HOME ECONOMICS JOURNAL

Home Economics Journal
Volume 10, No. 2, October 2026, 16-31
ISSN 2579-4272 (printed), ISSN 2579-4280 (online)
Online: http://journal.uny.ac.id/index.php/hej

Transforming Fashion Education Through Sustainable Fashion Pedagogy: A Systematic Literature Review

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ARTICLE INFO

Article History
Received:
02 September 2026;
Revised:
14 October 2026;
Accepted:
16 October 2023;
Available online:
30 October 2026.

Keywords
Fashion education,
Green material,
Sustainable fashion

ABSTRACT

Fashion education has a direct stake in whether the Sustainable Fashion (SF) agenda moves forward. Several reviews have already touched on this area, but their scope is narrow, and few describe how SF is actually built into everyday teaching and learning in fashion programmes. This paper addresses that gap through a systematic literature review of SF integration in higher-education fashion learning. Following the PRISMA protocol, 35 peer-reviewed articles indexed in Scopus (2014–2024) were selected and analysed. The articles were coded into four SF strategy groups and mapped onto five learning areas of a fashion programme. Challenge-Based Learning, circular fashion, zero-waste design, and slow fashion emerged as the approaches most often linked to stronger student understanding of sustainability and to new ideas in design and production. The review also points to three recurring needs: closer collaboration with industry, the use of Life-Cycle Assessment in coursework, and a deliberate choice of low-impact materials in studio and laboratory work. Where SF is embedded in the curriculum, students gain practical skills and, just as importantly, a more critical reading of the environmental consequences of their design decisions. Implementation is still held back by limited access to technology and by the comparatively high cost of sustainable materials.

Citation (IEEE Style): [1] D. Retnasari, P. D. A. Kusumadewi, and L. Nurwahyuni, Transforming Fashion Education Through Sustainable Fashion Pedagogy: A Systematic Literature Review. Home Economics Journal, 10 (2), 16-32.

INTRODUCTION

Concern about the social and environmental impact associated with textile manufacturing has drawn the importance of sustainability to the core of discussion in the fashion industry. Higher education is at a vital position within this transition. The present fashion students are tomorrow's designers, pattern makers and production managers and whatever knowledge of Sustainable Fashion (SF) they are taught will influence their future career practices. Aligning fashion and textile education with the Sustainable Development Goals (SDGs), especially SDG 4 which focuses on quality education and SDG 12 related to responsible consumption and production are examples of closing the gap between academic and industrial sector in this regard. It is generally acknowledged that reforming fashion education is inevitable if graduates are to integrate technical proficiency with environmental and social awareness [1].

However, it seems to be true that the incorporation of SF into curriculum is largely dependent upon the individual lecturer's efforts.

There have been obstacles in integrating SF into fashion education. One of the challenges for this process is that there is no systematic guidance regarding how to incorporate SF into the curriculum [2]. Limited information about appropriate teaching methods, shortage of sustainable materials and the lack of a clear definition of sustainability in fashion are further barriers [3]. From our early review of curricula of Indonesian fashion courses it appears to be consistent. There have been a number of cases where SF is incorporated into the theory courses of design while mostly considering it as an issue of production without considering the garment's complete lifecycle in other cases. Assignments also usually use single-use materials and in fashion laboratories there is no systematic handling of textile waste. According to Dutt and Gandhi most educational institutes find it hard to provide the teaching materials and practical facilities for SF incorporation into their curriculum [4].

Sustainability in fashion and textiles research is on the rise, yet it is very fragmented. Some research looks at an interdisciplinary approach to teaching sustainability, while others are limited to challenge-based learning [5] or are case studies based on one university [6]. Many look at one method only, like zero waste design or upcycling [7], while research on sustainability education generally does not address issues specific to fashion [8]. Research on SF in design education is mostly conceptual. Technology integration research puts an emphasis on the technological innovation itself, while sustainability awareness is mentioned less often. Project based research reports often describe short term results, and not long-term implementations of the idea. What is missing is the connection between the research and the educational practice of fashion. The goal of this literature review was to make such connection and examine how the concepts of SF are implemented in design, textile, pattern making, production and decoration learning in higher education.

Earlier reviews have approached the topic from different angles. Watkins et al. [52] examined sustainable product design education in general and did not deal with the material, cutting, and production problems that are specific to clothing. Wagner and Heinzel [34] reviewed how consumers perceive recycled textiles and circular fashion, while Yang et al. [48] focused on sustainable retailing; neither addressed teaching. Reviews of sustainable fashion design, such as Hou et al. [31], catalogue design strategies but stop short of asking how these strategies can be taught. As a result, the strategies that the industry already uses, such as alternative materials, natural dyes, recycling, zero-waste cutting, and longevity-oriented design, have not been systematically linked to the courses through which fashion students learn their craft.

The present review differs from this earlier work in two respects. First, it treats SF strategy studies and SF pedagogy studies as one body of evidence and codes them into four strategy groups: reduce impact, recycle, reduce waste, and extend life cycle. Second, it maps each group onto the five learning areas that make up a typical fashion programme, namely design, textile, pattern making, production, and decoration, and identifies the learning approaches reported for each area. The review was guided by three questions: (1) which SF strategies are reported in peer-reviewed literature published between 2014 and 2024; (2) how these strategies have been, or can be, translated into learning activities across the five learning areas; and (3) which conditions support or limit their implementation in higher-education fashion programmes.

