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Title **Cross-Cultural Implementation of Sustainability in Fashion Design Education through a Design-Based Research Approach**

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Abstract This study investigates the cross-cultural implementation of the course *Sustainable Fashion Design Strategies* in Germany and Iran applying a Design-Based Research (DBR) approach. Through four iterative cycles of design, enactment, evaluation, and refinement, the course and its pedagogical components were treated as knowledge-generating artifacts, aligning with the Research Through Design (RTD) paradigm. Data were collected via per-session written reflections, group interviews, e-portfolios, and structured classroom observations, and analyzed using Mayring's Structuring Content Analysis (SCA). Findings reveal progressive student development in conceptual understanding, practical skills, attitudinal shift, ethical awareness, and engagement with sustainability principles. Iterative refinement, scaffolded experiential learning, and context-sensitive adaptation supported holistic, systems-oriented learning, integrating ethical, aesthetic, and professional dimensions of design. The study underscores the epistemic role of pedagogical artifacts in both mediating learning and generating transferable design principles. These insights offer actionable guidance for educators aiming to embed Education for Sustainable Development (ESD) in fashion design programs and demonstrate the value of iterative,

practice-based, and culturally responsive approaches. By showing how pedagogical decisions, aesthetic considerations, and reflective tools function simultaneously as learning supports and sites of knowledge production, this research contributes to advancing DBR and RTD discourse while providing a practical model for sustainability-oriented fashion design education.

Keywords Fashion Design, Education for Sustainable Development (ESD), Design-Based Research (DBR), Iran, Germany.

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Cross-Cultural Implementation of Sustainability in Fashion Design Education through a Design-Based Research Approach

Hanieh Choopani

1.0 Introduction

Education for Sustainable Development (ESD) has become a central concern in higher education, as universities are increasingly expected to equip students with the knowledge, competencies, and value orientations necessary to address complex environmental, social, and economic challenges (UNESCO, 2020). Sustainability in education extends beyond factual knowledge, encompassing critical thinking, ethical reflection, systemic understanding, and practical problem-solving skills that enable learners to navigate interdependent societal challenges (Rieckmann, 2022). In fashion and apparel design, the urgency of integrating ESD is particularly evident since the global fashion industry is among the most resource-intensive and environmentally damaging sectors, contributing substantially to pollution, textile waste, and labor inequities (Fashion Revolution, 2025; Amed et al., 2025; Ellen MacArthur Foundation, 2021). Sustainability can no longer be treated as an optional topic in fashion design education but must be embedded as a guiding principle throughout the design process, integrating lifecycle thinking, ethical reasoning, and long-term impact assessment into creative and technical practices (Glomb, 2025; Ermer & Schwarzkopf, 2021). Despite increasing recognition of this need, empirical guidance on implementing ESD as a core principle in fashion design curricula remains limited (Grundmeier & Höfer, 2023; Choopani, Grundmeier, & Glomb, 2023; Ermer & Schwarzkopf, 2021). Existing initiatives often rely on short-term workshops, stand-alone courses, or declarative instruction on sustainability, which can result in fragmented learning and limited transfer to design practice (Choopani, Glomb, & Grundmeier, 2025c; Choopani et al., 2023). These challenges are especially pronounced in under-researched educational and cultural contexts, such as Iran, where scholarship on integrating sustainability in fashion design education is scarce (Choopani, Glomb, & Grundmeier, 2025a). Traditional fashion design programs emphasize aesthetic exploration, material experimentation, and technical skills, whereas sustainability-oriented education requires the integration of systemic thinking, ethical considerations, and long-term environmental and social impact across the entire design process (Glomb, 2025; Ermer, 2018). This raises a central question: How can ESD be implemented as a guiding principle in fashion design higher education to develop sustainable clothing design practices?

Addressing this question calls for methodological approaches that move beyond predefined instructional solutions. Design-Based Research (DBR) has been increasingly recognized as suitable for investigating educational challenges where learning outcomes are closely intertwined with disciplinary traditions, institutional conditions, and cultural contexts (Kidritsch et al., 2025; Schmiedebach & Wegner, 2021). DBR bridges educational theory and practice by iteratively developing interventions in authentic settings, allowing theoretical insights and practical improvements to emerge in parallel (Feulner, Rosendahl, & Serwene, 2026; Euler, 2024; Lehrmann, Skovbjerg, & Arnfred, 2022). Recent developments further emphasize the Research Through Design (RTD) paradigm, which treats design activity itself as an epistemic practice generating knowledge (Reinmann, 2023). From this perspective, pedagogical decisions including content sequencing, choice of didactic tools, aesthetic considerations, and orchestration of learning activities are central sites of inquiry rather than merely instrumental choices. This framing is particularly relevant for creative disciplines such as fashion design, where learning is embodied, visual, and processual, and sustainability understanding emerges through iterative design practice rather than propositional knowledge alone (Schmalenbach & Ashouri, 2025).

The present study is situated within a doctoral research project investigating the integration of ESD in fashion design programs in Germany and Iran through iterative course design. The project aims to develop and empirically examine pedagogical strategies that support students' engagement with sustainable fashion design practices. Following a six-phase DBR process, which will be described in the methodology section, the study focuses on the fourth iteration of the course *Sustainable Fashion Design Strategies*, implemented at Alzahra (Farah Pahlavi) University in Tehran with 23 undergraduate apparel design students. Building on three prior German iterations, this iteration examined the transfer, adaptation, and contextualization of the course within a culturally and institutionally distinct setting. The course combined lectures, interactive discussions, group work, hands-on workshops, and structured reflective exercises. The USE-LESS Product Lifecycle was the central didactic tool, scaffolding students' engagement with zero-waste, upcycling, and circular design strategies and supporting the translation of abstract sustainability principles into concrete design decisions. The specific aim of this paper is to investigate how an iteratively developed, DBR-informed course design can foster fashion design students' engagement with ESD in a cross-continental context. By analyzing students' per-session written reflections, group interviews, final e-portfolios, and structured classroom observations, the study examines how learners internalize sustainability concepts and integrate them into design practice within the Iranian context. By relating these findings to prior German iterations and earlier research phases, the study further contributes to understanding the cross-cultural transferability and contextual adaptation of sustainability-oriented pedagogical strategies, thereby providing empirically grounded, design-oriented knowledge to inform the integration of ESD in fashion design programs.

2.0 Methodology

This doctoral research employs a DBR approach, which integrates the iterative design, implementation, analysis, and refinement of educational interventions as a core means of generating knowledge (Reinmann, 2023; Schmiedebach & Wegner, 2021). The study explores how ESD can be integrated in fashion design programs in Germany and Iran and examines how pedagogical strategies that respond to institutional and cultural contexts can support students in developing sustainability-related knowledge, skills, and attitudes. The research is structured as a six-phase DBR process comprising: (1) systematic literature review, (2) curriculum analysis, (3) expert interviews and participant observations, (4) course development with iterative piloting and refinement, (5) cross-cultural course implementation, and (6) compilation of recommendations for integrating ESD as a guiding principle in fashion design programs.

