

Green Competence in Vocational Fashion Education: Trends, Learning Models, and Implementation Challenges

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ABSTRACT

Green competence, encompassing the knowledge, skills, and attitudes needed to address environmental sustainability challenges, remains underexplored in vocational fashion education. This study reviews literature on green competence integration in vocational and design-based fashion education published between 2021 and 2026. Following PRISMA 2020 guidelines, a systematic Scopus search identified 41 articles, of which 12 met the inclusion criteria. Three research questions examined research trends, pedagogical approaches, and implementation challenges. Findings identified five major research trends, revealing misalignment between existing curricula and green competence requirements. Seven learning models emerged, with Project-Based Learning (PjBL) being the most prevalent. Six implementation challenges were identified: curriculum gaps, knowledge-action gaps, resistance to change, insufficient scaffolding, technology barriers, and industry-academia misalignment.

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Introduction

The global fashion industry is among the most environmentally damaging sectors worldwide, responsible for approximately 10% of global carbon dioxide emissions, generating an estimated 92 million tons of textile waste annually, and consuming 79 trillion litres of water each year (Niinimäki

et al (2020). These alarming figures have intensified international pressure on educational institutions, particularly vocational schools, to produce graduates equipped not only with technical competencies, but also with the knowledge, attitudes, and skills to act in environmentally responsible ways. This multidimensional capacity is referred to as green competence, defined as the set of knowledge, skills, values, and attitudes enabling individuals to contribute to sustainable development through their professional practices European Commission (2022).

Despite growing global awareness of sustainability issues, vocational fashion education has been slow to systematically integrate green competence into its curricula. Existing research reveals a persistent disconnect between industry demands for sustainability-literate graduates and the actual competencies developed in fashion schools (Shen and Sethi, 2021; Murzyn-Kupisz and Holuj, 2021). This gap is especially acute in vocational secondary schools such as Indonesia's vocational fashion secondary schools (SMK Busana) where the primary mandate of producing work-ready graduates has traditionally prioritized technical skill formation over environmental and sustainability literacy.

A critical research gap exists in the systematic mapping of green competence development within vocational fashion education contexts. While individual studies have examined aspects of sustainability pedagogy in fashion design programs, no prior review has comprehensively synthesized the trends, instructional models, and implementation barriers specific to this domain. This absence of a structured evidence base impedes informed curriculum development and policy formulation, particularly for TVET (Technical and Vocational Education and Training) systems in developing economies where the fashion and garment manufacturing sector constitutes a major economic pillar.

Green competence is operationalized in this review through the GreenComp framework the European Sustainability Competence Framework European Commission (2022) which identifies four interdependent domains: (1) embodying sustainability values, (2) embracing complexity through systems thinking, (3) envisioning sustainable futures, and (4) taking action for sustainability. Crucially, green competence moves beyond environmental awareness to foreground action competence: the capacity to apply sustainability principles in real-world professional decisions. Within vocational fashion education, this manifests as selecting eco-friendly materials, applying Life Cycle Assessment (LCA) thinking, implementing zero-waste pattern-making, and evaluating environmental impacts of design decisions throughout the production chain.

Vocational fashion education occupies a distinctive niche between artistic design education and technical manufacturing training. In Indonesia, SMK Busana emphasizes practical skills, work readiness, and industry alignment. This creates both challenges and opportunities: sustainability integration must occur at the level of hands-on practice fabric sourcing, cutting waste minimization, and sustainable assembly methods not merely as supplementary environmental content. Murzyn-Kupisz and Holuj (2021) argue that fashion education requires multidimensional curricular adjustment seeking equilibrium across three axes: craft skills, artistic sensibility, and business acumen all animated by sustainability values. This triaxial framework maps directly onto the competency structure of these vocational fashion secondary schools, providing clear integration points for green competence.

Although there has been research discussing the skills needed in the post-pandemic hospitality sector, there is still a gap in the literature regarding how teaching methods can be adapted to meet the changing demands caused by COVID-19. Specifically, little is known about how methods such as experiential learning and work-integrated learning have been reconfigured in response to pandemic-era constraints, and what barriers educators and students face in implementing them. This study therefore aims to map the competencies needed in the hospitality sector between 2020 and 2025 and to analyze the teaching methods applied in hospitality TVET programs to develop these skills. The focus on the post-pandemic period enables a more targeted examination of how skills requirements and pedagogical approaches have shifted, providing a foundation for curriculum reform that is both timely and evidence-based.

This study addresses that gap by conducting a Systematic Literature Review (SLR) following PRISMA 2020 guidelines Page et al (2021). Three research questions guide this review:

- a. RQ1: What are the prevailing research trends regarding sustainability and green competence integration in fashion education during 2021-2026?
- b. RQ2: What learning models and pedagogical approaches are employed to develop green competence in fashion education?
- c. RQ3: What implementation challenges are encountered in vocational fashion education contexts?

This review adopts a three-dimensional analytical framework corresponding directly to its three research questions. The temporal dimension (RQ1) maps research trends across 2021-2026. The pedagogical dimension (RQ2) examines instructional models through which green competence is developed. The implementation dimension (RQ3) surfaces barriers impeding realization of green

competence in actual educational settings. Synthesis of these three dimensions generates actionable implications for vocational fashion secondary school curriculum development and TVET policy in Indonesia. The findings aim to provide an evidence map for curriculum developers, policymakers, and educators committed to embedding green competence in vocational fashion education with particular relevance to vocational fashion secondary schools in Indonesia and similar TVET contexts globally.

Method

Research Design

This study employs a Systematic Literature Review (SLR) design following PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines as outlined by Page et al. (2021). SLR was selected for its methodological rigor, transparency, and replicability, which minimize selection bias and ensure a defensible evidence synthesis. The protocol encompasses four sequential PRISMA phases: Identification, Screening, Eligibility assessment, and Inclusion.