METHOD

The current systematic literature review (SLR) has been designed based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach in order to make the

selection and analysis of the literature on sustainable fashion education systematic and transparent. The review involved four stages: identification, screening, eligibility, and inclusion. Scopus was chosen as the main database due to its wide coverage and credible citation data compared to Web of Science and Google Scholar. Five search strings were developed and executed on 17 November 2024 against titles, abstracts, and keywords: "Sustainable AND Fashion AND Education", "Green AND Fashion AND Education", "Sustainable AND Fashion AND Curriculum", "Sustainable Fashion AND Eco-Fashion", and "Fashion Sustainability AND Higher Education". The first search resulted in 1,900 records in different disciplines that indicates the multidisciplinarity of the topic.

Duplicates were eliminated with the help of Scopus filter and checked manually by comparing titles, DOIs, and authors' names, thus leaving 346 records. Exclusion of non-research article types (book chapters, notes, and conference papers) made 273 records. Limitation of the publication period to 2014–2024 helped to get up-to-date evidence and left 54 records. The latter have been screened for topical relevance, conceptual fit, and methodological quality and 35 peer-reviewed journal articles have been selected for further analysis. Figure 1 depicts the entire selection process and number of records excluded at each stage.

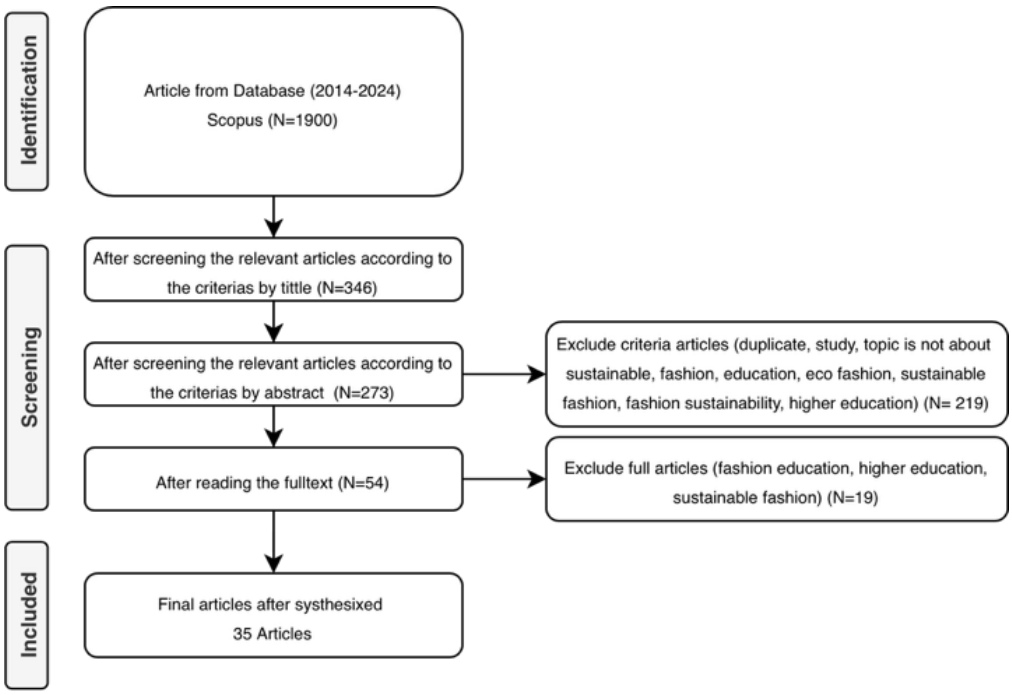


Figure 1. PRISMA Flow Diagram of the Literature Search

Screening was guided by explicit inclusion and exclusion criteria (Table 1). Records were first checked by title and abstract, and the remaining 54 articles were read in full. At the full-text stage, 19 articles were excluded because they mentioned sustainable fashion or fashion education only in passing, did not report a clear method or findings, or dealt with sectors outside fashion and textiles (Figure 1).

Table 1. Inclusion and Exclusion Criteria for Literature Screening

Criterion	Inclusion	Exclusion
Database	Indexed in Scopus	Records available only in other databases or as grey literature
Search field	Search string found in the title, abstract, or keywords	Search terms appearing only in the full text or reference list
Document type	Peer-reviewed journal article (empirical, conceptual, or review)	Book chapters, conference papers, notes, and editorials

Criterion	Inclusion	Exclusion
Publication period	2014–2024	Published before 2014 or after 2024
Language	English	Full text not in English
Topic	Discusses SF strategies (materials, dyeing, recycling, waste reduction, product longevity) or SF teaching and learning in fashion and textile education	Sustainability discussed only in general terms, without a fashion or textile context
Relevance and quality	Clear aim, method, and findings that can be linked to design, textile, pattern making, production, or decoration learning	Duplicates; insufficient methodological information; full text not accessible

Data Extraction, Coding, and Synthesis

Data from the 35 articles were extracted into a spreadsheet matrix that recorded the authors, year, journal, setting, study type, the SF practice discussed, the learning approach (where reported), and the main findings. The extracted data were then analysed through thematic synthesis in two coding layers (Table 2). The first layer was deductive. Each article was assigned to one of four SF strategy groups, namely reduce impact, recycle, reduce waste, and extend life cycle. These groups were adapted from strategy categories commonly used in the SF design literature, including the fast and slow approaches described by Goldsworthy et al. [37] and the environmental cost analysis of Niinimäki et al. [33]. Articles whose main focus was teaching or curriculum, rather than a particular strategy, were coded as SF pedagogy studies. When an article covered more than one group, it was assigned to the group that matched its main objective, and the other group was recorded as a secondary code.