In the first phase, a literature review of 13 German and two Iranian publications, selected from a broader pool of studies on ESD across various fields, identified existing approaches to implementing ESD specifically in fashion design education. German research focused primarily on curriculum-level frameworks and modules (Grundmeier & Höfer, 2023; Ermer & Schwarzkopf, 2021; Ermer, 2018), while Iranian studies emphasized student attitudes or isolated skill-based interventions (Rezvani Ahangar Kolaee, Talebpour, & Javadi, 2021; Davari, Talebpour, Dadvar, & Afhami, 2016). The second phase comprised a curriculum analysis of 23 documents from 14 German universities and two documents from Iranian fashion design programs, revealing a stronger integration of sustainability content in German programs compared with fewer explicit sustainability-related modules in Iran (Choopani et al., 2025c; 2023). This difference is closely linked to structural variations in the higher education systems of the two countries. In Iran, the Ministry of Science, Research, and Technology publishes a standardized curriculum for each field, which is implemented uniformly across all universities. In contrast, German universities develop independent and institution-specific curricula for their programs, allowing greater flexibility in integrating sustainability-related content (Choopani et al., 2025c; 2023).

In the third phase, data from expert interviews with 19 fashion design professors and one lecturer, 14 from Germany (13 professors and one lecturer) and six from Iran (all professors), together with classroom participant observations at Hochschule Hannover University of Applied Sciences and Arts, revealed differing levels of ESD integration in practice (Choopani et al., 2025a). The findings indicate that ESD implementation is strongly influenced by the institutional and cultural context. While Germany emphasizes digital tools, interdisciplinary collaboration, and structured sustainability frameworks, Iran prioritizes creative, practice-oriented approaches and resource-adapted strategies. Despite these differences, both countries share the goal of equipping

students with the knowledge and skills necessary for sustainable design (Choopani et al., 2025a). However, in Iran, a gap persists between providing students with relevant knowledge and its practical application in the industry, largely due to policy and economic constraints (Choopani et al., 2025a). In the subsequent phases, the study focused on course development through iterative piloting and refinement, cross-cultural implementation, and the compilation of recommendations for embedding ESD as a guiding principle in fashion design programs.

2.1 Iterative design cycles and Research Through Design

Guided by established DBR quality criteria (Reinmann, 2023), the study addressed the implementation of ESD in fashion design education through the design, implementation, and iterative refinement of the course *Sustainable Fashion Design Strategies*. The course functioned as the central research artifact, treating design activity as an epistemic practice and iterative refinement as a core analytical focus for generating knowledge from pedagogical decisions, instructional configurations, and learner responses (Schmalenbach & Ashouri, 2025; Reinmann, 2023). To achieve the intended learning outcomes (Figure 1), the course was organized into distinct phases that integrated theory, hands-on practice, and reflective activities. Each session began with theoretical input addressing foundational concepts such as sustainable versus unsustainable fashion, the Triple Bottom Line, and product lifecycle thinking (Amed et al., 2025; Gimenez, Sierra, & Rodon, 2012). These theoretical perspectives were consistently integrated across sessions to guide design tasks, including circular economy criteria, product lifecycle assessment, the Ecodesign for Sustainable Products Regulation (ESPR), and the EU Strategy for Sustainable and Circular Textiles (European Commission, 2025a, 2025b). This was followed by a practical phase in which students applied theoretical concepts through hands-on activities such as styling, photo shooting, upcycling, and zero-waste fashion design techniques (Choopani & Davari, 2025; Rissanen & McQuillan, 2023). Industry case studies were embedded throughout the course to strengthen the linkage between theory and practice and to illustrate real-world sustainable fashion design strategies (Claxton & Kent, 2020; Gwilt & Rissanen, 2011). Each session concluded with open-ended questions that enabled students to reflect on their learning and design practices (Choopani, Glomb, & Grundmeier, 2025b; Choopani, Glomb, & Grundmeier, forthcoming; Choopani, Glomb, & Grundmeier, 2026).

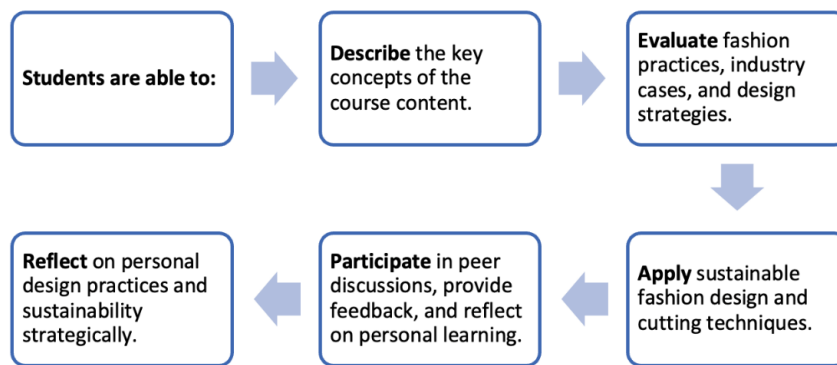


Figure 1. Learning goals of the course (@Author).

Throughout all iterations of the course, the research process was characterized by close research–practice collaboration, involving sustained cooperation between the researcher, the teaching and faculty staff at the participating institutions, and the supervisory team. Students were not positioned merely as research subjects, but as active contributors to the design process, engaging as co-constructors through peer discussions, reflective tasks, and design documentation. The course was developed and refined through four iterative DBR cycles between 2024 and 2026 across diverse institutional and cultural contexts, enabling continuous theory-informed analysis, empirical testing, and design adaptation in real-world educational settings (Feulner et al., 2026; Herzberg, 2022; Lehrmann et al., 2022). Figure 2 depicts the iterative DBR cycles of the course, highlighting how design modifications evolved through repeated phases of implementation, reflection, evaluation, and refinement.

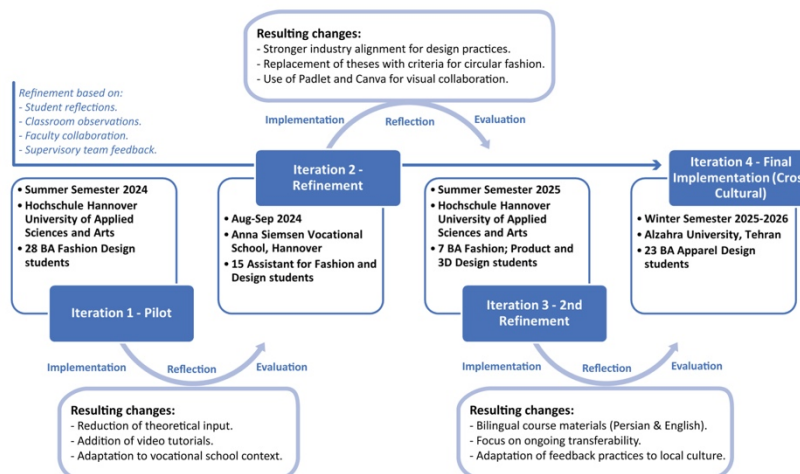


Figure 2. Iterative DBR cycles of the course (@Author).

