



FROM DENIM TO SUSTAINABLE ALTERNATIVES: STUDENTS' AWARENESS OF ENVIRONMENTAL IMPACTS AND THEIR ACCEPTANCE OF DENIM-LOOK PANTS

Scientific paper
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ABSTRACT: *The environmental impacts of conventional denim production, including intensive water and energy consumption, extensive chemical use, and wastewater generation, have increased interest in more sustainable alternatives. This study investigated textile and fashion students' awareness of these impacts and evaluated their acceptance of a sustainable denim-look garment developed through an industry–university collaboration. A qualitative research design was adopted involving nine female undergraduate students. Data were collected through semi-structured interviews before and after a 15-day wear trial of the developed trousers. The results showed that participants' environmental awareness was generally limited to excessive water consumption. Although attitudes toward sustainable fashion were positive, purchasing decisions remained primarily influenced by aesthetics, comfort, quality, and price. After the wear trial, the garment received highly positive evaluations for its visual similarity to conventional denim, comfort, breathability, and overall usability, with only minor suggestions regarding colour tone and fabric handle. The findings suggest that combining sustainability education with direct product experience can enhance sustainability-oriented design thinking and increase acceptance of environmentally responsible textile products.*

Keywords: sustainable denim; denim-look garment; environmental awareness; sustainable fashion; user experience.

OD TEKSASA DO ODRŽIVIH ALTERNATIVA: SVEST STUDENATA O EKOLOŠKIM UTICAJIMA I NJIHOVO PRIHVATANJE PANTALONA SA IZGLEDOM TEKSASA

APSTRAKT: *Uticaji konvencionalne proizvodnje teksasa na životnu sredinu, uključujući intenzivnu potrošnju vode i energije, ekstenzivnu upotrebu hemikalija i stvaranje otpadnih*



voda, povećali su interesovanje za održivije alternative. Ova studija je istraživala svest studenata tekstilne i modne industrije o ovim uticajima i procenila njihovo prihvatanje održivog odevnog predmeta sa izgledom teksasa razvijenog kroz saradnju između industrije i univerziteta. Usvojen je kvalitativni istraživački dizajn koji je obuhvatio devet studentkinja osnovnih studija. Podaci su prikupljeni putem polustrukturiranih intervjua pre i posle 15-dnevnog probnog nošenja razvijenih pantalona. Rezultati su pokazali da je ekološka svest učesnika uglavnom bila ograničena na prekomernu potrošnju vode. Iako su stavovi prema održivoj modi bili pozitivni, odluke o kupovini su i dalje prvenstveno uticale estetika, udobnost, kvalitet i cena. Nakon probnog nošenja, odevni predmet je dobio veoma pozitivne ocene zbog svoje vizuelne sličnosti sa konvencionalnim teksasom, udobnosti, prozračnosti i ukupne upotrebljivosti, sa samo manjim sugestijama u vezi sa tonom boje i opterećenjem tkanine. Rezultati sugerišu da kombinovanje obrazovanja o održivosti sa direktnim iskustvom sa proizvodom može poboljšati dizajnersko razmišljanje orijentisano na održivost i povećati prihvatanje ekološki odgovornih tekstilnih proizvoda.

Ključne reči: održivi teksas; odevni predmet sa izgledom teksasa; ekološka svest; održiva moda; korisničko iskustvo.

