

# Development of Sustainable Fashion Design Education Program

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## Abstract

**Background** Today's fashion is facing the environmental pollution and numerous countries and corporations have been attempting to solve such issues. Sustainable fashion is a measure to solve the issue that we are facing and is one of the most actively studied and utilized design methods. As the importance of sustainability has been more highlighted in the fashion industry, it indicates that it is necessary to conduct specific research such as the design of education programs for the continuous expansion and multidimensional practice of sustainable design education in the fashion industry. This study aims to systematize sustainable fashion design methods and processes, and to design and propose sustainable fashion design education programs.

**Methods** This study categorized sustainable fashion design methods through research on sustainable fashion based on reference materials such as specialized books, dissertations, and academic research journals. To present a sustainable fashion design process and to propose a sustainable design education program model, this study analyzed specific sustainable design methods that can be utilized in each design stage. For the evaluation of the educational process for the development and education application of sustainable fashion design education programs, a project was conducted to produce sustainable fashion design works was conducted. We performed an expert evaluation of the design results and processes of the project, in order to conduct an evaluation of the appropriateness of the systematized sustainable fashion design method and a sustainable fashion design education program course.

**Results** This study systemized representative factors of design strategies and activities that should be considered in sustainable design activities and categorized sustainable fashion design methods into 'utilization of eco-friendly sustainable materials' and 'utilization of eco-friendly sustainable manufacturing methods.' The sustainable fashion design processes were designed by dividing into the stages of 'problem identification and research, ideations, design development, design evaluation, and implementation'. To variably implement the 'utilization of sustainable materials and manufacturing methods', the most differentiated factor in the fashion design process, in the design process, design processes were suggested by subdividing design development processes in a more differentiated manner. In addition, based on the analysis of the structure of the sustainable design education program, a sustainable fashion design education program that can be used more specifically and practically in the fashion design practice process, was presented, and a study was conducted to verify and evaluate its appropriateness and utilization.

**Conclusions** The guidelines for sustainable fashion design methods and processes presented in this study went exceed the general fashion design methodology, systematized a more expanded concept of sustainable design and a complex design approach, and suggested an education program model from an intergrade design perspective to consider and apply sustainability in a circular structure. To develop design methods and processes that can simultaneously expand the aesthetic factor of design in a balanced way along with the design elements that must accompany for the special purpose of design, the fashion design process is designed to prevent the purpose of sustainability from acting as obstacles to the design concept, and education programs are systematized so that the design method could be selected according to purposes. This study is significant for the following reasons. While moving beyond the general fashion design methodology, a design approach with a more expanded concept of sustainable design is systematized. This study also proposes the approach as an education method with an integrated design perspective. The method can be utilized as a reference for sustainable fashion education methods.

**Keywords** Sustainable Design, Integrated Design, Sustainable Design Process, Design Method, Design Education

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## 1. Introduction

### 1. 1. Purpose and significance of this study

The eco-friendly concept has been developed and expanded to the 'Sustainable' concept and is currently being studied in various manners; this concept has been expanded and developed while considering nature and humans, and simultaneously, sustainability by applying environment friendliness, economic suitability, and social fairness. Today's fashion is facing the environmental pollution issue due to the habit of easily purchasing and discarding products, and the stages of production, consumption, and disposal of products; numerous countries and corporations have been making efforts to solve such issues. Sustainable fashion is a measure to solve the issue we are facing, and one of the most actively studied and utilized design methods; the 21<sup>st</sup> century fashion industry has changed its paradigm towards sustainability in consideration of the environmental impact and social- and ethical responsibilities. According to this paradigm transition, sustainable fashion is divided into three stages of production, use, and disposal from a perspective of a product lifecycle; active research is underway to make it possible to realize sustainable fashion from production and manufacturing processes to use and disposal processes (Hethorn, 2008). As the importance of sustainability has been more highlighted in the fashion industry, there have been several studies: sustainable fashion design cases and design methodologies (Kwon & Nah, 2019; Gwilt, 2014; Lee et al., 2013; McQuillan & Rissanen, 2011; Syn, 2011; Lawson, 2006; Fletcher & Grose, 2012; Kim & Lee, 2021; Oh, 2017; Kook & Kim, 2016; Kim & Na, 2015; Kim & Yeom, 2013; Fransson, 2010), sustainability fashion marketing studies (Shen et al., 2013; Koh & Lee, 2020; Kim, Park & Lee, 2016; Park, 2016; Son, 2016; Son & Yoon, 2016; Paiket al., 2014; Jung, 2013; Yoon, 2013; Brezet & Van, 1997), and research on fashion design education for sustainability (Lee et al., 2017; Cho & Lee, 2015; Do, 2015; Lee & Choy, 2014; McKeown, 2002). Although studies on fashion design education from a sustainable design perspective have recently been increasing, there has been insufficient research on practical training methods and education programs that can be operated in the educational field. It indicates that it is necessary to conduct specific research such as the design of education programs for the continuous expansion and multidimensional practice of sustainable design education in the fashion industry.

In this regard, this study attempted to examine cases of sustainable fashion design and various approaches to sustainable fashion design, to organize and analyze them, to classify and analyze design methods that can become guidelines for realizing sustainable fashion, and to analyze the characteristics. This study aimed to examine fashion design methods and their characteristics from a sustainable perspective considering such factors as social fairness, economic suitability, and environmental friendliness, and to study more specific implementation plans. Through this process, we attempted to present a design process and design education program model that can become a guideline for specific sustainable fashion design necessary to realize sustainable fashion in a more diverse manner. By presenting the direction and method of fashion design based on the eco-friendly paradigm, this study attempted to suggest a design education program that has eco-friendly utility and enables creative design thinking, and that naturally induces interest and actively approaches sustainable fashion design in the design and production processes. This study

has significance in methodological aspects - freely expressing aesthetic formativeness and simultaneously creating sustainable fashion design-, and it can be an important basic data for sustainable fashion design education.

## **1. 2. Structure and method of this study**

This study suggests a sustainable fashion design education program model, by analyzing the concept and current status of sustainable fashion based on general considerations of sustainable fashion, establishing the characteristics of the design methods, and studying the methods and processes of sustainable fashion design that can be used as a realistic implementation plan. This study mainly focused on the design, implementation, and evaluation of education programs that can be operated practically in the educational field, based on research on fashion design methods and processes with sustainability in consideration of the impact and responsibility on the environment and society in the entire process from planning, production, and disposal. The details and methods of this research are as follows.

First, the concept and status of sustainable fashion design were considered, and its value was defined through research on sustainable fashion based on reference materials such as specialized books, dissertations, and academic research journals.

Second, fashion cases were classified and analyzed by each type from a sustainability perspective, and design methods and characteristics found in the analyzed types were studied.

Third, this study presented a sustainable fashion design process based on research on fashion design processes and planned and proposed a sustainable design education program model through specific sustainable design methods that can be utilized in each design stage.

Fourth, for the evaluation of the educational process for the development and education application of sustainable fashion design education programs, a project to produce sustainable fashion design works was conducted through lectures, presentations, discussions, and practical work for 16 undergraduate majors in design for 15 weeks. Through comparative analysis of the differences between the design results and the design processes according to each method, the differences between the design elements considered in the two sustainable design methods and processes, presented in this study, were analyzed in terms of aesthetics and sustainability. To analyze the two types of sustainable fashion design process and the design outcomes, experimental analysis coding method were developed based on the meta-analysis method (Lee & Danko, 2017). Sustainable design evaluation checklist was developed based on the FEA proposed by Lamb and Kallal (1992) and common factors for sustainable design.