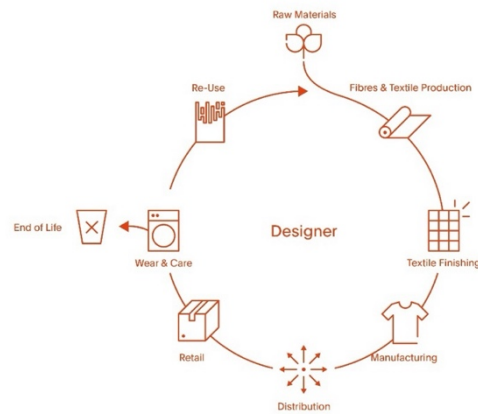
Empirical observation and student feedback from the first iteration (Choopani et al., 2025b) revealed that the extensive use of theoretical frameworks and a large number of abstract theses (Hoffmann, 1984)

caused cognitive overload, limiting students' ability to translate sustainability concepts into actionable design decisions. This finding revealed a specific theoretical insight: Abstract conceptual entry points, though intellectually coherent, hinder the transition from sustainability knowledge to design decision-making when lacking operational relevance at the level of individual material and aesthetic choices. Student feedback explicitly identified this gap. Requests for structured guidelines before individual exploration as well as descriptions of theory as overwhelming pointed to a mismatch between the framework's philosophical orientation and students' need for actionable design criteria (Choopani et al., 2025b). In DBR terms, this constituted a theoretical revision. The initial assumption that conceptual framing precedes practical engagement was reoriented toward a model in which operational criteria and embodied practice must scaffold conceptual understanding from the outset. These findings informed the second iteration, which shifted to a vocational education context and required pedagogical and structural adjustments to align content, pacing, and instructional methods with learners' educational backgrounds and professional orientations (Choopani et al., forthcoming). To address these challenges, the number of guiding theses was reduced from fourteen to seven to improve conceptual clarity and instructional focus. An asynchronous guest lecture video (von Hirschhausen, 2022; aligned with the first iteration, von Hirschhausen, n.d.) and step-by-step video tutorials were added to scaffold independent learning. Practice-oriented methods, including chalk talk, postcard-based ideation, and storytelling exercises, supported embodied and processual learning in the vocational school context. This pedagogical restructuring was not developed by the researcher alone. Following Iteration 1, consultation with the supervisory team and the tandem teacher at Anna Siemsen School revealed that the course's instructional assumptions, comfort with conceptual abstraction, and English-language proficiency were specific to the university context and did not transfer to the school setting. This input from practitioners constituted an epistemic contribution to the design: It identified the institutional embeddedness of the course's implicit learner model as a theoretical limitation, which directly motivated the contextual redesign for Iteration 2 (Choopani et al., forthcoming).

In the third iteration, although the reduced group size limited scalability, it allowed for more intensive observation and iterative refinement, particularly in interdisciplinary collaboration, hands-on design tasks, and translating sustainability concepts into concrete design decisions (Choopani et al., 2026). Based on earlier insights derived from student and supervisory team feedback, this iteration strengthened the connection between sustainability theory and professional fashion design practice. The earlier theses were replaced with fashion design criteria in circular economy (European Commission, 2025b) to provide more actionable guidance. Course content was more explicitly aligned with industry standards, additional cutting techniques and podcast-based discussion deepened technical engagement with circular and zero-waste strategies, and digital tools such as Padlet and Canva supported visual collaboration, peer feedback, and reflective documentation

throughout the design process (Choopani et al., 2026). This shift from the theses framework to fashion design criteria in a circular economy that aligns with ESPR was not merely a substitution of content, but rather a theoretically motivated redesign. It reflected a refined understanding, developed over two iterations, that the operationalization of ESD in design education requires frameworks that serve as both conceptual guidance and decision-support tools at the level of specific design decisions. This distinction has implications for the theoretical integration of ESD in creative disciplines. The transition was analytically supported by an emergent finding from Iteration 2: AI-assisted preliminary coding in MAXQDA (VERBI Software, 2026; Kuckartz & Rädiker, 2024) revealed that students engaged in critical evaluation of sustainable versus unsustainable practices, which was not anticipated in the original category framework. This evaluation was a distinct learning outcome, separate from both conceptual understanding and skill development. Initially coded as “Critical Thinking” and refined to “Attitudinal Change” in Iteration 3, this pattern revealed that ESD learning in design education produces dispositional shifts and changes in professional orientation and values that are analytically distinct from cognitive and practical gains (Choopani et al., 2026). Absent from the previous iteration framework, this distinction became a stable theoretical contribution of the DBR process, holding across the cross-cultural context of Iteration 4 without requiring further inductive modification.

The fourth and final iteration was implemented in the winter semester 2025–2026 at Alzahra (Farah Pahlavi) University in Tehran, Iran, involving 23 undergraduate students in apparel design and representing a cross-cultural transfer of the course. The course followed the same five-session structure, with each session divided into four 45-minute units and 15-minute breaks. To implement this iteration, the researcher traveled to Iran and conducted four of the five sessions in person from late October to late November 2025; however, due to severe air pollution in the final week, which posed health risks for all age groups, including young adults (IQAir, 2025), all university classes in Tehran were shifted online, and the fifth session was conducted virtually. Teaching formats combined lectures, interactive discussions, group work, and structured reflective exercises with a variety of collaborative and experiential methods including think–pair–share, poster-making, gallery walks, documentary- and podcast-based debates, and hands-on workshops, fostering active learning and reflection (Rissanen & McQuillan, 2023; Pillana, 2020; Roberts, n.d.). Further contextual adaptations were developed in consultation with the local faculty member at the Iranian university. This faculty member’s knowledge of the students’ prior educational experiences, institutional norms, and culturally embedded design practices informed the incorporation of more structured hands-on activities, bilingual (Persian–English) learning materials, and culturally relevant examples. These adaptations constituted a practitioner contribution that shaped both the pedagogical form and the contextual grounding of the final iteration. Across all iterations, the USE-LESS Product Lifecycle (Figure 3) functioned as a central didactic framework, enabling students to systematically connect sustainability theory with applied design practice.



use-less.org



Figure 3. USE-LESS Product Lifecycle (@USE-LESS Centre for Sustainable Design Strategies).

The research was inherently collaborative, involving the researcher, local faculty members, and the supervisory team in the iterative design and refinement of the course. This researcher–practitioner collaboration aligns with DBR principles emphasizing early negotiation of goals, roles, and evaluation criteria to balance practical relevance with theoretical knowledge generation (Schmalenbach & Ashouri, 2025; Euler, 2024). Consistent with participatory orientations in DBR, students were positioned as active contributors rather than passive recipients of the intervention. Students’ learning processes and reflections, documented through e-portfolios and per-session written responses, alongside group interviews, constituted the primary empirical data for the study.