Search Strategy and Query

The literature search was conducted in the Scopus database as the primary source. Scopus was selected due to its extensive indexing of fashion design, textile, and vocational education journals. The search was executed in March-April 2026. The search query was designed to capture four key elements: sustainable fashion, education context, research publication type, and temporal scope. Table 1 presents the search queries and initial results from each database.

Table 1. Search Queries Used to Retrieve Literature

<i>Database</i>	<i>Search String</i>	<i>Result</i>
Scopus (primary)	TITLE-ABS-KEY("sustainable fashion" OR "fashion sustainability") AND TITLE-ABS-KEY("education" OR "design education") AND PUBYEAR > 2020 AND PUBYEAR < 2027 AND LIMIT- TO(DOCTYPE,"ar") AND LIMIT-TO(PUBSTAGE,"final") AND LIMIT-TO(LANGUAGE,"English") AND LIMIT-TO(OA,"all")	41 articles
Web of Science	TS=("sustainable fashion" OR "fashion sustainability") AND TS=("education" OR "design education") AND PY=(2021-2026) AND DT=Article AND LA=English	Cross-validation only; no unique additions meeting all criteria
ERIC	("sustainable fashion" OR "fashion sustainability") AND ("vocational education" OR "design education") Year: 2021–2026	No additional relevant articles found

Inclusion and Exclusion Criteria

Seven inclusion and exclusion criteria were applied consistently across all retrieved articles to ensure relevance and quality, as presented in Table 2. Criteria were developed based on topic scope, educational context, document type, and direct relevance to the three research questions guiding this review.

Table 2. Inclusion and exclusion criteria applied in the screening process

<i>Aspect</i>	<i>Inclusion Criteria</i>	<i>Exclusion Criteria</i>
Publication year	Articles published between 2021–2026	Articles published before 2021
Language	English-language articles	Articles in other languages
Research topic	Addresses sustainability, green skills, sustainability competence, or environmental education related to fashion, textile, or apparel	Does not address sustainability or unrelated to fashion/textile/apparel
Research context	Within an educational context (formal/non-formal): vocational education, TVET, training, or design education	Focuses solely on the fashion industry without educational context
Study focus	Examines learning, curriculum, instructional models, or sustainability competency development	Does not address learning aspects or competency development
Document type	Peer-reviewed journal articles with full-text availability	Conference papers, book chapters, editorials, or no full-text access
Study relevance	Directly or conceptually linked to developing green competence in fashion education	Not relevant to sustainability competence development

Article Selection Process - PRISMA Flow

The article selection process adhered strictly to the PRISMA 2020 four-phase flow. In the Identification phase, the Scopus search yielded 41 articles. All 41 articles advanced to the Screening phase, where titles, abstracts, and keywords were reviewed; no articles were excluded at this stage as all required full eligibility assessment. In the Eligibility phase, each article was fully assessed against all seven criteria; 29 articles were excluded with documented reasons. The Inclusion phase resulted in 12 articles for full data extraction and thematic synthesis. Figure 1 presents the PRISMA 2020 flow diagram, and Table 3 summarizes the distribution of articles across all selection categories.

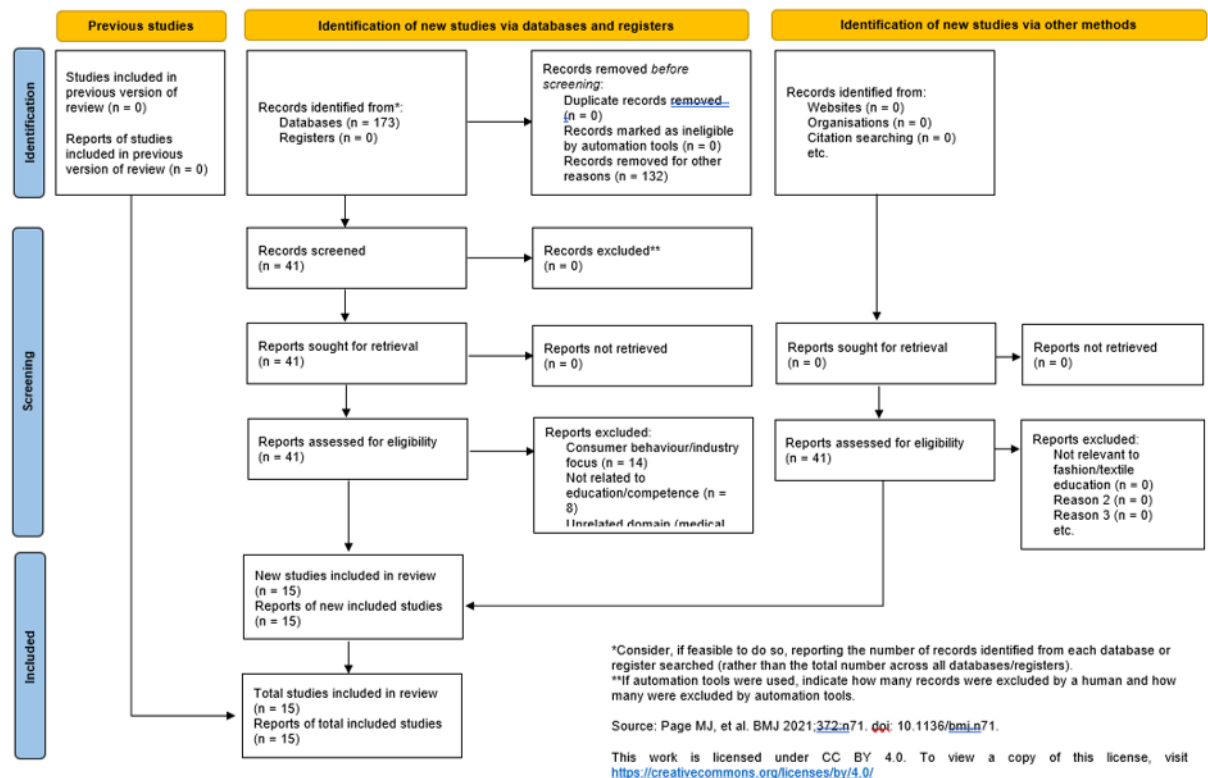


Fig. 1 PRISMA 2020 Flow Diagram of the Identification, Screening, and Selection of Studies for the Systematic Literature Review