Fifth, this study performed an expert evaluation of the design results and processes of the project, so as to conduct an evaluation of the appropriateness of the systematized sustainable fashion design method and the sustainable fashion design education program course. The expert evaluation consisted of an evaluation of the aesthetics and sustainability of the design results, and of the appropriateness of the two sustainable design methods and design education courses. The evaluators consisted of three experts with more than 10 years of experience in fashion design education at the university. In terms of the evaluation's content, there was an assessment of aesthetics, creativity and sustainability factors of design outputs based on sustainable fashion design process types, as well as a descriptive assessment of the

design process's suitability for developing an inclusive design education program. Based on the evaluations of the sustainable fashion design process model by experts, insights about the sustainable fashion design process for educational application were derived.

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## 2. Theoretical background

### 2. 1. Sustainable design

The concept of sustainability was derived from Sustainable Development, a concept first presented at the World Commission on Environment & Development (Brundtland) held in 1987; “sustainable development is the development that meets the need of the present generation without compromising the ability of future generations to meet their own needs” (United Nations General Assembly, 1987). Sustainable design is a progressive eco-friendly design emphasized in the 21st century, meaning that human society has the opportunity to develop freely in harmony with the surrounding environment without destroying the possibilities of future generations due to the need of the present generation (Kim & Lee, 2006); it can be also defined as a design concept with an environmentally friendly feature in combination with social responsibility for the environment, a long-term perspective on environmental protection, and innovative science and technology.

Oh (2017) classified sustainable design strategies into seven categories: innovation, society, materials, production, transportation, use, and disposal; design that successfully implemented sustainability satisfies more than two items among those seven strategic items, simultaneously. Therefore, this study attempted to identify strategic items that fashion designers and students majoring in fashion design can conveniently access and intensively use in the design process, through the analysis of the seven strategic items of sustainable design and details and set them as the main design strategic items in designing guidelines for designing sustainable fashion design processes and educational programs. Fig. 1 shows the extracted items that can be mainly used in the seven sustainable design strategic items and fashion design processes.

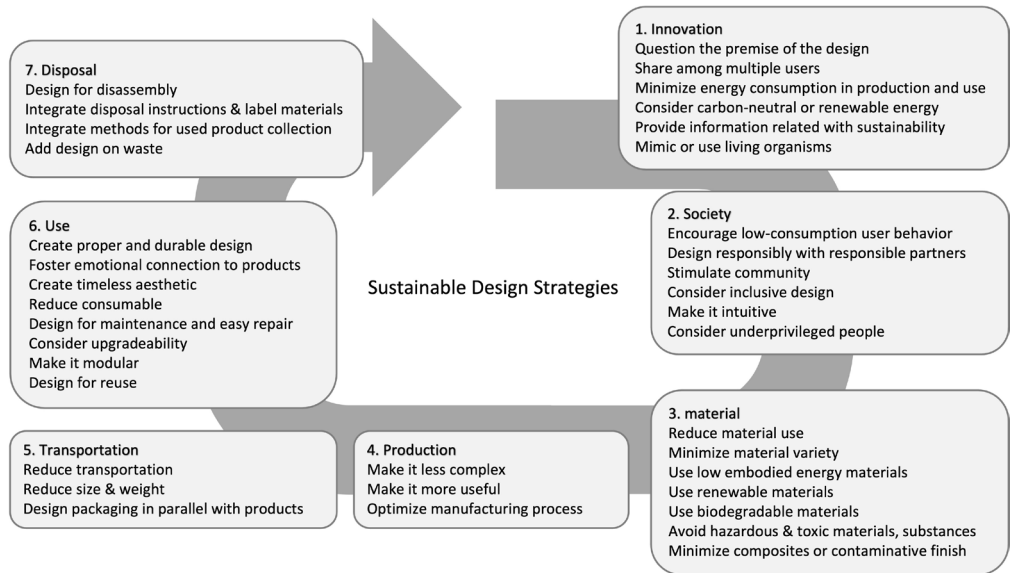


Figure 1 Sustainable Design Strategies (Oh, 2017)

## 2. 2. Sustainable fashion design

Sustainability in fashion is defined as not destroying the environment in the manufacturing process of products and reducing the waste of non-renewable resources; it also means that clothes can go back into the environment when their functions are completed (Brown, 2010); it can be defined as having social responsibility and environment-friendly value for all practices related to fashion design. Sustainable fashion design is a fashion design concept that goes beyond the simple use of eco-friendly materials and product recycling, and considers economic aspects (i.e., the entire process from the production of materials, the manufacturing process and distribution, use and disposal, and to post-disposal of products, as well as environmental and social aspects (Syn, 2011). This concept of sustainable fashion design has recently started to be applied in earnest to the fashion industry, and there has been diverse research to realize the concept and value of sustainable fashion design considering the correlations between environmental, economic, social, and ethical factors in the fashion design process

Sustainable fashion refers to a fashion design developed based on continuous perception and awareness of environmental issues. It also refers to design activities that have competitiveness in terms of design function and quality, minimize waste and environmental burden, and preserve a pleasant environment by applying the principle of cyclic processes of nature. Therefore, sustainable fashion design values design development in consideration of the impact and responsibility on society and the environment, taking into account environmental, economic, and social factors, and pursuing a design process equipped with a recycling and circular system.

## 2. 3. Sustainable fashion design education

As for the cases of sustainable fashion education that have been tried by Korean and foreign educational institutions, government agencies, social enterprises, and various social groups, sustainable fashion education programs are being actively operated mainly in the United

States, the United Kingdom, and Germany. In the case of the Department of Fashion Design at US universities, seminars on sustainable fashion are adopted as a compulsory subject, and in addition to the curriculum, various sustainable fashion courses are being operated (e.g., sustainable fashion workshops with experts, and professional certification courses) to teach sustainable fashion (Lee & Choy, 2014). In the UK, programs for training professionals in sustainable design are actively operated through creative and environmentally friendly textile design education. In addition, in cooperation with fashion companies, program organizers support sustainable fashion-related education and R&D activities, strive to provide solutions for sustainable fashion, and continuously educate students on a broader understanding of environmental issues from a social, political, and economic perspective by running sustainability education programs. (Lee et al., 2017). However, most educational activities are centered on social enterprises or non-profit organizations (Do, 2015). There has been no educational attempt to systematically operate sustainable fashion-specialized education programs in universities as a regular curriculum. A study on design education programs to increase sustainability in the fashion industry is essential in that it can suggest a new paradigm change that can solve the environmental problems faced by modern society. Therefore, this study suggested methods and design processes of sustainable fashion design, and based on this, attempted to present fashion design education programs that enable creative design thinking, and simultaneously, have the utility of sustainable design in the design process and production process.