2.2 Data sources, analysis, and quality criteria

To enhance validity, a central quality criterion in DBR, the fourth iteration drew on multiple complementary data sources, enabling triangulation across perspectives and data types. DBR emphasizes triangulation and robustness through variation across iterations as key strategies for establishing plausibility in complex educational settings where experimental control is limited (Brase, 2024; Reinmann, 2023). The data corpus comprised 84 per-session written responses across four sessions, two group interviews totaling 67 minutes (involving 21 of the 23 students), 20 final e-portfolios (three students were unable to submit their e-portfolios), and five structured observation forms completed by a faculty member at Alzahra (Farah Pahlavi) University. Together, these sources captured immediate learning reflections, collaborative meaning-making processes, and cumulative learning outcomes over time. Insights from earlier German iterations informed the course’s adaptation in Iran, supporting contextual refinement and enabling cross-cultural comparison. Students’ written responses were coded as S1–S23, e-portfolio entries as P1–P20, and group interview contributions as GI-S1–GI-S21 to ensure anonymity. All participants

provided informed consent, and some students explicitly granted permission for the publication of their design work and visual materials with name attribution. Observation reports were analyzed with particular attention to teaching strategies, lesson design, classroom climate, inclusivity, and resource use. Data analysis was conducted using a fully deductive approach based on Mayring's Structuring Content Analysis (SCA) (Mayring, 2022) and implemented in MAXQDA (VERBI Software, 2026; Kuckartz & Rädiker, 2024). Interview transcripts, e-portfolios, written responses (originally in Persian and some in English), and observation forms were translated into English, segmented, coded, and interpreted according to predefined categories (Table 1).

Table 1. Coding framework for analyzing student feedback and classroom observations.

Dataset	Coding category	Description
Student feedback	Knowledge and conceptual understanding	Students' grasp of sustainable vs. unsustainable fashion design, including product lifecycle, zero-waste strategies, recycling, upcycling, circular economy criteria, and pre-/post-consumer textile waste.
	Skill development and practical application	Students' ability to translate concepts into practice through workshops and activities such as styling and photo shooting, draping, zero-waste techniques, upcycling, case study research, and poster-making.
	Attitudinal change	Students' shifts in values, motivation, or intentions to apply sustainable design practices.
	Engagement and participation	Students' active involvement in discussions, group work, and activities, including fluctuations in participation and strategies to enhance engagement.
	Feedback on course design and pedagogy	Students' perceptions of course structure, content, and teaching methods, providing insights for potential improvements.
Observer documents	Teaching strategies and lesson design	Planning and structuring of lessons, clarity of objectives, sequencing of activities, and methods used.
	Student engagement and participation	Extent of student involvement, opportunities to contribute, equitable participation, and strategies to foster engagement in an international classroom.
	Atmosphere and inclusivity	Overall classroom climate, including openness, respect, and inclusion of diverse perspectives.

	Resources and practical application	Effectiveness of teaching tools and support for connecting theory to practice.
	Feedback and reflection	How lecturers provide guidance, facilitate student reflection, and conclude sessions with takeaways or suggestions for improvement.

These categories were derived deductively from the research questions, relevant literature, and insights from earlier course iterations. Inductive subcategories were not included because the study’s research framework and data sources were sufficiently structured, ensuring that all relevant phenomena could be captured within the predefined categories; this was further confirmed during two line-by-line reviews, in which no additional categories or themes emerged. For the initial analysis, the predefined coding categories were uploaded into MAXQDA’s AI Assist feature using the AI Coding tool (Figure 4), which automatically segmented transcripts, assigned text passages to the corresponding categories, and generated interpretive memos for each coded segment. The researcher then conducted careful line-by-line reviews of all AI-generated coding to verify contextual accuracy, ensure analytical relevance, and make necessary refinements. Anchor samples were extracted using the MAXQDA Summary Grid (Figure 4), organized systematically in Excel, and developed into interpretive paragraphs. Applying the same multi-step analytical procedure across both the student and the observer datasets ensured consistency and comparability.

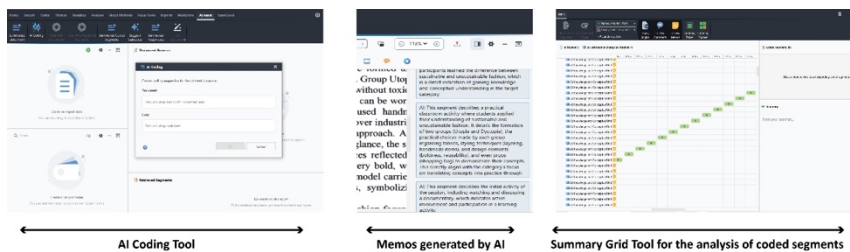


Figure 4. Tools used in MAXQDA during the qualitative coding process, including AI Coding, memo functions, and the Summary Grid (©Author).

Triangulation combining students’ written reflections, e-portfolios, group interviews, and structured observations enhanced the study’s robustness by incorporating multiple perspectives and supporting the traceability of design decisions, empirical observations, and theoretical reasoning. The study adheres to DBR-specific quality criteria, including validity, reliability, traceability, transferability, and accessibility across empirical, practical, and theoretical dimensions of Research Through Design (Brase, 2024; Reinmann, 2023). Both the evolving course design and student outputs functioned as knowledge-generating artifacts, producing a refined course model and a set of context-sensitive, transferable design principles for embedding ESD in fashion design programs across diverse institutional and cultural

settings. These principles, developed through a staged process from theory-informed orientations to application-oriented concretizations, offer conditional guidance that links theoretical assumptions with pedagogical decisions, enabling adaptation beyond the immediate research context (Feulner et al., 2026; Kidritsch et al., 2025; Reinmann, 2023; Herzberg, 2022).

3.0 Results

The analysis of data from both students and observers reveals how the iteratively designed course fostered the development of sustainability competencies in fashion design. The findings highlight not only the progressive evolution of individual learning trajectories but also the pivotal role of pedagogical choices such as scaffolded exercises, hands-on workshops, and structured reflection in enabling students to translate sustainability principles into informed, practice-based design decisions.

3.1 Insights from student feedback

Across all three data sources, the findings reveal a coherent and cumulative learning trajectory characterized by progressive conceptual development, increasing practical competence, attitudinal transformation, sustained engagement, and critical reflection on pedagogical design. Students' per-session reflections, group interviews, and e-portfolios consistently indicate that learning unfolded over time, moving from initial awareness toward integrated, reflective, and professionally grounded understanding of sustainability in fashion design. Prior to the descriptive analysis, Figure 5 presents the frequency of anchor samples across data sources for each analytical category. Frequency refers to the number of coded meaning units assigned to a category across all analyzed documents. In line with qualitative content analysis, these frequencies do not imply quantitative importance or learning impact; rather, they make visible how often particular learning dimensions were articulated within the dataset. The visualization enhances analytical transparency by illustrating the relative distribution of categories across written reflections, interviews, and e-portfolios.

