Green Digi Fash Tech Manager

Report

Research Report

Mapping Tool & Diagnostic Analysis

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Executive Summary

This report presents the findings of the Erasmus+ project, "Green DigiFashTech Manager," aiming to develop a new vocational profile capable of guiding fashion and textile companies through both digital and sustainable transitions. Drawing on the analysis of twenty digital technologies, case studies from Greece, the Netherlands, and North Macedonia, and an extensive academic review, the research confirms a clear pattern: digitalisation is no longer optional—it is a decisive driver of environmental impact reduction across the fashion and textile sector.

The key findings show two main types of digital tools: those used for visualizing and prototyping garments digitally, significantly reducing waste and sampling costs, and those for tracing, managing, and optimizing sustainability and transparency throughout the production and distribution processes. Major challenges identified include high costs of software licenses and hardware, resistance to technological change, and skill gaps in advanced digital tools and sustainability analytics.

Recommendations include structuring vocational education and training (VET) programs to gradually build competencies, providing economic incentives and accessible resources to smaller businesses, and integrating essential skills such as data analytics, ethical understanding, and circular design strategies into educational programs. This integrated approach is crucial for supporting companies to effectively navigate the industry's sustainable and digital evolution.

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1. Introduction

1.1. Project Background and Rationale

Green DigiFashTech Manager is a 24-month Erasmus+ KA220-VET cooperation partnership (01 Oct 2024 – 30 Sep 2026) that unites five organisations from Sweden, Greece, the Netherlands and North Macedonia. Its core ambition is to cultivate a new professional profile— the “Green Digital Fashion Manager” —able to steer fashion and textile companies through the twin transition to climate-neutral, circular and digitally enabled business models. By blending expertise in AI, 3D product development and data analytics with circular-economy thinking, the project answers EU calls for greener, more resilient industrial ecosystems while tackling the sector’s skills gaps.

1.2. Research Scope

Work Package 2 (WP2) provides the evidence base for designing the new job role and curriculum. It comprises three linked research strands:

WP2 Result	Focus	Key Output
Result 1 – Mapping of digital tools	Systematically catalogue AI, 3D, IoT, data-driven and other enabling technologies already used (or emerging) in fashion/textiles.	Consortium map and searchable database (≥ 10 tools per partner)
Result 2 – 25 case studies + interviews	Analyse pioneers’ real-world adoption pathways, business models and sustainability impact.	25 in-depth case files and expert interviews
Result 3 – Link to job profile and VET curriculum	Translate empirical insights into competence requirements and didactic building blocks.	Green Digital Fashion Manager job profile and curriculum.

These strands are delivered through seven tasks: from template design and secondary-data mapping, to primary case research, data synthesis and external validation (see WP2 guideline timeline).[3]

1.3. Objectives and Guiding Questions

WP2 is driven by three overarching research questions that will guide desk work, interviews and analysis:

- **Which digital technologies most accelerate the twin green–digital transition in fashion?**
  Mapping and case-study focus: identify high-impact AI/3D/Industry 4.0 solutions, their maturity and sustainability leverage points.
- **What benefits and challenges do companies report when deploying these tools?**
  Interview focus: capture efficiency, emissions, creativity and market-access gains versus barriers such as cost, skills, data or cultural change.
- **What skills gaps and pedagogical needs emerge for managers, designers and technicians?**
  Synthesis focus: translate findings into competence profiles, education modules and assessment concepts for VET providers.

Answering these questions will ensure the project's later work packages develop an evidence-based curriculum and mentoring ecosystem that equip future professionals—and their organisations—to thrive in a circular, digital fashion economy.

2. Methodology

The empirical strategy for Work Package 2 was built to serve two complementary purposes. First, it had to generate a systematic picture of the digital technologies that are already enabling—or are poised to enable—the green transition in fashion. Second, it needed to surface the lived experience of the companies and freelance professionals who are trying to make these tools work in practice. The consortium therefore combined a structured technology-mapping survey with an embedded multiple-case study. All research steps, from sampling and data collection to coding and cross-case synthesis, were specified in the WP2 Research Guidelines and in the dedicated interview and mapping protocols circulated to partners at the start of the work package. The sample of case companies are active in the countries of partners but could represent companies that were founded or HQs based in other european countries, they could also be globally present.

2.1. Digital Tools Mapping Design

Tool mapping followed an embedded multiple-case logic inspired by Yin's methodology. Each technology constituted a mini-case and the sections of the *WP2 Digital Technologies Mapping Tool* acted as the embedded units of analysis. The form invites the researcher to record general descriptors—name, developer, platform, licensing model, launch year and update rhythm—as well as a self-categorisation across thirteen functional clusters ranging from "3D modelling and virtual design" to "AI for workforce training". Beneath this descriptive layer the template drills down into a common analytic frame comprising a functional overview, a statement of key features and a four-dimensional sustainability lens that separates environmental, social, financial and operational impacts. The final blocks capture implementation considerations, educational relevance and an expert ranking of the tool's maturity and market importance.

Because every partner was tasked with uploading at least five tools, the consortium produced a purposive sample of twenty technologies covering design, production, logistics and marketing. The strict use of the common form ensured that each record could be imported directly into NVivo, where the section headings—*General Information, Category, Functional Overview, Key Features, Environmental Impact, Social Impact, Financial Benefits, Operational Benefits, Implementation, Education*—were converted into first-level parent nodes. Sub-codes mirrored the guidance text of the form; for example, *Environmental Impact* was split into *energy consumption, material*

usage and *digital sampling*, whereas *Implementation* branched into *skills, integration, cost* and *future potential*. These node structures provided an a priori coding frame that nonetheless left room for inductive open coding whenever respondents added information that did not fit neatly into the predefined boxes.

2.2. Case Study and Interview Design

The company-level investigation relied on an embedded multiple-case study design that follows the template set out in the project's *Interviews Methodology* document. Purposeful sampling was used to secure twenty-five cases that collectively span different value-chain positions, digital-maturity stages and sustainability orientations. Semi-structured interviews, conducted either face-to-face or via video call, employed the *Questionnaire for Businesses* as a flexible guide.

The questionnaire's architecture also provided the backbone for the coding scheme. Section 1 establishes background variables and then explores **company context, digital maturity, sustainability strategy** and **digitalisation goals**. Section 2 captures a **technology overview**, the **implementation process**, the **drivers of adoption** and **partnership constellations**. Section 3 focuses on **realised benefits, unexpected outcomes, challenges** and **mitigation strategies**. Section 4 turns to **employee training programmes, training effectiveness, identified skill gaps** and **future training needs**, while Section 5 interrogates **alignment with sustainability goals, quantifiable impacts, difficulties in alignment** and **innovative practices**. Each of these prompts became a parent node in NVivo; illustrative child nodes include *efficiency gains* versus *traceability gains* under **realised benefits** or *cost barrier, labour resistance* and *data security* under **challenges encountered**.

Additional material—annual reports, sustainability statements, screenshots and, where feasible, short periods of non-participant observation on the production floor—were coded into the same framework in order to triangulate interview claims. The project adopted an inductive stance, allowing unexpected categories to emerge, yet the predetermined node tree guaranteed that core topics would be covered consistently across all national sub-samples.

2.3 Data Analysis Procedures

Analysis unfolded in two iterative cycles. During the within-case phase each partner coded its own tool sheets and interview transcripts, attaching quotations and document excerpts to the relevant parent and child nodes. Case memos were then

drafted to capture the internal logic of each organisation or technology. In the cross-case phase the lead partner imported all coded datasets into a master NVivo project and ran matrix-coding queries that crossed, for example, **technology category** with *environmental impact > digital sampling* or **company digital-maturity level** with *training needs > 3D simulation*. This systematic pattern matching enabled the team to detect robust regularities—for instance, the link between the adoption of 3D virtual prototyping and a measurable reduction in physical prototype rounds—as well as outliers that warranted closer qualitative scrutiny.

Reliability was strengthened through double-coding of ten per-cent of the transcripts by an independent researcher; divergences were discussed until consensus was reached. Credibility was enhanced by member-checking: preliminary summaries were returned to respondents, who confirmed factual accuracy or provided clarifications.

2.4 Limitations

Despite these safeguards several limitations remain. The purposive sample offers analytical but not statistical generalisability, and southern Europe is over-represented owing to partner networks. Fast-moving fields such as generative AI in design make obsolescence a constant risk; the mapping database will therefore be updated during the second project year. Finally, the inductive coding strategy, while rich, requires careful reflexivity to avoid over-interpretation of singular success stories.

By combining a rigid scaffold of predefined codes with openness to emergent themes, the methodology delivers a balanced foundation for the diagnostic tool and, ultimately, for the competence framework of the future Green Digital Fashion Manager.

3. Digital Tools Mapping Results and Analysis

The present chapter translates the raw entries that were gathered through the WP2 Digital Technologies Mapping Tool into an analytically ordered narrative. In order to preserve full traceability every paragraph mirrors the section headings and code labels that structure the Google-Form template; consequently, the reader can move seamlessly from the synoptic discussion offered here to the original data sheets held in the consortium's shared drive. Section 3.1 establishes a panoramic overview of the twenty technologies documented by partners, highlighting their functional category, developer provenance, licensing regime, year of first commercial release and an initial judgement of sustainability salience. Section 3.2 then walks the reader through individual tool profiles, devoting greatest space to those applications—Illustrator, CLO 3D, Optitex 2D/3D and Browzwear V-Stitcher—that recur most frequently in the interviews or that are singled out by multiple partners as leverage points for circularity. The chapter closes with two integrative discussions: the first draws comparative insights on adoption barriers, cost structures, training burdens and realised environmental benefits, whilst the second distils the implications that flow directly into Work Package 3, namely the formulation of learning outcomes and module clusters for the future VET curriculum.

3.1. Overview of the Mapped Digital Tools Landscape

Table 3-1 summarises the basic descriptors captured in the mapping survey. Although the full spreadsheet contains twenty rows, the distribution is heavily skewed toward three functional clusters—vector-based visual-design suites, 3D garment-simulation environments and integrated 2D/3D CAD/CAM platforms—because partners judged these clusters to deliver the clearest and most immediate sustainability gains. Tools that live "further upstream" (for example, fibre-identification scanners or AI-driven demand-forecast engines) and "further downstream" (such as blockchain-enabled traceability ledgers) are represented, but they constitute a long tail rather than the core of the dataset. In licensing terms proprietary subscription models dominate: sixteen of the twenty entries require ongoing, cloud-mediated fees, three follow a perpetual licence model with optional maintenance and only a single entry—Inkscape—qualifies as genuine open-source software.

Year-of-release shows a bimodal distribution: half of the tools reached market maturity before 2010, indicating a stabilised feature set, whereas the other half emerged after 2018 and belong to the current wave of AI-enhanced or cloud-native offerings. With regard to sustainability relevance, fourteen tools are tagged “high”, five “medium” and one “exploratory”, a judgement based on the presence of features that directly curtail material sampling, reduce transport, or enable circular-design workflows.

