

The Impact of Bi-Directional Design Method in Sustainable Fashion Design Thinking and Development: A Case Study of the Fashion Design Process at Hunan Institute of Engineering

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Abstract. Sustainable fashion design thinking (SFDT) would be a popular trend and a challenge for fashion designers. Methods based on the Stanford model have been developed to aid designers as co-creator in synthesising sustainability into their design practices by Williams. We analysed the theoretical model to determine its fitness for purpose. However, the model has two vulnerabilities from a social development perspective. We propose the design practice of the bi-directional design method that aims to improve designers' sustainable fashion design (SFD) level and co-design capacity by a case study of the fashion design process at Hunan Institute of Engineering. The findings indicate that the method is an innovative practice in SFD, which helpfully extended research scopes of design thinking that the previous scholars presented. The findings may provide a significant impact on the design development of the sustainable education and fashion industry.

Keywords: Design Thinking, Sustainability, Practice, Sustainable Problem, Sustainable Solution.

1 Introduction

The increasing impacts of sustainability driven by sustainable fashion design (SFD) have contributed to a growing volume of fashion design (FD) products with innovative styling, durable life cycles, eco-friendly, accompanied by cultural expression and aesthetic taste (1). Sustainable fashion trends motivate creative designs of sustainability products that drive design thinking (DT) and contribute to further development. Some fashion designers who have sustainable DT formed a significant group for sustainable development(2). As the SFD concept has enlarged to FD regions, sustainable fashion design thinking (SFDT) in design practice has been paid increasing attention by fashion companies or university education and training(3).

SFD has highlighted the extent of DT's significance, which is as a 'specified process where designers take an approach to handle with concerned solutions to complex problems' (4). Some academics advocated DT as a way for creating new solution to sustainability issues (5),(6),(7). However, the concept of DT has existing argument that the term is misleading as the

DT process involves both effect and action. Henriksen et al. pointed to DT as a creative theoretical model to educational problems of practice. They applied the Stanford DT model as their DT framework basis (3). Williams' FD and sustainability research created design approaches for sustainability and FD, which is part of an emergent framework to describe fashion practices, and it is a development on the basis of their human-centred design from IDEO (8). The design approaches emphasise that new practices and models that broaden the boundaries of prosperity should emerge across relational domains (5). However, Williams found that two vulnerabilities in the model from social and economic perspectives regarding the studied model have outmoded and hierarchical defects. To promote the SFD model to further the perfection on Williams' research basis, we rethink DT of co-design about sustainability, which found that the unidirectional linear method is difficult to integrate users' needs and sustainability to achieve iteration design on each stage. Therefore, we propose a design practice of the bi-directional design method by circular design and co-design.

The bi-directional design method has two alternative beginning guidelines that took into consideration: guidance from the sustainable problem to the sustainable solution and guidance from the sustainable solution to the sustainable problem(9). The method is expected to protect an iterative approach to design projects to obtain the desired results and ideate while fulfilling the sustainable and innovation objectives. The design in practice aims to test it and confirm the gains provided in projects that follow the methodology for the design process with inspiration drawn from various fields. This is clear from the outcomes of the two practices' projects at Hunan Institute of Engineering (HIE), which also validated the method.

Given the increased consideration of sustainability in multiple domains, the bi-directional design method is considered an SFD model since it can bi-directional ideate and test in fashion DT. In sustainable development, the design may affect multiple product design elements and consumption, such as satisfying consumer demands, selecting materials and construction techniques and considering the product's whole life cycle. Based on that logic, this paper seeks to describe the potential impact of the bi-directional design method in SFDT and development.

2 Literature Review

2.1 Design thinking and fashion design

DT has been a trend, and everyone from students to designers, small workshops to multinational corporations, are utilising it to innovate. The concept came from the business IDEO(8), which was formed in 1991 by David Kelley and partner design firms(10). Kelley pushed DT implementation and practice even farther through the Stanford Design Centre (11).

The term 'DT' has been cumulatively popular in the design industry where researchers in different fields carry studying designers' practices to develop and refine education and training programmes and keep the discussion going on the character and purpose of design. In addition, DT improves an organisation's ability to innovate and solves more complicated business issues by bringing ideas, interests and values into the process(12), and it demonstrates the apparent feature of iteration (13).The Hasso-Plattner Institute of Design at Stanford, which is also known as the Stanford DT model, is at the forefront of applying and teaching DT (8). The Stanford model (3)has five stage processes that include empathise—with your user; define—your users'

needs, their problem and your insights; ideate—by challenging assumptions and creating ideas for innovative solutions; prototype—to start creating solutions and test—solutions.

Although FD is usually considered as a design's subfield, research on DT in FD is still an emerging situation and underdeveloped(14). Nixon and Blakley and Finn emphasised the importance of FD's domain-specific knowledge and methodologies to enhance its potential (14). Particularly, Visser thought that FD has unique characteristics that rely in the situation, the designers and the complex craft (15). She proposed undertaking practical research to better investigate FD. As a result, DT is also useful in the fashion industry concerned as it provides a problem-solving and practice-oriented design that can extend the scope of FD (6),(10).