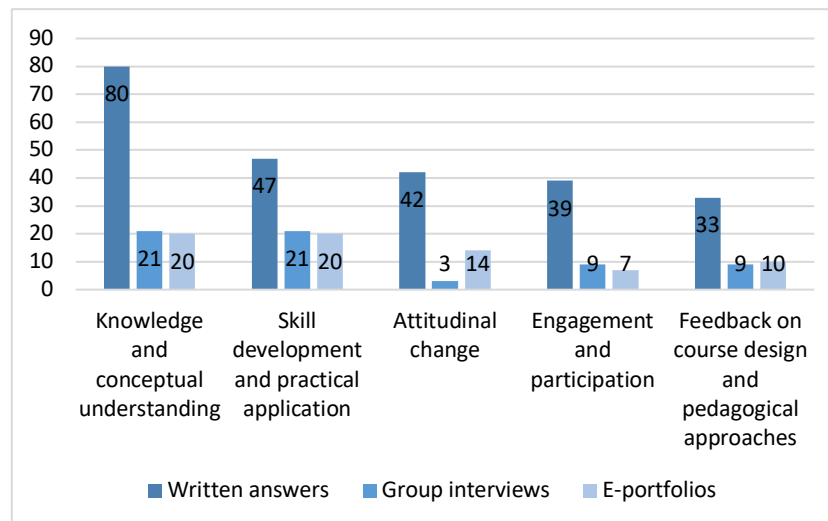


Figure 5. Frequency of anchor samples across data sources by category (©Author).

While Figure 5 illustrates distributional patterns, qualitative interpretation requires closer engagement with the substance of the coded units. Selected anchor samples are therefore presented below to exemplify how frequently occurring categories manifested in concrete reflections, design decisions, and professional positioning. Table 2 presents representative quotes from the fourth iteration at Alzahra (Farah Pahlavi) University across the five analytical categories and three data sources. Although a substantially larger number of anchor samples were identified across the full corpus of data documents, only two illustrative examples per category and per data source are included here to ensure analytical clarity and proportional balance within the publication format. The excerpts were selected through purposive sampling following the coding process, prioritizing units with strong semantic alignment to the respective category definition, conceptual richness, and representativeness of recurring patterns across cases. All anchor samples informed the category construction and interpretative analysis; the excerpts presented in Table 2 therefore function as illustrative condensations of the broader dataset rather than exhaustive representations, while still concisely reflecting the range and depth of student learning.

Table 2. Student voices on course impact.

Category	Per-session reflections	Group inter-views	E-portfolios
Knowledge and conceptual understanding	"Zero-waste fashion treats fabric as a fully utilized resource rather than disposable material." (S1)	"Moved from vague understanding to clarity on recycling, upcycling, redesign, and lifecycle thinking." (GI-S9)	"Sustainability is an interconnected environmental, social, and economic system integrated through zero-

			waste, upcycling, and circular design.” (P2)
	“Managing pre- and post-consumer waste is key to reducing textile waste.” (S7)	“Realized small fabric pieces have value; awareness of fabric transformation and minimizing waste increased.” (GI-S7)	“Demonstrates holistic lifecycle understanding, contrasting linear and circular systems while applying zero-waste and recycling.” (P5)
Skill development and practical application	“Applied zero-waste design through precise cutting and reuse of leftover materials.” (S1)	“Gained comprehensive workflow skills, including zero-waste methods such as folding, wrapping, pinning, and geometric construction.” (GI-S20)	“Applies zero-waste cutting, draping, upcycling, and garment transformation, demonstrating creative problem-solving in practice.” (P1)
	“Experimented with kinetic and geometric techniques to see how material constraints foster creative solutions.” (S2)	“Improved pattern placement and fabric waste reduction through collaborative, hands-on practice.” (GI-S12)	“Translates theory into practical exercises using zero-waste techniques and modular garments, minimizing waste while enhancing creativity.” (P14)
Attitudinal change	“Now sees recycling and upcycling as essential responsibilities, not optional design choices.” (S2)	“Shifted toward viewing sustainability as a core narrative and storytelling tool, not just a marketing strategy.” (GI-S1)	“Shifted from only aesthetic-focused design to sustainability-focused thinking, embracing zero-waste as ethical responsibility.” (P1)
	“Shifted from seeing zero-waste as technical to understanding it as a holistic design	“Recognized zero-waste as symbolic of environmental responsibility, reflecting a	“Moves from a consumption-driven view to an ethical, lifecycle-oriented design

	<i>philosophy.” (S14)</i>	<i>deeper value-based mind-set.” (GI-S2)</i>	<i>approach.” (P14)</i>
Engagement and participation	<i>“Actively participated in the kinetic design exercise as both designer and model.” (S2)</i>	<i>“Teamwork and portfolio building made learning active and enjoyable.” (GI-S4)</i>	<i>“Actively participated in group projects and zero-waste workshops, reflecting sustained engagement through hands-on experimentation.” (P1)</i>
	<i>“Engaged hands-on with Geo-Cut and fabric-width techniques and reflected on challenges.” (S5)</i>	<i>“Practical workshops and collaboration inspired engagement; suggested extending hands-on sessions.” (GI-S10)</i>	<i>“Demonstrates sustained engagement in workshops, experiments, and case studies throughout the learning journey.” (P3)</i>
Feedback on course design and pedagogical approaches	<i>“Combination of explanatory videos and hands-on zero-waste exercises effectively enhanced understanding and creativity.” (S2)</i>	<i>“Praised practical teaching for organizing prior intuitive knowledge and balancing function with aesthetics.” (GI-S2)</i>	<i>“Structured integration of theory and practice across sessions effectively developed skills and ethical awareness.” (P12)</i>
	<i>“Workshop clearly showed that zero-waste thinking must begin at the first design stage.” (S9)</i>	<i>“Valued the combination of teamwork, case studies, and structured workshops; suggested longer duration and exhibitions.” (GI-S13)</i>	<i>“Project-based learning and applied exercises fostered creativity, technical development, and responsible design thinking.” (P15)</i>

Students' conceptual understanding developed progressively throughout the course. Early reflections distinguished sustainable from unsustainable fashion in general or value-based terms, whereas later reflections demonstrated increasingly differentiated and structured reasoning. Students incorporated circular design criteria, recycling and upcycling strategies, zero-waste cutting techniques, and lifecycle thinking, frequently referencing durability, ethical labor, resource efficiency, material flows, and designer responsibility in early design stages. Group interviews confirmed this shift from intuitive awareness toward theoretically grounded and intentional knowledge. Sustainability was ultimately framed as multidimensional, encompassing environmental, social, economic, cultural, and political dimensions. The progression was most evident in e-portfolios, where students articulated holistic, systems-oriented perspectives linking theoretical frameworks, policy contexts (e.g., circular design criteria, eco-design regulations), and concrete design strategies. Sustainability emerged as a guiding mindset informing deliberate design decisions rather than an isolated concept. Students' per-session reflections documented hands-on engagement with upcycling, garment reconstruction, modular design, and zero-waste cutting techniques, including geometric, kinetic, and full-fabric-width approaches (Figure 6). These reflections emphasized translating theoretical principles into tangible design outcomes while navigating aesthetic, functional, and material constraints, as illustrated in Figure 6.



Figure 6. Sample page from a student e-portfolio illustrating the upcycling design process. (©Rojin Javahery, used with permission).

