developing the final garment model.

Figure 6.
A size 10 dummy in a body scanner TC2 and a virtual model of size 10 dummy.

Research Methods, Prototypes & Materials

(ii) Adding Ease Allowances Through 3D Body Scanning

- The amount of ease allowance added was carefully examined, as it determines the wearing comfort of the final 3D-printed garment. The final prototype was considered a first-degree garment, meaning clothing worn directly over underwear.

- Based on ease allowance data reported in the literature [19], the ease allowance percentage was calculated and applied to the 3D virtual dummy. A final 3D model of the size 10 dummy, incorporating the calculated ease allowances, was then created and used for the 3D modelling process of the final garment. The measurements of the size 10 dummy before and after the addition of ease allowances are presented in Table 1.

Table 1. Size 10 dummy measurements before and after ease allowance.

Measurement point	Original measure ment (cm)	Measure ment after adding ease (cm)	Ease allowance (cm) suggested by journals	(+)%
Neck	34	34.75	+0.75	2.2
Shoulder	38	41	+3	7.9
Bust	82	88	+6	7.3
Waist	60	68	+4	6.3
High hip (4” below waist)	79	85	+6	7.6
Top hip (9” below waist)	89.5	95.5	+6	6.7

Research Methods, Prototypes & Materials

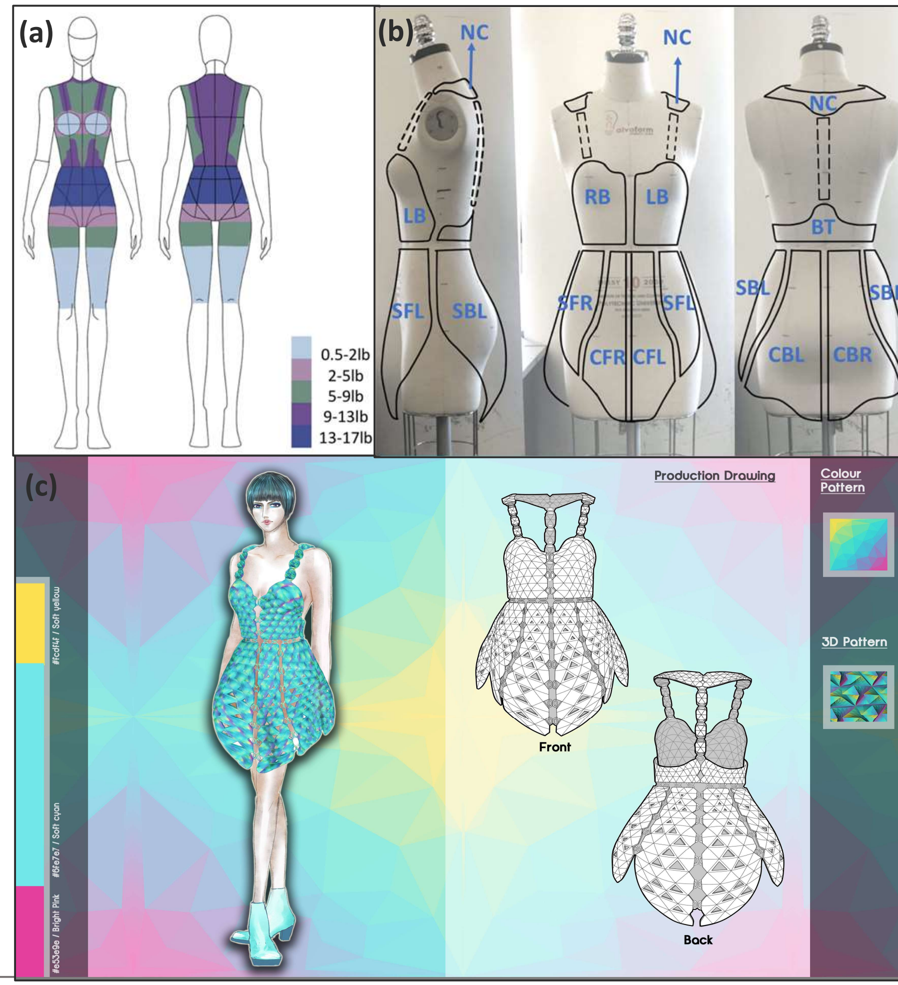
(iii) Design Considerations

- The weight distribution of the garment panels on the body and the additional load they imposed could cause discomfort in different body areas. A body map of acceptable load values for various body parts was developed and modified in this study to account for relevant factors (Figure 7a).