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### 3. Study on types and processes of sustainable fashion design

#### 3. 1. Sustainable fashion design elements

This study attempted to systematize design elements that should be considered in the evaluation of sustainable fashion design, in order to present design development guidelines and processes for utilization in design education. According to Lee (2013), the most commonly used evaluation methods for evaluating sustainable design are LCA (Consoli et al., 1993), Eco design Wheel (Keoleian and Menerey, 1993), and MET Matrix (Brezet and Van Hemel, 1997); the common elements derived through comparative analysis of such evaluation methods are 'Materials', 'Manufacturing', 'Distribution', and 'Use.' In sustainable design, the concept of 'Materials' is an extended concept from a simple dictionary concept, has the greatest influence throughout the entire design process, and has the characteristics of circular system; it is also highly related to concepts such as how to not contaminate the environment, recycling of chemical materials, and reuse, and there are numerous related studies. 'Manufacturing' is closely related to materials and refers to activities that can reduce material waste and environmental pollution and is a key factor that should be considered from the initial stage of the fashion design process. 'Distribution' is the stage in which produced products are transported to consumers and seeks to introduce various methods to reduce environmental pollution factors that occur during transportation, and to reduce energy costs. The main actors in the 'Use' phase are consumers and users, and the phase indicates specific activities that occur throughout the stages of use after purchase, and disposal. It presents a method to induce to minimize energy consumption in the process of

using clothes (Lee et al., 2013).

In this study, we systemized detailed items that should be considered for each element based on representative four design elements (i.e., Material, Manufacturing, Distribution, Use), on the basis of the studies on design strategy elements applied to sustainable design guidelines (Kim, 2011; White. et al., 2013, Oh, 2017) and sustainable design activities leading sustainable design (Consoli et al., 1993; Keoleian & Menerey. 1993; Brezet & Van Hemel, 1997; 2013, Lee et al., 2013). Fig. 2 systematized ‘main considerations for sustainable design’ applicable to the guideline for the sustainable fashion design process, and this also can be applied to the sustainable fashion design process.

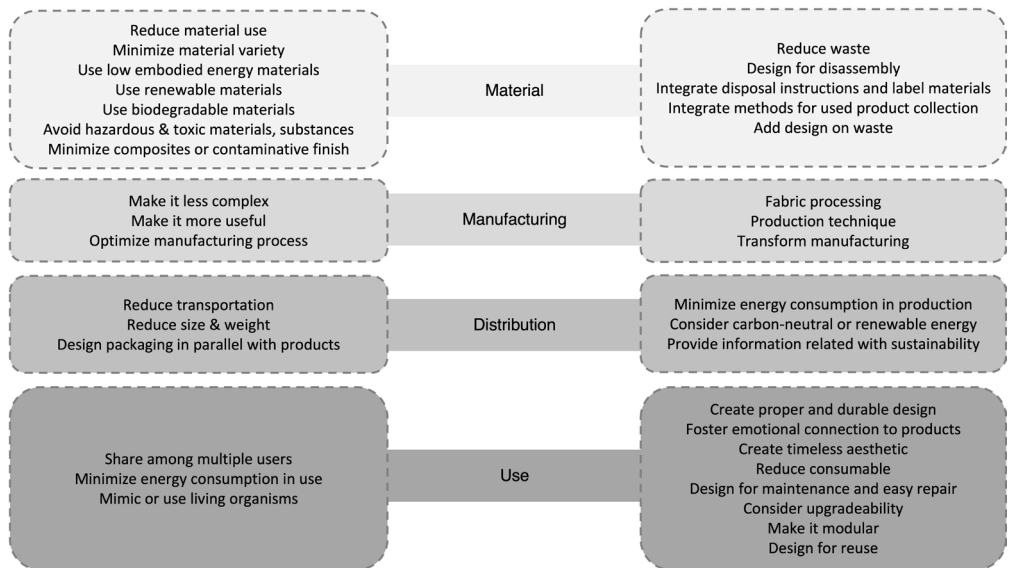


Figure 2 Common factors for sustainable fashion design

### 3. 2. Types of sustainable fashion design

Various methods have been proposed to realize sustainable fashion design. Fletcher (2008) indicated that the use of diverse materials, ethical production, eco-friendliness and economic feasibility of use, reuse/recycling/zero-waste, local production, lighter materials, and participatory design should be considered to realize sustainable fashion design.

From a perspective of a product lifecycle, sustainable fashion is largely divided into three stages: production, consumption, and disposal. In the ‘production’ stage of these three phases, ethical practice, the use of eco-friendly materials, and the minimization of fabric waste are suggested to realize sustainable fashion design; this phase also requires the minimization of environmental impacts in the production process (e.g., less use of energy, water, and toxic chemicals, and minimization of chemical emissions in wastewater (Fletcher, 2008). In the ‘consumption’ phase, eco-friendly use is presented as a practical measure, and eco-friendly use means a longer use cycle of a product and the prevention of increasing waste caused by frequent purchases. In addition, flexible wearable designs, the exclusion of unnecessary design elements, and the simplification of frequent washing are presented as concrete measures. In the ‘disposal’ stage, recycling of disused products, and eco-friendly disposal method are presented as practical specific measures. Recycling is a method of reusing waste, including dismantling only forms and using materials as they are and there

have been several attempts to re-create new materials via a special treatment of waste in various ways. Eco-friendly disposal means that energy consumption when disposing of products should be lower and the method should be eco-friendly. As such, sustainable fashion design can be considered a new paradigm of eco-friendly fashion design that takes into account the environment, economy, and ethics in the entire process including production, consumption, and disposal of products.

Sustainable fashion design methods can also be classified into five categories: eco-friendly material use, recycling design, design for minimizing textile waste, slow fashion design, and multifunctional design (Nam, 2010). The use of natural, recycled, or biodegradable fibers can control toxic gas emissions upon disposal. Recycling design, which reuses and reforms used clothes, creates new value. Design for minimizing textile waste can contribute to reducing waste treatment and environmental impacts by conserving textile resources. Slow fashion design aims for producing high-quality handmade products, which lead to higher product value and longer lifespan. Finally, the multifunctional design can increase product efficiency and prevent resource waste through a higher frequency of use. Therefore, sustainable fashion design can be classified according to the characteristics of various realization methods. Based on previous studies (Kim & Lee, 2006; Fletcher, 2008; Dresner, 2008; Brown & King, 2010; Nam, 2010), this study classified feasible sustainable fashion design methods in the phases of 'production, consumption, and disposal' into two types based on features (see Fig. 3).