The second layer was inductive. The findings of each article were linked to the learning area in which they could be applied, using the five learning areas of the fashion programme (design, textile, pattern making, production, and decoration). The learning approaches reported in the pedagogy studies, such as challenge-based, project-based, problem-based, and experiential learning and critical pedagogy, were recorded alongside these links. Coding was carried out by the first author and checked by the co-authors, and disagreements were resolved through discussion until consensus was reached. Finally, the codes within each group were compared across studies to identify recurring patterns, points of agreement, and gaps. These comparisons form the synthesis presented at the end of the Results and Discussion section.

Table 2. Coding Framework Used to Categorise and Synthesise the Reviewed Articles

Coding layer	Code	Operational definition
Layer 1: SF strategy (deductive)	Reduce impact	Lowering environmental burden at the material and process stage: alternative and bio-based fibres, natural dyes, and cleaner dyeing processes
	Recycle	Keeping textiles in use through pre- and post-consumer recycling, downcycling, upcycling, and waste-to-fibre technologies
	Reduce waste	Preventing waste at the design and production stage: zero-waste cutting, digital prototyping, design for disassembly, and on-demand production
	Extend life cycle	Lengthening the use phase: timeless, emotional, flexible, and smart design; repair, resale, and after-sales services
	SF pedagogy	Studies on curricula, teaching methods, or learning outcomes related to SF in fashion and textile education
Layer 2: Learning area (inductive mapping)	Design	Concept development, collection planning, and design briefs
	Textile	Fibres, fabrics, dyeing, and material experiments
	Pattern making	Pattern construction, cutting layout, and digital pattern tools
	Production	Production planning, costing, and life-cycle assessment
	Decoration	Surface embellishment, embroidery, patchwork, and reworking of garments

RESULTS AND DISCUSSION

Characteristics of the Reviewed Studies

Table 3 lists the 35 articles included in the review. The articles span the whole review period but become more frequent after 2018: six were published in 2014–2018, fifteen in 2019–2021, and fourteen in 2022–2024. Most appeared in fashion, design, and sustainability journals, with *Sustainability* (n = 7) and the *International Journal of Fashion Design, Technology and Education* (n

= 5) as the most frequent outlets. In terms of content, 28 articles dealt with specific SF strategies, namely reduce impact (n = 8), recycle (n = 7), reduce waste (n = 5), and extend life cycle (n = 8), while seven were pedagogy studies on curricula, teaching methods, or student learning. Experimental and laboratory studies dominated the reduce-impact group, whereas the extend-life-cycle group relied mainly on consumer and design research. Most of the empirical pedagogy studies were single-course or single-institution cases, which is consistent with the fragmentation noted in the Introduction.