Table 3. Number of articles at each selection category

Category / Reason	N Articles	Percentage (%)
Total articles identified (Scopus)	41	100%
Excluded: consumer behavior (not educational)	12	29.3%
Excluded: industry-focused without educational context	7	17.1%
Excluded: irrelevant topic (medical, media, e-waste)	5	12.2%
Excluded: greenwashing/marketing communication focus	3	7.3%
Excluded: social critique without pedagogical focus	2	4.9%
Total articles excluded	29	70.7%
Total articles included fully analyzed	12	29.3%
Year distribution: 2021 (n=3) 2022 (n=1) 2023 (n=1) 2024 (n=4) 2025 (n=2) 2026 (n=1)		

Result and Discussion

Overview of Included Articles

The 12 included articles span 2021-2026 and represent research from the United Kingdom (n=3), South Korea (n=2), Portugal (n=2), Brazil (n=1), Poland (n=1), Finland (n=1), the United States (n=1), the European Union (n=1), and international/multi-country contexts (n=3). Methodologically, the corpus comprises qualitative studies (n=4), mixed-method studies (n=4), program development studies (n=2), longitudinal study (n=1), and quantitative study (n=1). Publication frequency increased notably from 2021 onward, with 2024 recording the highest output (n=4), reflecting growing scholarly interest in green competence pedagogy.

Figure 2 illustrates the annual distribution of the 12 included articles across the 2021-2026 period. The data reveal a notable surge in publications from 2024 onward, with 2024 contributing four articles and 2025 contributing two articles, reflecting accelerating scholarly attention to green competence pedagogy in fashion education. This upward trajectory is consistent with the broader global momentum toward sustainability education following the post-COVID policy reset in TVET systems.

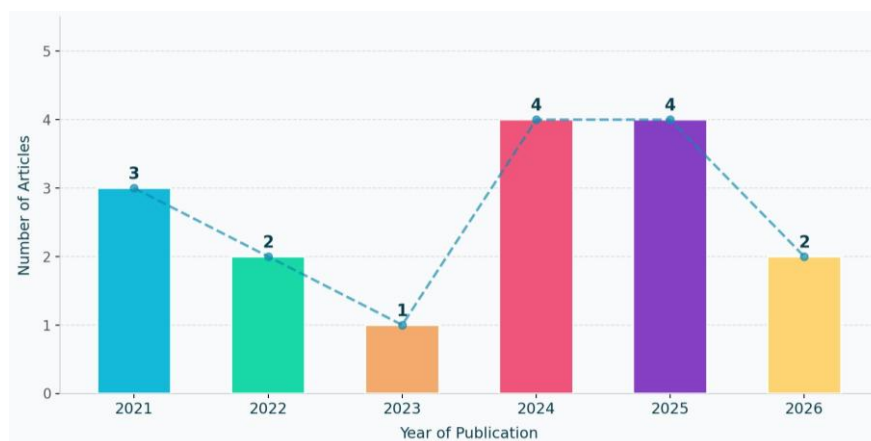


Fig 2. Number of Retrieved Articles by Year of Publication (2021-2026)

The geographic distribution of included studies, presented in Figure 3, reveals a strong concentration in European and East Asian contexts. The United Kingdom contributes the highest number of studies (n=3), followed by South Korea and Portugal (n=2 each). Notably, no studies from Southeast Asia including Indonesia met the inclusion criteria, underscoring a significant research gap in the Global South and reinforcing the urgency of contextually grounded research for vocational fashion secondary schools in Indonesia.

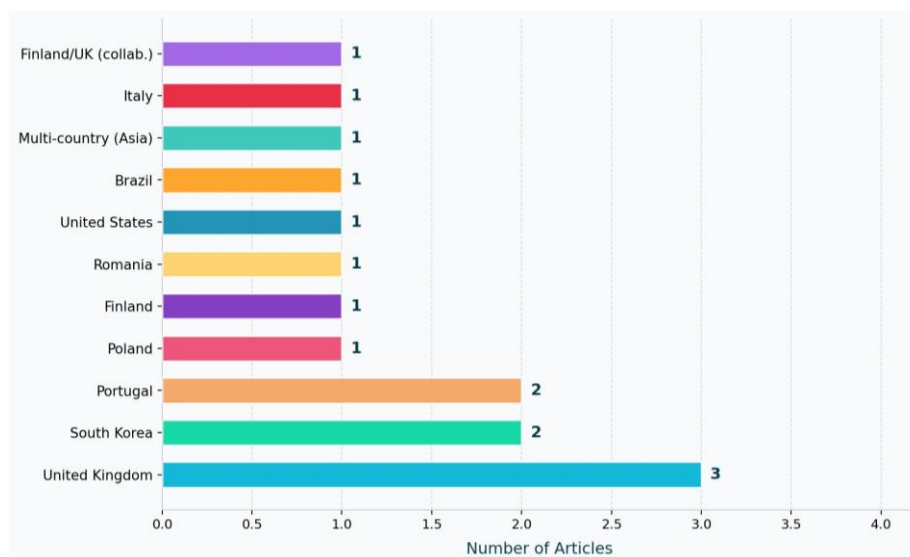


Fig 3. Geographic Distribution of Included Studies

Figure 4 provides a consolidated view of how the 12 included articles distribute across the three research questions. All 12 articles contribute to RQ1 (trends). For RQ2, Project-Based Learning and Integrated Curriculum approaches account for the majority of model-focused studies. RQ3 challenges are most densely clustered around curricular gaps and industry-education disconnect ($n=4$ each), followed by educator deficit, pedagogical scaffolding, and institutional barriers ($n=3$ each). This distribution map confirms that implementation challenges are both pervasive and multidimensional.