1. INTRODUCTION

The fashion industry is one of the world's largest consumer-driven sectors, generating substantial economic value while creating significant environmental and social challenges. The shift from seasonal production to fast fashion has led to shorter product life cycles, rapid turnover, and increasing consumption. Global clothing sales nearly doubled from approximately USD 1 trillion in 2002 to USD 1.8 trillion in 2015, illustrating the expansion of apparel consumption and overconsumption [1]. Growing environmental concerns have made sustainability a strategic priority, accelerating the adoption of circular economy principles that promote resource efficiency, waste reduction, and sustainable production and consumption [2]. At the same time, globalization and complex supply chains have increased demands for transparent sustainability reporting and responsible production [3]. Initiatives such as the Green Carpet Fashion Awards and the Sustainable Apparel Coalition encourage sustainable materials, circular design, ethical production, and standardized environmental performance assessment [4]–[6]. Despite these initiatives, the fashion industry remains largely dependent on a linear production model based on virgin materials, resulting in intensive resource consumption and waste generation. This has also intensified concerns about greenwashing, emphasizing the need for transparent and verifiable sustainability claims [7], [8]. Accordingly, recent studies highlight that meaningful sustainability requires a transition from fast fashion to circular production systems and responsible consumption across the fashion value chain [10], [15]–[18]. Within this context, educating future fashion designers is essential for supporting sustainable transformation. This study aims to increase students' awareness of the environmental impacts of conventional denim production and promote sustainability-oriented design thinking. Through an industry–university collaboration, a sustainable denim-look garment



was introduced as an alternative to conventional denim trousers, and students' perceptions of the product were evaluated to encourage sustainability-oriented material selection, product development, and design decision-making.

2. DENIM PRODUCTION AND ENVIRONMENTAL IMPACTS

According to the United Nations Environment Programme (UNEP), achieving sustainability in the textile value chain requires a systemic transformation of production, consumption, and circular infrastructure, as incremental improvements alone are insufficient to address the sector's environmental challenges [14]. Likewise, the Pulse Score (2018) reported that the fashion industry achieved only 38 out of 100 in sustainability performance, despite improvements in resource efficiency [15]. As a result, the industry continues to face major challenges, including textile waste, excessive water and chemical use, microfiber pollution, poor labour conditions, child labour, and greenwashing, increasing pressure for transparent and circular production systems [11]–[13]. Denim, originally developed as workwear, has become one of the world's most widely consumed textile products because of its durability and versatility. However, its environmental impacts extend across the entire life cycle, from cotton cultivation and indigo dyeing to garment manufacturing, transportation, and consumer use. Despite these impacts, global demand continues to grow. North America accounted for 31.2% of global denim revenue in 2024, while Europe and the Asia–Pacific region are projected to grow at CAGR rates of 6.0% and 7.0%, respectively, between 2025 and 2030 [19]. Growing consumer interest in sustainability has encouraged the adoption of recycled fibres, organic cotton, low-impact dyeing, and water-efficient finishing technologies. Nevertheless, conventional denim production remains highly resource intensive. Therefore, current research focuses on developing sustainable alternatives that preserve denim's appearance, comfort, durability, and consumer acceptance while reducing environmental impacts, including denim-look fabrics, regenerated cellulosic fibres, recycled materials, and other circular textile solutions [19]. Environmental impacts occur throughout the denim life cycle, from cotton cultivation to consumer use, with dyeing and finishing representing the most resource-intensive stages. Consequently, reducing the environmental footprint of denim production through cleaner technologies and circular strategies has become a major sustainability priority [20].

Water consumption is a major environmental challenge because cotton cultivation and wet processing require large volumes of freshwater, while textile production contributes approximately 20% of global water pollution. Denim wastewater contains dyes and processing chemicals, encouraging the adoption of water-saving technologies such as laser finishing, ozone treatment, foam dyeing, and water recycling systems [20]–[22]. Conventional denim production also depends on intensive chemical and energy use. Therefore, enzymatic treatments, bio-based chemicals, renewable energy, waste heat recovery, and process optimization have become key strategies for reducing environmental impacts [20]–[23]. In addition, greenhouse gas emissions from yarn, fabric, and wet processing highlight the need for integrated sustainability strategies across the denim supply chain [22].