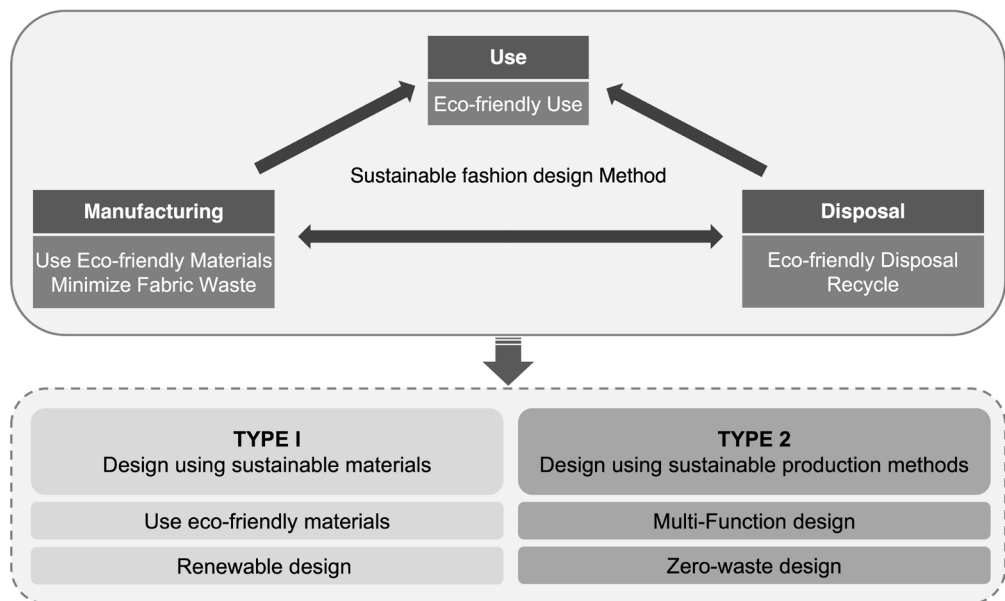


Figure 3 Type & Method of Sustainable fashion design

The first type is a fashion design method that uses environmentally friendly and sustainable materials, which are made of materials that do not cause pollution from production to disposal, such as natural fibers and regenerated fibers made from biodegradable polymers, or that create a sustainable design in the material production process. Methods of continuously obtaining materials without polluting the environment encompass a dyeing



method that reduces pollution, re-collecting raw materials from nature and developing eco-friendly materials harmless to nature, and a method of maximizing the utility of materials by minimizing waste; they also include methods to maximize the efficiency of materials, via reproduction that prevents resource waste and realizes energy-saving effects, and re-creation of new materials through recycling, which contributes to preventing resource waste and realizing energy saving effects. The second type is a method that utilizes an eco-friendly and sustainable manufacturing method; new functionality and design value can be given through transformation of various uses, and transformation is possible according to various purposes, uses, and functions; multi-function fashion, the method of producing designs that can be utilized as complex and multi-functional design, and zero-waste fashion, the method of planning and producing in order not to generate textile waste in the production process, belong to this type. Based on previous studies (Gwilt, 2014; Cho & Lee, 2015; Kim & Na, 2015; Kook & Kim, 2016; Kim & Lee, 2021), the types of sustainable fashion design methods focused on sustainability were classified and analyzed in more detail (see Table. 1).

Table 1 Type of Sustainable Fashion Design Methods

Type	Specific Type	Detailed methods	
Design using sustainable materials	Design using eco-friendly materials	Dye with germs (clone and incubate DNA of animals and plants)	
		Dye with green algae (incubate green algae)	
		Seaweed (incubate microalgae)	
		Wood-peel/Bamboo-peel (mixed wood fiber and plastic resin)	
		Bioplastics (100% biodegradable material Using Glucose)	
		Bio-fabrication (Bacteria incubation, Biodegradable fiber cultivation)	
	Renewable Design : Create design value through reproduction, reuse, recycle	Re-create using fabric swatches and end-of-life clothes (From Somewhere)	
		Create surplus clothing, not waste clothing (Trash to Trend)	
		Recycling factory work clothes, advertising banners, boat sails, etc. (Globe Hope)	
		Redesigning that give new fashion value to disposal Clothes (RE:CODE)	
Design using sustainable production method	Multi-Function Design : Complex, multi-functional design that can be transformed for different purposes, applications, and functions	Multi-functional design to combine clothes and items that can be converted into unique props (C.P.company)	
		Designs that can be converted to multiple items by being worn in many ways (MOJA MOJA)	
		Functional design that can be transformed for various purposes (Hussein Chalayan)	
		Designs that can be transformed into various shapes (Rohan Chhabra)	
	Zero-waste Design : Design to plan and produce no fabric waste	Fabrication method to minimize fabric loss of 15-20% during the Cut & Sew manufacturing process	A-POC, Puzzle Cutting, Subtraction Cutting, Fold Cutting, Figure Cutting, Module Cutting
			Garment Molding
			Non-woven manufacturing
		Use Converting	Knitting, Weaving
			Rebuild with surplus products and re-purpose them to be recreate as new products

### 3. 3. Sustainable fashion design process

This study intended to design a sustainable fashion design process model based on an understanding of existing fashion design processes, and to present a sustainable fashion design method that can be applied and utilized for each step of the design process. Therefore,

this study summarized general fashion design process model types based on a literature review of existing fashion design processes (see Table. 2). Watkins (1988) defined fashion design processes based on Koberg and Bagnall (1981) as follows: ‘Seven stages: Accept, Analyze, Define, Ideate, Select, Implement and Evaluation.’ Lamb and Kallal(1992) developed a fashion design process model by integrating the design process models of Koberg and Bagnall(1981); Hanks, Belliston, and Edwards(1977); and Watkins (1988), based on the consumer needs model on the basis of Functional-Expressive-Aesthetic (FEA) factors; this model consists of six steps, such as Problem identification, Preliminary ideas, Design refinement, Prototype development, Evaluation, and Implementation. Franson (2010) organized the previous fashion design process model into four stages: Generate design idea, Sketch & Construct the first garment, Evaluate feasibility & Plan production, and Implement plans & Re-evaluate; LaBat and Sokolowski (1999) defined fashion design processes as three main stages, based on the analysis of the design process models of Koberg and Bagnall(1981); Hanks, Belliston, and Edwards(1977); Watkins(1988); and Lamb and Kallal(1992). The problem identification and research stage include definition of initial problems and research or definition of design problems; the creative exploration stage includes preliminary ideas, design refinement, and prototype development and evaluation; the final phase encompasses design improvement, immediate production, and implementation via improvement/maintenance. Gwilt (2012) organized collection design processes of sustainable fashion designers as follows: research, collection design and editing, materials, selection of materials and techniques, pattern production and fitting, sample production planning, and final selection.

Table 2 Previous fashion design process models

	Watkins (1988)	Lamb and Kallal (1992)	LaBat and Sokolowski (1999)	Franson (2010)	Shina (2002)
<b>stage1</b>	Accept Analyze Define	Problem identification	Problem definition & Research	Generate design idea	Market & trend research design research
<b>stage2</b>	Ideate	Preliminary ideas	Creative exploration	Sketch & Construct first garment	Designing & editing the collection Fabric, materials, techniques selection
<b>stage3</b>	Select	Design Refinement	Implementation	Evaluate feasibility & Plan production	Pattern making & costings
<b>stage4</b>	Implement	Prototype development		Implement plans & re-evaluate	Producing the sample making
<b>stage5</b>	Evaluation	Evaluation			Selection
<b>stage6</b>		Implementation			

This study constructed a sustainable fashion process model, based on Table. 2 which analyzed previous research models on fashion design processes, and Table. 1 that classified and categorized sustainable fashion design methods focusing on sustainability. The sustainable fashion design processes suggested in this study consist of four stages of ‘Problem identification and Research, Ideation, Design development, and Design evaluation and implementation.’ In Fig. 4, this study summarized and presented processes of sustainable fashion design processes and details of each stage. As the utilization of sustainable materials

and production methods is essential and crucial in sustainable fashion design, we designed while considering the establishment and utilization of concepts on differentiated two types of sustainable fashion design methods in the entire design process: a method of utilizing sustainable materials (Type 1) and a method of utilizing sustainable manufacturing method (Type 2). Based on the conceptual understanding of those two types of fashion design methods that can realize sustainability, we considered sustainability from the initial stage of design processes and made it possible to expand design ideas. In addition, the detailed design processes were designed as ‘design textile and ideation of sustainable materials’ and ‘design garment and ideation of sustainable production methods,’ so that those two sustainable fashion design methods can be practically practiced in the design development process, and that one can experience those methods, and resultantly, and sustainable fashion design ideas can be further developed into extended concepts. Therefore, the sustainable fashion design process in this study has the distinction in that it enables exploring not only the trend, aesthetic, and creative elements that are the focus of the general fashion design process, but also the expansion of various ideas and differentiated approaches toward sustainability.