Table 3. Characteristics of the 35 Reviewed Articles

No	Author(s) (Year)	Title	Main findings	SF code
1	Hur & Cassidy (2019) [3]	Perceptions and attitudes towards sustainable fashion design: challenges and opportunities for implementing sustainability in fashion	Designers and design students view sustainability positively but lack practical knowledge, tools, and resources; education and design support are needed.	SF pedagogy
2	Agarwal (2021) [7]	Integration of sustainable practices in fashion design education: An experimental study based on experiential learning	Hands-on, experiential projects improved students' awareness of sustainable practices and their ability to apply them in design work.	SF pedagogy
3	Domskiene et al. (2019) [13]	Kombucha bacterial cellulose for sustainable fashion	Kombucha-derived bacterial cellulose shows potential as a leather-like fashion material, although moisture sensitivity and durability limit its use.	Reduce impact
4	Ng & Wang (2016) [14]	Natural self-grown fashion from bacterial cellulose: A paradigm shift design approach in fashion creation	Growing bacterial cellulose directly into garment shapes offers a design approach that removes cutting waste and changes the design process.	Reduce impact
5	Ke et al. (2021) [18]	Dyeing of cochineal natural dye on cotton fabrics treated with oxidant and chitosan	Oxidant and chitosan pretreatment improved the uptake and fastness of cochineal dye on cotton.	Reduce impact
6	Shim & Kim (2019) [19]	Coloration of bacterial cellulose using in situ and ex situ methods	Both in situ and ex situ methods can colour bacterial cellulose, with different colour outcomes and process demands.	Reduce impact
7	Rahman et al. (2023) [20]	Sustainable one-bath natural dyeing of cotton fabric using turmeric root extract and chitosan biomordant	One-bath turmeric dyeing with a chitosan biomordant produced good colour strength and fastness while reducing process steps and chemical use.	Reduce impact
8	Pattanaik et al. (2020) [22]	Life cycle cost analysis of natural indigo dye production from Indigofera tinctoria L. plant biomass: a case study of India	Life-cycle costing indicates that natural indigo production can be economically viable, supporting its use as an alternative to synthetic indigo.	Reduce impact
9	Čorak et al. (2022) [23]	Natural dyeing of modified cotton fabric with cochineal dye	Modifying cotton before dyeing increased cochineal dye uptake and colour depth, reducing reliance on conventional mordants.	Reduce impact
10	Stanescu (2021) [24]	State of the art of post-consumer textile waste upcycling to reach the zero waste milestone	Reviews upcycling routes for post-consumer textile waste; sorting and separation of mixed fibres remain key bottlenecks.	Recycle
11	Haq & Alam (2023) [25]	Implementing circular economy principles in the apparel production process: Reusing pre-consumer waste for sustainability of environment and economy	Reusing pre-consumer cutting waste in apparel production brought both environmental and economic benefits.	Recycle
12	Koszewska (2018) [26]	Circular economy – Challenges for the textile and clothing industry	Moving to a circular textile system requires design for recycling, collection and sorting systems, and supportive policy.	Recycle
13	Shi et al. (2022) [28]	A qualitative study on internal motivations and consequences of consumer upcycling	Consumer upcycling is driven by creativity, self-expression, and environmental concern, and strengthens attachment to the products made.	Recycle
14	Castro-López et al. (2021) [29]	Slow fashion trends: Are consumers willing to change their shopping behavior to become more sustainable?	Consumers express willingness to shop more sustainably, but this depends on product attributes, price, and available information.	Extend life cycle
15	Suen et al. (2023) [30]	Sustainable textile raw materials: Review on bioprocessing of textile waste via electrospinning	Electrospinning can turn bioprocessed textile waste into new fibrous raw materials, although scale-up remains a challenge.	Recycle
16	Carrico & Kim (2014) [32]	Expanding zero-waste design practices: a discussion paper	Zero-waste practice should extend beyond pattern cutting to the whole design and production process.	Reduce waste
17	Niinimäki et al. (2020) [33]	The environmental price of fast fashion	Fast fashion generates large water, chemical, carbon, and waste burdens; slowing production and new business models are needed.	Reduce waste

No	Author(s) (Year)	Title	Main findings	SF code
18	Wagner & Heinzel (2020) [34]	Human perceptions of recycled textiles and circular fashion: A systematic literature review	Consumer perceptions of recycled textiles are mixed, with concerns about hygiene and quality and limited knowledge of circular fashion.	Recycle
19	Goldsworthy et al. (2018) [37]	Circular speeds: A review of fast & slow sustainable design approaches for fashion & textile applications	Proposes fast and slow circular design approaches, including design for disassembly and recycling, matched to product life spans.	Reduce waste
20	Casto & DeLong (2020) [42]	Classic design: From cultural knowledge to individual experience	Classic garments endure because they combine shared cultural knowledge with personal experience, supporting longer use.	Extend life cycle
21	Zhou et al. (2023) [43]	Sustainable fashion product innovation: Continuous value of apparel products on second-hand product trading platforms	Apparel that keeps its value on second-hand platforms shares attributes such as quality and classic design that extend product life.	Extend life cycle
22	Kam & Yoo (2022) [46]	Practice of sustainable fashion design considering customer emotions and personal tastes	Including customer emotions and personal tastes in the design process increases product attachment and supports longer use.	Extend life cycle
23	Wang et al. (2022) [47]	Promoting emotional durability and sustainable fashion consumption through art derivatives design methods	Art-derived design methods can build emotional durability and encourage more sustainable fashion consumption.	Extend life cycle
24	Yang et al. (2017) [48]	Sustainable retailing in the fashion industry: A systematic literature review	Sustainable retailing practices include take-back, repair, and transparent communication, but research on them is fragmented.	Extend life cycle
25	Li et al. (2022) [51]	The status quo and prospect of sustainable development of smart clothing	Smart clothing can extend functionality and service life, but electronic components create recycling and waste challenges.	Extend life cycle
26	Watkins et al. (2021) [52]	Sustainable product design education: Current practice	Sustainable design is taught through varied formats (lectures, workshops, seminars, flipped classes), with uneven depth and limited assessment.	SF pedagogy
27	Atalay Onur (2020) [53]	Integrating circular economy, collaboration and craft practice in fashion design education in developing countries: A case from Turkey	Collaborative, craft-based projects linked circular economy principles to fashion design education and benefited both students and artisans.	SF pedagogy
28	Kozlowski et al. (2018) [54]	The reDesign canvas: Fashion design as a tool for sustainability	Proposes a design tool that covers five dimensions of sustainable fashion innovation: environmental, social, economic, aesthetic, and cultural.	Reduce waste
29	Rana & Ha-Brookshire (2019) [55]	New conceptual framework for fashion business ideation, negotiation, and implementation undergraduate curricula for sustainable development	Proposes a curriculum framework in which creativity, critical thinking, and collaboration are core skills for sustainable fashion.	SF pedagogy
30	Palomino et al. (2024) [56]	Traditional fish leather dyeing methods with indigenous Arctic plants	Documents and revives traditional dyeing with locally gathered plants, showing the value of local natural dye knowledge.	Reduce impact
31	Jaiswal et al. (2024) [58]	Sowing the seeds of change: educating emerging textile and apparel professionals on sustainability from cotton industry perspective	An industry-informed learning programme improved students' knowledge of sustainability in the cotton supply chain.	SF pedagogy
32	McQuillan (2020) [59]	Digital 3D design as a tool for augmenting zero-waste fashion design practice	3D design software supports zero-waste practice by letting designers test pattern layouts and garment form virtually.	Reduce waste
33	Riiho & Kokko (2024) [60]	Critical pedagogy approach in developing an online course on sustainable fashion to support consumer choices	A critical-pedagogy online course helped learners reflect on the environmental impact of their clothing choices.	SF pedagogy
34	Klepp et al. (2022) [61]	Local clothing: What is that? How an environmental policy concept is understood	"Local clothing" is promoted in environmental policy but understood in different ways, which calls for a clearer definition.	Extend life cycle
35	Lee (2023) [63]	The dual strategy for textile and fashion production using clothing waste	Post-consumer clothing waste can be converted into recycled nonwoven fabric for fashion accessories.	Recycle