A notable pattern in the group interview data merits attention regarding attitudinal change. A small number of students, three explicitly and two partially ($n = 5$, 21.7% of the cohort), described their learning as recognizing and naming practices already familiar from their cultural and material context rather than acquiring new sustainability knowledge. GI-S5 described the course as reframing techniques known out of necessity as professionally and scientifically validated design methods, which produced confidence rather than new content. Similarly, GI-S6 described gaining an understanding of

the rationale behind techniques that were previously practiced intuitively. GI-S3 articulated a shift from an intuitive, aesthetics-focused practice to a systematically organized design knowledge. This pattern of tacit competence becoming professionally articulated throughout the course was corroborated in the e-portfolios. Two students described sustainability principles as resonating with existing practices rather than as unfamiliar frameworks requiring adoption.

Group interviews also highlighted how workshops and collaborative experimentation transformed intuitive practices into conscious, professional strategies. Frequently mentioned competencies included waste-reducing pattern placement, garment reinterpretation, reuse of fabric remnants, and collaborative problem-solving. Teamwork enhanced both confidence and design quality. E-portfolios documented sustained and increasingly complex applications of these techniques, integrating upcycling, zero-waste and subtraction cutting, draping, and experimental construction. Sustainability was embedded within creative problem-solving and technical proficiency rather than treated as an external constraint. The findings indicate pronounced attitudinal changes over time. Early reflections revealed emerging awareness of mindful consumption and ethical responsibility, which gradually evolved into a value-based professional stance. Group interviews framed sustainability as a core design narrative and ethical commitment rather than a marketing strategy. Students increasingly positioned zero-waste and circularity as expressions of environmental responsibility and long-term thinking. These attitudinal shifts were most clearly articulated in e-portfolios, where students integrated sustainability into their emerging professional identities, framing design decisions as socially and environmentally consequential.

Engagement was consistently high and closely linked to learning outcomes. Written reflections highlighted active participation in workshops, discussions, collaborative tasks, and material experimentation, describing the learning environment as experiential, reflective, and motivating. Group interviews reinforced the importance of teamwork and shared problem-solving in sustaining engagement. Attendance records supported these qualitative findings, showing an overall participation rate of 87.4%. Group 1 (n = 13) maintained consistently high attendance, while Group 2 (n = 10) showed moderate fluctuations, particularly in the second session, yet overall participation remained stable. Across all data sources, students critically and constructively engaged with the course design. The documentary, the podcast, theoretical input, comparative analyses, brand case studies, and hands-on workshops were consistently evaluated as effective. The deliberate contrast between sustainable and unsustainable practices and the use of material constraints were described as particularly powerful strategies for learning. E-portfolios highlighted theory–practice integration and project-based learning as central to developing both conceptual clarity and professional confidence, while the structured session progression supported the perception of sustainability as both a conceptual framework and an embodied design practice. In addition to these evaluations, the data also revealed constructive suggestions. Table 3 documents these recommendations as identified through qualitative analysis.

3.2 Insights from structured observations

Analysis of the structured classroom observations identified five recurring categories capturing key dimensions of teaching and learning: teaching strategies and lesson design, student engagement and participation, atmosphere and inclusivity, resources and practical application, and feedback and reflection. These categories appeared consistently across all five observed sessions, indicating stable instructional patterns over time. Observations documented clear lesson sequencing with explicit learning objectives and a strong alignment between theory and practice, supported by lectures, guided questioning, case studies, multimedia materials, and structured practical tasks with progressively increasing complexity. Student engagement was sustained through discussions, hands-on activities, and group work with rotating roles, while the classroom atmosphere remained positive and inclusive through respectful communication and facilitative teaching practices. Instruction was supported by diverse resources and a consistent progression from theoretical explanation to professional examples and student implementation. Feedback was ongoing and multifaceted, with instructor feedback prominent throughout and peer feedback present but variably enacted due to culturally mediated factors.

3.3 Key suggestions from students and the observer

Building on the triangulated analysis of student reflections and structured observations, targeted recommendations emerged for the refinement of the course design. These suggestions did not indicate structural weaknesses; rather, they reflected critical engagement with the pedagogical framework and identified areas for deepening the course's impact.

Table 3. Design refinement implications derived from triangulated feedback.

Design dimension	Validated elements	Refinement implication
Temporal structuring	- Extend overall course duration. - Allocate more workshop time. - Provide earlier access to theoretical readings.	Recalibrate pacing and redistribute theoretical inputs to strengthen theory–practice integration and allow deeper experimentation.
Experiential learning core (validated strength)	- Project-based learning. - Practice-based experimentation. - Use of material constraints. - Comparative analysis of sustainable and	Consolidate experiential learning as the structural backbone of the course design and formalize these elements.

	unsustainable practices.	
Feedback culture & professional orientation	- Integrate public dissemination formats (e.g., exhibition). - Provide structured scaffolding for peer feedback.	Introduce guided peer-feedback and include exhibition or presentation formats to improve students' critique skills and confidence.

The refinement implications demonstrate that feedback from both students and structured observation converged on three central dimensions: temporal structuring, consolidation of experiential learning, and the formalization of feedback processes. The suggestions therefore reinforce the coherence of the pedagogical design while providing concrete direction for the final recommendations. Importantly, the feedback highlights the influence of contextually mediated factors on participation and critique practices, underscoring the necessity of adaptive scaffolding within sustainability-oriented design education.

4.0 Discussion

This study contributes to the discourse on DBR and RTD by demonstrating how ESD can be systematically embedded in fashion design education through iterative, research-informed course development. Consistent with contemporary conceptualizations of DBR, the course was treated not as a static object of evaluation but as an evolving epistemic object whose development, enactment, and refinement constituted primary sites of knowledge generation (Euler, 2024; Reinmann, 2023). Through four iterative cycles across German and Iranian higher education contexts, the research operationalized DBR's central premise: Theoretical advancement and practical improvement evolve in parallel through sustained engagement with authentic educational settings (Feulner et al., 2026; Lehrmann et al., 2022). Framing the course as RTD emphasized that design decisions including content sequencing, pedagogical tools, aesthetic constraints, and participation formats functioned as legitimate forms of knowledge production (Schmalenbach & Ashouri, 2025; Reinmann, 2023). Although DBR and RTD have each been applied independently in educational contexts, their systematic integration within a cross-cultural implementation where the course itself functions as an intervention and an epistemic object in institutionally distinct settings extends the scope of existing single-site applications of this combined approach (Schmalenbach & Ashouri, 2025; Reinmann, 2023).

A cross-iteration synthesis revealed both incremental improvements and structural evolution in the pedagogical model. Across the German iterations, the course progressed from a concept-heavy introduction to sustainability toward a practice-based, industry-relevant framework structured around circular economy principles (Choopani et al., 2025b; forthcoming; 2026). Early cycles demonstrated that students could engage conceptually with sustainability, understanding lifecycle thinking and zero-waste strategies but initially struggled to translate these principles into design decisions. Subsequent redesigns, including scaffolded exercises, video tutorials, and digital tools, bridged this theory–practice gap, supporting students’ procedural and strategic competence. Over time, students’ engagement evolved from curiosity to a professional, value-driven commitment, reinforced by experiential, project-based learning and peer exchange. The Iranian iteration illustrated the transferability and contextual sensitivity of the course rather than direct replication. Despite a larger cohort and partially online delivery, engagement remained high, with students integrating theoretical frameworks, policy contexts, and practical strategies from the outset. While design skills such as zero-waste cutting, upcycling, and modular construction were strong, initial scaffolding was required to link technical skills with systemic sustainability principles.