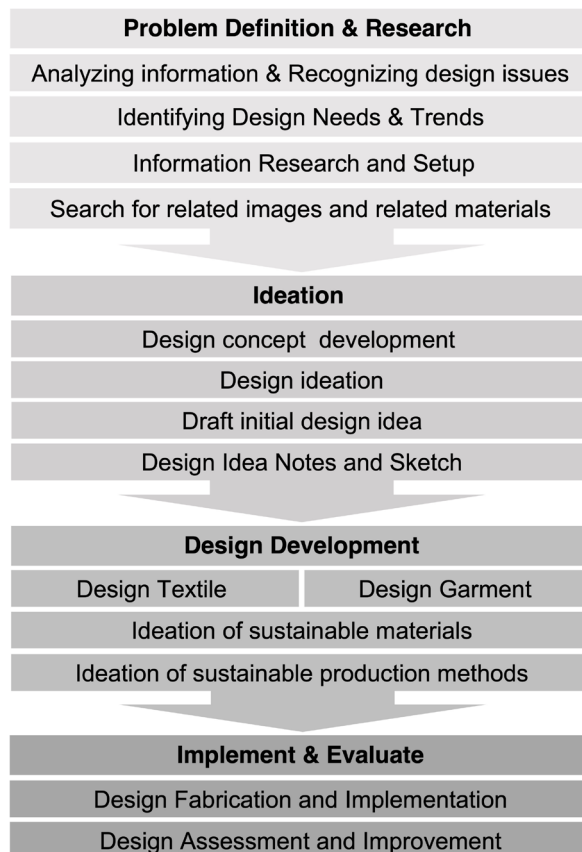


Figure 4 Sustainable fashion design process

## 4. Development of sustainable fashion design education programs

### 4. 1. Educational goals of sustainable fashion design education programs

Sustainable fashion design education aims to educate students on how to explore fundamental values and possibilities of sustainable development, recognize social issues, and find solutions to problems, beyond simply educating how to implement sustainable fashion design. The right education on sustainability has a future-oriented value in that it can lead to a change in the perception of students who will become design professionals in the future and more expanded design skills, by sharing new ideas about sustainable design and expanding the scope. Therefore, this study aimed to inspire the sustainability concept and to develop sustainable fashion design educational indicators, and to suggest the direction of sustainable fashion design courses. In this sense, this study developed a sustainable fashion design program for college students majoring in fashion design, based on research on the concept of sustainable fashion design, and design methods and processes.

### 4. 2. Structure of sustainable fashion design education program

The main elements of sustainable design education are Awareness, Skill, Internalization, and Action; the education aims to induce sustainable behavior change in students (McKeown, 2002). According to Lee (2017), in sustainability-related education, the content, difficulty levels, and program composition of education can be variably adjusted according to the subject of education, and an expandable modular education program frame can be constructed to implement it. Therefore, in this study, based on the frame of a modular education program according to levels of education targets suggested by Lee (2017), we attempted to suggest education programs suitable for the level of design majors, and structure for sustainable fashion design education program centered on practice; given that, we adjusted and constructed difficulty levels and content of education. Based on previous studies (McKeown, 2002; Kim, 2014; Lee & Choy, 2014; Do, 2015; Lee et al., 2016), this study divided the structure of the sustainable fashion design education program into five phases (see Fig. 5).

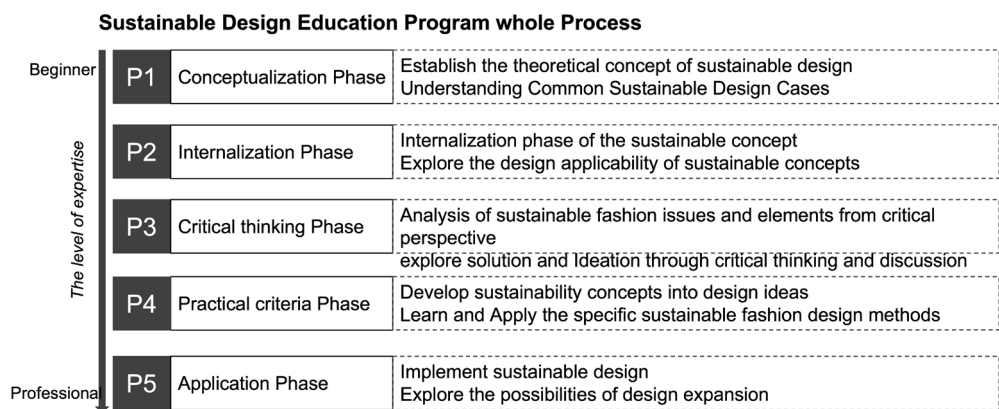


Figure 5 Framework for sustainable fashion design education program

The sustainable fashion design education program in this study consists of five steps: P1 ‘Phase of establishing a theoretical concept on sustainable design’, P2 ‘Internalization phase of sustainability concept’, P3 ‘Phase of exploring solution via critical thinking’, P4 ‘Phase of developing sustainability concepts into design ideas’, and P5 ‘Phase of implementing practical sustainable design.’ P1 is a stage that mainly handles the concept and understanding of sustainability and understanding of general sustainable design cases, and that establishes the theoretical concept of sustainable design. P2 is the internalization phase of the sustainability concept, focusing on finding ways to actually apply the sustainability concept through linking sustainability-related cases that are actually taking place, with application methods. P3 is the phase to seek solutions and propose ideas through analysis based on critical thinking on sustainable elements and sustainable methods found in concrete cases of sustainable design. P4 is the phase in which the sustainability concept, elements, and methods are connected to sustainable fashion design ideas, and through this, the sustainable concept is naturally developed into design ideas. P5 is the phase to expand the sustainability criteria, specific guides, and methodologies of the actual design planning, production, and consumption processes, and to explore the practical implementation of sustainable design and the possibility of design extension as a product.

### 4. 3. Planning sustainable fashion design education program courses

Based on the structure of the sustainable fashion design education program consisting of a total of five stages proposed in this study, we planned a 15-week educational program course that can be operated in universities. The course started from the phase of establishing theoretical concepts at Weeks 1-2, handles the phase of design problem identification and research at Weeks 3-4, the phase of ideation at Weeks 5-6, the design development phase at Weeks 7-10, and the phase of design implantation and evaluation at Weeks 11-15. The details of the 15-week sustainable fashion design program course were summarized in Table. 3.