2.2 Theoretical framework of the sustainable fashion process

Fashion and sustainability are not new buddies, but issues about fashion as a positive shift are often overlooked(5). Fashion represents the epitome of economics, society, environment and politics worldwide(16). Specific to sustainable fashion is that sustainability effects during design, produce, use and disposal should be considered. Sustainable fashion is integrating human, energy, natural resources, financial and cultural capital into DT in a collaborative and co-design way(14). Williams explored the role of designers in the contribution of fashion from the study of the practice of FD. He created a theoretical framework of the sustainable fashion process to describe the fashion practices that result from a deeper look at our connected world. Williams' approach serves as a foundation for guiding DT in the creation and support of sustainable design practices (5). Claxton and Kent adopted the model to develop an SFD strategies framework by design practice from the designer's role (2). Hoololan et al. developed a theory of DT and social practice to support sustainable practice (17). Buhl et al. created a research framework that illustrates the applicability of DT's core concepts to the identified sustainable-oriented innovations problems (7). Geissdoerfer et al. integrated DT into a value mapping process in the sustainable business model because the features of DT drive the ideation process and contribute in the balancing of frequently competing stakeholder interests (13). With a trend of using DT for sustainability, DT has become an effective approach to enhance multiple areas of sustainability.

Williams' theoretical framework's five stages are based on Stanford model processes (empathy, define, ideation, prototype and test) to develop and integrate the sustainable concept into it. In this framework, fashion as agency is presented since multiple information can be expressed through tangible design elements or intangible culture idea (5). As a result, agency stage is a way to test the sustainable fashion if design purpose is achieved or not, and it is also a voice for change for sustainability. On the other hand, the framework aims to seek more sustainable practices from public engagement and participation action. The process-related sustainable fashion principle to form new styles of practice depends on balancing among social, economic, environmental, and individual schemas. The created theoretical framework includes five stages: *empathy—engage citizen participation, define—dream with eyes wide open, ideate—radicalise design practices, prototype—challenge conventional aesthetics and agency—be a voice for change* (5).

According to the analysis of the models, we found that the model contributed new DT's insights in the SFD practice based on circular design and co-design trends for sustainability. Design filter is used in the circular five stages to reflex the sustainable fashion process by integrating these methods and practices. It can be a guidance and measurement method to help designers better innovate their SFD products. However, the model's two vulnerabilities from social and economic perspectives regarding the studied model have features of outmoded and

hierarchical defects. With the continually increasing population, overuse and overconsumption of limited resources, SFDs are challenges that need audiences and participators to have the sustainability perception and acceptance. Still, the design purpose is fulfilling human needs and desires to reach human-centred DT. Cutting down the resources waste and slowing the foot of lifestyle push us to explore the combination of sustainability and a human-centred design approach. To further promote an SFD model to perfection on Williams' research basis, we rethink DT of co-design about sustainability, which found that the unidirectional linear method is difficult to integrate users' needs and sustainability to achieve iteration design on each stage. Therefore, we propose a design practice of the bi-directional design method by circular design (2) and co-design (18).

2.3 The theoretical framework of bi-directional design method in sustainable fashion design

SFD product is beneficial to the environment and meets human needs based on the development needs of society and nature. In FD, bionic design (19,20) has been applied widely by designers. In the research by Carlos and Denis, it can be found that the bi-directional method is developed based on the design practice of bionic design in products. The purpose is to achieve continuous adjustment and restructuring of products through iterative design to better develop and design products. The method took into account two guidelines: guidance from sustainable problems to sustainable solutions (DM-A), and direction from sustainable solutions to sustainable problems (DM-B)(9). DT entailed a design process that began with sustainable problems and progressed to sustainable solutions, as well as a design process that began with sustainable solutions and progressed to sustainable problems.

Design methods are critical elements in the design process that include routes, objectives and technical assistance. These are often essential to reduce the costs and period of a product's development process. To describe the outlines of the SFD process, we applied Coelho's bi-directional design method (see **Figures 1 and 2**) to create works of sustainable fashion. The teacher who undertook the course introduced two alternative starting guidelines for students: from the design problem to the sustainability solution (DM-A) and from the sustainability solution to the design problem (DM-B). The typical steps in both directions of analysis consist of the same activities, contain the exact description and create sustainable design work. **Figures 2 and 3** show a design phase that begins with the design problem and leads to the solution (**Figure 2**) and a design process that begins with the sustainable solution and moves to the sustainable problem (**Figure 3**), separately. Students may select one of the alternative methods to complete design work.

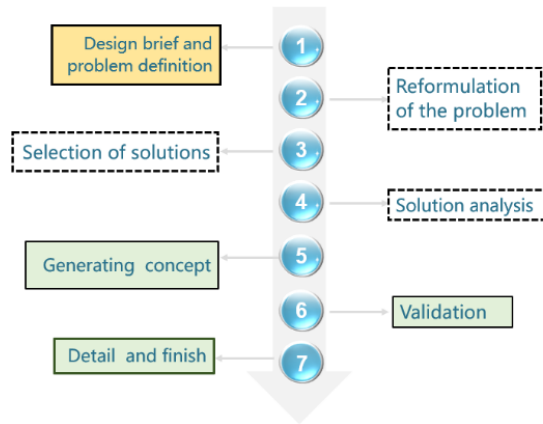


Figure 1. Design method: from problems to solutions (DM-A)

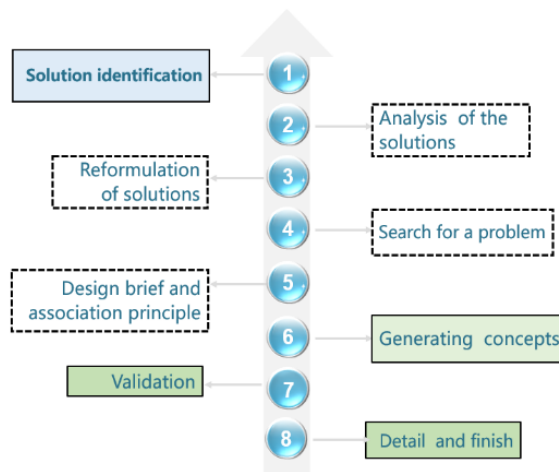


Figure 2. Design method: from solutions to problems (DM-B)