Systemic and cultural differences emerged as defining factors in learning dynamics. Students in Germany actively engaged in conceptual discourse and critical peer feedback, demonstrating their comfort with collaborative critique and reflective debate (Choopani et al., 2025b; forthcoming; 2026). In contrast, students in Iran were more reserved when providing peer feedback and relied more heavily on instructor guidance. This pattern is shaped by a hierarchical educational culture and a centralized institutional system in which students have historically had limited agency in curricular and pedagogical processes (Choopani et al., 2025a; 2025c; 2023; Tohidian, Abbaspour, & Khorsandi Taskoh, 2021). These patterns suggest that cultural or systemic norms around authority and hierarchy directly influenced how students internalized and expressed sustainability competencies. However, this did not prove to be pedagogically deterministic. Once scaffolding normalized critical engagement progressively, moving from instructor-led feedback through pair-based reflection to group critique, students developed collaborative orientations comparable to those observed in German cohorts. Thus, what initially seemed like a cultural or systemic constraint on critical learning can be better understood as a systemic-structural habit that responds to pedagogical redesign. This distinction has significant implications for how cross-cultural ESD transfer is theorized and practiced (Brase, 2024; UNESCO, 2020).

Beyond cultural scaffolding, the Iranian iteration revealed a qualitatively distinct learning dynamic. Notably, a subset of students described their learning not as acquiring new sustainability knowledge but as recognizing and professionally validating practices already embedded in their prior experience and cultural context. This pattern was

corroborated across group interviews and e-portfolios. While some students in the German iterations had prior exposure to sustainable design techniques from earlier semesters, the Iranian pattern was different. It was not about familiarity with specific methods, but rather about the legitimization of resource-efficient practices shaped by cultural tradition and economic necessity as professionally valid design knowledge. For this group, the course functioned not as knowledge transmission, but as epistemic legitimation. It provided a professional-scientific framework through which existing competencies could be identified, valued, and consciously applied to design decision-making. This pattern was not universal across the Iranian cohort, but its presence reveals a gap in cross-cultural ESD pedagogy (UNESCO, 2020). In contexts where resource-efficient practices are already embedded in everyday cultural and economic realities, pedagogical scaffolding may need to begin with the epistemic recognition and professional legitimization of existing practices rather than the construction of new sustainability knowledge. This finding complicates the dominant assumption in ESD literature that sustainability education is primarily the transmission of new knowledge and competencies. It also suggests that current ESD frameworks do not yet sufficiently account for contexts in which sustainable practices are already tacitly present in learners' lived experiences (Brase, 2024; Rieckmann, 2022; UNESCO, 2020).

Further findings from the Iranian implementation expand the scope of this analysis beyond the expectations of cross-cultural ESD frameworks. When severe air pollution forced the fifth session online (IQAir, 2025), student engagement and the classroom atmosphere remained positive and sustained, as documented in structured observer reports. This finding has a recursive theoretical dimension beyond the logistical adaptation: A course designed to cultivate sustainability awareness was disrupted by the environmental consequences of the very unsustainable systems and made those systemic interdependencies an immediate lived reality for participants rather than an abstract concern. Although the literature on ESD acknowledges the role of environmental context in shaping learning, whereby the systemic crises that sustainability education seeks to address simultaneously disrupt the conditions under which it takes place, the recursive dimension has received limited theoretical attention (UNESCO, 2020). This dimension is particularly salient in contexts such as Iran, where ESD research remains underrepresented in international literature (Choopani et al., 2025c; 2023). These findings also invite critical reflection on the assumptions embedded in the DBR methodology itself. Standard DBR quality frameworks position robustness through variation, the stability of findings across diverse contextual implementations, as a key criterion for validating knowledge claims (Brase, 2024; Reinmann, 2023). The Iranian implementation confirmed the stability of the course framework and category system across a culturally distinct context, meeting this criterion. However, it simultaneously revealed that framework stability does not guarantee process equivalence. The same pedagogical design produced epistemic legitimation rather than

knowledge construction for a subset of learners. This qualitative divergence within structural stability is not yet accounted for by the current theory of robustness through variation. Furthermore, DBR's participatory epistemology emphasizes the input of human practitioners and students as the primary sources of knowledge for redesign (Schmalenbach & Ashouri, 2025; Euler, 2024).

The iterative analytical process of this study also reveals a methodologically relevant observation: AI-assisted preliminary coding in MAXQDA contributed to the identification of the Attitudinal Change pattern inductively in Iteration 2 (Choopani et al., 2026). This finding emerged from the analytical process itself, not from practitioner consultation. It is impossible to determine whether this pattern would have been identified through conventional coding alone. What is significant is that computational tools functioned as a source of unexpected knowledge generation within the DBR cycle rather than merely as a processing aid. This suggests that, when applied critically and reviewed systematically, AI-assisted analytical tools may constitute a complementary epistemic resource within the DBR knowledge-generation process. This role has not yet been systematically theorized in existing DBR frameworks (Brase, 2024).

Across all iterations, experiential, collaborative, and materially grounded pedagogical components supported the translation of sustainability principles into deliberate design strategies. Didactic tools such as the USE-LESS Product Lifecycle, workshops structured around material constraints, draping and upcycling exercises, and structured reflective formats simultaneously functioned as learning supports and analyzable data sources. E-portfolios, reflective writings, and group interviews externalized tacit knowledge, enabling students to articulate design reasoning, material choices, and sustainability decisions (Delijs, 2022; Chaudhuri & Cabau, 2017), with artifacts progressively displaying clearer integration of circularity, deliberate material reduction, and coherence between aesthetic intention and sustainability rationale (Choopani et al., 2025b; forthcoming; 2026). The reciprocal relationship between student outputs and ongoing course refinement illustrates how DBR-informed pedagogical design can simultaneously generate knowledge for practice and theory: Students contributed feedback that informed iterative redesigns, ensuring alignment between theoretical intentions and classroom realities (Drepper & Hoffmann, 2025; Euler, 2024), while artifacts including e-portfolios, upcycled garments, and zero-waste designs revealed a critical integration of ethical, systemic, and creative considerations that extended beyond technical competence alone. Notably, across all four iterations students consistently described material and aesthetic constraints as generative conditions that expanded rather than restricted design possibility. This pattern runs counter to the common assumption in design education that sustainability requirements impose creative trade-offs (Gwilt & Rissanen, 2011; Niinimäki & Hassi, 2011). Whether constraint-based pedagogy functions as a specific driver of sustainability-oriented

creative agency is a question that requires further theoretical development beyond the scope of this study.

The study is distinctive in three respects. First, it positions the course itself as an evolving epistemic object, with pedagogical design decisions and student artifacts as sources of theory-building. Second, it integrates DBR and RTD in a cross-cultural framework, extending single-site applications through iterative testing and refinement across Germany and Iran. Third, it interweaves theory, practice, and reflection systematically through hands-on workshops, exercises structured around material constraints, and structured documentation, producing both transferable design principles and empirical insight into student learning. Building on these findings, Figure 7 presents a framework comprising ten empirically grounded recommendations for integrating ESD in fashion design programs. The framework is structured into three interconnected domains: foundational integration, pedagogical strategies, and contextual and impact-oriented dimensions. Iterative arrows indicate dynamic feedback loops linking reflection, research, and implementation.