Overview of the Mapped Tools

#	Technology / Tool	Principal category	Developer / HQ	First release	Licensing	Assessed sustainability salience
1	Adobe Illustrator	Vector graphics / digital prints	Adobe Inc., USA	1987	Proprietary	Medium
2	Optitex 2D & 3D	Integrated CAD/CAM	Optitex Ltd., ISR	1998 / 2011	Proprietary	High
3	CLO 3D	3D virtual prototyping	CLO Virtual Fashion, KOR	2011	Proprietary	High
4	Browzwear V-Stitcher	3D prototyping & PLM	Browzwear, SGP	2000	Proprietary	High
5	Inkscape	Vector graphics (open-source)	Inkscape Org, global	2003	Open Source	Medium
6	CorelDRAW Graphics Suite	Vector + page design	Corel, CAN	1989	Proprietary	Medium
7	Figma	Cloud UI & vector design	Figma Inc., USA	2016	Proprietary	Medium

#	Technology / Tool	Principal category	Developer / HQ	First release	Licensing	Assessed sustainability salience
8	Style3D	Cloud 3D collaborative platform	Style3D, CHN	2020	Proprietary	High
9	Marvelous Designer	3D drape & concept- ing	CLO Virtual Fashion, KOR	2010	Proprietary	Medium
10	Adobe Substance 3D Sampler	PBR material authoring	Adobe Inc., FRA	2021	Proprietary	Medium
11	Autodesk Fusion 360 Additive	Generative CAD / additive	Autodesk, USA	2013	Proprietary	Medium
12	Pointcarré	Textile repeat & colourway CAD	Pointcarré SA, BEL	1995	Proprietary	Medium
13	Scanatic™ Nuno + StyleBook	AI size-set / pattern cloud	TG3D Studio, TWN	2019	Proprietary	High
14	Lectra (Modaris, Diamino, Vector, and Kubix Link)	Industrial CAD / PLM link	Lectra SA, FRA	2014 (3D)	Proprietary	High
15	EON Digital ID	Traceability & DPP platform	EON, USA	2017	Proprietary	High
16	Smartex AI	Real-time knit defect vision	Smartex.ai, PRT	2019	Proprietary	High

#	Technology / Tool	Principal category	Developer / HQ	First release	Licensing	Assessed sustainability salience
17	Res.Q	QC & repair workflow SaaS	Res.Q, BGD	2018	Proprietary	High
18	Tex Chain	Blockchain product passport	Tex Chain EU, NLD	2022	Proprietary	Exploratory
19	Gravity Sketch	3D spatial ideation (VR)	Gravity Sketch, GBR	2014	Proprietary	Medium
20	Procreate	Digital Art and Design	Savage Interactive, AU	2011	Proprietary	High
21	Fairly Made	Supply Chain & Inventory, Sustainability & Circularity Tools	Fairly Made, FRA	~ 2021	Proprietary	High
22	Flair	Virtual Showroom	Flair.Fashion , GBR	~ 2023	Proprietary	Medium
23	Midjourney	Generative AI for Design & Creativity	Midjourney, Inc., USA	2022	Proprietary	High
24	Filmora	Video Editing	Wondershare Technology Co., Ltd., CN	2015	Proprietary	Midjourney

#	Technology / Tool	Principal category	Developer / HQ	First release	Licensing	Assessed sustainability salience
20	Canva (with Magic Design AI suite)	Cloud layout & branding	Canva Pty Ltd., AUS	2013	Proprietary	High

3.2. Individual Tool Profiles

The following subsections translate each completed mapping sheet into a concise narrative. To retain comparability, every mini-profile follows the same arc: functional overview, key feature set, evidence of sustainability contribution, implementation prerequisites, training implications and observed uptake in formal or non-formal VET settings.

3.2.1. Adobe Illustrator

Adobe Illustrator, first commercialised in 1987 and now updated on a continuous Creative-Cloud cadence, remains the de-facto standard for vector artwork across the creative industries. In a fashion context the program is indispensable for drawing technical flats, constructing repeat prints and preparing scalable logos and care-label icons. Its newest releases add generative-AI modules—"Text to Vector Graphic" and "Generative Recolor"—that can deliver fifty colourways in seconds, thereby obviating the need for multiple material strike-offs. Interview evidence from G-06 confirms that these AI functions accelerate marketing campaigns and drive a measurable reduction in paper comps and courier shipments. Sustainability relevance is therefore rated "medium-to-high": the tool itself does not directly simulate garments, but it serves as the digital nexus for line drawings, spec sheets and e-commerce imagery, all of which can be exchanged entirely online. In educational terms Illustrator is already embedded in most European VET curricula; nonetheless, the arrival of the AI panels necessitates refresher modules that explain prompt engineering, ethics and colour-profile management when working in a generative workflow.

3.2.2. Optitex 2D and Optitex 3D

Optitex offers an end-to-end CAD/CAM suite that integrates 2D pattern drafting, automatic marker nesting, fabric utilisation analytics and a 3D surface engine derived from the open-source Bullet physics library. The tool shines in industrial settings

thanks to its granular seam-method database, which mirrors real sewing operations and thus yields highly accurate cost and time estimates. Sustainability dividends arise from three channels: first, fewer physical prototypes, because the 3D module resolves 80 percent of fit issues virtually; second, higher fabric yield ratios thanks to advanced nesting algorithms; and third, a tight PLM bridge that links digital patterns to bill-of-materials dashboards for compliance reporting. The principal barrier is cost: perpetual licences plus maintenance can exceed €6 000 per seat, while annual subscription rivals are cheaper up front. Yet, as the G-05 case illustrates, the investment pays off for micro-factories that manage a high style turnover and cannot afford fabric waste. Educational penetration is weaker than Illustrator's but growing; several Greek IEKs now run cut-down student licences in joint pattern-and-grading classes.

3.2.3. CLO 3D

CLO 3D stands at the opposite end of the fidelity spectrum: it simulates the drape of fabrics on photorealistic avatars in real time, allowing designers to evaluate proportion, fit and aesthetic detail before a single centimetre of cloth is cut. The mapping exercise highlights four killer features: a parametric fabric laboratory that stores bend-and-stretch coefficients; instant grading from base size to a full size-set; a PBR-compliant material and top-stitch library that feeds directly into Unreal or Unity; and one-click animation tools for digital runway generation. Partners estimate a forty-per-cent reduction in sample yardage and a two-week shortening of the design-to-approval timeline when CLO is used consistently. Hardware demands are moderate—a mid-range GPU suffices for real-time viewport work, with only final ray-traced renderings requiring heavy compute—and the vendor's generous thirty-day rolling trial lowers entry barriers for VET cohorts. Training challenges revolve around cognitive load: novices must master both 2D pattern logic and 3D spatial manipulation. The mapping sheets thus recommend a stepped instructional design that begins with basic pattern import, proceeds to fabric calibration and culminates in animation or AR dressing-room experiments.

3.2.4. Browzwear V-Stitcher

Browzwear's flagship couples enterprise-grade garment simulation with a bill-of-materials (BOM) and costing panel, allowing designers to toggle seam constructions and instantly view fabric consumption deltas. Unlike CLO 3D, the software ships with an industry stitch library that translates directly into production, hence its adoption by vertically integrated brands such as Adidas and Hugo Boss. Field data suggest a 45 percent cut in physical prototypes and an eight-to-ten

percent gain in fabric yield when the automatic-marker plugin is enabled. Implementation hinges on GPU-ready laptops and PLM connectors; learning curves are steep but mitigated by Browzwear's certified-trainer network.

3.2.5. Inkscape

As the only genuinely open-source vector package in the list, Inkscape offers a cost-free entry point for NGOs, freelancers and VET colleges with limited budgets. While the interface lacks Illustrator's AI panels, its SVG-native workflow integrates smoothly with web storefronts and laser-cutter pipelines. Sustainability impact stems mainly from democratised access: students can iterate digitally from home without pirated software or print-heavy studio sessions.

3.2.6. CorelDRAW Graphics Suite

Longstanding rival to Illustrator, CorelDRAW combines Bézier illustration, multi-page layout and print-shop colour management. Several North-Macedonian SMEs in the sample retain legacy Corel workflows because local print bureaux supply ready-made colour profiles. Transition costs to cloud subscriptions remain a deterrent; however, when paired with PDF-X export, Corel files travel cleanly into PLM platforms, thereby supporting paper-less tech-pack exchange.

3.2.7. Figma

Although born as a UI tool, Figma's vector canvas and shared libraries are increasingly used by marketing teams to co-create e-commerce assets. G-06's growth team, for instance, collaborates in real time on seasonal landing pages, cutting out agency print proofs altogether. The primary sustainability lever is accelerated approval rather than material savings, but the indirect climate benefit of fewer courier trips is notable.

3.2.8. Style3D

A newcomer positioned as "Google Docs for 3D garments", Style3D allows simultaneous co-editing of patterns, avatars and animation scenes in the browser. Early adopters praise its asset marketplace, where parametrically generated trims and fabrics carry embedded environmental metadata that can be queried by LCA dashboards. Bandwidth and cloud-GPU charges remain barriers for resource-constrained SMEs.

3.2.9. Marvelous Designer

Geared to concept artists and gaming cross-overs, Marvelous offers fast drape solvers but lacks industrial seam libraries. Sustainability value lies in digital-lookbook generation rather than production accuracy; educators therefore use it as a gateway drug to heavier 3D suites.

3.2.10. Adobe Substance 3D Sampler

Converts smartphone photos into PBR-ready fabric textures, enabling realistic digital swatches. When paired with CLO or V-Stitcher, brands can evaluate print scale and colourways virtually, avoiding lab-dip shipping. GPU rendering is compute-intensive, raising questions about energy-related rebound effects that future versions might address via cloud carbon-offset dashboards.

3.2.11. Autodesk Fusion 360 Additive

Although primarily engineered for metal additive manufacturing, the generative-design plug-ins are now used by sports-footwear teams to produce lattice midsoles that slash material mass by up to 30 percent. The tool's integrated LCA module estimates embodied CO_2 for each topology suggestion, illustrating how additive workflows can dovetail with circular-design criteria.

3.2.12. Pointcarré

Specialised in textile repeats and colourways, Pointcarré automates right-first-time rapporting. Greek print-service providers report a ten-per-cent reduction in test strikes when designers supply Pointcarré files with calibrated colour books, cutting ink waste and water use.

3.2.13. Scanatic™ Nuno + StyleBook

TG3D Studio's AI platform scans end-user bodies via a smartphone turntable, builds a parametric avatar and auto-generates a pattern block library. Sustainability pay-off comes from size-set reduction and on-demand production, but GDPR-grade data governance is essential to avoid consumer push-back.

3.2.14. Lectra (Modaris, Diamino, Vector, and Kubix Link)

A heavyweight in industrial apparel CAD, Lectra lives at the heavy end of Industry 4.0, offering an integrated pipeline that stretches from digital sketch through to IoT-connected cutting tables. Unlike the lightweight, software-only tools that dominate the market, Lectra's stack, comprising Modaris (pattern-cutting), Diamino

(nesting), Kubix Link (cloud PLM), and Vector (automated cutting), forms a cyber-physical ecosystem where hardware and software are inextricably linked. The integration of Modaris 3D into this workflow offers a profound shift in efficiency: pilot data from a Dutch partner indicate that transitioning from 2D to 3D eliminated two sample rounds per style and increased marker efficiency by twelve percentage points. When the full stack is deployed, customers report fabric-yield improvements above ten percent and, more importantly for climate accounting, a thirty-to-forty-percent reduction in cutting-room electricity thanks to the newest single-vacuum Vector cutters. The sustainability gain is therefore both material and energetic. Barriers remain: capital expenditure is steep, integration into legacy ERP requires meticulous data mapping, and staff must master CAD logic, nesting heuristics and machine-maintenance routines. For VET colleges the message is clear: tomorrow's production planners need hybrid competence—pattern science, data-exchange standards and an eye for circular KPIs—to run such cyber-physical factories.

3.2.15. EON Digital ID

Cloud SaaS for item-level digital passports. By embedding QR/NFC tags, brands like Chloé disclose fibre provenance and care instructions, enabling resale platforms to verify authenticity and recyclers to triage fibre mixes. As forthcoming EU Digital Product Passport legislation crystallises, EON's market relevance is projected to spike.

3.2.16. Smartex AI

Combines high-speed cameras with edge AI to flag knitwear defects in real time, reducing seconds rates by thirty percent in pilot Turkish mills. Energy overhead is minimal relative to steam-room consumption, making net carbon savings unambiguously positive.

3.2.17 Res.Q

SaaS dashboard that tracks repair tickets and worker performance on sewing-line fixes. Although not glamorous, this incremental technology extends garment lifespans and yields granular waste-avoidance metrics that feed CSR reporting.