- The final garment prototype was divided into several panels according to the specifications of the 3D printer. Cutting lines were strategically placed along areas of joint stretch or flexion to facilitate effective body movement and flexibility (Figure 7b).

- Another important design consideration involved the application of shape factors to influence visual weight. Regular, simple, geometric, or vertically oriented forms tend to appear heavier than irregular or oblique shapes. Consequently, the final 3D-printed garment was designed with an hourglass silhouette, while the lower portion was shaped into an irregular, tulip-like form to create a sense of fullness (Figure 7c).

Figure 7.
(a) Body map of affordable load values for different body parts;
(b) Panel cutting design;
(c) Fashion illustration and production drawings.



Research Methods, Prototypes & Materials

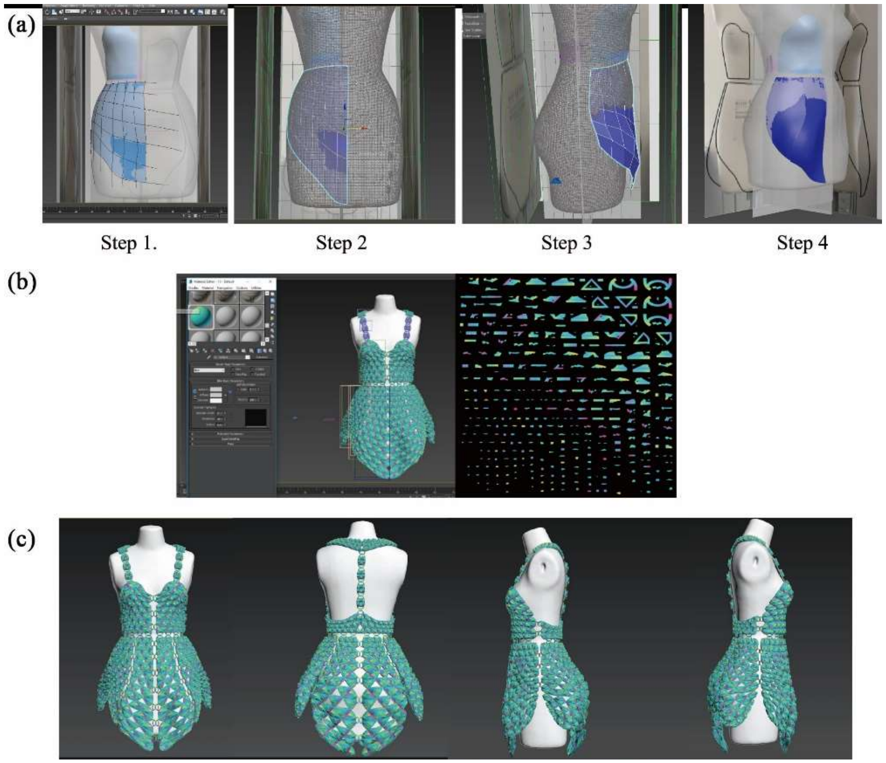
(k) Modelling of the Final 3D Printed Prototype

- A 3D model of the dummy and a draft drawing of the final garment with specified cutting panels were prepared for import into 3ds Max. The PolyDraw function in 3ds Max was used to quickly outline the desired silhouette directly on the surface of the dummy's 3D virtual model (Figure 8a).