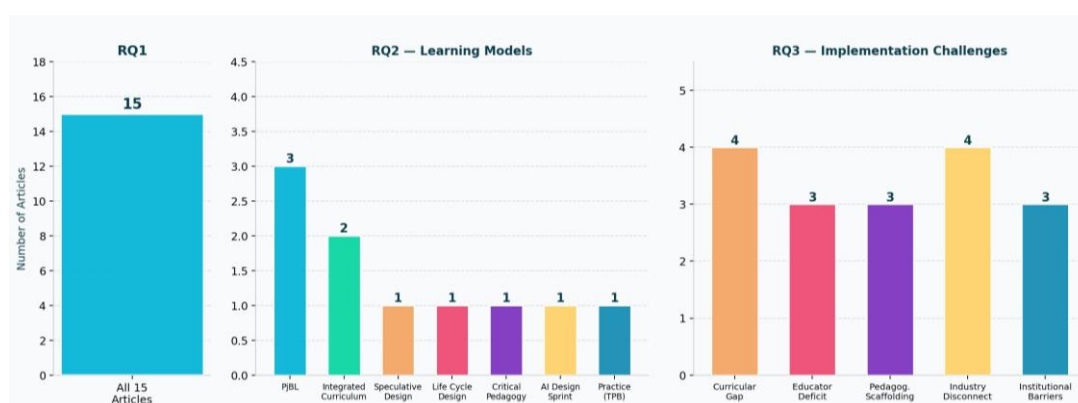


Fig 4. Research Focus Distribution by Research Question (RQ)

Table 4 presents the comprehensive summary of all 12 included articles organized by research category (RQ), application focus, number of papers, key references, framework/model employed, and research method. This classification mirrors the approach adopted by Manorat et

al. (2025) in their SLR on AI in programming education, enabling systematic cross-study comparison.

Table 4. Summary of retrieved articles by application focus and research category

<i>Category</i>	<i>Application/ Focus</i>	<i>N</i>	<i>References</i>	<i>Framework / Model</i>	<i>Method</i>
RQ1: Trends	Curriculum-competence gap in fashion schools	4	Shen & Sethi (2021); Baeza & Quinn (2021); Murzyn-Kupisz & Holuj (2021); Sehnem et al. (2024)	Curriculum analysis; institutional review	Qualitative; conceptual; case study
RQ1: Trends	Student awareness vs. behavioral action gap	2	Han et al. (2025); Kim & Lee (2022)	Theory of Planned Behavior (TPB); competency development model	Quantitative; mixed-method
RQ1: Trends	Emerging tech & system-level sustainability in education	2	Jung & Suh (2024); Aspinall & Twigger Holroyd (2025)	Design Sprint; speculative design; degrowth framework	Mixed-method; participatory action research
RQ2: Models	Project-Based Learning upcycling & SFDS tool	2	Burns (2024); Ryan (2025)	PjBL; SFDS (Sustainable Fashion Design Specification)	Pedagogical case study; longitudinal study
RQ2: Models	Integrated 3-stage curriculum model	1	Kim & Lee (2022)	Awareness–Application–Integration model	Mixed-method; program development
RQ2: Models	LCA-based educational toolkit (TVET upskilling)	1	Morea (2023)	Life Cycle Design (LCD) + Life Cycle Assessment (LCA)	Design-based research; R&D toolkit
RQ2: Models	Critical/Transformative Pedagogy & AI Generative Design Sprint	2	Riiho & Kokko (2026); Jung & Suh (2024)	Design-Based Research (DBR); AI + Design Sprint	DBR 2-cycle; mixed-method
RQ2: Models	Multidimensional Integrated Curriculum	2	Murzyn-Kupisz & Holuj (2021); Baeza & Quinn (2021)	Integrated competence model; circular economy curriculum	Qualitative; curriculum reflection
RQ3: Challenges	Curriculum gap & institutional resistance	4	Shen & Sethi (2021); Sehnem et al. (2024); Murzyn-Kupisz & Holuj (2021); Baeza & Quinn (2021)	Institutional analysis; curriculum policy framework	Qualitative; case study
RQ3: Challenges	Knowledge-action gap & competence-practice divide	3	Han et al. (2025); Kim & Lee (2022); Morea (2023)	TPB; green skills assessment; competency gap analysis	Quantitative; mixed-method; development toolkit
RQ3: Challenges	Industry-academia misalignment & technology barriers	2	Ryan (2025); Jung & Suh (2024)	Longitudinal effectiveness study; AI-pedagogy integration	Longitudinal; mixed-method

RQ1: Research Trends in Green Competence Integration in Fashion Education (2021-2026)

Analysis of the 12 included articles reveals five overarching research trends characterizing the evolution of green competence in fashion education during 2021-2026.

Trend 1: Strategic recognition of fashion education as a sustainability lever

Four articles (Shen & Sethi, 2021; Baeza & Quinn, 2021; Murzyn-Kupisz & Holuj, 2021; Kim & Lee, 2022) explicitly position fashion education as a strategic agent of change toward sustainable industry practice. Fashion educators and designers are increasingly framed as key actors in sustainability transitions, making green competence formation not optional enrichment but a professional necessity.