(Source: Denis A. Coelho, condensed descriptions of the steps of the method of bionic design(9))

Figure 1 and 2 show the step organisation of the design methodology. Although most of the time every step of the two design methods may be iterated, aims to refine the design using the appropriate steps and encourage comparisons between the solution and the problem continue. In the methodological process, it is possible to return to every prior stage during the validation phase. The objective is to adjust, correct or enhance some aspects while keeping in mind the needs identified by the findings from previous phases' assessment.

Through our work, we have developed a theoretical framework of bi-directional design method in SFD (see Figure 3) as part of sustainable design practices of fashion. We created the integration of sustainable fashion design's five stages with the bi-directional design method that

relies on a starting centre of sustainable problem and solution to interact with each stage to achieve circular design and co-design. It guides designers to break through the inherent knowledge system to expand the DT and form innovative design concepts. First of all, the circular design process constitutes the utilisation of the method from sustainable problems to sustainable solutions or from sustainable solutions to sustainable problem to generate empathy that is the starting point of DT. Then, defining, ideation and prototype phases of creation follow, where participants are encouraged through collaboration to critically test the feasibility of iteration sustainable practice. Next, sustainable fashion as agency to communicate and shape the cultural concepts and fashion perceptions delivers aesthetics and culture value to obtain more sustainable fashion participator to empathise from sustainable fashion products. To undertake a reflexive process through design practices in the framework, we use problem and solution in our work, to both explore and solve interaction design issues to measure sustainable design objectives.

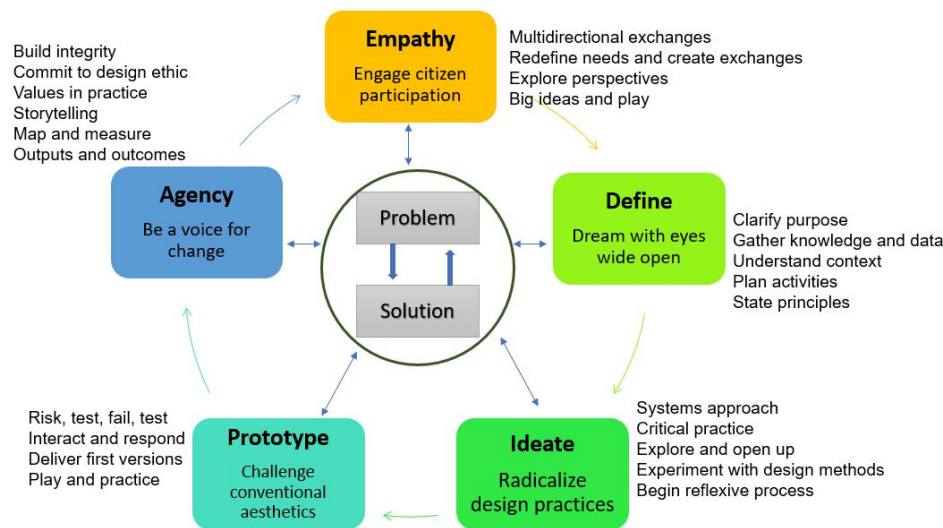


Figure 3: A theoretical framework of bi-directional design method in SFD

3 Research Methodology

Given the importance of DT in the design field, the first research question is ‘What is the current situation of DT in SFD?’ The second research question is ‘How do we use the bi-directional design method in SFD and development to achieve the circular design and co-design?’ To answer these questions, we create a theoretical framework of the bi-directional design method in SFD based on Williams’ model to examine the DT process in sustainable design practices..

3.1 Research methods

This paper undertook the qualitative method (21) that was utilised as the study, which primarily analysed participants' DT and development in their sustainable design practice. It was performed in two stages. To form a theoretical framework derived from existing related research articles collected, an inductive approach was utilised. First, a literature review aims to identify two aspects of contents: the current research situation of DT in SFD and the theoretical framework of sustainable fashion process, which helps to develop a theoretical framework of bi-Directional design method in SFD. Second, the aims are to evaluate and examine the developed framework, if it is reasonable or not, that was used to access the first-hand experience of DT and bi-directional design method in SFD, contributing to fashion designers and practitioners using the developed framework to guide them through designing more innovative sustainable design products. The research was conducted using an observation approach to evaluate the ways of design works in which 10 FD student groups engage the SFD process.

The research was conducted using an observation approach to evaluate the ways of the effectiveness and applicability of this two-way design method to SFD. Through observation methods, we implemented research in the design practice of creative courses. Thirty students were divided into 10 groups and used the two-way design method to experiment with sustainable design. We selected 2 representative series of works from 10 groups of works for visual presentation and analysis. One work is the design expression from the design problem to the solution, and the other is the design proposal from the solution to the problem. The difference between these two design concepts also directly led to the final difference in the design works, but it was found that the design works of these two series are always performed out around the concept of sustainability.