Table 3 Sustainable fashion design education program

	Design Process	Course	Course contents
1	Conceptualization	Conceptualization of Sustainable design	<ul style="list-style-type: none"> <li>- Establish the theoretical concept of sustainable design</li> <li>- Analysis Common Sustainable Design Cases study on the scope, characteristics, and methods of sustainable design</li> </ul>
2		Analysis of Sustainable fashion design	<ul style="list-style-type: none"> <li>- Case study Sustainable fashion design</li> <li>- Presentation &amp; Discussion the method of Sustainable fashion design</li> <li>- Analysis the characteristics and expandability of Sustainable fashion design</li> </ul>
3	Problem Identification & Research	Trends research	<ul style="list-style-type: none"> <li>- Fashion trends research</li> <li>- Research related to the aesthetics of design such as shape, material, and color</li> </ul>
4		Problem & Needs Analysis	<ul style="list-style-type: none"> <li>- Exploring design solutions</li> <li>- Finding ways to utilize material development &amp; pattern making methods</li> </ul>
5	Ideation	Design concept development	<ul style="list-style-type: none"> <li>- Overall design concept development</li> <li>- Develop sustainability concepts into design ideas</li> <li>- Produce Design Concept Board</li> </ul>
6		Design idea sketches	<ul style="list-style-type: none"> <li>- Design idea sketches related to textiles and shapes of design (planning design style, shape, color, material)</li> </ul>

7	Design Development	Design Textile	- Learn and apply the specific sustainable fashion design methods - Practice the ways to make sustainable textile making samples - Choosing and specifying materials, methods of fabrication - Material design refinement
8			
9		Design Garment	- Design collages and design sketches - Practice sustainable pattern making methods and making samples - Refining the design of garments using the pattern making method
10			
11	Implementation & Evaluation	Implementation	- Implement sustainable design - Explore the possibilities of design expansion
12			
13		Evaluation	- Evaluate final design
14			
15			

The details of each stage of the educational program courses and the process are as follows.

#### Stage 1 – Establishment of theoretical concept (Weeks 1-2)

In the first step, the theoretical concept of 'Sustainable' should be established, along with the theoretical concept and case analysis of sustainable fashion design. Through case analysis via accurate concept establishment and research, it is possible to explore various development possibilities of sustainable fashion design.

#### Stage 2 – Design problem identification and research (Weeks 3-4)

Fashion trend research design, materials, and colors related to design aesthetics should be researched so that sustainability can be considered and a design approach that considers emotional and aesthetic elements can be achieved simultaneously. Through the establishment of an accurate theoretical concept of sustainable design and case analysis of sustainable fashion design, specific sustainable fashion design methods that can be considered in the design stage, should be explored. Instructors should provide details (Table.1) that classified and analyzed types of sustainable fashion design types, enabling learners to explore sustainable fashion design methods and suggest specific and active solutions to problems for the development of actual materials and design.

#### Stage 3 – Ideation (Weeks 5-6)

Based on sustainable design methods and trend research, the overall design concept should be established. Design concepts and concept-related ideas should be derived. Design elements such as style, shape, color, and materials according to the concept should be specifically planned, a design concept board should be produced, and detailed design ideas related to material and form should be sketched. In the process, learners can try to solve problems more actively through practices for practical design development, along with theoretical lectures and discussions.

#### Stage 4 – Design development (Weeks 7-10)

Through material manufacturing method practice and sample production, material design should be more specific, and materials and manufacturing methods should be selected and specified. Through the practice of producing sustainable patterns for garment production and the practice of producing samples, the design production method should be selected and specified. In this process, an appropriate material selection and manufacturing method according to the design concept can be specified, and the design manufacturing method can also be selected and specified.

Stage 5 – Design implementation & evaluation (Weeks 11-15)

Finally, learners can proceed with the production of materials and garments with the selected and decided design. In the design production process, the following items should be considered: Has the sustainable fashion design method been properly used and implemented? Were the initial design concepts and ideas well implemented in consideration of formative characteristics and functionality? Such items should be evaluated, and the possibility and measures of design improvement can be explored through the final design evaluation.

The structure of the sustainable fashion design education program, which is composed of a total of five stages, is a structure in which the order and details of each stage can be changed in a more flexible manner according to the target and purpose.

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## **5. Implementation and Results**

### **5. 1. Implementation of sustainable fashion design education program**

For the evaluation of the educational process for the development and education application of a sustainable fashion design education program, this study conducted a sustainable fashion design project with 16 Y University students for 4 hours a week for 15 weeks from March 2022. This project consisted of lectures, presentations, discussions, and practices while sharing opinions with each other and trying to find the best way. In consideration of economic, social, cultural, and design features of sustainable fashion, sustainable fashion design work was produced.

This project suggested two differentiated types of design methods that can realize sustainability in fashion: sustainable fashion design method 1 (design method using sustainable materials) and 2 (design method utilizing sustainable manufacturing method). In the project, the sustainable fashion design education program course (Table 3), which was designed in this study, was utilized. To systematize the sustainable fashion design method, the differences between the design results and the design processes according to each method were compared and analyzed. An expert evaluation was conducted to analyze the differences in design elements considered in the two sustainable design methods and processes in terms of aesthetics, creativity, and sustainability, and to evaluate the appropriateness of sustainable fashion design methods and education programs. Evaluations consisted of an evaluation of the aesthetics and sustainability of the design results, and a descriptive evaluation of the appropriateness of the two sustainable design methods and design education courses.

### **5. 2. Expert evaluation of sustainable fashion design project results**

As for the expert evaluation of the sustainable fashion design process, the differences in design results according to the two differentiated types of sustainable fashion design methods were evaluated based on aesthetic & creativity, and sustainability factors; there was an evaluation of the appropriateness of the two differentiated sustainable design methods. Table. 4 presents a statistical comparative analysis of expert evaluations of design results in terms of aesthetics & creativity and sustainability. As a result of evaluating design results according to the Sustainable fashion design method types, the Type 2 method (6.1) was more highly evaluated in terms of aesthetics & creativity, compared to Type 1 (4.7). In

particular, in the evaluation of design form and silhouette, there was the biggest difference (i.e., Type 2 (6.7) and Type 1 (4.7)); the evaluations in terms of the implementation of new ideas and creative design approaches also showed a big difference (i.e., Type 2 (6.3) and Type 1 (4.7)). Type 2 was generally evaluated higher than Type 1 in terms of the implementation of design concepts, reflection of trends, and balance and harmony between design materials and colors. The rating of the Sustainability item was summed up similarly: Type 1 was 5.2, and Type 2 was 5.8; the sustainability of Type 2 outputs was evaluated higher. Among them, the difference in the evaluation of the reflection of the characteristics of sustainable fashion design was evaluated as follows: Type 2 was 5.7, and Type 1 was 4.7; it indicates the characteristics of sustainable fashion design were more reflected in the method using the sustainable production method. In addition, as for the evaluation of sustainable fashion material development and the utilization of the garment manufacturing method, Type 2 was 6.3, and Type 1 was 5.3, indicating that the sustainable fashion material development and applicability of the manufacturing method of Type 2 outputs were more highly evaluated.