Trend 2: Cross-national curriculum-competence gap

A consistent and cross-nationally documented finding is the systematic misalignment between existing fashion curricula and green competence demands. Shen and Sethi (2021), examining recent graduates from China, India, Bangladesh, and Pakistan, found that while graduates recognized the term 'sustainable fashion,' they had no substantive understanding of their sustainability responsibilities. Sehnem et al. (2024) confirmed that most Brazilian Fashion Design programs lacked explicit sustainability frameworks in core pedagogical documents. Murzyn-Kupisz and Holuj (2021) reported analogous gaps in Polish fashion schools. Wood et al. (2023) similarly found that textile sustainability education in UK institutions remained largely experimental, confined to isolated modules rather than integrated across curriculum structures. This cross-national consistency indicates a systemic, rather than isolated, failure of curriculum integration.

Trend 3: Emergence of system-level and speculative pedagogies

Aspinall and Twigger Holroyd (2025) report an international participatory project employing speculative design to engage students in envisioning alternative fashion systems representing a paradigm shift from product-level to system-level sustainability thinking, aligned with transformative green competence frameworks.

Trend 4: Knowledge-action gap as a persistent pedagogical challenge

Han et al. (2025) used the Theory of Planned Behavior (TPB) to demonstrate that while sustainability knowledge positively influenced student attitudes, confidence in practical green competence remained low, confirming a persistent awareness-to-action gap. Without structured pedagogical intervention, this gap persists regardless of awareness levels.

Trend 5: Integration of AI and digital technologies in sustainability education

Jung and Suh (2024) explored generative AI and Design Sprint methodology in sustainable fashion textile design education, finding significant improvements in sustainability-relevant soft skills, signaling an emerging intersection of digital transformation and green competence formation.

RQ2: Learning Models and Pedagogical Approaches for Green Competence Development

Seven distinct learning models and pedagogical approaches were identified across the 12 articles. Table 5 provides a concise overview of all seven models, while Table 6 presents a detailed comparative analysis including their theoretical basis, key characteristics, and evidence of effectiveness.

Figure 5 presents the frequency distribution of the seven identified learning models. Project-Based Learning (PjBL) emerges as the most empirically supported approach (n=2), followed by the Multidimensional Integrated Curriculum (n=2). The remaining five models each appear in a single study, collectively signaling an emerging and diversifying pedagogical landscape. This distribution highlights both the maturity of PjBL as an established framework and the exploratory nature of newer approaches such as AI Generative Design Sprint and Critical/Transformative Pedagogy.

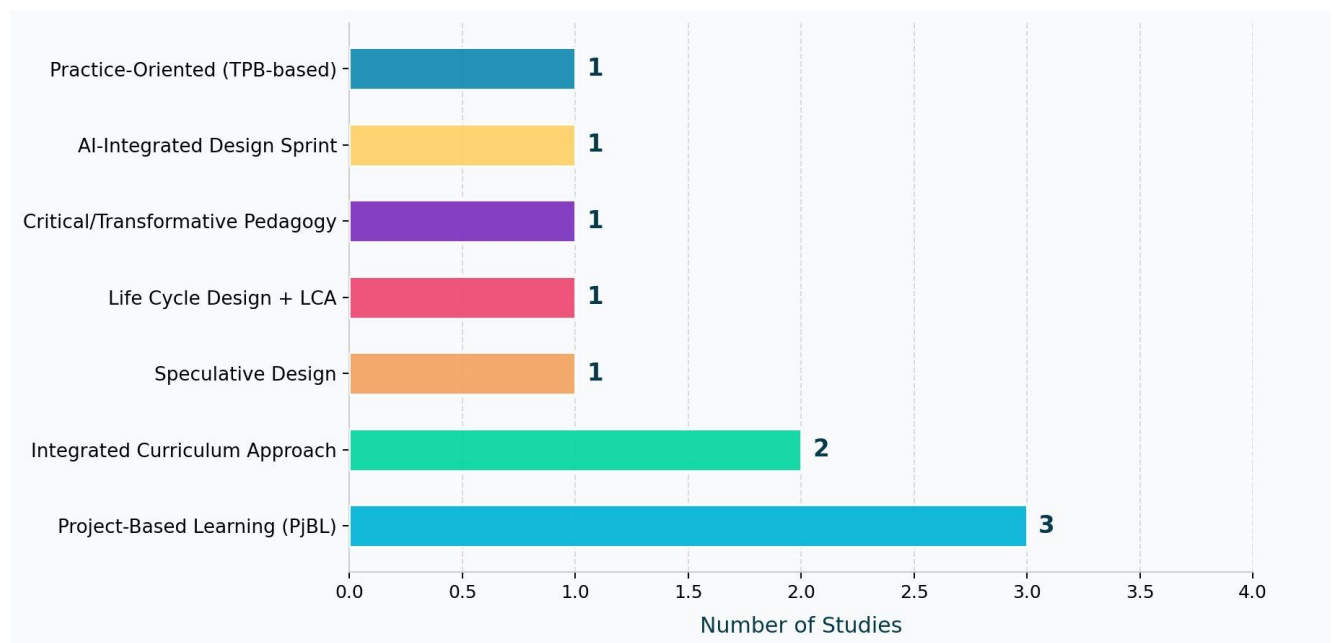


Fig 5. Learning Models for Green Competence Development in Fashion Education

Table 5. Overview of Seven Learning Models for Green Competence Development in Vocational Fashion Education