- Topology, a geometry tool within PolyDraw, was then used to draw lines forming a grid of quadrilateral (quad) polygons. This new mesh was layered over the dummy's 3D model (Figure 8b). The panel meshes were subsequently smoothed to form the basic silhouette of the final garment, creating the base template for use with the Para 3D plugin (Figure 8c).

- A minimum shell thickness of 1.5–2 mm was selected to ensure structural reinforcement. The panel weight at different shell thicknesses was calculated using GrabCAD Print, the software recommended for the Stratasys J750 3D printer. The total weight of the final 3D-printed garment was 5,684 g (12.53 lb), which is within the maximum load capacity of 13 lb that human shoulders can comfortably bear.

Figure 8.
(a) The PolyDraw process: Step 1: Drawing grid of quads; Step 2: Creating a new mesh; Step 3: Dragging vertexes; Step 4: Smoothing the mesh;
(b) Texture mapping process and a UV map after the unwrapping process;
(c) Rendering pictures of the final prototype in different views.



Research Methods, Prototypes & Materials

- The final 3D-printed fashion prototype with a multi-coloured surface texture was completed and displayed on a size 10 dummy. Different side views and detailed features of the prototype are presented in Figure 9.

Figure 9. Different views of the final fashion prototype.

Research Outcomes, Findings & Further Research

- This practice-based study involved the development of a distinctive theoretical design process model for 3D-printed fashion garments with multi-coloured surface textures, alongside a practical design concept and physical prototypes. The study applied 3D colour printing technology (PolyJet 3D printer with resins), 3D modelling using CAD (3ds Max with the Para 3D plugin), and incorporated ergonomic considerations (ideal garment ease allowances) and aesthetic factors (specific garment panel cutting designs).

- The resulting 3D-printed fashion prototype with multi-coloured surface textures contributes both theoretically and practically to the fields of high fashion, education, and research in fashion and textiles. The design process model developed in this study offers a structured framework to assist designers, researchers, and engineers in addressing related design challenges.

- Creating 3D-printed prototypes requires technical knowledge, including 3D modelling in CAD and generating file formats compatible with 3D printers. However, fashion designers may lack these computer skills, while engineers may not possess expertise in fashion design, creating a knowledge gap between design and practical technology skills. The practice-based methodology and design process model established in this study help integrate technology with design practice, ensuring the successful development of projects that meet specific criteria.

- This study demonstrated the application of 3D body scanning technology to 3D printing and proposed a model for generating 3D garment meshes with ideal ease allowances. Designers can use a 3D body scanner to enhance their 3D modelling process, such as by scanning a desired paper pattern or directly building the garment structure in CAD. These contributions offer new opportunities for creating high-quality, innovative designs in the field of fashion design.

Research Outcomes, Findings & Further Research

- When applying 3D printing technology to fashion and textile design, colour fidelity and the platform size of the 3D printer remain major technical limitations that researchers are still addressing. Currently, only PolyJet technology can 3D print objects using a mixture of materials. However, when colour printing with texture mapping is required, rigid resins are the only viable printing materials. Using exclusively hard materials in 3D-printed fashion garments may be unsuitable, as the final product could cause discomfort or restrict body movement.

- In addition, colour 3D printing is time-consuming because it operates at a pixel-wise level, and the cost of 3D printing remains relatively high due to expensive materials. As a result, 3D colour printing may not yet be practical for mass production of garments.

- In summary, although 3D printing technology still faces several limitations, it is advancing rapidly, and the fashion industry cannot ignore its growing significance [22]. 3D multi-colour printing with textures represents a promising area for innovation in fashion and textiles, as colour remains one of the most compelling elements for creative design. Therefore, further research is needed to overcome current limitations and enable the production of more successful 3D-printed garments for the fashion market.

Research Dissemination

- Chan, I., Au, J. (corresponding author), Ho, C., & Lam, J. (2021). Creation of 3D printed fashion prototype with multi-coloured texture: A practice-based approach. *International Journal of Fashion Design, Technology and Education,* 14(1), pp. 78–90. DOI: 10.1080/17543266.2020.1861342
- Seminar presentation, “Innovative fashion: Creation process of a 3D multi-coloured printed fashion prototype with PolyJet technology”. University Research Facility in 3D Printing Open Day Seminar: How 3D printing makes your dreams come true. The Hong Kong Polytechnic University, Hong Kong. Date: 8 Oct 2021.