Table 4 Comparative analysis results of Experts' evaluation of the design outputs

Evaluation items	Detailed evaluation items	Type 1	Type 2
Aesthetic & creativity	Implementation of the design concept	4.7	5.7
	Implementation of new ideas and creative design approaches	4.7	6.3
	Trends and Style	4.3	5.3
	Texture/Fabric/materials/Color combination and balance	5.0	6.3
	Design Shape and Silhouette	4.7	6.7
	Mean	4.7	6.1
Sustainability	Implementation of the concept of sustainable design	5.7	5.7
	Implementation of the characteristics of sustainable fashion design	4.7	5.7
	Implementation of sustainable fashion material methods & production methods	5.3	6.3
	Usability of sustainable materials (recycling, multi-function, zero waste, etc.)	5.0	5.3
	Mean	5.2	5.8

Table 5 shows the classified design results based on the two differentiated design methods provided to experts for design evaluation. As for the descriptive evaluation of the experts (E1, E2, and E3) on the results, both experts indicated that the two methods had common features in that both methods met the purpose of a sustainable fashion design method, but there were differentiated design intention and results depending on the type of design method.









In terms of the expert evaluation outcomes in detail according to the design type, it was evaluated that Type 1 seemed to focus on developing the design through methods such as collage, replacement, and linking of recycled materials to existing items, and implementing design to show material utilization and features of upcycled materials rather than focusing on other aspects such as the shape of clothes and way of wearing (E1). In addition, Type 1 had the feature of developing design by focusing on materials, a combination of materials, and use and usability of materials, and it was evaluated that an appropriate design expression that well uses and can use materials appeared in the results (E2). Furthermore, Type 1's design tended to focus on materials, so its formativeness was somewhat monotonous compared to Type 2, in terms of design silhouette and clothing composition; but it was evaluated as a method of deriving typical sustainable fashion design outcomes sticking to the basis by using



heterogeneous materials and scrap fabric, transforming, dismantling, and recreating existing clothing, and a method of expressing sustainable fashion allowing beginners to easily access (E3).

On the other hand, Type 2 seemed to be designed by reinterpreting and redesigning materials, compared to Type 1, creating a new material shape, and then linking the characteristics and design of the materials; it was also evaluated that it had a characteristic of suggestive design in terms of formative shape and new method of wearing. The design concept was expressed in a more balanced and harmonized manner while focusing on the diversity of design accesses and of materials for utilization (E1). Type 2 was evaluated as more focusing on structural aspects of design and production techniques rather than sustainable materials. Type 2 has fewer restrictions on the use of materials, which does not affect the harmony between colors and materials, so the students' intended design concept is more balanced and harmoniously expressed. In addition, to fit the planning intention of multifunctional, multi-form changes, visual differences have emerged, such as the structure of the garment being more complex than Type 1. Type 2 was evaluated as a method of creating a diversity of designs that generates a sense of balance between creative forms and materials in a way that the designer's new interpretation and formative characteristics are visible, although the characteristics of sustainable materials are not well found (E2). Type 2 was also evaluated as a design method that can try and apply various methods of completely using materials, and a method of obtaining insight on new methodological extensions about the combination and balance of diverse design access methods. Furthermore, since the sustainable fashion design production method presented in Type 2 does not change significantly depending on the design with a specific theme, even if the limited theme of sustainable design is given, relatively free design attempts can appear in the form of the diversity of functions and expressions (zero waste), according to an evaluation (E3).

Table 5 Design outputs according to the Type of Sustainable Fashion Design Methods

TYPE 1	TYPE 2
	
P1	P2
	
P3	P4
	
P5	P6
	
P7	P8



### 5. 3. Expert evaluation of sustainable fashion design methods and educational programs

As for the question about the appropriateness of the two sustainable design methods presented in this study, there were opinions that they were suitable for the purpose of a sustainable fashion design method. Along with opinions that it was interesting to classify sustainable fashion design methods based on materials and production methods, the sustainable design method that combined materials and production methods, made it

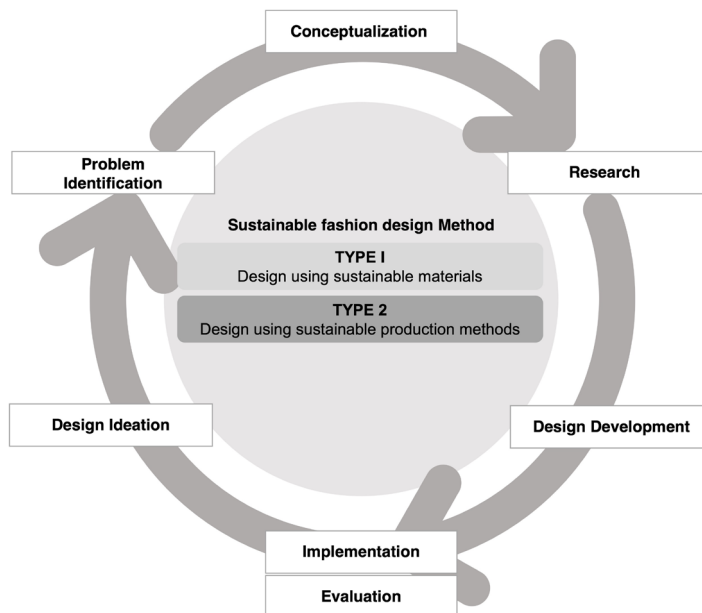
possible to know various approaches to sustainable fashion design in detail; it was also evaluated that it was a necessary method to expand the sustainability concept. Furthermore, experts gave a positive evaluation that systematic sustainable fashion design practice and education would be possible regarding the possibility of utilizing sustainable design methods and design processes that combined materials and production methods in the educational field. By providing a way to broaden the scope of thinking so that various problems can be solved creatively, it was evaluated that there would be various application possibilities. There was also an opinion that it would be good if the concept that sustainability could be approached from various methods and perspectives rather than a simple perspective of recycling materials, could be sufficiently conveyed in the curriculum. Sustainable fashion is an issue that needs to reflect the consciousness of various stakeholders from planning and producers to consumers as well; there were opinions on expanding the possibility of flexibly changing the composition of this study's education programs into more flexible programs targeting diverse stakeholders. There was feedback that it could become a more effective education method, if the possibility of variable composition of the education program according to the subjects of education is expanded. Due to the fact that the sustainable fashion design production method presented in this study was a method that focused on diversity rather than production methods focusing on mass production, there were other opinions that studies on other aspects (e.g., mass production and stability of properties) for industrial application and expansion would be needed; there was feedback that if various additional studies for industrial expansion are included in sustainable fashion education, there would be a higher social impact.

#### **5. 4. Development of a complex and sustainable fashion design process for fashion design education**

This study presented two types of differentiated design methods that can realize sustainability in fashion: 'design method using sustainable materials' and 'design method using sustainable production method'; through this process, this study attempted to enable accessing sustainability in more specific and diverse manners in the fashion design process. As a result of running the program course, it was evaluated that the specific presentation of two types of differentiated sustainable fashion design methods affected the design results. Based on the understanding of the sustainable design concept, it was found that the concept of specific design cases and design methods was expanded, and the practical practice process contributed to higher possibilities of sustainable fashion design. In the process of developing design, it was found that the two types of sustainable design methods resulted in differences in design results. Experiments confirmed that various practice processes on sustainable design methods can affect students' design approach and attitude, and that the design development process and design results can be different.