3.2.18. Tex Chain

A blockchain consortium prototype that stores fibre certificates and transaction logs. Still exploratory: partners welcome immutable records but question energy intensity

and integration complexity; a shift to side-chains or proof-of-stake could improve the carbon balance.

3.2.19. Gravity Sketch

VR-enabled spatial design tool popular with footwear concept teams. Remote collaborators iterate on last shapes without physical foam models, saving time and PU waste. The barrier is headset costs and VR motion-sickness; training shorter sessions mitigate the latter.

3.2.20. Procreate

Procreate is, at first glance, “just” a professional drawing app for the iPad, yet in day-to-day fashion work it has become a pocket-sized print studio. Designers sit on a train, sketch repeat motifs with the Apple Pencil, drop the file straight into Illustrator or CLO, and skip the scanner and tracing-paper stage altogether. The environmental dividend therefore lies in the almost complete disappearance of paper mood-boards and strike-off swatches during the concept phase. Because the licence is a one-off twelve-euro purchase, independent designers and vocational students can afford professional digital-sketch tooling without entering the Adobe subscription treadmill. From a skills perspective Procreate teaches brush physics, layer discipline and colour-profile thinking—the very fundamentals that later transfer to enterprise-scale vector or 3D platforms—so tutors can deploy it as a low-threshold gateway into digital-first, waste-averse ideation.

3.2.21. Fairly Made

Fairly Made positions itself not as a design tool but as a “360-degree traceability engine”. Fashion brands upload purchase orders, supplier addresses and fibre mixes; the platform then sources certificates, calculates water, CO_2 and social-compliance scores, and spits out an EU-ready Digital Product Passport. The principal sustainability effect is transparency: once the numbers are public a brand can no longer hide a Tier-2 dye-house that dumps effluent. Because the interface resembles a cloud CMS, the technical threshold for brand users is low, yet real impact depends on data-literacy—teams must understand how to interpret lifecycle indicators and turn hotspots into redesign briefs. Teaching material-flow mapping, supplier-data vetting and passport storytelling will therefore be essential modules in the Green DigiFashTech Manager syllabus.

3.2.22. Flair

Flair is a virtual showroom and e-commerce marketplace that lets graduate designers upload look-books, spin garments in browser-based augmented reality and transact without building their own web-store. The sustainability promise is two-fold: first, designers reach a global audience without shipping trunk shows or renting trade-fair booths, and second, on-demand production logic—make it only when a customer clicks “buy”—cuts the dead-stock mountain typical of fledgling labels. Barriers are cultural rather than technical: creators must invest time in storytelling, high-fidelity photography and AR asset preparation. VET programmes can turn these obstacles into learning objectives by pairing students from pattern-making streams with peers in digital-marketing tracks to populate a live Flair capsule as a capstone exercise.

3.2.23. Midjourney (text-to-image generative AI)

Midjourney turns a typed prompt—“biodegradable algae-based parka, Neo-Tokyo streetwear, dusk lighting, 32-bit” —into a high-resolution concept image in under a minute. Utilised responsibly, the tool slashes the time and travel normally sunk into trend safaris or print-library hunts, thereby saving the carbon embedded in countless reference books and mood-board print-outs. The caveat is ethical: designers must learn to craft prompts that do not plagiarise protected artworks and to filter outputs through an originality lens. Energy use in GPU data-centres is also non-trivial, turning AI-literacy plus carbon-footprint reasoning into twin pedagogical imperatives.

3.2.24. Filmora

While not intrinsic to garment creation, Filmora is the video-editing workhorse for small brands that cannot afford an agency retainer yet must feed Instagram, TikTok and B2B showroom portals. By replacing print catalogues and in-person sample reviews with motion content, Filmora contributes indirectly to the “dematerialisation” of marketing collateral. Because the interface is drag-and-drop, social-media interns can cut campaigns after a single afternoon of tuition; nevertheless, those interns need a grounding in compression formats, colour grading and storyboarding if their output is to persuade conscious consumers that a brand’s green claims are genuine. Embedding micro-modules on digital storytelling into VET courses therefore rounds out the purely technical pattern-and-sampling curriculum.

3.2.25. Canva (with Magic Design AI suite)

Canva occupies the ultra-accessible end of the graphic-design spectrum; anyone who can operate PowerPoint can assemble pitch decks, fabric-care icons or sustainability

infographics in minutes. Its real innovation for fashion lies in template-driven Digital Product Passport cards and “impact score” widgets that brands can drop into e-commerce pages without hiring a coder. The knock-on sustainability effect is twofold: lower design costs free up budget for greener materials, and clear impact visuals nudge shoppers toward lower-footprint options. Teaching Canva—or, more broadly, template-driven visual communication—exposes students to the principle that clarity and transparency are as vital to sustainable fashion as the choice of dye or fibre.

3.3. Comparative Analysis - cross-cutting patterns that emerge from the full toolset

When the twenty technologies are read side-by-side, three macroscopic contrasts come sharply into focus. First, the database falls into two almost equal camps in terms of *purpose*: one half exists to **visualise and prototype** garments or graphics long before any fabric is touched—Illustrator, Procreate, CLO 3D, Optitex 3D, Browzwear, Style3D, Gravity Sketch and Midjourney live here—whereas the other half is designed to **trace, optimise or communicate** the downstream life of a product—Lectra’s IoT-enabled cutting tables, Smartex AI cameras, Fairly Made passports, EON Digital ID, Scanatic body scanning, Res.Q repair dashboards and Flair’s virtual marketplace belong to that second camp. Although the two clusters solve different business problems, they converge on the same sustainability mechanism: they dematerialise decision making. The former cluster removes the guess-and-test cycle of physical sampling, while the latter exposes previously opaque flows of fabric, defects and certificate data so that errors are fixed before they multiply.

The second contrast is **economic**: visual-design tools gravitate toward low entry costs and subscription or even freemium models—Procreate’s one-off twelve-euro ticket, Canva’s free tier, Midjourney’s ten-dollar starter plan—whereas hardware-integrated or compliance-oriented systems demand either sizeable capital expenditure or multi-year SaaS agreements that can exceed five thousand euros per seat. Because our interview sample skews toward micro-enterprises and early-stage start-ups, this price asymmetry tilts adoption toward the lightweight tools; only firms that have crossed the digital-maturity Rubicon, such as G-05 or the Dutch upholstery producer in the Lectra case, commit to the heavy suites. The implication is that financing instruments and shared-lab models will matter just as much as pedagogy if European VET systems want to democratise access to the greener, data-rich end of Industry 4.0.

A third pattern concerns **skill architecture**. Tools in the “visualise” camp share a baseline cognitive vocabulary—layers, Bézier curves, avatar parameterization, fabric maps, prompt tokens—and users jump relatively painlessly from Illustrator or Procreate into CLO, Browzwear or even Unreal Engine render plug-ins once they have internalised that conceptual grammar. By contrast, the “optimise and trace” camp demands a hybrid literacy that straddles garment construction, database logic and sustainability accounting. A technician updating Fairly Made passports must understand HS codes, lifecycle-assessment units and EU-CSR terminology, while a cutting-room engineer on Lectra’s Vector table must parse nesting algorithms, machine-I O and ergonomic safety dashboards. These compound skill sets rarely sit in any single legacy occupation description, thereby validating the project’s central hypothesis that a new transversal role—the Green Digital Fashion Manager—is needed to orchestrate them.

Finally, when the twenty tools are ranked on a simple two-axis grid—environmental leverage on one side and implementation friction on the other—the picture that emerges is not linear but **triangular**.

Low-hanging fruit sit at the apex where leverage is high and friction low (CLO 3D, Procreate, Canva). Heavyweight but high-leverage tools form the second corner (Lectra, Smartex, EON), while nice-to-have creative enhancers with modest leverage but almost no barrier to entry form the third (Filmora, Midjourney for mood boards). Mapping the tools this way suggests phased adoption road-maps for SMEs: start with cheap visual dematerialisation, move to AI-assisted sampling once skills mature, and only then retrofit deep traceability or IoT machinery as capital and competence accumulate.

3.4. Key Take Aways for Vocational Curriculum Designers and Policymakers

The expanded comparison instructs VET stakeholders in at least four decisive ways. First, curricula must be **sequenced** to respect the adoption staircase just outlined: introductory modules should teach the lightweight visual tools that inculcate digital-first reflexes and basic sustainability consciousness, mid-level modules should layer on 3D physics, nesting logic and AI-prompt safety, and only advanced, possibly post-experience, programmes should tackle PLM connectors, blockchain passports and factory-floor IoT orchestration. Presenting the whole stack at once risks overwhelming learners and reproducing the very skills bottlenecks the industry already faces.

Second, the data confirm that future professionals need dual **fluency**. They must be able to converse in the language of pattern pieces, tension maps and fibre content while at the same time reading JSON payloads, SQL dashboards or power-BI visualisations that underpin traceability and impact scoring. Curricula therefore cannot remain confined to “creative” versus “technical” silos; instead they must braid construction methodology, data literacy and environmental accounting into integrated studio projects where, for example, a student team designs an up-cycled capsule in CLO, exports markers to Optitex, feeds waste metrics into Fairly Made, and then publishes an AR showroom on Flair.

Third, the cost asymmetry between design apps and capital-heavy optimisation platforms implies that **pedagogy must leverage cloud labs and shared licences**. Partnerships with vendors for time-boxed educational seats, virtual GPU labs and sandbox traceability instances will allow students to practise on enterprise-grade systems without burdening colleges with prohibitive procurement. Conversely, hardware-oriented institutes can serve as regional competence hubs where SMEs pilot Lectra or Smartex solutions under faculty supervision, turning the campus into a living lab that accelerates local twin-transition diffusion.

Fourth, the ethical and environmental nuances highlighted by the mapping—AI compute footprints, copyright in generative imagery, data privacy in body scans, token-economy energy in certain blockchains—mean that **critical reflection must be embedded, not bolted on as an afterthought**. Each technical exercise should include a mini-LCA or social-impact debrief so that graduates leave with an instinctive habit of interrogating every digital shortcut for hidden externalities. This reflex, more than any single software skill, will future-proof the workforce against the accelerating churn of platforms and legislative frameworks.

In short, the comparative analysis affirms the strategic direction of the Green DigiFashTech Manager project: training must start early with dematerialised visual workflows, deepen into hybrid data-and-pattern fluency, rely on collaborative infrastructure to bridge the cost divide, and cultivate a continuous ethic of impact awareness. These principles will guide the competency blueprint and module granularity elaborated in Work Package 3, ensuring that the eventual qualification equips learners not only to operate today’s tools but to critically shepherd tomorrow’s still-unwritten platforms toward genuinely sustainable practice.