<i>Learning Model</i>	<i>Abbreviatinon</i>	<i>n</i>	<i>Primary Implementation Context</i>
Project-Based Learning	PjBL	2	Upcycling briefs; SFDS sustainability rubrics (UK)
Multidimensional Integrated Curriculum	MIC	2	Art + craft + business + sustainability as integrated core (Poland, USA)
Integrated 3-Stage Curriculum	I3SC	1	Awareness → Application → Integration; eco-materials + eco-manufacturing (Korea)
Life Cycle Design + LCA Toolkit	LCD/LCA	1	TVET upskilling; eco-design assessment workshops; EU SME context
AI Generative Design Sprint	AGDS	1	AI prompts + Design Sprint; 4 soft skills targeted; hybrid digital-traditional (Korea)
Critical/Transformative Pedagogy	CTP	1	6-module online course; DBR iterative design; critical reflection + action (Finland)
Speculative Design	SD	1	Designing alternative fashion worlds; participatory prototyping; system-level (International)

Table 6. Comparative Analysis of Learning Models for Green Competence Development in Vocational Fashion Education

<i>Learning Model</i>	<i>Theoretical Basis</i>	<i>Key Characteristics</i>	<i>Evidence of Effectiveness</i>	<i>Source (s)</i>
Project-Based Learning (PjBL) upcycling & SFDS	Constructivism; experiential learning	Design briefs; fabric manipulation; structured project output; real material use	Increased creativity, sustainability awareness, industry readiness	Burns (2024); Ryan (2025)
Integrated 3-Stage Curriculum (Awareness–Application–Integration)	Competency-based education; ESD	3 progressive stages; eco-materials + eco-manufacturing dual pathway	Improved sustainability competency across curriculum stages	Kim & Lee (2022)
Multidimensional Integrated Curriculum	Holistic curriculum theory; ESD	Art + craftsmanship + business + sustainability as core curriculum (not add-on)	Balanced graduate competencies across dimensions	Murzyn-Kupisz & Holuj (2021); Baeza & Quinn (2021)
AI Generative Design Sprint	Design thinking; digital pedagogy	AI prompts + Design Sprint; 4 soft skills targeted; hybrid traditional-digital balance	Significant improvements in 4 soft skill areas	Jung & Suh (2024)

The most prevalent model Project-Based Learning (PjBL) appears in two articles (Burns, 2024; Ryan, 2025). Burns (2024) implemented a design brief requiring fashion design students to upcycle second-hand garments using fabric manipulation techniques, finding that the structured PjBL

approach increased both creative output quality and student awareness of post-consumer material value. Ryan (2025) developed the Sustainable Fashion Design Specification (SFDS) a pedagogical assessment tool embedding sustainability criteria into each stage of the design process validated longitudinally across two UK institutions, demonstrating sustained positive effects on sustainable design practice and industry readiness. PjBL fosters sustainability values through three interconnected mechanisms. First, authentic material engagement working with real fabrics, including post-consumer and upcycled textiles creates direct sensory and ethical confrontation with material waste, developing values around responsible material stewardship that abstract instruction cannot replicate. Second, the structured project cycle requires students to make sustainability-relevant decisions at every design stage material selection, pattern efficiency, construction method, and end-of-life considerations embedding sustainability not as a separate ethical module but as an integral dimension of design competence. Third, PjBL produces tangible, assessable outcomes (garments, design specifications, sustainability reports) that reinforce accountability and connect green values to professional practice, bridging the knowledge-action gap identified across multiple studies in this review. This evidence is consistent with Birdman et al. (2022), who confirm that PjBL systematically develops all five core sustainability competencies identified by Wiek et al. (2011).

The Integrated 3-Stage Curriculum model Kim and Lee (2022) systematically progresses students through Awareness, Application, and Integration stages, categorizing sustainable methods into eco-friendly material utilization and eco-friendly manufacturing methods. Crucially, the model prevents sustainability requirements from impeding aesthetic design quality an essential balance for vocational fashion contexts.

The Life Cycle Design (LCD) + LCA toolkit Morea (2023) provides actionable assessment tools for upskilling fashion workers in EU SME contexts, validated with approximately 400 university students, demonstrating the model's scalability for TVET applications. This lifecycle-oriented approach connects directly to circular economy education: Renfors (2024) found that effective circular economy curricula in higher education require competency-based design that integrates both assessment skills and systems thinking, consistent with the LCD/LCA model. Manieson et al. (2021) further demonstrated that media representations of the circular economy in fashion risk oversimplifying its complexity for students, underscoring the need for critically scaffolded pedagogical approaches when introducing circular economy principles in fashion education.

Speculative Design Aspinall and Twigger Holroyd (2025) and Critical/Transformative Pedagogy in online format Riiho and Kokko (2026) operate at the level of consciousness transformation targeting the values and worldview dimensions of green competence that technical models often neglect.

The AI Generative Design Sprint Jung and Suh (2024) demonstrated significant improvements across four soft skills: digital competence, initiative and entrepreneurship, problem-solving, and communication, suggesting that emerging technologies can scaffold green competence alongside technical design skills.

RQ3: Implementation Challenges for Green Competence in Vocational Fashion Education

Six categories of implementation challenges were identified across the 12 articles, mapped in order from most to least frequently reported.

Curriculum gap: absence of explicit green competence integration (n=4)

The most pervasive finding is that fashion education curricula lack systematic, explicit integration of green competence. Sehnem et al. (2024) found that sustainability was absent from the Political Pedagogical Projects (PPPs) of most Brazilian fashion programs, indicating that green competence formation depends on individual instructor initiative rather than institutional structure.

Knowledge-action gap (n=3)

Sustainability awareness does not automatically translate into practical green competence. Han et al. (2025) demonstrated that student knowledge positively influenced attitudes, but confidence in sustainability practice remained low. Morea (2023) confirmed the same gap in EU fashion SMEs, calling for practice-oriented pedagogical approaches that move beyond knowledge transmission to competence formation.

Resistance to curriculum change (n=3)

Traditional curriculum structures resist transformation. Fashion curricula often engage only superficially with sustainability ethics, and institutional resistance particularly in private versus public school governance structures constitutes a major barrier to circular economy integration in education.