3.2 Participants

The design practices represented by FD students of HIE followed and attempted the bi-directional design method, which Coelho presented to design works of sustainable fashion and analysing the design process with the design problem and sustainable solution to explore design themes and approaches to achieve SFD (**Tables 1 and 2**). This approach was further split into from the design problem to the sustainable solution and from the sustainable solution to design problem to distinguish the design theme and inspiration formation of the design process in this section. The design practices represented a target that has adopted sustainability as a central concept from the outset. These practices are defined by design problems and the solutions of the sustainability and approaches of sustainable design strategies found in their future-focused innovation projects and inspiration of DT.

3.3 Data collection: a design Programme at Hunan Institute of Engineering

FD belongs to the design art discipline, which requires designers to have solid aesthetics and values, the style and ideas that the method wants to express and balance beauty and fashion. It consists of a collection of factors involving several causes or variables as well as interaction. Controlling certain variables is the essential purpose of providing meaningful data for research on sustainable fashion. This paper aims to discuss DT in design practices in the field of FD. Creative design, a design programme, is all the FD senior students need to take at HIE. HIE is one of the engineering application universities in China. It is also the first batch of the 'Excellent Engineer Education and Training Program' and the 'New Engineering Research and Practice Project' implemented by the Ministry of Education; it is a master's degree awarded by Hunan

Project construction unit, and the first batch of the ‘2011 Plan’ was selected by the university. In 2018, the school was selected as a high-level application characteristic college in Hunan Province’s ‘Double First-Class’ construction.

One of the critical pillars of design programmes is DT (22). This course uses multidisciplinary-related knowledge and multi-angle views to broaden outlooks and design skills, and this programme also collaborates through joint design competition and projects. Furthermore, the programme focuses on cultivating sustainable and creationary DT and methods of active learning. Meanwhile, students are encouraged to make many attempts to design works by discovering and solving problems to learn by doing. It can help FD students obtain more satisfying works under the continuous improvement and perfection of the design, and it is a neoteric heuristic and experiential learning method that subverts the traditional pedagogical approach. The creative course plan is shown in **Figure 4**. Students can form small design groups (usually 2–3 students) to complete design assignments in this course. A teacher who teaches the creative design course will supervise the project. Many projects relate to engagement from other disciplines. Students must complete conceptual and design rendering in half of the process and submit a ‘design proposal’ and sketches as part of their mid-term delivery. The study focuses on evaluating sustainable fashion DT through practices.

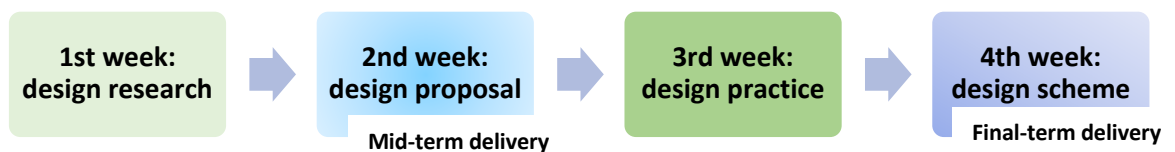


Figure 4. Schedules of creative design courses

This course combines the application of multidisciplinary content, creatively relieves design problems in the fashion industry, incorporates the concept of sustainability into the thinking training of creative design courses and understands the connotation, meaning and social responsibilities of environmental protection and socially sustainable development. For example, the product development phase can efficiently lower textile waste in the fashion industry if designers consider ecosystem and sustainable development in FD projects such as sustainable fashion as an inspiration origin is considered in the design. The project asks for a complete design target to design a scheme that followed the theme of sustainability based on the theoretical framework of bi-directional design method in the SFD.

4 Finding and discussion

With the design processes acting up the created theoretical framework, we used the observation approach of the qualitative method to evaluate and analyse the FD students’ innovation designing scheme. Below, we exemplified design theme, sustainable problem, design inspiration and sustainable solution to explore the formed process of sustainable fashion DT. We selected a typical design scheme to explore the DT model in more detail, which the process

includes empathy, define, ideate, prototype and agency. The aim is to evaluate and analyse how the bi-directional design method interplay to sustainability and existing thinking in FD field.

4.1 DM-A in design practices

In FD, designers are interested in finding a problem and looking for a solution(23). The design processes are centred on problem exploration, which identifies different perspectives of the problem before moving on to solutions. The problem investigation processes are also characterised as proceeding and afterwards guiding the designer’s search for solutions(2).

Table 1: Design practices from sustainable problems to sustainable solutions

Design theme	Design method	Design inspiration	Sustainable problem	Sustainable solution
Circus	DM-A	The weird and funny circus brings joy to people, and sustainability can bring hope to the world.	The relationship between animals and humans	Reconstructing old clothing
Self-salvation	DM-A	From the person who helps sheep.	Pollution of material	Use sustainable material
Stop speaking	DM-A	Language is the most effective weapon.	Environmental noise	Deconstruction and reorganisation
The daughter of the sea	DM-A	Inspired by jellyfish, it aims to pursue a harmonious marine ecology.	Ocean pollution	Use sustainable material
Tetris	DM-A	All kinds of toys from childhood can recall many good memories, let us go to a party with friends.	Pollution of plastic toys	Upcycling, reorganisation, and sustainable material

Remarks: All design problems of Table 1 come from the ecological and environmental attentions.