Denim-look fabrics have emerged as sustainable alternatives that replicate the appearance of woven denim while reducing environmental impacts. Circular knitted structures, digital printing, engineered jacquard fabrics, and innovative finishing technologies enable authentic denim aesthetics with substantially lower water and chemical consumption. These fabrics increasingly incorporate recycled cotton, regenerated cellulosic fibres, recycled polyester, and elastane to improve environmental performance. The development of sustainable denim has also promoted the use of recycled cotton, organic cotton, hemp, and regenerated cellulosic fibres such as lyocell [24]. Recycled cotton reduces the demand for virgin resources, while regenerated cellulose fibres and recycled polyester support circular material flows [24]–[26]. Hemp requires less irrigation and fewer agrochemicals than cotton, whereas lyocell offers a closed-loop production process, biodegradability, effective moisture management, and favourable mechanical properties, making both fibres promising alternatives for sustainable denim applications [25], [27].

3. YOUNG CONSUMERS’ ENVIRONMENTAL AWARENESS AND SUSTAINABLE FASHION ATTITUDES

Generation Z, born between the mid-1990s and early 2010s, is a key consumer group shaping the future of the fashion industry. Growing up in a digitally connected environment, they increasingly consider sustainability, transparency, and ethical production alongside price, quality, and style when making purchasing decisions, encouraging brands to adopt more sustainable production practices. Although environmental awareness has increased demand for recycled materials, circular design, repair services, and second-hand markets, purchasing decisions remain strongly influenced by comfort, aesthetics, quality, price, and brand reputation. Reducing this gap requires consumer education together with affordable, attractive, and genuinely sustainable products. User experience is a key factor influencing the acceptance of sustainable denim. Besides environmental performance, consumers evaluate comfort, fit, appearance, durability, quality, and similarity to conventional denim, while price, brand reputation, product availability, and trust in sustainability claims also affect purchasing decisions. Environmental awareness alone does not ensure sustainable purchasing behaviour. Consumers are more likely to adopt sustainable denim alternatives when they provide aesthetics, comfort, quality, and functionality comparable to conventional products. Therefore, successful market adoption depends on both improved environmental performance and positive user experiences supported by effective sustainability communication [28]–[31]. Accordingly, this study investigates consumers’ perceptions, user experiences, and purchase intentions regarding denim-look trousers developed as an environmentally friendly alternative to conventional denim.

4. MATERIALS AND METHODS

4.1 Research Design

The study was conducted in three phases; First, a denim-look garment was designed and produced to replicate the appearance of conventional denim while avoiding resource-

intensive manufacturing processes. Second, participants wore the garment during a controlled wear trial. Finally, semi-structured interviews explored their experiences, perceptions of comfort, aesthetics, sustainability, and purchase intentions. This sequential approach enabled participants to evaluate the product through direct use, generating richer qualitative data. It adopted a qualitative product evaluation design integrating sustainable product development, wear trials, and user experience assessment. Rather than relying solely on interviews, the research combined the development of an environmentally friendly denim-look garment with user-centred evaluation to investigate participants' environmental awareness and perceptions of a sustainable alternative to conventional denim.

4.2 Production of the Denim-Look Trousers

The trousers were manufactured from a two-thread knitted cotton fabric engineered to resemble woven indigo denim, with the denim appearance achieved through digital printing (Fig.1-4). Cotton production is associated with intensive water use and the extensive application of pesticides and fertilizers, creating significant environmental concerns [25]. This study addresses the use of denim-look fabrics as a sustainable alternative to conventional denim.