Figure 7. Framework for integrating ESD in fashion design education (©Author).

These recommendations synthesize insights from course iterations, student reflections and artifacts, expert interviews, curriculum comparisons, and literature review, connecting conceptual sustainability with studio-based practice:

- 1) **Conceptual and curricular integration:** Embed sustainability as a guiding principle rather than a standalone module. Progressive scaffolding from discrete exercises to integrated, system-oriented projects, develops cognitive, technical, and reflective competencies, while alignment with program objectives and accreditation ensures long-term curricular coherence.

- 2) **Operationalization through practice:** Students internalize sustainability concepts most effectively through embodied engagement with materials, tools, and real-world design challenges. Workshops on zero-waste cutting, upcycling, and multifunctionality transform theoretical discourse into practical strategies. Case studies, textile waste examples, and industry collaborations situate studio exercises within broader economic, societal, and environmental systems.
- 3) **Generative constraints:** Material, aesthetic, and conceptual limitations should be framed as opportunities. Structured boundaries stimulate creative problem-solving, ethical reflection, and innovation, helping students navigate complexity while developing responsible and imaginative design strategies.
- 4) **Reflective and documentation practices:** E-portfolios, journals, and group discussions enable students to articulate design reasoning, material choices, and sustainability decisions. Reflection consolidates learning, fosters professional identity formation, ethical awareness, and long-term competence development, while providing rich data for course refinement.
- 5) **Experiential and collaborative learning:** Combining individual experimentation with collective activities enhances multidimensional understanding. Co-creating concept maps, posters, and case study analyses fosters peer learning, critical dialogue, and integration of social, environmental, and economic perspectives. Iterative, project-based collaboration reinforces resilience, adaptability, and transferable design skills.
- 6) **Student-centered participation and agency:** Positioning students as co-creators strengthens engagement and ownership. Opportunities to formulate personal sustainability manifestos or design “commandments” foster internalized sustainability mindsets, ethical self-positioning, and autonomous professional identities aligned with sustainability values.
- 7) **Contextual adaptation and cultural sensitivity:** Pedagogical strategies should be adapted to institutional structures, prior knowledge, and cultural norms without compromising epistemic integrity. Local adaptation of tools, materials, and collaborative formats ensures accessibility and relevance while maintaining conceptual depth.
- 8) **Ethical, societal, and industry connections:** Sustainability education must extend beyond studio exercises to address environmental, economic, and societal interdependencies. Linking design tasks to production systems, consumer behaviors, cultural heritage, and ethical dilemmas fosters systemic awareness and prepares students for real-world professional challenges.

- 9) Research-informed iteration and knowledge generation:** Iterative course evaluation integrates teaching and research, allowing continuous refinement and theory-building. Qualitative tools track student learning trajectories, design reasoning, and professional identity development, producing insights transferable to other sustainability-focused design programs.
- 10) Implementation, scaling, and transferability:** Effective integration of ESD depends on principled adaptation rather than rigid replication. Codifying tools, workshops, constraints, and reflection mechanisms ensures coherence while allowing flexibility in diverse educational contexts, supporting robustness through variation rather than uniformity.

Despite the study's methodological rigor and iterative design, a few limitations should be acknowledged. First, the study involved specific cohorts of students, and the observed learning trajectories may vary with different student populations, program structures, or levels of prior sustainability knowledge. Second, administrative and institutional factors, such as class size limitations and scheduling constraints, affected the feasibility of certain pedagogical interventions. Third, the researcher's simultaneous roles as course designer, teacher, and primary analyst introduce the risk of interpretive bias. This risk can be mitigated through consultation with supervisors, external observer reports, and transparent documentation of analytical choices, but it cannot be eliminated entirely. Fourth, although four iterative cycles allowed for substantial refinement, longer-term implementation could reveal additional challenges or affordances not captured within the study period. These limitations highlight the importance of contextual sensitivity when applying the articulated framework and suggest avenues for further research to test, adapt, and expand its applicability across diverse institutional and cultural settings. In sum, this DBR-based study demonstrates that embedding ESD in fashion design education requires a holistic orchestration of conceptual framing, embodied experimentation, reflective documentation, and contextual adaptation. Through repeated cycles of design, enactment, analysis, and refinement, pedagogical decisions were continuously aligned with sustainability-oriented learning goals and informed by empirical observations, expert insights, comparative curriculum analysis, and systematic literature review. By synthesizing these findings into a coherent, evidence-based framework of recommendations, the study provides actionable guidance for educators and researchers aiming to foster transformative sustainability learning in fashion design programs and offers a robust foundation for future DBR studies addressing complex educational challenges. However, as a DBR study situated in specific institutional and cultural contexts, the findings should be understood as transferable through principled adaptation rather than statistical generalization.

5.0 Conclusion

This study demonstrates that iterative, research-informed course development grounded in DBR can effectively embed ESD in fashion design education across culturally diverse contexts. Across four cycles implemented in Germany and Iran, students exhibited a progressive learning trajectory marked by increasingly differentiated conceptual understanding, enhanced practical competence, deepened ethical awareness, and sustained engagement with sustainability principles. Central pedagogical components including zero-waste and upcycling workshops, the USE-LESS Product Lifecycle, reflective e-portfolios, and collaborative exercises functioned as epistemic artifacts. These elements not only mediated student learning but also generated transferable design principles through iterative refinement. The integration of scaffolded experiential learning and structured reflection enabled students to connect theoretical frameworks, material experimentation, aesthetic decision-making, and professional responsibility, fostering a holistic and systems-oriented understanding of sustainable fashion design. At the same time, the cross-cultural implementation revealed that ESD integration is not achieved through replication but through principled adaptation. Beyond confirming the value of contextual adaptation, the cross-cultural implementation revealed findings that surpassed the original theoretical framework. For a subset of Iranian students, the course served as epistemic legitimation rather than knowledge transmission. This suggests that ESD pedagogy in culturally embedded sustainability contexts must recognize existing competencies alongside their development. Additionally, the forced transition to online delivery due to severe air pollution revealed a recursive dimension: The environmental crisis that motivates sustainability education simultaneously shapes the conditions under which it can occur. Variations in institutional structures, classroom norms, and student backgrounds required flexible pacing, context-responsive feedback practices, and contextually grounded examples. These findings highlight that sustainability-oriented pedagogy depends on contextual sensitivity while simultaneously maintaining conceptual coherence. More broadly, the study advances the discourse on RTD by positioning pedagogical design itself as a site of knowledge production. The course evolved as an epistemic object whose iterative transformation yielded both improved educational practice and theory-informed insights. By articulating empirically grounded and design-oriented recommendations, the study offers a robust framework for embedding sustainability as a guiding principle in fashion design programs. In doing so, it contributes to fostering systemic thinking, responsible material practices, and the ethical positioning of future designers within increasingly complex economic, environmental, and societal landscapes.

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