4.1.1 Obtainment of Sustainable problem

The fashion industry is one of the unsustainable consumption sectors on the planet. Sustainability has been increasingly of great concern in the fashion industry in recent years(16),(1). Kolko proposed that the DT particularly contributes to solve sustainability-related problems because it investigates problem context before starting a design practice(7). One of the principles of DT is the finding of problems that can produce more possible solution schemes(17). To offer sustainable design scope to design students for innovation design, the study of DT process begins with thinking of problem related sustainability that the adviser proposed. First of all, the teacher who teaches the creative courses presents some problems for students: ‘How do we understand the current fashion industry?’, ‘Could you find some issues

of pollution in your life?’ and ‘How are you going to solve them?’ Second, the teacher will guide them to write some problems by mind mapping. Their sustainable problems are related to many sub-problems (6) such as climate change, overuse materials, environmental pollution, ecological imbalance, endangered animals, technological developments, and resource limitations, and so on, so they wrote down the following problem keywords: the relationship between animals and humans, pollution of material, environmental noise, ocean pollution and pollution of plastic toys. Overall, empathy is when the designer begins to explore and understand problems from a sustainable perspective(3). We found that the design problem led fashion designers to question and recognise sustainable issues to enhance insights and challenge their limited knowledge. *Empathy* was a broadly applicable skill for understanding design problems’ features, causes, influences and possible solutions across SFD problems(5).

4.1.2 Establishment of the design theme

In ‘Define---dream with eyes wide open’, this method of DM-A may enhance and broaden the students’ DT. The five groups searched for different problems (animals and humans, pollution of material, environmental noise, ocean pollution, and pollution of plastic toys) surrounding sustainability. Table 1 shows five design themes from five groups; the design themes are ‘Circus, Self-salvation, Stop speaking, The daughter of the sea and Tetris’ (see **Table 1**). An initial review of design theme observations reveals that most design groups used from problem to solution method when they came across design assignments. However, they concentrated on their solution throughout the design aimed at future SFD. Design themes are defined incrementally from the original sustainable problem. They usually proposed highly abstract and imaginative initial ideas as main drivers (24). For example, the design theme of ‘Self-salvation’ is mainly evolved by some keywords of problem-orientation in brainstorming to form the design theme of ‘Self-salvation’ progressively (See **Figure 5**). Figure 4 depicts the evolution of the design theme definition primary process: pollution of material—natural material—wool—the person who helps sheep—hope (save)—self-salvation.

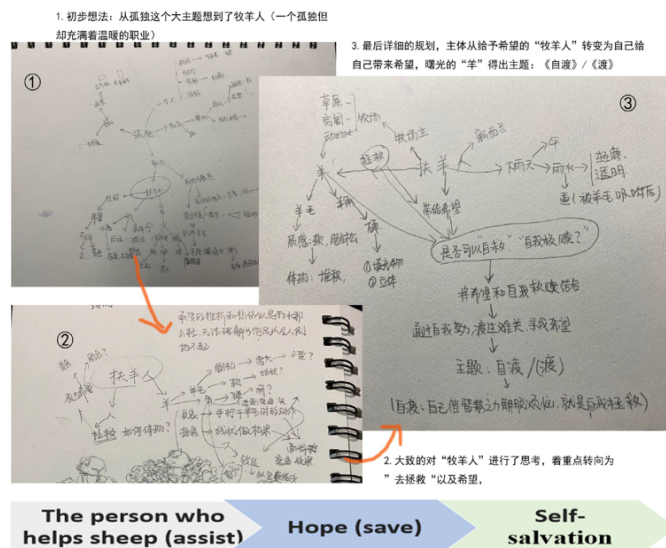


Figure 5. An initial definition process based on sustainable problems

(Source: Lin Xin, a fashion design student of HIE, Study period:2017.9-2021.6, Advisor: Zuo Shuangxi)

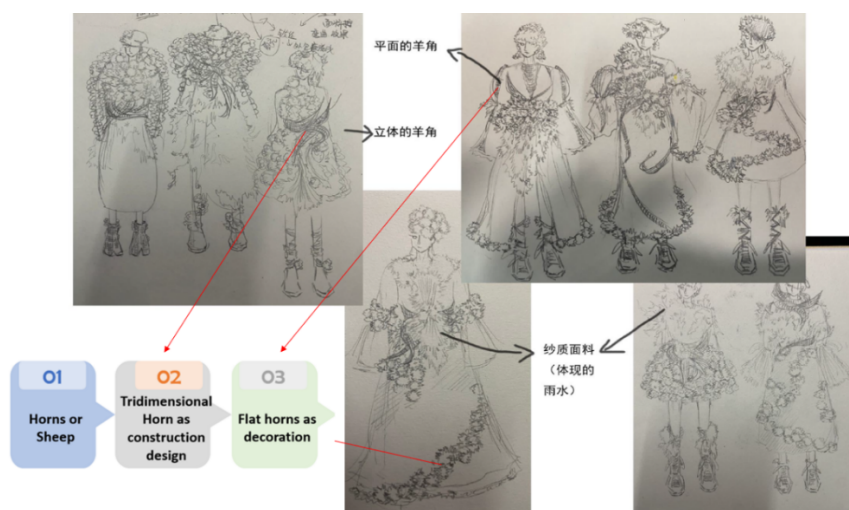


Figure 6. An example of concept growth processes from problems to solutions

(Source: Lin Xin, a fashion design student of HIE, Study period:2017.9-2021.6, Advisor: Zuo Shuangxi)

4.1.3 Design inspiration

To visualise design inspiration(22), *Ideate—radicalise design practices* generates a series of keywords with the related sustainable problem and then extends alternative design elements from a mass of design keywords. The progressive keywords extension is marked with the orange arrows and annotations to help the new design inspiration from the elements restructure. For instance, the keywords underlying this design inspiration were ‘horns or sheep’, ‘tri-dimensional horn as construction design’ and ‘flat horns as decoration’. In **Figure 6**, designers used the sustainable material wool to associate ‘sheep’ and ‘horns’ and adopt these elements to create their works. Finally, the abstract design concepts were gradually embodied and perfected through concrete design elements that draw in sketches, though designers may move between multiple stages of DT.