Figure 1: (left) Model1-(17194D-ZR-467-V1) **Figure 2:** (right) Model2- (17186D-ZR-03-V1)

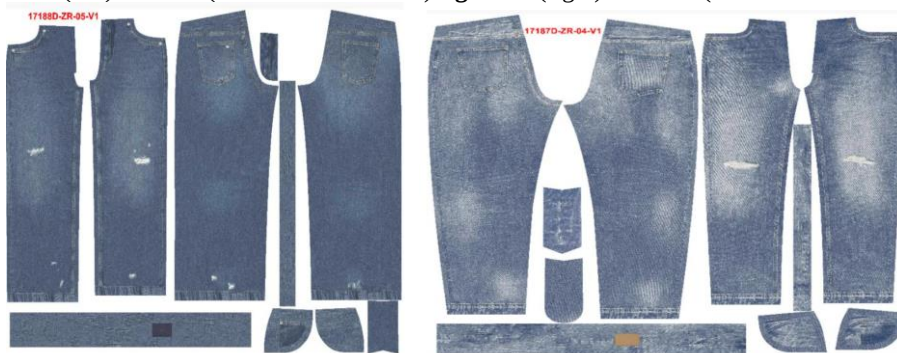


Figure 3: (left) Model3-(17188D-ZR-05-V1) **Figure 4:** (right) Model4- (17187D-ZR-04-V1)

Model #1 (17194D-ZR-467-V1): To minimise the influence of fashion style on participants' evaluations, the first prototype adopted a familiar five-pocket jeans construction with a waistband, belt loops, back yoke, fly opening, and decorative topstitching. Digital printing reproduced washed indigo effects, subtle fading, and twill-like textures without conventional dyeing, washing, or finishing processes. A regular-fit, straight-leg silhouette preserved the visual identity of traditional denim while providing everyday comfort, enabling evaluation of a sustainable alternative with authentic denim aesthetics.

Model #2 (17186D-ZR-03-V1): The second prototype was developed as a straight-leg distressed denim-look trouser retaining the essential construction details of conventional jeans. Digitally printed stonewashed effects, whiskering, abrasion marks, and distressed details recreated the appearance of aged denim through twill-like textures and tonal colour variations without mechanical abrasion or chemical washing.

Model #3 (17188D-ZR-05-V1): The third prototype featured a dark indigo denim-look design with a classic straight-leg silhouette and the characteristic construction details of conventional jeans. A deep indigo base combined with digitally printed fading, abrasion effects, and twill textures reproduced authentic denim while creating a cleaner, premium appearance. The design demonstrated how digital printing can replicate conventional denim aesthetics without resource-intensive dyeing, washing, or abrasion processes.

Model #4 (17187D-ZR-04-V1): The fourth prototype was designed as a stonewashed denim-look trouser with a classic straight-leg silhouette and the standard construction details of conventional jeans. A medium-to-dark indigo palette with digitally printed stonewashed effects, localized fading, whiskering, distressed details, and twill textures recreated the appearance of naturally aged denim. The design successfully combined aesthetic and functional requirements while reproducing the visual characteristics of conventional denim through appropriate fabric structure, colour, surface texture, and garment details.

Among four digitally developed alternatives, Model 4 was selected for production because it most closely resembled authentic denim. The design was digitally printed onto transfer paper using a Konica Minolta textile printing system and applied to the fabric by heat-transfer printing, providing high-quality image reproduction while reducing water, chemical, and wastewater consumption compared with conventional denim finishing (Fig.5-8).

The digitally printed fabric was cut and sewn into a complete garment. The addition of a zipper and metal button created a waistband and overall appearance closely matching that of conventional denim jeans (Fig.5-8). After printing, each pattern piece was cut through energy-efficient laser processing and assembled using conventional sewing techniques. Laser cutting enhances sustainability by minimizing fabric waste through precise nesting optimization, reducing consumable use with contact-free cutting, improving production accuracy to decrease rework, enabling on-demand and customized manufacturing to reduce overproduction, and supporting seamless integration into automated digital production systems. The remaining unprinted white fabric offcuts were sufficiently clean and homogeneous to remain suitable for further use. The garment required only a zipper and a single metal button as additional components. Decorative rivets and eyelets were reproduced through digital printing rather than attached as metal hardware, substantially reducing the metal content of the garment. This approach also preferred to improve recyclability, as metal accessories such as rivets, buttons,

and zippers are recognised as factors that complicate textile recycling and material recovery in denim products.