Sustainable Fashion Concept

Sustainable Fashion (SF) refers to ways of designing, producing, and using clothing that lower environmental harm while supporting social and economic well-being. It covers practices ranging from zero-waste design and cleaner production to recycling. In this review, the SF literature is organised under four headings: reduce impact, recycle, reduce waste, and extend life cycle. These four groups are

the result of the first coding layer described in the Method section (Table 2), and the number of articles in each group is shown in Table 3.

Reduce Impact

Eight of the reviewed articles fall into this group, and most of them are laboratory or material-development studies on bio-based fibres and natural dyes. Strategies in this group aim to cut the environmental footprint of the industry, mainly through changes in materials and production processes. The most common route is a switch to greener materials such as organic cotton, linen, hemp, bamboo, and recycled fibres. Natural fibres are usually regarded as more sustainable than synthetics, yet they are not free of problems; cotton in particular demands large amounts of water and land [9]. Alternatives have therefore been developed, for instance Tencel/Lyocell fibres made from wood pulp [10] and fibres obtained from the hemp plant.

Recycled materials are receiving growing attention as well, a well-known example being polyester fibre recovered from used plastic bottles [11]. Beyond natural and recycled sources, the industry has begun to test biomaterials as alternative textile fibres. Bacterial cellulose, grown through microbial fermentation, yields a fibre with properties similar to cotton [12]. Textile waste is also being regenerated into new protein fibres in support of a circular economy. Experiments with kombucha-based textile materials [13] suggest that microorganism-based approaches may become a realistic option for the fashion industry.

Table 4. Sustainable Material Use Strategy

Material Category	Example	Advantages
Natural Fibre [10]	Organic cotton, linen, hemp	Biodegradable, fewer chemicals used
Recycled Fibre **[11]**	Recycled polyester, recycled cotton	Reducing textile and plastic waste
Bio-materials **[14],** [13]	Cellulose bacteria, kombucha leather	Innovative, potentially more sustainable

A wide range of plant and animal sources has been studied for textile dyeing, including turmeric [15], madder root [16], logwood [17], and indigo. Cochineal insects have long been used to obtain red and pink shades [18]. More recent work extends natural dyeing to bacteria-based materials, as in the coloration methods for bacterial cellulose developed by Shim and Kim [19]. Combining natural dyes with grown materials could make dyeing less dependent on scarce natural resources.

Table 5. Natural Dyes Use Strategies

Source	Color	Advantages
Turmeric [20]	Yellow	Natural, Non-Toxic, Biodegradable
Madder root [16], [21]	Red, Pink	Durable colours with minimal chemical use
Logwood [17]	Purple, Black	Supports sustainable forestry practices
Indigo plants [22]	Navy blue	Biodegradable; lower water and material use
Cochineal-like insects [18], [23]	Red, Pink	Vivid colours; supports sustainable trade

Recycle

Seven articles address recycling, ranging from technical reviews of textile-waste processing [24], [30] to studies of consumer upcycling [28] and of how recycled textiles are perceived [34]. Reuse

and recycling of textile materials form the second group of strategies. In certain cases, reusing textile waste and recycling garments is the more environmentally favourable option [15]. Recycling in fashion is commonly divided into pre-consumer and post-consumer streams [24]. Pre-consumer recycling uses waste generated during manufacturing [25]: cutting scraps from garment factories, defective items, and materials that fail quality checks. Because it keeps materials in use for longer, this practice is closely tied to the circular economy. For manufacturers, it lowers dependence on virgin raw materials and makes production more efficient [26], which in turn reduces both waste and raw-material costs.

Upcycling works differently. Used garments or textile waste are turned into new clothing of equal or greater value. Because the process depends heavily on creativity and skilled handwork, upcycled pieces are often unique and may sell at a higher price than new mass-produced clothing. Upcycling reduces textile waste, encourages more careful consumption, and lengthens product life [27]. Its popularity has risen with consumer awareness of sustainability, and demand is growing among buyers who value fashion with artistic as well as environmental merit [28]. A number of fashion brands now include upcycled lines in their collections as part of their sustainability and design innovation strategies.