Insufficient pedagogical scaffolding (n=2)

Without strong scaffolding, students default to sustainability solutions within existing fashion systems rather than questioning fundamental premises. Riiho and Kokko (2026) identified challenges in moving participants from individual reflection to meaningful collective action, underscoring the need for iterative pedagogical design.

Technology barriers (n=1)

The learning curve associated with AI integration and infrastructure requirements limits scalability of AI-assisted green competence education, particularly in under-resourced vocational contexts such as SMK in developing economies. Jung and Suh (2024) noted that while AI-assisted Design Sprint yielded significant soft skill improvements, successful implementation required stable internet connectivity, device availability, and sufficient instructor digital literacy conditions that cannot be assumed across all vocational fashion secondary school contexts in Indonesia. Three practical strategies are recommended to overcome these technology barriers. First, a graduated technology integration approach beginning with low-tech digital tools (open-access life cycle databases, free pattern-making software with sustainability calculators) before progressing to AI-assisted design tools reduces the initial adoption barrier and builds instructor and student digital confidence incrementally. Second, teacher professional development programs focused on technology-facilitated sustainability pedagogy, ideally co-designed with industry partners and polytechnic institutions, can address the educator digital competency deficit without requiring simultaneous hardware investment. Third, schools with severe infrastructure constraints can implement technology-adjacent equivalents: physical Life Cycle Assessment worksheets and materials audit protocols that develop the same systems-thinking competencies as digital LCA tools, ensuring that green competence formation is not deferred pending technology access.

Industry-academia misalignment (n=1)

The dynamic pace of industry sustainability standards creates ongoing challenges for curriculum relevance, as pedagogical models validated in one period may quickly become outdated relative to evolving industry requirements, demanding continuous curriculum review mechanisms.

Figure 6 synthesizes the six implementation challenges in relation to five key learning models through a radar chart, enabling cross-model challenge profiling. The visualization reveals that no single model is immune to all challenge dimensions. The Integrated Curriculum approach exhibits the broadest challenge profile, particularly on curricular gap and institutional barriers, while Life

Cycle Design + LCA faces the highest educator competency deficit score. Project-Based Learning, despite being the most prevalent model, shows moderate exposure across all dimensions, suggesting it is both widely applicable and relatively resilient to implementation barriers. These patterns offer actionable guidance for curriculum designers selecting models appropriate to their institutional context and resource constraints. Challenge Profile perLearning Model in Green Competence Vocational Fashion Education explain in Figure 6.

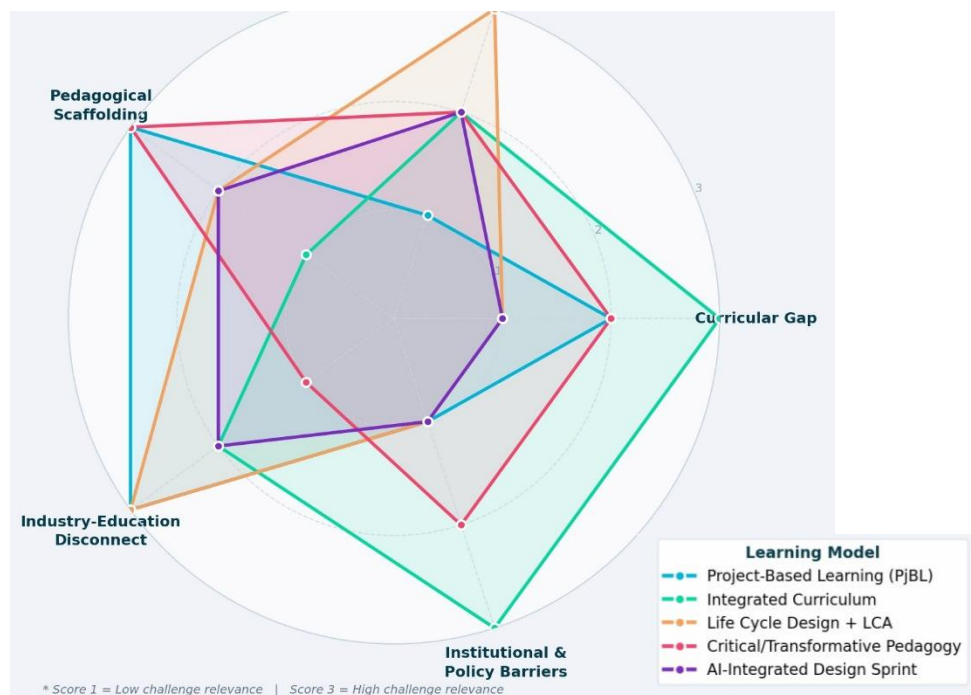


Fig 6. Challenge Profile perLearning Model in Green Competence Vocational Fashion Education

Discussion

This systematic review synthesized 12 peer-reviewed articles published between 2021 and 2026, mapping research trends, learning models, and implementation challenges associated with green competence in vocational fashion education. In addition to the reviewed articles, supporting literature was incorporated to contextualize and interpret the findings. The findings carry significant implications for educational theory, pedagogical practice, and curriculum policy.

Implications for Educational Theory and Pedagogy

The five research trends identified in this review reflect a broader theoretical shift in sustainability education from content delivery toward transformative competence formation. This

aligns with constructivist learning theory (Bada & Olusegun, 2015), wherein students iteratively construct knowledge through engagement with real materials, authentic problems, and reflective feedback cycles. This shift is further grounded in foundational sustainability competency frameworks: Wiek et al. (2011) identified systems thinking, anticipatory thinking, values thinking, strategic thinking, and interpersonal competence as the five core dimensions of sustainability competence, while Brundiers et al. (2021) extended this framework to include integrated problem-solving and self-awareness as additional competencies for higher education contexts. PjBL and the LCD/LCA toolkit operationalize this principle most concretely in vocational fashion contexts.