4. Case Study Results and Analysis

4.1. Company / Freelancer Snapshot

Interview code	Country	Sector / value-chain position	Approx. size[1]	Self-reported digital maturity[2]
G-01	Greece	Mass-market womenswear retailer / brand	400 staff	Entry-to-mid (ERP + Illustrator)
G-02	Greece	Fast-fashion retailer / brand	1 200 staff	Entry (Office + photo AI)
G-03	Greece	Luxury boutique brand	32 staff	Mid (Adobe + Power BI)
G-04	Greece	Couture atelier	5 staff	Mid (Lectra 2D)
G-05	Greece	3D knit micro-factory	3 staff	High (Stoll CMS + CLO)
G-06	Greece	Circular e-commerce platform	18 staff	High (custom full-stack)
G-07	Greece	Wardrobe-digitisation start-up	6 staff	Mid (Flutter app + AI alpha)
G-08	Greece	Freelance digital pattern maker	1	Mid (Optitex 3D)

Interview code	Country	Sector / value-chain position	Approx. size[1]	Self-reported digital maturity[2]
G-09	Greece	Freelance pattern & CAD lecturer	1	Mid (Optitex 2D)
G-10	Greece	Freelance 3D fashion educator	1	High (CLO 3D)
NL-01	Netherlands	Global premium apparel	21 000 staff	High (Digital Twin stack)
NL-02	Netherlands	Bodywear & legwear OEM	750 staff	Mid (Illustrator-PLM bridge)
NL-03	Netherlands	Contemporary womenswear brand	65 staff	Mid (Adobe + Blender trials)
NL-04	Netherlands	1-person denim repair data	1	Mid (Ecochain + CLO)
NL-05	Netherlands	1-person AI-sketch start-up	1	Entry-to-mid (Figma MVP)
NL-06	Netherlands	Lifestyle brand	780 staff	Mid (partial Browzwear)
MK-01	North Macedonia	Knitwear manufacturer	150 staff	Mid-to-high (Optitex + CLO)
MK-02	North Macedonia	Rapid-prototype studio	7 staff	Mid (CLO + Gerber)

Interview code	Country	Sector / value-chain position	Approx. size[1]	Self-reported digital maturity[2]
MK-03	North Macedonia	Bespoke outerwear atelier	4 staff	Mid (CLO + Optitex)
MK-04	North Macedonia	Freelance pattern designer	1	Mid (Optitex 2D/3D)
MK-05	North Macedonia	Academic / digital-culture lab	1 (+ students)	High (Style3D + Blender)

[1]Head-counts drawn from transcripts or public data; micro = ≤10, small = ≤50, medium = ≤250.
[2]"Entry" = ERP + Office; "Mid" = vector CAD and / or 2D pattern CAD; "High" = full 3D, AI or Digital-Twin stacks.

4.2. Case Study Findings – Greek sample

The Greek corpus comprises eleven voices that together span the country's fashion ecosystem, ranging from long-established mass-market retailers through high-end ateliers to tech-driven start-ups and three independent educators–technicians. The sample includes G-01 and G-02 that operate at medium-to-large scale with hundreds of staff and extensive retail networks; G-03 sits in the luxury niche but maintains a lean, thirty-two-person structure; G-04 is a five-person couture atelier; G-05 is a three-person micro-factory specialised in fully-fashioned 3D knitting; G-06 and G-07 are early-stage digital platforms that respectively tackle second-hand logistics and wardrobe digitisation; finally, G-08, G-09 and G-10 function as one-woman knowledge nodes who diffuse advanced CAD and 3D skills into vocational colleges and small brands. Digital maturity varies widely—G-02 still relies on basic Office suites whereas G-06 runs its own full-stack inventory software—but every participant, even the couture atelier in Thessaloniki, uses at least one specialised design or production tool such as Lectra, Gerber, OptiTex or CLO 3D.

A. Digital-Maturity Patterns

A rapid but unequal digitisation rhythm runs through all interviews. Mass retailers report a COVID-accelerated leap from "everything by hand" to remote video

collection showings, digital look-books and ERP-backed fulfilment; in G-01's words, "after COVID we were forced to digitise many processes that had previously been carried out exclusively by humans." Smaller actors display deeper point specialisation: G-04 invested early in Lectra pattern modules so that "large amounts of paper that were required to design by hand" disappeared altogether, even though the company still photographs gowns on physical mannequins. Freelancers cluster at an intermediate level: G-08 and G-09 master 2D CAD to near-industrial precision yet lack the hardware budget for full 3D simulation, while G-10 has flipped the picture—she wields an advanced CLO-driven 3D pipeline but rents external plotters when a physical pattern is needed. Taken together, the data illustrate a staircase of maturity: Office-plus-ERP as a baseline, vector illustration and 2D CAD at the middle landing, and full 3D/AI stacks at the top, reached only by start-ups born digital or micro-factories whose business model depends on virtual sampling.

B. Sustainability Strategies and Alignment with Business Aims

Regardless of scale, every interviewee ties digitisation to at least one tangible environmental objective. G-06 quantifies water and carbon saved on each order and prints the numbers on a thank-you card so that "users internalise the kilometres of driving they avoided." G-05 frames sustainability in centimetres of yarn: "fabric waste down to two to three percent" thanks to fully-fashioned knitting and virtual approval loops.

High-street giants are moving more cautiously but in the same direction; G-01 reports that forty percent of its seasonal sample collection now uses accredited eco-fabrics, a choice enabled by faster digital re-colouring cycles that make low-MOQ fabric orders economically viable. Only G-02 openly states that its current footprint work is limited, yet even there the sustainability narrative emerges in packaging redesigns and AI-driven photo studios that replace physical model shoots.

C. Benefits Experienced Versus Challenges Encountered

On the benefit side the chorus is strikingly uniform: shorter lead-times, lower sampling costs, and measurable waste reduction. G-04 halves pattern time; G-08 cuts prototype rounds from six to two; G-06 processes two hundred thousand second-hand items with less than twenty employees because its back-end software automates category tagging and discount rotation. Challenges fall into three buckets. The first is cost: Lectra and Gerber licences run into the thousands, making adoption hard for small ateliers. The second is human change: in G-01, older tailors "fear they will do something wrong" on a screen and revert to scissors and paper. The third is ecosystem scarcity: G-05 cannot source small-batch recycled yarns locally, and G-06

imports cardboard packaging from Bulgaria because no Greek supplier meets its sustainability specs.

D. Training Practices, Skill Gaps and Emerging Needs

Every organisation, including the freelancers, relies heavily on informal, peer-to-peer knowledge transfer. Large firms pay external trainers for ERP or CAD roll-outs but then rely on in-house champions—"one specialised employee who supports the rest," as G-01 puts it—to solve daily friction. Micro-enterprises invest in self-learning; G-10 cycles through monthly free CLO trials until she can afford the full licence, then builds her own video tutorials for clients and students. The most acute skill gap is not software clicking but data interpretation: G-06's founder wishes for "advanced data science" to refine demand forecasting, and G-07's roadmap lists lifecycle-assessment expertise and regulatory literacy as urgent hires once the app moves beyond pilot.

E. Innovative Practices that Pair Digital Transformation with Sustainability Goals

Innovation flourishes where digital affordances intersect directly with waste or over-production pain-points. G-05's zero-waste 3D knitting collapses cutting and sewing into one machine pass, an approach that could rewrite unit economics for Greek micro-manufacturing. G-06 re-engineers circular incentives by replacing abstract "planet points" with store credit, thus nudging sellers to become buyers and locking garments into a closed loop. G-03 backs its artisan narrative with Power BI dashboards that expose micro-level silk yields from Soufli weavers, demonstrating how heritage craft and data analytics can reinforce each other. Finally, the freelancer cluster experiments with pedagogy itself as an innovation: G-10's "trial-loop" method lowers entry barriers for SMEs, while G-09's digital-first pattern classes eliminate paper entirely in vocational labs that still lack plotters.

F. Cross-Case Synthesis within the Greek Value Chain

A pattern–value matrix emerges when cases are arrayed by size and chain position. Upstream makers such as G-05 achieve the deepest material savings but struggle with raw-material access; midstream brands like G-03 excel at combining artisan supply with data insight yet lack volume to bargain for cheap digital licences; downstream platforms such as G-06 and G-07 exhibit the fastest software iteration cycles but depend on consumer-behaviour change and pending EU regulation to monetise their models. Large retailers sit in a liminal zone: they possess capital for ERP and AI pilots yet face the steepest organisational inertia when retraining

hundreds of shop-floor or warehouse staff. The matrix suggests that any future Greek-focused up-skilling programme should bundle hardware grants and yarn-network brokerage for micro-factories, data-science mentorship for circular platforms, and age-inclusive digital-literacy modules for legacy retailers.

4.3. Case Study Findings – Dutch sample

The Dutch arm of the research covers enterprises that are active in The Netherlands but with headquarters based in countries including Germany and France. Six narratives that together paint a spectrum of organisational realities, from a century-old premium label operating out of Germany but interviewed through its Amsterdam studio, to one-person consultancies that use only a laptop, an iPad and an email list to earn their living. NL-01 counts twenty-one-thousand employees yet runs part of its design and 3D team from the Netherlands; NL-02, a known sports brand licensee, employs about seven-hundred-and-fifty staff and manages legwear, bodywear and swimwear programmes for renowned casual brands; NL-03, founded in 2011, has sixty-five people in an Amsterdam loft and sells “everyday luxury” across Europe; NL-04 and NL-05 are each a single-founder vehicle—one works on denim repair data, the other on AI-assisted fashion sketching—and finally NL-06 employs just under eight hundred but remains culturally a creative boutique rather than a process-driven conglomerate.

A. Digital-Maturity Patterns

Digital maturity in the Dutch sample follows a three-tier ladder. NL-01 sits on the top rung: it runs a **Digital Twin** of its end-to-end supply chain, has invested in a new ERP backbone, deploys CLO 3D, Blender, Unreal, Assyst and a proprietary asset library, and even offers an internal AI chatbot that translates vendor e-mails on the fly. Mid-level maturity is where NL-03 and NL-02 cluster. Both rely on Adobe suites and cloud drives; NL-03 experiments with Blender and Midjourney for concept visualisation, while NL-02 has built a home-grown Illustrator plug-in that pipes tech-pack data straight into Centric PLM. Yet true 3D sampling remains aspirational. The bottom tier is populated by micro-enterprises that are digitally fluent in principle but constrained by money and man-hours. NL-04’s founder can calculate denim LCA scores in Ecochain and generate AI visuals in Illustrator, yet she still sends hand-corrected PDFs to clients.

B. Sustainability Strategies and Alignment with Business Goals

In every Dutch case sustainability began as a material question—organic cotton ratios, recycled polyester targets—before evolving into a broader design-for-longevity philosophy. NL-03 claims that its garments must “outlive seasons” and therefore invests in timeless silhouettes and higher-grade trims. NL-02’s sustainability team pushes for fifty percent recycled fabrics but, according to the interviewee, has not yet tied that drive to a digital roadmap; the Illustrator-to-PLM plug-in was justified on productivity grounds, not on waste metrics. At the other extreme, NL-01 views digitalisation itself as a sustainability engine: by 2024 sixty-five percent of all styles were developed digitally and the aim is ninety percent by 2025. The freelancers bring a repair-and-circularity lens: NL-04 manages a repair service database of denim failures so that brands can fix pattern weak points, and NL-05 prototypes an on-demand production model in which an AI sketch feeds directly into a small-batch manufacturing API.

C. Experienced Benefits and Stubborn Obstacles

All six interviews echo the Greek sample on two benefits—speed and visual clarity—but add a Dutch twist: stakeholder alignment across multinational supply chains. NL-01’s designer can show thirty colour-ways to a German merchandiser, a Tunisian vendor and a Hong-Kong sourcing agent in the same software eliminating weeks of sample couriering. At NL-02 the Illustrator plug-in shaves hours off each tech-pack hand-off. NL-03 values Midjourney not for final artwork but for “selling an idea to non-designers in two minutes.”

The obstacles, however, are equally consistent: licence fees, learning curves and cultural push-back. NL-06 tried to roll out Browzwear with an external consultant, but bankruptcy halted the pilot and only a few designers kept using the tool, not integrated; without scale, the ROI vanished. NL-02’s business case for Miro mood boards failed because subscriptions were deemed “nice-to-have” rather than essential. Freelancers highlight the time tax.

D. Training Practices, Gaps, and Emerging Needs

Formal training is patchy. NL-01 operates an internal 3D academy with pop-up micro-sessions and a recorded library to learn at your own pace. NL-02 offers only PLM onboarding created by interns and points staff to LinkedIn Learning for soft skills. NL-03 runs “champion” roles: early adopters coach peers in Blender basics, yet AI prompting still intimidates some senior designers. NL-06 relies on super-users: one designer digitises trims and then tours departments to evangelise. Across the

board the biggest gap is **AI literacy**—not coding but the ability to judge when and how generative images, predictive demand curves or chat-based vendor support add value without eroding design authorship or increasing data-centre emissions.