Table 6. Summary of Recycling Strategies in The Fashion Industry

Strategy	Description	Advantage
Pre-Consumer Recycling [26]	Utilization of textile waste from the production process before it reaches consumers.	Less production waste, higher efficiency, lower raw material costs
Post-Consumer Recycling [29]	Recycling of clothes or textiles that consumers have already used	Less post-consumer clothing waste; greater sustainability awareness
Downcycling [30]	Converting used textiles into lower-value products	Allows large-scale reuse of textile waste
Upcycling [27], [28]	Converting clothing or textile waste into higher-value products	Unique products, longer textile life, added aesthetic value

Reduce Waste

Five articles were coded in this group. They share the view that waste is best prevented at the design and pattern-cutting stage rather than handled after production [32], [37]. Waste reduction in SF relies on new technologies and design methods that use resources more efficiently [31]. Zero-waste design is a central example: through careful pattern layout and draping, designers can use close to 100% of the fabric width and leave few or no offcuts [32]. The same thinking is applied to modular and multifunctional garments that stay in use for longer. Producing according to actual market demand, rather than forecast volumes, also prevents overproduction, and here fashion digitisation and 3D modelling are especially useful [33]. Virtual prototyping lets designers test garments on screen, catch errors before production, and shorten the design cycle without repeated physical samples [34].

AR and AI may also play some part in achieving sustainability through other means. AR virtual try-on may enable customers to pick out the right item to buy and therefore prevent returns and waste. At the same time, trend prediction with the use of AI and logistics planning will help to provide more accurate demand forecasting and prevent overproduction and excess products. Both these technologies are rather novel in the fashion industry and require empirical studies to identify their impact on the environment. From the design aspect, the idea is to create cradle-to-cradle clothes and items, which are easy to either be recycled completely or will eventually biodegrade [35], [36]. As for design for disassembly, it helps to make garments easily repairable and recyclable [37].

Table 7. Summary of Reduce Waste Concept

Strategy	Description	Advantage
Zero Waste Design [31], [38]	Optimising cutting patterns to avoid fabric waste	Reduce textile waste, material use efficiency
Digitalisation (3D & AR) [34]	3D and AR modelling for virtual fitting and fewer production errors	Less overproduction and fewer product returns
Cradle-to-cradle design [35], [36]	Designing clothes to be recyclable or biodegradable	Lower long-term impact of fashion waste
Design for disassembly [37]	Designing clothes to be easy to disassemble and reuse	Easier repair and recycling

Extend Life Cycle

This group is as large as the reduce-impact group (n = 8), but its evidence comes mostly from consumer and design research rather than from classroom studies. Slow fashion aims to keep clothing in use for longer through durable, well-made design, in contrast to the high-volume, rapid-turnover model of fast fashion [39]. Growing consumer concern about environmental impact gives designers room to create garments that last both aesthetically and functionally. Circular business models such as rental, resale, and repair further reduce the need for new production [31]. Classic, timeless designs are central to this strategy. Pieces such as tailored suits, trench coats, and denim jackets are easy to combine with other items, suit many occasions, and can remain wearable for decades.

Minimalist design, with its simple shapes and restrained colours, works in a similar way: garments stay relevant across seasons and trends, which discourages excessive buying [33], [40]. Genderless fashion is another emerging route. Clothing that is not tied to one gender can be worn by a wider group of users, which extends its potential period of use [41]. Designs that draw on local culture or heritage may also be kept and valued longer by consumers because of their historical and symbolic meaning [3]. Taken together, these forms of timeless style are among the main slow fashion strategies for curbing overconsumption and supporting sustainable clothing design.

Table 8. Extend Life Cycle Concept Summary

Strategy	Description	Advantage
Timeless Style [42], [41], [43]	Classic, minimalist, genderless, and cultural design	Fewer new purchases; higher consumer appreciation
Better Quality [31], [44]	High-quality materials (organic cotton, hemp, merino wool) and quality-controlled production	More durable and comfortable clothes; less textile waste
Flexible Design [33], [45]	Clothes that are transformable, multi-functional, or have customizable sizes.	Longer garment life, less waste from size changes, flexible use
Emotional Design [46], [47]	Garments with emotional value from customisation or personal memories	Lower disposal rates; stronger user attachment
After-Sales Services [48], [49]	Repair services and take-back/recycling programmes	Less fashion waste; greater consumer confidence
Smart Clothing [50], [51]	Smart sensors or materials that adapt to body temperature	Better functionality, longer service life, greater comfort

Mapping SF Strategies to Fashion Learning Areas

The second coding layer linked the four strategy groups to the learning areas of a fashion programme. The seven pedagogy studies provided direct evidence on teaching methods, while the strategy studies supplied the content that these methods can carry. The mapping showed a consistent pattern: extend-life-cycle strategies were most often linked to design courses, reduce-impact strategies

to textile courses, reduce-waste strategies to pattern making and production, and recycling strategies to decoration and textile work. The following subsections discuss each learning area in turn.

Sustainable Design

Challenge-Based Learning (CBL) is one method that has been used to bring SF into fashion education. CBL is intended to strengthen students' problem-solving when they face sustainable design problems [5]. Typical challenges include circular fashion briefs, zero-waste design tasks, and slow fashion projects. All of them start from the idea that a fashion product need not have a short life and can be redesigned to remain relevant and functional. Watkins et al. list a range of teaching formats that support these principles, among them seminars, workshops, flipped classrooms, lectures, and instructional videos [52]. Through such formats, students come to see how their designs affect the environment and are pushed to try sustainability-led ideas in their own projects.