4.3. Participants and Wear Trial Procedure

The second phase consisted of a controlled wear trial in which participants examined and wore the developed garment. The study group consisted of 11 female university students enrolled in different academic departments at various universities who voluntarily agreed to participate in the research. A purposive sampling strategy, specifically criterion sampling, was employed to recruit the participants. Purposive sampling enables researchers to obtain rich and in-depth information from relatively small samples by selecting participants who are particularly relevant to the research objectives [32]. According to Yıldırım and Şimşek (2011), criterion sampling involves selecting all cases that meet a set of predetermined criteria established either by the researcher or by previously defined standards [33]. Accordingly, three inclusion criteria were established for participation in the study: (i) being currently enrolled as a university student and (ii) having previous experience in purchasing and wearing denim trousers (iii) having basic knowledge of textiles, garment construction, or fashion products, enabling them to evaluate the developed garment from both functional and aesthetic perspectives. These criteria ensured that all participants were familiar with conventional denim products and were therefore capable of providing informed evaluations of the alternative garment developed within the scope of this research. Participation was voluntary, and informed consent was obtained prior to data collection.



Figure 5 (left): Printing process by Konika Minolta

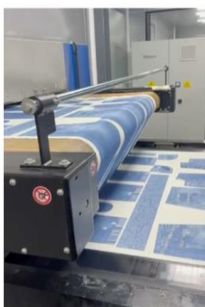


Figure 6 (right): Two-thread fleece



Figure 7 (left): Wist band and zipper closure



Figure8 (right): Manufactured pants

4.4. Wear Trial and User Experience Evaluation

Participants first received a brief explanation of the environmental impacts of conventional denim production and the sustainability objectives of the developed garment. They then examined and wore the denim-look trousers under identical conditions, evaluating their appearance, denim similarity, comfort, fit, flexibility, freedom of movement, and overall quality. Immediately after the trial, semi-structured interviews were conducted to record participants' initial impressions and user experiences.



Figure 9: Wear trials

4.5. Data Collection Procedure

Data were collected in two consecutive phases using semi-structured interviews. In the first phase, participants completed interviews addressing **Theme 1** (Awareness of the Environmental Impacts of Denim Production) and **Theme 2** (Attitudes Toward Sustainable Fashion and Environmental Responsibility), focusing on their environmental awareness, sustainability perceptions, and clothing consumption behaviours before product exposure. Participants then wore the developed denim-look trousers under normal daily conditions for 15 days. After the wear trial, a second round of interviews explored **Theme 3** (Evaluation of the Denim-Look Alternative Product), examining aesthetic and functional evaluations, user experiences, and perceptions of the garment as an alternative to conventional denim. Conducting interviews after the wear trial ensured that the findings reflected actual user experience and enhanced the ecological validity of the study. Data were collected through face-to-face semi-structured interviews comprising open-ended questions covering five dimensions: environmental awareness, aesthetic perception, perceived comfort, sustainability evaluation, and purchase intention. Each interview lasted approximately 10–15 minutes. Nine participants completed both interview rounds, and their interviews were transcribed verbatim.