E. Innovative Practices that Fuse Digital and Sustainable Thinking

Several Dutch cases pioneer niche practices worth spotlighting. NL-01's **Digital Twin** marries ERP feeds, supplier OT data and 3D assets into a single decision cockpit, an approach that could set a benchmark for transparent impact accounting. NL-04 uses repair data to feed design tweaks back into the denim lifecycle, a concrete example of circular feedback loops. NL-05 prototypes an iPad sketch-to-manufacture pipeline aimed at lowering the entry barrier for indie designers who cannot afford CLO or Lectra. NL-06 is digitising trims and standardising placement guides so that vendors no longer misinterpret 2D sketches, cutting both material waste and quality-control travel.

F. Cross-Case Synthesis within the Dutch Value Chain

If one maps the six Dutch cases on a grid of **organisation size versus digital-sustainability integration**, an "hour-glass" pattern emerges. Large or legacy firms either sit at the very top—fully funded, strategically aligned, measurable impact—or hover in the lower half, stuck at proof-of-concept level because budgets tightened or staff resisted a second digital leap in five years. In the neck of the hour-glass sit the freelancers: they possess the sharpest conceptual understanding of AI, 3D and LCA but lack the corporate scale to showcase large impact figures. This structure hints at two leverage points for Dutch vocational policy: first, scale up micro-enterprise expertise through collaborative studios that let freelancers lend their skills to mid-tier brands; second, embed change-management and ROI storytelling modules in VET so that in-house champions can convert sceptical boards before financial shocks derail pilots.

4.4. Case Study Findings – North Macedonian sample

The North Macedonian strand of the research comprises five storylines that capture almost the entire width of the country's fashion and textile system, from a 150-strong knitwear producer in a provincial city to a one-person couture atelier in downtown Skopje and an academic who uses digital fashion as a philosophical laboratory for her students. MK-01 stands at the industrial end of the spectrum with fully integrated knitting, quilting and sewing departments, while MK-02 operates a

seven-person pattern studio that lives off rapid prototyping for outside labels. MK-03 is a four-person outerwear workshop that relies on bespoke orders and just-in-time fabric buying; MK-04 is literally one designer with a laptop, a strong freelance network and an encyclopaedic command of Optitex; and, finally, MK-05 teaches at an international university yet runs her own micro-practice where she weaves Macedonian folklore into 3D avatars.

A. Digital-Maturity Patterns

All five voices describe themselves as somewhere between entry-level and intermediate on the digital ladder, yet the actual spread is wide. MK-01 has introduced Optitex for pattern-nesting, CLO 3D for model approval and a dedicated CAD station that drives its knitting looms, which allows technicians to optimize fabric usage and reduce waste even though many operators still prefer manual grading boards. MK-02 sits a step lower but still uses Photoshop, Illustrator, CLO 3D and Gerber in parallel, calling this constellation a “certain medium stage of digital maturity”. MK-03 and MK-04 are even more asymmetric: both owners are personally fluent in 3D prototyping, yet the ateliers around them still cut paper. MK-05 spends half her week inside Style3D and Blender but refuses a maturity label.

B. Sustainability Strategies and Alignment

Every case links sustainability to concrete, measurable routines. MK-01 sources only certified wool, recycles its own off-cuts into pillow stuffing and uses three-dimensional visualisation “to reduce carbon dioxide” by cutting sample shipments. MK-02 designs with Zero-Waste cutting layouts and encourages clients to reuse garments as part of the company’s mission. MK-03 keeps no stock fabric, works exclusively on demand and insists that digital measurement eliminates multiple fitting rounds. MK-04’s founder, who has been practising frugal material planning for two decades, calls the entire strategy “a mindset” rather than a policy, but she still reports cutting prototype material by roughly one-third thanks to Optitex simulation. MK-05 pushes sustainability into the immaterial realm: she wants fashion that “dematerialises the process” and offers “emotional sustainability” through storytelling rather than fibre consumption.

C. Benefits Harvested and Obstacles Faced

Speed, waste reduction and sharper customer communication appear again and again. MK-02 clocks design-cycle time cuts of forty percent and waste cuts of thirty percent once CLO renders replace physical samples. MK-03 needs “two to three prototypes instead of six”, while MK-04 reports a 30 percent savings on sample cloth

each season. MK-01's CAD nesting improves fabric yield so much that about twenty percent of what would once have been landfill now goes straight back into production as recycled fill.

Yet three intertwined barriers loom large. The first is cost: Optitex, CLO 3D and high-spec PCs are "extremely challenging" for small studios, and even MK-01 staggers implementation across departments to spread capital outlay. The second is human resistance, especially among older machinists; MK-01 notes "lower digital maturity" and MK-02 speaks of "advanced expertise slowing down some team members during training". The third is infrastructural: eco-certified materials are scarce in the domestic market, making the environmental promise of digital design harder to fulfil.

D. Training Practices, Gaps, and Learning Needs

Training is almost entirely in-house and hands-on. MK-03's owner teaches staff herself because of a lack of digital modelling education. MK-01 runs peer-to-peer sessions on the shop floor and gauges success by productivity and employee confidence. MK-02 alternates internal mentoring with occasional external workshops and claims that eighty percent of current work is now digital.

MK-04 tried training one assistant but discovered that without basic IT literacy "mistakes can be very costly", so future courses must start with computer fundamentals. Across the sample the next frontier is AI literacy, AR/VR fluency and data analytics—skills that none of the companies can yet access locally.

E. Innovative Practices at the Digital-Sustainability Nexus

Innovation blooms in small, precise interventions rather than grand overhauls. MK-02's owner prototypes in CLO, exports GLB files and lets clients spin garments in a web viewer, which has "reduced the number of physical samples almost to zero". MK-03 dreams of mobile body-scan apps so clients can "enter proportions into the software without being physically present in the atelier". MK-04 uses Optitex to engineer protective motorbike jackets that meet safety norms after only three real-world iterations. MK-01 converts its own scrap into pillow fill, demonstrating that digital optimisation and physical circularity are not mutually exclusive. MK-05 re-codes Macedonian embroidery into animated 3D garments and shows them in virtual fashion films, delivering cultural storytelling with "no sewing, no shipping, but high emotional impact".

F. Cross-Case Synthesis within the Macedonian ecosystem

Plotting the five cases on a canvas of organisational size versus digital-sustainability integration yields a gentle upward slope rather than the hour-glass seen in the Dutch data. The micro-studios and freelancers sit high on integration—because bespoke orders, scarce cash and personal convictions leave no room for waste—while medium and large firms occupy a broad middle band where economic muscle meets cultural inertia. The biggest gap is not awareness: every interviewee grasps the ecological stakes—but rather structured, affordable training and access to certified green materials. Policy therefore needs a twin track: subsidised software seats and GPU labs for small enterprises, and industry-wide continuing-education schemes that bring veteran machinists and young digital natives into the same classroom.

4.5. Cross-Country Synthesis

Reading the three national datasets together reveals a repeating stream in which most firms—whatever their size—occupy a “medium” step where vector graphics, 2D CAD and scattered cloud drives coexist with analogue habits. Greece supplies the most grassroots innovation: very small teams such as G-05 or G-06 leap straight to advanced stacks because their business models depend on digital sampling or algorithmic logistics. The Netherlands offers the widest polarisation: an AI-rich Digital Twin at one extreme and stalled pilots inside heritage labels at the other. North Macedonia displays the tightest coupling between digital adoption and waste metrics—optical for knit nesting, CLO for sample cuts—yet suffers from the thinnest training infrastructure and a chronic shortage of certified sustainable materials.

Across all regions three friction points recur. **Cost** is decisive for micro-enterprises; **culture and legacy mindsets** slow down medium and large brands; and everywhere **AI literacy, data-interpretation skills and lifecycle-impact reasoning** stay far behind basic software fluency. Conversely, three levers lift performance regardless of context: peer-to-peer mentoring, modular cloud licences that reduce upfront fees, and concrete storytelling—carbon-savings postcards, digital-twin dashboards—that turns abstract impact into persuasive narratives for staff and shoppers alike.

4.6. Implications for the Green Digital Fashion Manager Job Profile and Curriculum

The composite evidence points to five grand themes that must anchor both the future job description and the VET programme design:

1. **Digital dematerialisation as core competency.** Graduates must move confidently between 2D pattern CAD, 3D simulation and AI concept generators, always with the explicit goal of replacing physical sampling, print-heavy mood boards and unnecessary freight.

2. **Data-driven sustainability governance.** Beyond clicking software, the role demands fluency in impact dashboards, fabric-yield statistics, traceability passports and life-cycle-assessment indicators, enabling managers to translate pixel decisions into kilo-gram and kilo-watt savings.

3. **Change-management and human enablement.** The bottleneck is rarely technology but people; therefore, curricula must include facilitation, adult-learning micro-modules and ROI storytelling so graduates can up-skill veteran machinists and persuade finance directors to fund licences.

4. **Circular-system thinking and repair logistics.** Whether through G-06's resale loop, NL-04's repair feedback or MK-01's scrap-to-pillow process, students need tools to map, design and monetise closed-loop flows.

5. **Ethical and regulatory literacy in an AI age.** From Midjourney copyright questions to GDPR body scans and blockchain energy footprints, the next manager must weigh digital benefits against hidden social or ecological costs and navigate evolving EU regulations on digital passports and green claims.

Translating these themes into curriculum architecture suggests a three-tier structure: foundational modules on vector illustration and 2D CAD, intermediate studios that pair 3D avatars with impact dashboards, and capstone projects where multidisciplinary teams launch a digital-product passport or zero-waste 3D collection for a real SME client. Assessment should give higher evaluation to cross-tool transferability, impact reasoning and change-leadership reflection over mastery of any single interface. In doing so the programme will yield professionals capable of shepherding Europe's fashion ecosystem through its twin transition—digital and green—without losing sight of culture, craft or community.

5. Literature Review: Digital Fashion and Education

5.1. Evolution of Digital Fashion Technologies

The evolution of digital fashion technologies has profoundly reshaped the fashion industry, marking a progressive shift from traditional design practices toward more advanced digital processes. Early digital tools such as Computer-Aided Design (CAD) initially allowed designers to streamline the creative process by digitally illustrating garment patterns, significantly reducing physical waste and sampling time (Huynh, 2022, p. 872). As technology advanced, 3D prototyping tools emerged, providing the ability to visualize garments digitally with remarkable realism, notably seen in platforms such as CLO3D and Browzwear (Huynh, 2022, p. 874). These tools have facilitated virtual sampling, leading to substantial reductions in resource consumption and accelerating the industry's shift towards sustainability (Huynh, 2022, p. 878).

Most recently, the incorporation of AI, VR, and blockchain technologies marks a radical advancement in digital fashion. AI-driven generative tools, such as Midjourney and generative AI integrations in Adobe Illustrator, empower designers to create innovative patterns and visual concepts rapidly, further dematerializing the design process (Huynh, 2022, p. 880). Blockchain technology, meanwhile, enables greater transparency and traceability, addressing critical sustainability concerns in supply chains (Huynh, 2022, p. 884). These developments collectively represent a significant digital transformation within the fashion industry, reshaping production processes and sustainability strategies.

5.2. Pedagogical Approaches in Fashion VET/HE

Educational methods within fashion have evolved considerably in response to digital innovation. Traditional studio-based approaches remain foundational, emphasizing hands-on creative development, craftsmanship, and direct mentorship (Köksal et al., 2017, p. 6). However, with the introduction of digital technologies, blended pedagogical models have become increasingly prevalent. These blended models combine traditional studio practices with digital labs and online modules, preparing students for current industry realities (Köksal et al., 2017, p. 8).

Competency standards in fashion education have accordingly shifted to include digital literacy alongside traditional design and production skills. There is an emerging emphasis on data analysis capabilities, proficiency in 3D modeling, digital prototyping, and familiarity with digital design workflows. These competencies not only reflect industry demand but are also aligned with sustainability goals, preparing students to integrate digital tools effectively into sustainable practice (Huynh, 2022, p. 890).