Slow fashion can be incorporated into the studio setting through the assignment of a capsule collection project of timeless and functional garments. Atalay Onur explains that slow fashion values quality over quantity and favors ethical production [53]. Through a capsule brief, students will be able to design timeless garments which fit into a sustainable life style. This is because the capsule brief helps students understand how overproduction and fast fashion are harming the environment. It also provides an opportunity to students to value craftsmanship and think about how their designs affect consumers and garment workers. According to Kozlowski et al., there are five dimensions of sustainable fashion innovation including environmental, social, economic, aesthetic, and cultural [54]. The aesthetic dimension provides room for sustainability through visual quality while the cultural dimension demonstrates how design can support sustainability through preservation of traditional and low-impact practices. Rana and Ha-Brookshire further state that creativity, critical thinking, and collaboration are the key skills for sustainable fashion design [55].

Eco-Friendly Textile

Textile courses can build sustainability principles through experimentation, project-based learning, case studies, and problem-based learning. A practical entry point is work with natural materials and low-impact dyes. Students can run dyeing experiments with bark, flowers, or leaves, which carry a smaller carbon footprint than synthetic dyes and avoid many hazardous chemicals. Palomino et al. show how traditional dyeing with locally gathered plants can be documented and revived [56]; in Indonesia, comparable local sources include secang (sappan wood), turmeric, teak leaves, and mengkudu (noni). Projects of this kind help keep dyeing traditions alive, deepen students' understanding of sustainability, and build the technical skills needed for environmentally responsible production.

Natural dyeing can be extended to biomaterials. Khamisani et al. present "The Fashion Kitchen" as a case of integrating biomaterials into fashion design education [6]; work of this kind helps students understand the properties, durability, and environmental impact of grown materials through direct experimentation. Case studies and problem-based learning are also well suited to sustainable fashion education. They ask students to analyse the difficulties industry faces in adopting sustainable materials and to propose design solutions grounded in environmentally friendly innovation. Students might, for example, compare the properties and environmental impacts of natural fibres (organic cotton, linen, hemp), recycled fibres (recycled polyester, recycled cotton), and biomaterials (kombucha leather, bacterial cellulose). Such comparisons mirror current industry practice, in which post-consumer textile waste is increasingly sorted by fibre composition using near-infrared spectroscopy combined with deep learning [57]. Problem-based tasks such as reducing production waste or designing a more circular production system give students hands-on experience with real industry problems. According to Jaiswal et al., this approach sharpens critical thinking and encourages students to develop solutions that can be applied in industry [58].

Sustainable Pattern Making

For pattern making, SF is usually introduced through interactive, practice-based learning: experimentation, case studies, collaborative projects, digital simulation, and sustainable production exercises. Zero-waste work by designers such as Julian Roberts, known for his Subtraction Cutting technique, offers useful case material. Studying such work shows students how a design concept is carried into actual practice and how unconventional cutting methods can reduce fabric waste.

Zero-waste pattern cutting can build sustainability into a design without compromising its aesthetics or function [32]. By analysing these techniques, students can develop more inventive and sustainable pattern solutions of their own. McQuillan shows that 3D design software can extend zero-waste practice [59]; tools such as CLO 3D let students simulate pattern layouts and production efficiency without producing physical waste, which raises sustainability awareness and prepares them for industry practice. Life Cycle Assessment (LCA) projects add a further layer by helping future designers make better-informed choices about materials and production methods.

Sustainable Production

In addition, students can perform a life cycle analysis of a fashion product in order to understand the environmental impact of all stages of the product life cycle – from material sourcing and manufacturing to distribution, consumer use, and final recycling or disposal. Through the use of LCA, students can compare different materials and production methods and discover which of them have a lesser environmental impact, thus making their choice of materials and production method evidence-based. According to Riiho and Kokko, the application of critical pedagogy to sustainable fashion education can help students think about the environmental impacts of their clothes [60]. Through LCA, they can get a quantitative understanding of the problem. As part of the fashion curriculum, it will make students more aware of the environmental impact of their products and encourage them to innovate for the sake of sustainability.

Another approach that can be taught is on-demand production, because it responds to the problem of overproduction inherent to fast fashion. Using the on-demand approach, students will understand why efficiency is important in production management and how the company can stay profitable while taking into account the environmental impact. According to Klepp et al., “local clothing” is increasingly promoted in environmental policy as an alternative to globalised mass production, although the definition of this concept is ambiguous [61]. Thus, it is a good basis for discussions on small-batch production, local production, and made-to-order production.

Recycle-Based Decoration

Within decoration courses, the incorporation of SF principles is linked to the idea of recycling-based decoration and material exploration. Projects involving recycling not only make students aware of sustainable practices but also help develop their creativity since textile waste is used as a material for decorative purposes. Reworking used garments, such as jeans, by means of patchwork or embroidery adds value to them and prolongs their life cycle [62].