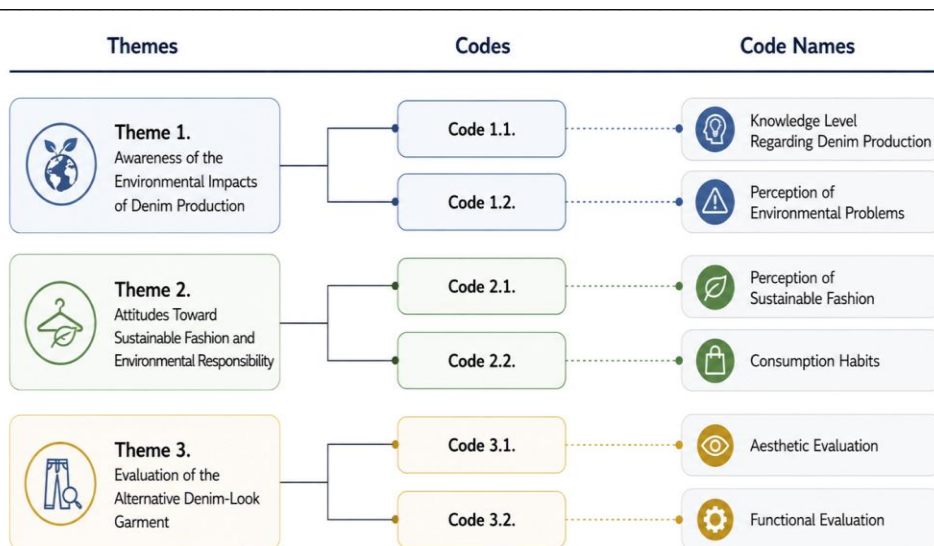


Figure 10: Thematic framework of the study

4.6. Data Analysis

The interview transcripts were analysed using thematic analysis. Meaningful statements were coded and grouped into categories and themes using an inductive approach. The findings were interpreted based on participants' actual wear experiences, enhancing the credibility and ecological validity of the study.

5. RESULTS AND DISCUSSION

The findings present participants' evaluations of the developed denim-look garment regarding aesthetics, comfort, sustainability, and purchase intention, based on their experiences following the 15-day wear trial.

5.1. Theme1: Awareness of the Environmental Impacts of Denim Production

Code 1.1. Knowledge Level Regarding Denim Production

Participants demonstrated a basic awareness of the environmental impacts of denim production, although their knowledge was mainly limited to excessive water consumption. Most identified high water use ($f = 7$), while fewer mentioned chemical use ($f = 2$), energy consumption ($f = 2$), or environmental pollution ($f = 3$). Two participants reported little or no prior knowledge. Water-intensive processes were most frequently identified as the stage causing the greatest environmental impact ($f = 5$), followed by stone washing and finishing ($f = 2$) and dyeing ($f = 1$), while two participants could not identify a specific stage. University education was the primary information source ($f = 6$), followed by social and digital media ($f = 4$). Overall, awareness existed but remained largely restricted to water consumption.

Code 1.2. Perception of Environmental Problems

Participants regarded denim production as environmentally burdensome, mainly because of excessive water use ($f = 6$), and several emphasized the need for more sustainable production methods ($f = 3$). Two participants suggested replacing conventional denim with environmentally friendly alternatives. Chemicals and production waste were widely recognized as environmental and health risks ($f = 6$), although many participants admitted limited knowledge of the chemicals involved ($f = 4$). Stone washing was identified as one of the most harmful processes ($f = 2$). All participants agreed that public awareness of denim's environmental impacts is insufficient ($f = 9$) and believed that greater awareness could encourage more sustainable production and consumption. Overall, participants associated denim production primarily with water use and chemical pollution, while demonstrating limited understanding of broader environmental issues.

5.2. Theme 2. Attitudes Toward Sustainable Fashion and Environmental Responsibility

Code 2.1. Perception of Sustainable Fashion

Participants generally expressed positive attitudes toward sustainable fashion, although the level of understanding varied. Sustainable fashion was most frequently associated with environmentally responsible production and consumption ($f = 4$) and ethical production and resource conservation ($f = 4$). Some referred to recyclable materials and circular production ($f = 2$), while others emphasized durability and long product life ($f = 3$). Only one participant associated sustainability mainly with recycled fabrics ($f = 1$).