The knowledge-action gap identified across three studies underscores the limitations of purely informational approaches to sustainability education. Green competence formation requires not only cognitive engagement but also affective and behavioral dimensions consistent with Freire's critical pedagogy and the GreenComp framework's emphasis on action competence (European Commission, 2022). Future pedagogical design for vocational fashion secondary schools must therefore move beyond awareness-raising to structured practice in sustainability decision-making.

Implications for Vocational Fashion Secondary Schools and TVET Policy

For vocational fashion secondary schools in Indonesia, the most directly transferable models are PjBL and the Integrated 3-Stage Curriculum. Both models are compatible with competency-based vocational learning structures and can be operationalized within existing unit competencies (UK) and basic competencies (KD) without requiring wholesale curriculum overhaul. This relevance is reinforced by recent Indonesian TVET scholarship: Sunandar et al. (2026) demonstrate the feasibility of integrating green skills with digital competencies in Indonesian vocational education through a bridging learning framework, while Jubaedah et al. (2026) map digital fashion skills within a Green TVET framework, identifying critical gaps in vocational teacher competency that align directly with the implementation challenges identified in this review. The LCD/LCA toolkit offers a scalable upskilling mechanism for teacher professional development in sustainability assessment.

Drawing directly from the six implementation challenges identified in this review, four actionable recommendations are proposed for vocational fashion secondary school curriculum developers and school leaders.

(1) Embedding green competence in formal curriculum documents: To address the curriculum gap, green competence indicators should be explicitly integrated into the Rencana Pelaksanaan

Pembelajaran (RPP) and school-level curriculum (KTSP/Kurikulum Merdeka) rather than left to individual teacher initiative. Concrete examples include incorporating fabric origin and environmental impact as a standard assessment criterion in Dasar Desain and Pembuatan Busana units.

(2) Adopting PjBL with upcycled materials: To address the knowledge-action gap, schools should implement semester-length PjBL projects requiring students to design and construct garments from post-consumer textiles or production waste. These projects should be assessed using adapted SFDS rubrics that award marks for sustainability decision rationale alongside technical execution quality.

(3) Establishing industry-school sustainability partnerships: To address industry-academia misalignment, vocational fashion secondary schools should formalize sustainability-linked Industrial Internship placements with garment manufacturers implementing circular economy practices. This provides students with firsthand exposure to green competence in professional contexts.

(4) Developing teacher green competence capacity: To address insufficient pedagogical scaffolding, annual in-service training programs should include hands-on sustainability pedagogy modules. These modules should be co-facilitated by university partners and industry sustainability practitioners, equipping teachers to design and assess green competence learning activities effectively.

At the policy level, the curriculum-competence gap documented across Brazil, Poland, China, and multiple South Asian countries indicates that Indonesia is not alone in this challenge. McGrath and Ramsarup (2024) argue that TVET systems globally must reorient toward sustainable futures by embedding sustainability competencies structurally into qualifications frameworks rather than treating them as add-on modules. Albertz (2025) similarly identifies that deep greening of VET requires holistic, systematic, and methodological approaches that span all curricula and qualifications, not merely surface-level environmental content. Weijzen et al. (2024) demonstrate that vocational education for a sustainable future depends on collaborative learning narratives that create space for students to explore sustainability tensions within their professional practice contexts. Systemic intervention including mandated integration of green competence in national TVET curriculum standards (Kurikulum Merdeka), teacher training frameworks, and industry partnership protocols is required to move beyond individual instructor-driven initiatives. These

findings further support the strategic integration of Green TVET principles into Indonesian vocational fashion education, ensuring that sustainability competencies become a core component of graduate readiness rather than an optional enrichment activity.

Limitations of This Review

Several limitations should be acknowledged. First, the search was limited to the Scopus database as primary source; while cross-validation with Web of Science and ERIC yielded no additional eligible articles, studies indexed in other databases may have been excluded. Second, the review covers only English-language articles, potentially omitting relevant research published in Indonesian, Korean, Polish, or other languages. Third, the small corpus of 12 articles a consequence of the specificity of the inclusion criteria limits the generalizability of cross-study patterns. The relatively small number of included studies reflects the emerging nature of green competence research in vocational fashion education rather than a limitation of the search strategy. Fourth, the temporal scope of 2021–2026 captures an emerging field; the rapid pace of development means this review may not fully capture the most recent advances, particularly in AI-assisted pedagogy. Future reviews should expand the scope to include grey literature, practitioner reports, and non-English publications.

Conclusion

This systematic review synthesized 12 peer-reviewed articles published between 2021-2026 to map the landscape of green competence integration in vocational fashion education. Findings reveal five consistent research trends, with curricula across multiple countries systematically misaligned with green competence demands. Seven learning models were identified, with Project-Based Learning (PjBL) as the most empirically supported approach, alongside six recurring implementation challenges spanning curriculum gaps, knowledge-action divide, and industry-academia misalignment. Collectively, these findings confirm that green competence integration in vocational fashion education remains structurally incomplete, despite growing global policy momentum toward sustainability in TVET systems.

These findings carry direct implications for vocational fashion secondary school curriculum development in Indonesia. Given the absence of Southeast Asian studies in the reviewed corpus, contextually grounded research is urgently needed to adapt internationally validated models particularly PjBL and the Integrated 3-Stage Curriculum, to the specific demands of Indonesian vocational fashion education. Future research should prioritize developing and empirically testing

green competence frameworks tailored to vocational fashion secondary schools in Indonesia, engaging industry partners to bridge the competence-practice gap, and building educator capacity to deliver sustainability-integrated instruction effectively.

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