References

[1] Campbell, T., Williams, C., Ivanova, O., & Garrett, B. (2011). Could 3D printing change the world? Technologies, potential, and implications of additive manufacturing. Washington, DC: Atlantic Council.

[2] Petrick, I.J., & Simpson, T.W. (2013). 3D printing disrupts manufacturing: How economies of one create new rules of competition. Research-Technology Management, 56(6), 12–16.

[3] Ahearn, L. (2014). 3D game textures: Create professional game art using Photoshop. USA: CRC Press.

[4] Mullen, T. (2011). Mastering blender. New York: Wiley.

[5] Stratasys. (2018). J750 digital anatomy printer. https://www.stratasys.com/-/media/files/printer-spec-sheets/BR_MED_DAP_0919a

[6] Vidimče, K., Wang, S. P., Ragan-Kelley, J., & Matusik, W. (2013). Openfab: A programmable pipeline for multi-material fabrication. ACM Transactions on Graphics (TOG), 32(4), 136.

[7] Xiao, K., Sohiab, A., Sun, P.L., Yates, J.M., Li, C., & Wuerger, S. (2016). A colour image reproduction framework for 3D colour printing. SPIE Proceedings of Advanced Laser Manufacturing Technology, 10153, 1015318.

[8] Candy, L. (2006). Practice-based research: A guide (CCS Report, V1.0, 1-19). University of Technology, Sydney.

[9] Chapman, W. L., Bahill, A.T., & Wymore, A.W. (1992). Engineering modelling and design. Boca Raton: CRC Press.

[10] Medland, A.J. (1992). The computer-based design process (2nd ed). London: Chapman and Hall.

[11] Jones, J. C. (1992). Design methods (2nd ed). New York: Wiley.

[12] LaBat, K.L., & Solkolowski, S.L. (1999). A three-stage design process applied to an industry-University textile product design project. Clothing and Textiles Research Journal, 17(1), 11–20.

References

[13] Lamb, J.M., & Kallel, M.J. (1992). A conceptual framework for apparel design. Clothing and Textiles Research Journal, 10(2), 42–47.

[14] Regan, C.L., Kincade, D.H., & Sheldon, G. (1998). Applicability of the engineering design process theory in the apparel design process. Clothing and Textiles Research Journal, 16(1), 36–46.

[15] Cross, N. (2008). Engineering design methods: Strategies for product design (4th ed.). New York: John Wiley.

[16] Fiore, A.M., & Kimle, P.A. (2010). Understanding aesthetics for the merchandising and design professional (2nd ed). New York: Fairchild.

[17] Wynn, D., & Clarkson, J. (2005). Models of designing. London: Springer.

[18] Saito, M. (1994). A cross-cultural study on colour preference in three Asian cities. Japanese Psychological Research, 36(4), 219–232.

[19] Haggar, A. (2004). Pattern cutting for lingerie, beachwear and leisurewear (2nd ed). Oxford: Blackwell Publishing.

[20] Zeagler, C. (2017). Where to wear it: Functional, technical, and social considerations in on-body location for wearable technology 20 years of designing for wearability. Proceedings of the 2017 ACM International Symposium on Wearable Computers, 130534, 150–157.

[21] Arnheim, R. (2004). Art and visual perception: A psychology of the creative eye (2nd ed.). Berkeley, CA: University of California Press.

[22] Sedhom, R.V. (2015). 3D printing and its effect on the fashion industry: it's more than just about intellectual property. Santa Clara Law Review, 55(4), 880.

Appendices

Appendix I. The Gold Award of the Special Edition 2022 Inventions Geneva Evaluation Days

Appendix II. The Winner of the Red Dot Design Award (Design Concept Category) 2024