4.1.4 Sustainable solution

An initial review of the design theme to inspiration observations reveals that five design groups used from problem to solution method when they came across design assignments. However, they concentrated on their solution throughout the DT process aimed at iteration and circular design. During the problem-solving phase, the ‘Self-salvation’ theme tended to use the pollution of material to find the sustainable problematic situation. **Figure 7** demonstrates an ideation of the design scheme named ‘Self-salvation’ for a sustainable DT process based on a design concept. Colour and construction adjustments were made based on factors specific to the target situation.

Designers select a clue or idea of ‘the person who helps sheep—hope (save)—self-salvation’ to develop the design scheme after generating many ideas from design keywords. At

the *Prototype* mode, the designer creates an element of tangible horns of sheep as a solution to redesign and to challenge conventional aesthetics. The group members discussed prototyping related to creating, sustainability or crafting. They experienced the excitement and satisfaction in ideas bringing to design works and creating real out of SFD works through DT.

Agency—the final ‘Self-salvation’ design scheme (see **Figure 7**) was generated quickly that involved how sustainable problems reacted to be a voice for change. DM-A can be more design creative and learning-oriented in the SFD. In this design process, designers explored various related sub-problems based on sustainable problem orientation and performed many solutions thinking and then selected the best plan that can be achieved to perfect and form a prototype. Based on the DT of the model framework, DM-A is used to realise the iterative design and co-design.



Figure 7. An ideation of the design scheme named “self-salvation”
 (Source: Lin Xin, a fashion design student of HIE, Study period:2017.9-2021.6, Advisor: Zuo Shuangxi)

4.2 DM-B in design practices

Design practices from sustainable solutions to sustainable problems followed the reverse path, collecting the existing sustainable solutions for future DT as design clues. The existing sustainable solutions can help designers to understand the current sustainable status better and identify emerging issues. The first stage is to identify sustainable solutions, which is followed by the stages outlined below.

4.2.1 Collecting sustainable solution

Following the collected sustainable solutions with outstanding features, designers can easily find the potential design clues as design scheme keywords. The five groups collected different solutions: ‘Harmonious ecological and living environment’, ‘Protecting Mother Nature’, ‘Protecting the ocean’, ‘Increasing the value and longevity of clothing, multi-function’ and ‘Use sustainable material’. Afterwards, the concerning design keywords are obtained to implement the extension of the design theme. On the other hand, empathy is when the designer begins to understand sustainable solutions if they are useful and reasonable or not and if they will empathise their perception of sustainability and enhance insights and knowledge.

4.2.2 Establishment of the design theme

At the DM-B, the five design groups will generate design clues by analysing one of the collected sustainable solutions to form and generate a preliminary design theme. **Table 2** shows five different design themes by DM-B (Ideal country, Kallima inachus, Wave, Origami Art and Bamboo shoots are friendly). The themes’ generation is based on the sustainability solution in the current different industries, such as ‘Harmonious ecological and living environment’, ‘Protecting Mother Nature’, ‘Protecting the ocean’, ‘Increasing the value and longevity of clothing, multi-function’ and ‘Use sustainable material’. Design themes are defined incrementally from the collected sustainable solutions. For example, the design theme of ‘Kallima inachus’ is mainly evoluted by some keywords of solution-orientation in brainstorming to form the design theme progressively. Figure 7 describes the evolution of the design theme definition primary process: sustainability—protecting mother earth—endangered animals—Kallima inachus.

Table 2: Design practices from sustainable solutions to sustainable problems

Design theme	Design method	Design inspiration	Sustainable solution	Sustainable problem
Ideal country	DM-B	I selected a lot of old clothes from my wardrobe to redesign, using the aesthetics of mix and match to design a new silhouette	Harmonious ecological and living environment	Textile waste
<i>Kallima inachus</i>	DM-B	Inspired by the shape and texture of the <i>Kallima inachus</i>	Protecting Mother Nature	<i>Kallima inachus</i> may be endangered.
Wave	DM-B	Inspired by the waves of the ocean, the skirt is designed into a wave shape using bionic design techniques	Protecting the ocean	Pollution is threatening marine life
Origami Art	DM-B	Traditional handicrafts can increase the value and service life of clothing	Increasing the value and longevity of clothing, multi-function	Traditional handicrafts

Bamboo shoots are friendly	DM-B	Inspired by the outline of bamboo shoots, use sustainable bamboo fibre fabrics	Use sustainable material	Sustainability of clothing materials
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Remarks: All sustainable solutions of **Table 2** are approaches and ideas for the environment and ecosystem.

4.2.3 Design inspiration

Initial proposed design ideas were usually specific and figurative because the solution-orientation method develops a figurative natural object as design clues. **Figure 8** explains how design inspiration came to be. The keywords underlying the design theme were ‘sustainability’, ‘protecting mother earth’, ‘endangered animal’ and ‘Kallima inachus’. These specific visualisations of objects were represented and perfected through sketches and inspiration images; designers may utilise the approaches of deconstruction and recombination to generate new design concepts and create a unique style (shown in **Figure 9**). For example, the design theme of ‘Kallima inachus’ was inspired by its natural features. In Figure 8, designers used Kallima inachus's colour, shape and texture to associate design ideas and adopt these elements to create their works. Finally, design concepts were gradually embodied and perfected through concrete design elements that draw in sketches.