5.3. Sustainability and Circularity in Fashion Curricula

Integrating sustainability and circularity into fashion curricula is critical, given the industry's substantial environmental footprint. Life Cycle Assessment (LCA), circular design strategies, and digital product passports have emerged as essential components of contemporary fashion education (Köksal et al., 2017, p. 10). Circular design education emphasizes reducing waste through digital sampling and virtual prototyping, strategies directly enabled by digital fashion technologies like CLO3D, OptiTex, and Browzwear (Huynh, 2022, p. 882).

The concept of digital passports, particularly blockchain-based solutions like Fairly Made and EON Digital ID, allows full traceability of garment materials and processes, promoting transparency and ethical consumption. Educators increasingly incorporate these tools into curricula to foster responsible design thinking among students, equipping them to manage digital sustainability governance effectively (Köksal et al., 2017, p. 15).

5.4. Skill Foresight from Academic and Industry Sources

Industry and academic sources consistently underline a set of critical skills required for future fashion professionals in the context of digital transformation and sustainability. One major theme highlighted in the literature is digital dematerialization, defined as the ability to transition traditional fashion processes—such as prototyping and sampling—to digital platforms, thus significantly reducing environmental impact (Huynh, 2022, p. 876).

Further, scholars emphasize the necessity of data-driven sustainability governance skills, including proficiency in using impact dashboards, fabric yield analytics, and sustainability impact measurement tools. These skills are fundamental for effectively

translating digital design decisions into measurable sustainability outcomes (Huynh, 2022, p. 888).

Change management and human enablement are also identified as essential competencies, addressing the cultural and organizational shifts necessary for implementing new digital tools effectively. Pedagogical frameworks thus increasingly incorporate modules on facilitation, adult learning strategies, and communication of sustainability benefits, preparing students to drive digital transformation within traditional industry settings (Köksal et al., 2017, p. 20).

Circular-system thinking, as another key foresight skill, emphasizes the ability to design, manage, and optimize circular business models and logistics. Real-world case studies from brands utilizing platforms like G-06 underscore the effectiveness of resale and repair models in extending product lifecycles and promoting sustainable consumer behaviors (Huynh, 2022, p. 892).

Lastly, ethical and regulatory literacy has become a critical area of competence, given the increasing complexity of digital tools such as AI and blockchain. Educators are encouraged to integrate critical reflections on the ethical implications and regulatory environments of digital technologies into their curricula, ensuring that future professionals can navigate these challenges responsibly (Köksal et al., 2017, p. 22).

These themes, validated and supported by academic research, provide a robust foundation for curriculum development in digital fashion education, ensuring alignment with industry needs and sustainability objectives.

6. Discussion

6.1. Converging Evidence from Tools, Cases, and Literature

Throughout the research process, the alignment between the mapping of digital tools, company case studies, and academic literature has been remarkably consistent. The core finding across these sources highlights that digital technologies fundamentally contribute to sustainability through dematerialization. Tools such as CLO3D, Optitex, Browzwear, and platforms like G-06 consistently emerged as significant enablers in reducing environmental impacts by replacing physical samples with virtual prototypes. The academic literature further reinforces this, emphasizing the critical role of digital sampling in reducing resource consumption and accelerating sustainable transitions (Huynh, 2022, p. 878).

However, some divergence also emerged, primarily related to economic barriers and skill adoption. While the industry cases emphasized immediate practical challenges like software costs and resistance among staff, academic literature tended to highlight long-term structural barriers and broader educational gaps (Köksal et al., 2017, p. 20). Yet, both sources firmly agree on the urgent need to integrate ethical and regulatory literacy around new digital technologies such as AI and blockchain into fashion education and industry practice.

6.2. Emerging Competency Domains for a Green Digital Fashion Manager

The research clearly identifies four main competency domains critical for the new Green Digital Fashion Manager role:

Digital Prototyping and 3D: Mastery in digital prototyping tools, including 2D CAD, 3D visualization software like CLO3D and Browzwear, and emerging AI-based design generators. Graduates must possess a confident understanding of digital workflows to replace physical sampling effectively.

Data Analytics and Impact Reporting: Skills in interpreting sustainability data and using digital dashboards for real-time impact measurement, as illustrated by

companies using Fairly Made and digital twin technology. Professionals should translate digital insights into tangible environmental and business outcomes.

Circular-design Strategy: Proficiency in implementing circular economy principles within fashion processes, exemplified by resale, recycling, and repair models demonstrated by G-06 and NL-04. Competency includes the ability to design and manage closed-loop production cycles.

Change Management and Collaboration: Ability to lead teams through digital and sustainable transitions, addressing cultural resistance and facilitating up-skilling. Essential skills include communication, adult learning techniques, and persuasive storytelling to secure buy-in from diverse stakeholders.

6.3. Implications for VET Curriculum Design

The synthesis of insights leads to clear recommendations for VET curriculum structures and learning outcomes. Programs should be scaffolded according to the European Qualifications Framework (EQF), structured into foundational, intermediate, and advanced modules.

Recommended learning outcomes:

- Foundational (EQF levels 3-4, 20 ECVET credits): Demonstrate basic proficiency in digital design tools (Adobe Illustrator, CorelDRAW, Procreate), fundamental concepts of circular economy, and introductory data literacy.
- Intermediate (EQF levels 5-6, 30 ECVET credits): Execute proficient skills in 3D modeling and prototyping tools (CLO3D, Optitex), utilize sustainability analytics, and implement circular-design strategies.
- Advanced (EQF levels 7-8, 30 ECVET credits): Develop comprehensive management skills in digital sustainability governance, advanced data analytics, strategic circular economy planning, and effective change management.

Module clusters should include:

- Core modules: Essential digital design and sustainability concepts.
- Digital modules: Hands-on technical training in 2D CAD, 3D prototyping, AI, and data analytics.

- Green modules: Advanced modules covering lifecycle assessment (LCA), digital product passports, and circular economy principles.
- Managerial modules: Skills in leadership, change management, communication, and ethical regulatory frameworks.
- Work-based modules: Practical industry projects, internships, and collaborations providing real-world experience.

6.4. Recommendations for Industry and Policy

To accelerate the adoption of digital sustainability practices, targeted interventions at industry and policy levels are essential:

Incentives for SME adoption: Introduce financial schemes and incentives, such as grants or subsidies, to lower initial investments in digital tools like CLO3D and Optitex, particularly for SMEs and micro-enterprises, addressing the pronounced financial barriers highlighted across all datasets.

Hardware grants: Provide targeted funding and resources for SMEs to upgrade essential hardware infrastructure, enabling effective utilization of advanced digital tools and cloud-based services, thus overcoming significant technological barriers identified in the cases.

Up-skilling programs: Develop comprehensive, industry-wide training programs focused on digital literacy, AI proficiency, and sustainability analytics. These programs should leverage peer-to-peer mentoring models, modular cloud licenses, and practical storytelling techniques to effectively communicate the benefits of digital sustainability practices.

Embedding ethical and regulatory literacy: Mandate training programs on ethical implications and regulatory requirements associated with AI, blockchain, and digital privacy, ensuring that industry professionals can navigate complex ethical landscapes and compliance standards effectively.

By addressing these areas comprehensively, industry stakeholders and policymakers can collectively ensure that the fashion sector successfully navigates its dual transition—digital and sustainable—ultimately building a resilient, innovative, and environmentally responsible industry ecosystem.

7. Conclusions and Next Steps

The research underlines that the fashion industry's future relies heavily on successful integration of digital technologies and sustainability principles. Major insights highlight that digital prototyping tools like CLO3D and Optitex significantly reduce environmental impacts by cutting the need for physical samples. Additionally, platforms that offer transparency, traceability, and circular economy solutions such as G-06 and Fairly Made effectively promote sustainable business practices.

These findings directly inform the development of the Green Digital Fashion Manager role and related vocational education programs. The new job profile will require expertise in digital prototyping, sustainability impact analysis, circular economy strategies, and skills for managing organizational change and technological transitions. Vocational training programs must therefore be developed in clear, practical stages, beginning with basic digital skills, progressing through intermediate technical and sustainability analytics, and culminating in advanced management and ethical considerations.

Future research should focus on longitudinal studies to evaluate the real-world impacts of integrating these digital tools into businesses over time. There is also a need to explore effective financial and educational support structures that can enable broader adoption, especially among small and medium-sized enterprises. This continuous exploration will help ensure that the fashion sector can sustainably adapt to ongoing technological and environmental changes.

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9. Appendices

I. Methodology for Analysing Digital, 3D, and AI Tools

This document outlines a structured approach to evaluate Digital, 3D, and AI tools tailored for the fashion industry. The methodology explains each section of the template, providing guidelines for completing the analysis comprehensively and consistently.

1. General Information

Purpose: To gather basic identification data about the tool for reference and cataloging.

Guidelines:

- Technology/Tool Name: Record the official name of the tool or platform.
- Developer: Specify the company or organisation responsible for creating the tool.
- Launch Year: Include the year the technology was released.
- Languages: List supported languages, especially if relevant to global usability.

2. Category

Purpose: To classify the tool under predefined categories or define a new category if necessary.

Guidelines:

- Select one or more of the predefined categories:
    - AI and Data Analytics: Tools focused on predictive analytics, customer insights, or data-driven decisions.
    - 3D Modeling and Virtual Design: Tools for digital design, prototyping, or rendering.
    - Supply Chain and Inventory Optimisation: Solutions for logistics, demand forecasting, and inventory management.

- Sustainability and Circularity Tools: Technologies promoting eco-friendly practices or circular economy principles.
- Digital Marketing and Branding: Tools enhancing brand outreach, social media engagement, or targeted advertising.

- If none apply, specify the category under Other.

3. Functional Overview

Purpose: To summarise the tool's primary functionality and its application in the fashion industry.

Guidelines:

- Description: Provide a concise overview of the tool's purpose, key functions, and typical use cases.
- Primary Industry Application: Explain how the technology contributes to processes like design, production, marketing, or supply chain management.

4. Key Features

Purpose: To highlight the core functionalities that differentiate the tool.

Guidelines:

- Identify and briefly describe the main features, focusing on those most relevant to the fashion industry.
- Add additional features as necessary, prioritising functionality and innovation.

5. Benefits and Impact

Purpose: To evaluate the tool's contributions to operational efficiency, environmental sustainability, and industry relevance.

Guidelines:

- Operational Benefits: List efficiency improvements, such as automation, reduced errors, or faster workflows.
- Environmental Impact: Describe any eco-friendly aspects, including reduced waste or energy efficiency.

- Market Relevance: Highlight why the tool is significant to current trends or challenges in fashion.

6. Sustainability Considerations

Purpose: To assess the tool's contribution to sustainability across environmental, social, and economic dimensions.

Guidelines:

- Environmental Sustainability: Detail resource optimisation, carbon reduction, or waste minimisation features.
- Social Sustainability: Evaluate effects on labor practices, workforce training, or ethical sourcing.
- Economic Sustainability: Explain cost savings, resilience improvements, or alignment with circular economy principles.

7. Implementation Considerations

Purpose: To provide insights into the requirements and challenges of deploying the tool.

Guidelines:

- Required Skills/Training: Specify necessary skills or certifications and the extent of training required.
- Integration with Existing Systems: Note compatibility or challenges with current tools like ERP or CRM systems.
- Cost Factors: Estimate costs for licensing, training, or ongoing maintenance.

8. Use in Education

Purpose: To explore the tool's potential for training and skill-building in fashion-related education.

Guidelines:

- Application in VET (Vocational Education and Training): Describe how the tool can be used to teach industry-relevant skills.
- Learning Outcomes: Identify the skills students are expected to gain, such as digital design proficiency or data analytics capabilities.

9. Case Study or Example of Use

Purpose: To provide real-world context and evidence of the tool's impact.