The sustainable fashion design process for education programs (Fig. 6) suggested in this study, went beyond the fashion design methodology that simply emphasizes the formative and aesthetic aspects, and systematized a more extended concept of sustainable design and a complex design approach. The sustainable fashion design curriculum with an integrated design perspective is presented, by designing the two types of an extended concept of sustainable design methods to be considered and applied as a more circular structure in the entire design process. From the initial planning stage of the design process, sustainability

and the characteristics and methods of sustainable design were designed to be accurately recognized; a structure was designed to include the attribute of sustainability as an extended concept from fashion design in the entire process. This leads to the transition of an existing general perception of fashion design, which mostly focused on aesthetics & creativity, and the expansion of thinking. In detail, the provision of information on the characteristics and cases of sustainability and the provision of information on the design method, and the timing of the practice process were set to be able to change flexibly; by suggesting differentiated design processes that allow to differently select and utilize the selection and utilization of design methods based on the purpose of the design, in the educational process, design flexibility can be enhanced. and a more balanced design process can be developed while the aspects of 'aesthetic and creative factors' and 'sustainability' coexist in a complex way.



**Figure 6** Sustainable fashion design process for education program

In the design curriculum, 'sustainability' is no longer just a design methodology based on trends or special purposes, but a holistic educational method that can solve social issues and pursue fundamental human values; it enables understanding of the meaning of coexistence between humans and nature, learning systematic and creative problem-solving methods, and furthermore, it can bring about a change in perception that realizes human values, by suggesting the role of fashion design in solving social issues. In terms of coexistence between humans and nature, as awareness of the role of fashion has increased, sustainable design education should present a more systematic and creative problem-solving method. This study proposed a design process model for a sustainable fashion design education program so that more specific sustainable design approaches can be explored in the entire design education process from multiple perspectives, thereby having a positive effect on deriving more creative and effective sustainable work in the new fashion design field.

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## 6. Conclusion

Sustainable design is no longer a design concept with a specific goal or purpose, but an essential design concept. Future design is an Eco-Ethos design that considers the sustainable direction essential. Rather than emphasizing the identity of a special process for sustainable fashion design, the use of materials (environment-friendly) suitable for the design itself and the concept of zero waste should be always accompanied, and education and industrial application in a broad sense of design approach that can satisfy multi-functions should be prioritized.

Most fashion design methodologies and processes have mainly focused on the creativity of design results. On the other hand, as for a design process centered on a special purpose or targets, one limited theme or design element emerge as an issue in terms of the design approach, and when this is applied from the initial information collection stage of the design idea and process, the design perception point of view (especially non-professionals) tended to limit the scope of design ideas and mainly used methods for solving functional problems, so the aesthetic and creative desires did not become the focus of the design concept. In addition, although the importance of material-based eco-friendly design is spreading in sustainable fashion, it was confirmed that designs that were insufficiently eco-friendly and not attractive were eventually ignored. Education and industry also require sensible thinking and consumption in the eco-friendly era, but simultaneously, creative and aesthetically attractive design results based on expanded ideas are also crucial. Various approaches to design that fully consider the stages and depth of design ideas, and process strategies through the expansion of production methods can become the future direction of the sustainable fashion design process. Therefore, to develop design methods and processes that can simultaneously expand the aesthetic factor of design in a balanced way along with the design elements that must accompany for the special purpose of design, the fashion design process was designed to prevent the purpose of sustainability from acting as obstacles to the design concept, and education programs were systematized so that the design method could be selected according to purposes.

Based on the analysis of Korean and foreign sustainable education program cases, this study considered such details as the desired value of education, purposes, program items, detailed education content, education methods, education tools, and discriminative features to constitute the education program; it also designed a sustainable fashion design education program that can suggest more specific and applicable design methods in fashion design practice processes, beyond the textbook-based education. Based on the sustainable fashion design method proposed in this study and the structure of the sustainable fashion design education program consisting of a total of 5 steps, we designed a 15-week-course of education program that can be operated in universities. The composition of the course is as follows: the phase of establishing theoretical concept at weeks 1-2, the design problem identification and research stage at weeks 3-4, the ideation phase at weeks 5-6, the design development phase at weeks 7-10, and design implementation and evaluation at weeks 11-15.

For the evaluation of the educational process for the development and educational application of a sustainable fashion design education program, a 15-week education program

was implemented for 16 undergraduates, and sustainable fashion design works were produced. To systematize the sustainable fashion design method, the differences in design results according to each method were comparatively analyzed, and expert evaluation was conducted to evaluate the appropriateness of the sustainable fashion design method and education program.

As a result of evaluating and analyzing design differences based on the two differentiated sustainable fashion design methods, Design method 1 using sustainable materials used heterogeneous materials and scrap fabrics, and transformed, dismantled, and recreated existing clothing while focusing on materials, a combination of materials, and use and usability of materials, and developing design; it was also evaluated as an appropriate design expression that fully uses or can use materials, and a method of deriving typical sustainable fashion design results, and simultaneously, a method of expressing sustainable fashion for beginners to have easier access. Design method 2, which utilizes a sustainable manufacturing method, had relatively diverse formativeness such as design silhouette and clothing composition, and reinterpreted materials to create a new material shape, and then designed by linking the characteristics of materials with the design; it was evaluated that various design developments regarding formative form and new ways of wearing were distinct, and that it showed the characteristics of the design process, which focuses on more diverse design approaches and uses materials according to the diversity. Although the characteristics of sustainable materials are not clearly visible, it was evaluated as a way to create a diversity of designs that generates a sense of balance between creative forms and materials in a manner that shows the designer's new interpretation and formative features; there was another evaluation that it was a design method that allowed relatively free design attempts from limited themes like sustainable design, and limited materials.

The guidelines for sustainable fashion design methods and processes presented in this study went beyond the general fashion design methodology, systematized a more expanded concept of sustainable design and a complex design approach, and suggested an education program model from an intergrade design perspective to consider and apply sustainability in a circular structure. This study continuously considered sustainability, and features and methods of sustainable design from the initial planning step of design processes, included the attribute of sustainability as a more expanded concept from fashion design, and suggested differentiated design processes to lead to perception change from existing general fashion design methods and expansion of thinking; through this process, this study also designed and suggested a design education program that suggests various design approaches and can change flexibly, in order to enhance design flexibility in the educational process, and develop a balanced design while complex design elements such as aesthetic and creative elements, and sustainability coexist.

This study operated an educational program course that practically utilizes two sustainable fashion design methodologies that can realize the sustainability of fashion, and discovered the difference between the two sustainable design methods in the design process and results. Through the experiments, it was confirmed that various practical processes for sustainable design methods can influence students' design approaches and attitudes, and that the design development process and design results may be different. Furthermore, this study suggests education program model from intergrade design perspective to consider in circular structure. Therefore, this study is meaningful in that it provided the basic data

and foundation for creating a program of sustainable fashion design education with a more integrated perspective and can be used as basic research data for sustainable fashion education methods. The results of this study will be able to contribute to the study of fashion design methods that can expand the diversity and social value of fashion design education, and to establishing a more systematic, flexible, and sustainable fashion design education system through future research. On the other hand, the types of sustainable fashion design methods using sustainable materials and sustainable manufacturing methods presented in this study are limited in that they are based on existing sustainable design methods. Therefore, to implement a more integrated and differentiated sustainable fashion design education program, it is necessary to further research and establish new and different types of sustainable fashion design methods based on new technologies and mechanisms such as biotechnology and digital environment.

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