During the ideate stage, the ‘Kallima inachus’ theme tended to select organic cotton and wool as material to achieve sustainability. The theme consideration was related to craft in the sustainability of slow fashion by adapting deconstruction approaches and recombination to shape the appearance of ‘Kallima inachus’. The craft design involved stitching, embroidery, folding, stacking and hollowing out.

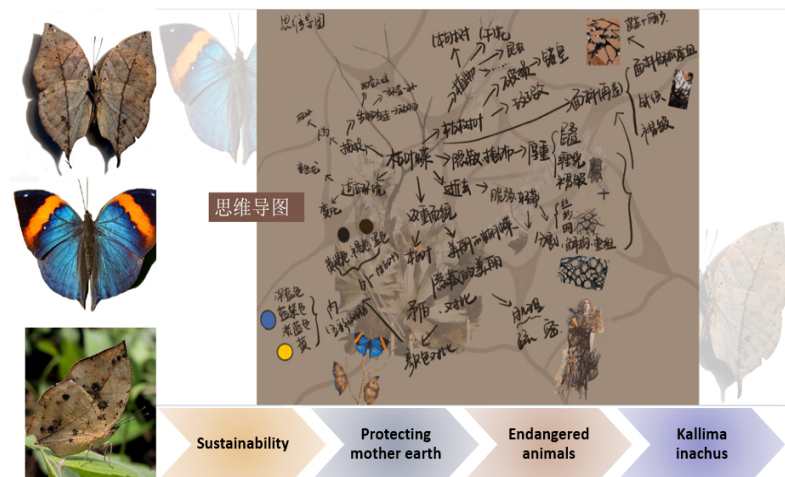


Figure 8. An initial definition process based on sustainable solutions
 (Source: Cheng Anni, a fashion design student of HIE, Study period:2017.9-2021.6, Advisor: Zuo Shuangxi)

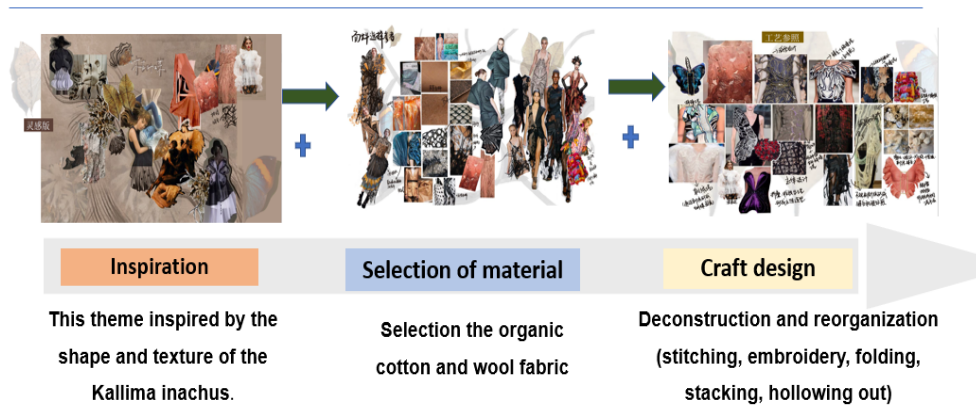


Figure 9. An example of concept growth processes from solutions to problems
 (Source: Cheng Anni, a fashion design student of HIE, Study period:2017.9-2021.6, Advisor: Zuo Shuangxi)

4.2.4 Sustainable problem

An initial review of the design theme to inspiration observations reveals that five design groups used DM-B when they came across design assignments. The '*Kallima inachus*' theme tends to use protecting Mother Nature to find the sustainable problem (*Kallima inachus* may be endangered). **Figure 10** demonstrates the final formation of the design scheme '*Kallima inachus*' for a sustainable DT process based on a design concept. Colour, material and construction adjustments were made based on factors specific to the target situation.

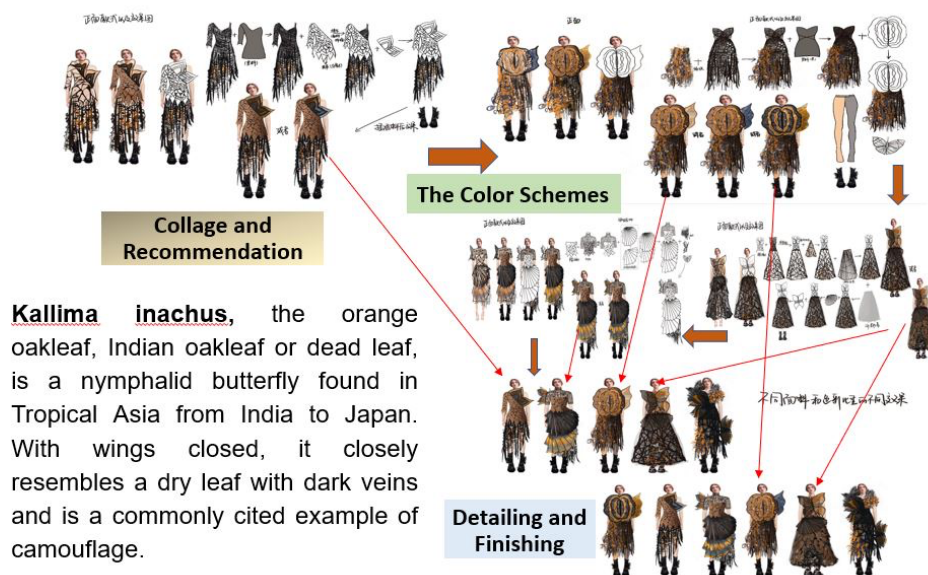


Figure 10. An ideation of the design scheme named '*Kallima inachus*'

(Source: Cheng Anni, a fashion design student of HIE, Study period:2017.9-2021.6, Advisor: Zuo Shuangxi)

Designers select a clue or idea of ‘protecting mother earth—endangered animals—*Kallima inachus*’ to develop the design scheme after generating many ideas from design keywords. In the *Prototype* mode, the designer creates elements of *Kallima inachus*'s texture and colour as *prototype* to create innovation design works.