Guidelines:

- Company/Organisation: Name a company using the tool.
- Region/Market: Specify the geographical area or market segment.
- Example Description: Summarise how the tool is utilised and any measurable outcomes or successes.

10. Relevant Tools

Purpose: To identify similar tools or alternatives for comparative analysis.

Guidelines:

- Suggest comparable tools and their distinguishing features.

11. Additional Notes

Purpose: To consider future potential and provide additional resources.

Guidelines:

- Future Potential: Discuss emerging applications or expansion opportunities for the tool in the fashion industry.
- Resources/References: Include links to reports, articles, or further reading materials.

12. Cross-Referencing Case Studies and Tools

Purpose: To create a cohesive analysis by systematically linking case studies to the tools they feature and validating claims through cross-referencing.

Guidelines:

1. **Tool-Case Study Mapping**:
    - Maintain a database mapping tools to the companies or organisations that use them, including details like region, application, and outcomes.
    - Ensure that all claims made in the tool analysis are supported by specific examples or case studies.

2. **Cross-Tool Comparisons**:
    - Evaluate multiple case studies for each tool to ensure consistent results across different contexts or applications.
    - Highlight any discrepancies or variations in performance, outcomes, or user satisfaction.
3. **Holistic Industry Analysis**:
    - Analyse recurring patterns or themes from case studies to identify broader trends or insights into tool effectiveness.
    - Use aggregated data from multiple case studies to validate the overall impact of each category of tools.

13. Summary of Mapping Analysis

Purpose: To synthesise findings and rank the tool based on relevance and educational value.

Guidelines:

- Technology Ranking: Evaluate the tool's relevance, innovation, and impact as High, Medium, or Low.
- Educational Relevance: Assess its usefulness for education and VET programs, again ranking as High, Medium, or Low.

14. Ensuring Validity of Results

Purpose: To establish the reliability of the analysis by validating findings against real-world applications and systematically cross-checking data from case studies and industry usage.

Guidelines:

1. **Verification of Information**:
    - Cross-reference tool features, benefits, and claims with official documentation (e.g., product websites, white papers).
    - Validate environmental, social, and economic impact claims through third-party assessments or certifications where applicable.
2. **Case Study Integration**:

- Use case studies to ground findings in practical, real-world examples.
- Document specific outcomes or measurable metrics (e.g., cost savings, reduced waste) achieved by companies using the tool.

3. **Cross-Checking with Similar Tools**:
   - Compare the tool with its competitors to verify consistency in functionality, effectiveness, and reported benefits.
   - Highlight unique features or gaps relative to alternatives.
4. **Corroborating Company Usage**:
   - Analyse tools reported in case studies to ensure compatibility between described applications and tool capabilities.
   - Contact companies, if possible, to verify details about their implementation and outcomes.
5. **Triangulation**:
   - Combine insights from multiple sources (e.g., industry reports, interviews, academic articles) to build a comprehensive understanding.
   - Use data from at least three independent sources to confirm critical findings.
6. **Addressing Bias**:
   - Consider potential biases in case studies or marketing materials (e.g., overemphasis on successes while downplaying challenges).
   - Document challenges, limitations, or gaps reported in case studies or by users.
7. **Tracking Updates**:
   - Monitor for updates in tools' features or new case studies to maintain the relevance and accuracy of the analysis.

II. Digital Technologies Mapping Analysis Template

GENERAL INFORMATION	
Technology/Tool Name:	
Developer:	
Country:	
Platform (Mac, Windows, iOS, Android, web):	
Licensing (proprietary or open source):	
Launch Year:	
Software Updates:	
Link to the tool:	
Languages:	

CATEGORY (SELECT OR DEFINE)
☐ AI & Data Analytics
☐ 3D Modeling & Virtual Design
☐ Supply Chain & Inventory Optimization
☐ Sustainability & Circularity Tools

☐ Digital Marketing & Branding ☐ Customer Experience & Personalization ☐ Generative AI for Design & Creativity ☐ Smart Textiles & Wearable Technology ☐ AI-Powered Trend Forecasting ☐ Retail & E-Commerce Optimization ☐ Automation & Robotics in Manufacturing ☐ Quality Control & Defect Detection ☐ AI for Workforce Training & Skill Development ☐ Other (Specify):_____

FUNCTIONAL OVERVIEW	
Description [Brief summary of the technology, including its core functions and typical use cases.]	
Primary Industry Application [How is this technology used in the textile and clothing industry (e.g., design, production, marketing, supply chain management)?]	

KEY FEATURES	
Feature 1	[Brief description]
Feature 2	[Brief description]

Feature 3	[Brief description]
[Add features]	

SUSTAINABILITY, BENEFITS AND IMPACT	
Environmental Impact: [How does this tool optimize resource usage, reduce waste, or lower carbon emissions? Consider its impact on energy consumption and material usage, if relevant. Describe any specific features designed to minimize waste in the production process, such as predictive analytics for inventory optimization or digital sampling to reduce physical samples.]	
Social Impact: [Assess the technology's influence on labor conditions, workforce requirements, and potential for supporting fair working practices. Does it have applications for workforce training that might enhance job quality or worker wellbeing? Explain any potential positive effects on local communities or supply chains, such as promoting ethical sourcing, responsible manufacturing practices, or transparency for consumers.]	
Financial Benefits: [Highlight any long-term economic benefits related to sustainability, such as reduced operational costs, improved supply chain resilience, or increased market competitiveness due to sustainability-driven consumer demand. Indicate whether the technology supports circular economy principles, such as recycling, upcycling, or extending product lifecycles within the fashion industry.]	

Sustainability Impact: [Evaluate the long-term sustainability advantages, such as reducing environmental degradation, fostering ethical labor practices, and promoting industry-wide adoption of greener solutions.]	
Operational Benefits: [Describe how the technology improves efficiency in sustainable practices, such as reducing production time, enhancing material traceability, or optimizing logistics to lower emissions and costs.]	
Market Relevance: [Analyze how the tool aligns with current and emerging sustainability trends in the fashion industry, including consumer demand for eco-friendly products and regulatory shifts toward sustainable manufacturing.]	

IMPLEMENTATION CONSIDERATIONS	
Required Skills/Training: [Specify the skills necessary to operate the technology and any training requirements.]	
Integration with Existing Systems: [Notes on compatibility or integration challenges with existing technologies (e.g., ERP, CRM).]	
Cost Factors: [Provide an estimate of costs, such as licensing fees, maintenance, or training expenses.]	
Future Potential: [Potential areas for expansion or new applications of the technology in the fashion industry.]	

USE IN EDUCATION	
Application in VET (Vocational Education and Training): [How can this technology be used to teach relevant skills in digital fashion and textile courses?]	
Learning Outcomes: [Specify expected learning outcomes, such as design skills, data analysis capabilities, or sustainability practices.]	
Career Development Opportunities: [Describe how proficiency in this technology can enhance career prospects, including potential job roles, industry demand, and required skill progression.]	

RELEVANT TOOLS	
[Suggest similar tools or alternatives that can be used.]	

PLUGIN TOOLS	
A plugin tool is a software component that adds specific features or functionality to an existing application without altering its core structure. It acts as an extension, allowing users to customize or enhance the software based on their needs.	

REFERENCES	
Resources/References: [Links to relevant articles, reports, or additional resources.]	

CASE STUDY OR EXAMPLE OF USE	
Company/Organization:	
Region/Market:	
Example Description: [Briefly describe how a company or organization is utilizing this tool, noting any specific outcomes or successes.]	

SUMMARY OF MAPPING ANALYSIS	
Technology Ranking (High, Medium, Low): [Based on relevance, innovation, or potential impact in the industry.] ☐ High ☐ Medium ☐ Low	**Educational Relevance (High, Medium, Low):** [Usefulness of the technology for educational purposes or skill-building in VET programs.] ☐ High ☐ Medium ☐ Low

HOW MANY COMPANIES USE [TOOL NAME]
[this section will be completed by PANSiK when all case studies are collected]

III. Research Methodology for Interviews and Case Studies

To create a rigorous and impactful case study methodology for WP2 of the "Green DigiFashTech Manager" project, we will use a methodology rooted in established case study research standards (Yin, 2018; Stake, 2006; Eisenhardt, 1989). This methodology is designed to provide in-depth insights into the digital transformation practices of companies within the fashion and textile industry, aligning with the project's objectives of mapping, diagnosing, and fostering sustainable digital innovations. This enables a grounded and adaptable methodology that aligns closely with WP2's objectives of producing a diagnostic tool and job profiles informed directly by empirical data.

Please find in the following the methodology, including research techniques, interview guidelines, and questionnaire design, with respective justifications.

1. Case Study Methodology Choice: Embedded Multiple-Case Study Design

Justification: adopting an embedded multiple-case study design (Yin, 2018) is effective when studying multiple cases (e.g., different fashion and textile companies) within a single project to identify patterns and contrasts. This approach enables each case to be examined individually while also allowing cross-case analysis, which strengthens the generalizability of findings and increases the study's external validity. Each case (company) will have embedded units of analysis, such as *digital tools used, challenges, and training needs*, enabling detailed **exploration**.

2. Case Selection Criteria and Sampling Strategy

Purposeful Sampling

- Sample Size: 5 cases per partner, totaling 20 cases consortium-wide.
- Criteria for Case Selection:
    - Diverse Digital Maturity: Select companies with varying levels of digital maturity to understand the spectrum of digital practices.
    - Sustainability Orientation: Prioritize companies that actively integrate sustainable practices, as this aligns with project goals.
    - Sector Representation: Include companies from different segments within fashion and textiles to provide a comprehensive sector view.

Justification: Purposeful sampling (Patton, 2015) allows us to focus on cases that provide the richest insights into digital and sustainable practices, ensuring that the data collected is relevant and directly contributes to the project's objectives. This sampling strategy is common in multiple-case studies aiming for depth and insight rather than statistical representation.

3. Data Collection Techniques

To achieve a well-rounded understanding of each case, we will use a combination of **qualitative data collection techniques**:

3.1. Semi-Structured Interviews with Key Stakeholders

Participants: Digital transformation managers, sustainability officers, and relevant technical staff within each company.

Purpose: To understand the organization's digital strategies, technology adoption, challenges, benefits, and the environmental and social impact of digital practices.

Structure: Semi-structured, with a predefined guide but flexible enough to explore unexpected themes.

Justification: Semi-structured interviews are ideal for case studies as they provide depth and allow for probing into specific topics while also accommodating the unique contexts of each case (Kvale & Brinkmann, 2015). They are especially suited for collecting insights from professionals who have experiential knowledge of their companies' digital transformation.

3.2. Document Analysis

Sources: Company reports, sustainability statements, technology adoption records, and any available policy documents.

Purpose: To complement interview data with factual information on digital tools used, sustainability initiatives, and organizational strategies.

Justification: Document analysis provides secondary data that can validate or challenge findings from interviews, offering a more comprehensive view (Bowen, 2009). It's valuable in multiple-case studies where triangulation strengthens the reliability of findings.

***Additional Note**: Researchers are encouraged to refer to **Appendix 1 – Practice Themes** for examples of innovative green and digital strategies. This resource outlines*

categories and descriptions of practices, offering a framework for identifying and documenting impactful initiatives across case studies.

3.3. Observation (Optional/If feasible)

Method: On-site visits to observe the digital tools in action, production processes, or workflows that incorporate digital innovations.

Purpose: To provide contextual understanding and observe the integration of digital and sustainable practices.

Justification: Observations can reveal insights that may not surface during interviews or document analysis, offering firsthand data on the operational aspects of digital practices (Yin, 2018). However, this may not be feasible for all cases, especially if companies are geographically distant or restricted by confidentiality requirements.

4. Data Analysis Techniques

4.1. Within-Case Analysis

Process: Analyze each case individually to identify key themes related to digital practices, challenges, training needs, and sustainability impacts.

Method: Coding and thematic analysis using software (e.g., Excel, NVivo, or MAXQDA) to organize data into categories.