Most participants reported considering environmental factors when purchasing clothing ($f = 6$), and several intentionally preferred durable products or reduced denim consumption ($f = 4$). However, two participants prioritized design, price, and quality over environmental concerns ($f = 2$). Attitudes toward sustainable textile products were unanimously positive ($f = 9$); participants described them as beneficial for the environment and human health ($f = 5$), supported wider adoption ($f = 3$), and one participant noted that sustainability labels could influence purchasing decisions ($f = 1$). Overall, favourable attitudes did not always translate into purchasing behaviour.

Code 2.2. Consumption Habits

Purchasing decisions were mainly driven by quality ($f = 5$), comfort ($f = 5$), price ($f = 5$), and fabric characteristics ($f = 6$), whereas sustainability-related attributes were mentioned less frequently ($f = 4$). Colour ($f = 2$), design ($f = 1$), and product labels ($f = 1$) had relatively little influence. Most participants were willing to pay more for environmentally friendly products ($f = 8$), provided they also offered good quality, durability, comfort, or reasonable pricing ($f = 5$), while one participant remained uncertain ($f = 1$). Aesthetics was the primary purchasing criterion for most participants ($f = 5$), four preferred products combining aesthetics and sustainability ($f = 4$), and only one prioritized sustainability ($f = 1$). Overall, sustainability complemented rather than replaced conventional purchasing criteria.



5.3. Theme 3. Evaluation of the Denim-Look Alternative Product

Code 3.1. Aesthetic Evaluation

Participants evaluated the denim-look garment positively and considered it visually similar to authentic denim. Most described it as visually successful ($f = 6$), and several stated that it was difficult to distinguish from real denim ($f = 4$). Others appreciated its environmentally friendly concept ($f = 4$) and comfort ($f = 3$), although a few noted the absence of the rigid structure and tactile feel of conventional denim ($f = 2$). Most participants agreed that the garment successfully replicated authentic denim ($f = 7$), while suggesting minor improvements in colour tone ($f = 3$) and printed pocket details ($f = 1$). The realistic texture, colour, washing effects, stitching, and overall appearance were the most appreciated visual characteristics ($f = 6$). Overall, participants considered the garment an aesthetically successful sustainable alternative, requiring only minor refinements.

Code 3.2. Functional Evaluation

Participants reported a high level of acceptance, particularly because of the garment's comfort and flexibility. Most expressed willingness to wear it regularly ($f = 8$), emphasizing its softness and comfort ($f = 5$), while some suggested minor design improvements ($f = 3$). Comfort, flexibility, and freedom of movement were the most expected performance characteristics ($f = 7$), and lightweight structure and breathability were also valued ($f = 4$). Several participants considered the garment more comfortable than conventional denim because it avoided stiffness and heat discomfort ($f = 4$). Most believed it could successfully replace conventional denim in daily use ($f = 8$). Although some noted that it did not fully replicate denim's rigid handle ($f = 4$), they still regarded it as a practical alternative because of its superior comfort, recommending only minor structural or visual improvements ($f = 3$). Overall, the denim-look garment was considered a comfortable and practical alternative with high user acceptance.

6. CONCLUSIONS

The findings indicate that although future textile and fashion designers are aware of the environmental impacts of conventional denim production, their knowledge is largely limited to water consumption, highlighting the need for broader sustainability education covering textile production and circular design principles. Although participants expressed positive attitudes toward sustainable fashion, purchasing decisions remained primarily influenced by aesthetics, quality, comfort, and price. A key contribution of this study is the evaluation of a sustainable denim-look garment developed through an industry–university collaboration. Produced using digital printing instead of conventional indigo dyeing and washing processes, the garment reduced water, chemical, and energy consumption while maintaining the appearance of traditional denim. Participants evaluated the product positively, particularly for its visual similarity, comfort, and flexibility, with only minor suggestions regarding colour, fabric handle, and structure. Overall, the findings suggest that combining sustainability education with direct product experience can strengthen sustainability-oriented design thinking and increase acceptance of environmentally



responsible textile products, especially when sustainability is combined with attractive design, comfort, and functional performance.

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