Agency—the final ‘*Kallima inachus*’ design scheme (see **Figure 11**) was generated quickly that involved how sustainable problems find a voice to protect our mother earth. DM-B can be more figurative and attractive in the SFD. **Figure 11** shows the design scheme named ‘*Kallima inachus*’ for a sustainable DT process based on a design concept. At the design process, designers explored various related sustainable problems based on sustainable solutions and collected many solutions and then selected the best plan that can be achieved to perfect and form a prototype.

Detailing and Finishing of “*Kallima inachus*”



Figure 11. An ideation of the design scheme named ‘*Kallima inachus*’

(Source: Cheng Anni, a fashion design student of HIE, Study period:2017.9-2021.6, Advisor: Zuo Shuangxi)

4.3 Discussion

The design practices of this paper followed the theoretical framework of bi-directional design method in SFD in Section 2.3 to develop students’ DT and expand sustainability conception. Bi-directional methods supplied two alternative starting guidelines for students: from sustainable problems to sustainable solutions (DM-A) and from sustainable solutions to sustainable problems (DM-B). Bi-directional methods changed the traditional single way of

thinking that designers apply the only problem-oriented finding to search appropriate solutions. However, DT is also a practical approach to explore design conception if the design starts with existing solutions to discover problems.

We applied DT in the SFD in practice, which involves *empathy, define, ideate, prototype and agency*. We have analysed and discussed these contents of sustainable problem, design theme, design inspiration and sustainable solution in DM-A and DM-B in Sections 4.1 to 4.2. Through design practice, the design concepts formed by the two design methods are different. DM-A is based on the current negative issues to consider using advanced or innovative design to achieve sustainability. This type of design uses abstract DT to associate and diverge into concrete things at the stage of design concept formation. For example, during the problem analysis stage, the 'Self-salvation' theme groups tended to use the pollution of material to find the sustainable problematic situation. They obtained a design clue based on the 'help' abstract keyword to advance their DT. DM-B tends to search the sustainability solutions to find some new problems. They attempt to advance the design scheme through analysis of the existing solutions because of considering sustainability. DM-B depends on positive thought (mindfulness) to develop design concepts and thinking(25). For example, the '*Kallima inachus*' theme tended to select organic cotton and wool as material to achieve sustainability by positive thought (mindfulness) at design starts. The theme is specific DT from specific issues using bionic design or mirroring from Sister art and ideal vision. These design guidelines will provide designers with valuable inspiration and creative concepts when expressing design concepts and themes.

The current fashion has played the most significant and most lively industries in the world. Designers create a product that aims to make the world better and valuable. Sustainable fashion performed the sustainability approach to innovation products. In addition, sustainable fashion emphasises the vital craft technique and emotions designers put into it. FD is a synthesis of architecture, DT, philosophy and the social sciences. The course of creative design is integrated into a sustainable concept as a practice to cultivate creative design capacity for fashion students of HIE. The aim was to wake up our students to the possibilities the present world offered fashion designers. The students attempt to address textile and apparel overconsumption and waste problems through their design work because sustainability is essential in this design project. The generating inspiration is robust and extensive after sustainable DT is transferred into design task as seeds. Therefore, SFD can be an agency for communication and show the aesthetic and values by creative DT (24).

Bringing FD into the context of sustainability is similar to opening Pandora's box. Because fashion has many phases, including conception, design, production, market, consumption and eventual disposal, most decisions made by designers may indicate socially-minded views and perceptions since designers play an influential role in the fashion industry. However, problem-solving and finding solutions are at the heart of design; this practice supplies some significant attempting designs in the sustainable fashion field, which involved original designs and materials utilisation (sustainable materials, recycle, upcycle, reuse), and so on. Therefore, the bi-directional design method is considered an SFD model since it can achieve co-design, iteration design and circular design in sustainable fashion.

5 Conclusion

This paper explored DT in the sustainable fashion. It developed ideas on the sustainability of design in fashion and explained how bi-directional methods could help designers create design works. We obtained many sustainable knowledge on how sustainable fashion can design valuable products through the creative design course and design practices. Following the analysis conducted on the sustainable fashion, DT and bi-directional design method and proposing a theoretical framework of the bi-directional design method in SFD, then applying the framework to explore and practice as a case study of the FD process at HIE. The key findings are listed below:

- This work showed a series of generating the DT process from sustainable activities in the fashion industry. Integration of sustainability into DT (empathy, define, ideate, prototype and agency) can develop the design scheme by design theme, design inspiration, sustainable problems and sustainability solutions.
- Design practices utilised bi-direction methods to advance the innovation of design work using sustainable DT. The method is considered an SFD model since it can achieve co-design, iteration design and circular design in sustainable fashion.
- SFD can be an agency for communication and show its aesthetic and values by creative DT.

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