The idea of the “Green Label” can also be used within the course to explain the necessity of sustainability labeling. Once the students learn about such indicators as low emissions or minimal chemical use, they will be able to select recycled materials for decoration. Within the course, used clothes may be transformed into new value-added products using such techniques as patchwork, embroidery, or fabric reprocessing. As Lee proves, it is possible to convert post-consumer clothing waste into nonwoven fabric produced from recycled fibers and use it for the production of fashion accessories [63]. Thus, recycling is not only prolonging the life of the product but also helping to produce new materials which may serve as an alternative to traditional ones. Overall, recycling-based decoration within higher education not only makes students aware of the importance of sustainability for the fashion industry but also teaches how to produce products from recycled materials.

Synthesis of Findings

Taken together, the 35 articles show three patterns. First, the evidence base is uneven. Most studies describe what SF strategies are and how they perform technically or in the market, while only seven examine how these strategies are taught, and few of those report learning outcomes beyond a single course. Fashion education therefore draws much of its SF content from industry and materials research, and translating this content into classroom practice is still largely left to individual lecturers, as noted in the Introduction.

Second, the four strategy groups do not map evenly onto the curriculum. Reduce-impact and recycling strategies are well supported by hands-on, experiment-based activities such as natural dyeing, biomaterial trials, and upcycling projects [7], [13], [56], [63], which suit textile and decoration courses. Reduce-waste strategies are closely tied to pattern making and depend on digital tools [59] and zero-waste cutting knowledge [32]. Extend-life-cycle strategies, in contrast, are mainly conceptual in the literature (timeless, emotional, and flexible design) and enter the curriculum through design briefs and capsule-collection projects [53], [54]. Production is the least developed learning area: life-cycle assessment and on-demand or local production are discussed as possibilities [22], [60], [61], but few studies report them as established coursework.

Third, the learning approaches that recur across the pedagogy studies, namely challenge-based, project-based, problem-based, and experiential learning together with critical pedagogy, share an emphasis on real problems, making, and reflection [7], [52], [58], [60]. Where these approaches were used, students gained practical sustainability skills and became more critical of the environmental consequences of their design decisions. The same studies point to recurring constraints, including limited access to technology such as 3D software and testing equipment, the higher cost and limited availability of sustainable materials, and weak links with industry [3], [53], [59]. Table 9 summarises how these findings relate to each strategy group and learning area. These patterns form the basis of the conclusions that follow.

Table 9. Synthesis of SF Strategy Groups, Learning Areas, and Learning Approaches

SF group (n)	Main learning area	Typical learning activities	Key findings	Reported constraints
Reduce impact (8)	Textile	Natural-dye and biomaterial experiments; fibre comparison projects	Natural dyes and bio-based materials are technically feasible; bio-mordants and fibre pretreatment improve dye uptake and fastness	Laboratory equipment; variable material quality and durability
Recycle (7)	Decoration; Textile	Upcycling projects; patchwork and embroidery reworking; waste-to-material exploration	Pre- and post-consumer waste can become value-added products and new materials; upcycling builds creativity and product attachment	Sorting of mixed fibres; labour-intensive processes
Reduce waste (5)	Pattern making; Production	Zero-waste cutting; 3D virtual prototyping; design for disassembly	Waste is prevented most effectively at the design and cutting stage; digital tools extend zero-waste practice	Software cost and skills; design constraints of zero-waste patterns
Extend life cycle (8)	Design	Capsule collections; timeless, emotional, and flexible design briefs; repair services	Product longevity depends on design quality, emotional value, and after-sales services as much as on materials	Consumer behaviour is hard to change; little classroom evidence
SF pedagogy (7)	All five areas	Challenge-, project-, and problem-based learning; experiential learning; critical pedagogy; industry collaboration	Active, problem-oriented approaches strengthen sustainability awareness and practical skills	Mostly single-course evidence; reliance on individual lecturers; weak industry links

CONCLUSION

From the results of the review, it is evident that the principles of Sustainable Fashion can be incorporated into fashion programmes at higher education establishments via certain learning approaches. By coding 35 articles into four strategy groups and mapping them onto five learning areas, the review shows that each learning area offers a distinct entry point: textile courses for reduce-impact strategies, decoration for recycling, pattern making and production for waste reduction, and design for extending product life. Challenge-Based Learning, zero-waste design, circular fashion, and eco-friendly textile creation were associated with higher levels of both technical skills and environmental awareness and responsibility of learners. Experimental activities, cooperation with industries, and problem-based learning also facilitate the development of sustainable design practices among students. This systematic review provides evidence for curriculum developers to build a deliberate approach to sustainable fashion education. Since fashion programmes educate future designers, they are well placed to prepare graduates to address the sustainability issues of the industry.

There are several limitations to the present study. Firstly, only one database was used for conducting the literature search. Secondly, only seven of the 35 articles were pedagogy studies, so part of the mapping to learning areas rests on interpreting industry-oriented research rather than on classroom evidence. The selected studies are based on programmes which have varying levels of sustainable fashion adoption. There are also limited data on the effectiveness of sustainable practices in classrooms in terms of their long-term effects and interaction with industries. Further research can follow graduates to evaluate how sustainable fashion education affects their career and how the industry reacts to it. In addition, comparative research among establishments with different levels of sustainability integration can reveal the most effective methods of teaching. Lastly, interdisciplinary designs of sustainable fashion programmes, which include fashion, environmental sciences, and business, can be beneficial for education.

ACKNOWLEDGMENT

The authors thank everyone who contributed to this project. The research reported in this publication was supported by Universitas Negeri Yogyakarta.

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