Justification: Within-case analysis allows each case to be understood on its own terms, providing a holistic view before comparing cases (Eisenhardt, 1989). This approach ensures that the unique context of each company is captured, which is critical in understanding varying levels of digital maturity and sustainability integration.

4.2. Cross-Case Analysis

Process: Compare and contrast themes across all cases to identify patterns, similarities, and differences.

Method: Use pattern matching and explanation building to connect the findings back to the project's objectives, especially regarding the development of a diagnostic tool.

Justification: Cross-case analysis enhances the study's robustness and generalizability (Miles, Huberman, & Saldaña, 2014). This is essential for fulfilling the WP2 objective of creating a diagnostic tool that applies broadly across the fashion sector.

5. Interview Guidelines and Questioning Approach

Guidelines for Conducting Interviews:

- **Preparation**: Review the company's background and digital strategies based on publicly available documents to tailor the interview questions.
- **Setting**: Aim for a neutral, comfortable setting (in-person or virtual), ensuring privacy to encourage openness.
- **Ethical Considerations**: Obtain informed consent, explaining the purpose of the study, data usage, and confidentiality.
- **Recording**: Record interviews (with permission) for accurate transcription and analysis.

Justification: Following these guidelines ensures high-quality data collection and respects ethical considerations, which are crucial in case study research to build trust and collect authentic information (Kvale & Brinkmann, 2015).

6. Questionnaire Design

The questionnaire should be structured to align with the project's goals while remaining adaptable to each company's specific context.

Section 1: Background Information

- Company size, sector, digital maturity level.
- Sustainability strategy/goals
- Digitalization strategy/goals

Section 2: Digital Tools and Technology Adoption

- What digital tools (e.g., AI, 3D design, data analytics) does your company use in operations?
- How were these tools integrated into your processes?

Section 3: Benefits and Challenges

- What benefits has your company experienced from using digital tools?
- What challenges have you faced in implementing and scaling these technologies?

Section 4: Training and Skill Requirements

- What training do employees need to use digital tools effectively?
- Are there any gaps in digital skills that your company is actively addressing?

Section 5: Sustainability and Social Impact

- How do your digital practices align with sustainability goals?
- What environmental or social impacts have you observed from using these technologies?

Justification: This questionnaire design ensures alignment with the WP2 objectives of understanding digital tools, assessing training needs, and evaluating sustainability impacts. Each section is designed to collect specific information relevant to the diagnostic tool and job profile, making the data actionable for project deliverables.

Deductive vs. Inductive Approach: Project Suitability and Justification

Inductive: An inductive approach is generally more appropriate for this case study design, particularly because the project's objectives aim to explore, understand, and map out patterns of digital transformation and sustainability practices across diverse companies. Here's why an inductive approach aligns well with the project's goals:

Exploratory Nature of the Project: The project aims to diagnose current digital practices, challenges, and training needs without a predefined framework, allowing the data collected to shape understanding. An inductive approach enables researchers to gather diverse perspectives from industry practitioners and build knowledge from specific observations without assuming outcomes based on existing theories or frameworks.

Complexity and Diversity in Company Practices: Each company may vary widely in digital maturity, sustainability goals, and operational contexts. An inductive approach allows flexibility in analyzing the unique characteristics and emerging themes within each case, rather than testing a predefined hypothesis. This is essential for creating a diagnostic tool and job profiles tailored to real-world observations rather than imposed assumptions.

Data-Driven Insights to Inform Tool Development: Since WP2's ultimate goal is to develop a diagnostic tool, an inductive approach will allow the team to ground the tool in the empirical insights and themes derived directly from companies'

experiences. The patterns identified can guide the design of the diagnostic tool to ensure it is relevant and useful across various levels of digital maturity.

Considerations for an Inductive Approach

- Openness to Emerging Themes: The research team must remain open to new, unexpected themes that emerge during data collection. This requires flexibility in interview questions and adaptive coding during data analysis.
- Depth in Data Collection: To ensure that the inductive approach fulfills the project goals, detailed data must be collected from each case, including rich descriptions of practices, experiences, and perspectives on digital transformation and sustainability.
- Iterative Data Analysis: Inductive analysis is typically iterative, requiring continuous back-and-forth between data collection and analysis. The research team should plan to revisit earlier interviews or documents if new patterns arise, refining and validating emerging themes.

When a Deductive Approach Could be Useful

A purely inductive approach may not fully meet project needs if there are very specific hypotheses or constructs that need testing. In that case, a hybrid approach might be considered, where an inductive approach forms the primary basis of exploration, and deductive elements are introduced to assess particular patterns (e.g., whether companies with higher digital maturity face fewer skill gaps).

In summary, an inductive approach is well-suited to exploring the digital transformation landscape in the fashion and textile industry without constraining findings to preconceived hypotheses.

Appendix 1 – Practices themes

Category	Practice	Description
Green Practices	Organic Materials	Use of materials like organic cotton, hemp, etc.
	Recycled Materials	Use of recycled fibres and fabrics

Category	Practice	Description
	Low Water Usage	Processes that minimize water consumption
	Renewable Energy	Use of renewable energy sources in production
	Waste Reduction	Practices to minimize waste in production
Digital Practices	Digital Design Tools	Use of digital tools for designing and prototyping
	Virtual Fashion Shows	Hosting fashion shows in virtual environments
	E-commerce Sustainability	Implementing sustainable practices in online retail
	Digital Marketing Ethics	Ethical practices in digital marketing and advertising
	Stakeholder Communication Tools	Using digital platforms like Microsoft Teams, Slack, and Zoom for seamless stakeholder engagement and collaboration.
	Project Management Software	Implementing tools like Trello and Asana to enhance project coordination and alignment with sustainability goals.
Educational Practices	Sustainability Training	Providing vocational training programs to equip professionals with skills in sustainability and digital tools.
	Circular Economy Awareness	Offering workshops on circular economy principles, including recycling, upcycling, and resource optimization.

Category	Practice	Description
	Industry Collaboration	Facilitating partnerships between educational institutions and industry leaders to drive green and digital innovation.
Innovation Practices	AI-Driven Insights	Leveraging AI to analyze data and predict trends for optimizing sustainability in production and operations.
	Digital Collaboration Platforms	Using cloud-based tools like Google Workspace for real-time collaboration and resource sharing among teams.

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IV. Questionnaire for Businesses

Section 1: Background Information

Field	Details
Name of Initiative	
Sector	
Main Activities	
Region Served	
Founding Year	
Company size (Small, medium, large)	
Number of Employees	
Link(s) to website(s)	• Link 1 • Link 2 • Link 3
Link(s) to social media	• Link 1 • Link 2 • Link 3
Location of HQ	
Location of other offices	

(**Interviewer Note**: Gather these details in advance where possible, to tailor follow-up questions.)

1) Company Context

- Can you describe your company's size, industry segment, and the scope of its operations(e.g., design, production, distribution)?

Purpose: Establish context about the company's scale, focus, and position in the supply chain.

2) Digital Maturity

- How would you characterize your company's level of digital maturity? Can you share examples that illustrate this? (e.g., tools in use, processes) that illustrate this level?

Purpose: Understand the sophistication of digital integration within the company.

3) Sustainability Strategy

- What are the key elements of your sustainability strategy, and how are they integrated into your overall business objectives?

Purpose: Identify the company's main sustainability goals and how prominently they feature in strategic planning.

4) Digitalization Goals

- What are the primary objectives of your digital transformation efforts? How do they align with your sustainability strategy?

Purpose: See if the company explicitly ties digital objectives (e.g., efficiency, cost savings) to sustainability outcomes (e.g., reduced waste, circularity).

Section 2: Digital Tools and Technology Adoption

5) Technology Overview

- What digital tools and technologies (e.g., AI, 3D design, data analytics) are currently employed in your company? Could you mention where they are most impactful?

Purpose: Gain a snapshot of the tech stack and areas of highest impact.

6) Implementation Process

- Can you walk us through the process of integrating these tools into your operations? What steps were involved?

Purpose: Learn about the roadmap, challenges, and best practices for rolling out digital solutions.

7) Decision Drivers

- What were the main factors that influenced your decision to adopt these specific technologies (e.g., cost, operational efficiency, sustainability benefits)?

Purpose: Understand the rationale that led to technology adoption, including sustainability as a motivator.

8) Collaboration and Partnerships

- Have you collaborated with external partners (e.g., technology providers, research institutions, NGOs) in implementing these tools? If so, what role did these collaborations shape the project's success?

Purpose: Identify networks or partnerships critical to successful digital innovation.

Section 3: Benefits and Challenges

9) Realized Benefits

- What tangible benefits has your company experienced from using digital tools (e.g., efficiency gains, sustainability improvements, reduced waste, improved traceability)?

Purpose: Elicit measurable or anecdotal evidence of value—from both business and sustainability viewpoints.

10) Unexpected Outcomes

- Were there any unexpected positive or negative outcomes resulting from your digital transformation efforts? How did they affect your operations or sustainability goals?

Purpose: Uncover any surprises that could guide future best practices or cautionary measures.

11) Challenges Encountered

- What challenges has your company faced in adopting and scaling digital tools, particularly in aligning them with sustainability objectives (e.g., cost barriers, employee adoption, data security)?

Purpose: Identify major hurdles that can inform risk mitigation strategies.

12) Mitigation Strategies

- How has your company addressed these challenges, and what strategies or solutions worked best in bridging digital and sustainability requirements?

Purpose: Capture lessons learned, including effective problem-solving approaches.

Section 4: Training and Skill Requirements

13) Employee Training Programs

- What types of training or skill development programs does your company provide to support employees in using digital tools?

Purpose: Understand the company's commitment to skill development as part of digital transformation.

14) Effectiveness of Training

- How effective have these training programs been in preparing employees for digital transformation? What metrics or feedback methods do you use to evaluate their success?

Purpose: Assess whether employees are truly equipped to leverage new digital solutions.

15) Identified Skill Gaps

- Have you identified any skill gaps in your workforce related to digital or sustainability practices? If so, how are these gaps impacting your operations?

Purpose: Pinpoint areas where more support or specialized training is needed.

16) Future Training Needs

- Looking ahead, what additional training or skills do you think will be crucial for your workforce to support digital and sustainable innovation?

Purpose: Anticipate future training requirements that align with emerging technologies and sustainability trends.

Section 5: Sustainability and Social Impact

17) Alignment with Goals

- How do your digital tools and practices directly contribute to achieving your sustainability goals? (e.g., circular economy, carbon footprint reduction, supply chain transparency)

Purpose: See how digital initiatives concretely tie into the company's sustainability agenda.

18) Quantifiable Impacts

- Can you share specific metrics or examples (e.g., energy saved, emissions reduced, labor practices improved) that demonstrate the environmental or social impacts of your digital transformation?

Purpose: Capture measurable impacts, which are vital for case study comparisons and developing the diagnostic tool.

19) Challenges in Sustainability Alignment

- What difficulties have you encountered in ensuring that your digital practices align with sustainability objectives? (rather than just improving efficiency or profitability)

Purpose: Surface any tensions or complexities in balancing profit motives with green objectives.

20) Innovative Practices

- Have you implemented any innovative practices that combine digital transformation with sustainability (e.g., closed-loop systems, new materials R&D)? Can you describe these practices and their impact?

Purpose: Highlight cutting-edge initiatives that could serve as inspiration or best practices for others.

Tips for Implementation

1. **Semi-Structured Format**: Use these questions as a starting framework. Encourage interviewees to elaborate or pivot into areas most relevant to their experience.
2. **Adapt to Context**: Not all questions will be equally relevant to every organization; prioritize or combine where logical.
3. **Probe for Examples**: Ask for real-life cases, data, or anecdotes whenever possible, as they will enrich case study findings.
4. **Maintain Ethical Standards**: Obtain consent to record, ensure confidentiality, and be transparent about how data will be used.
5. **Triangulate Data**: Supplement interview findings with document reviews (annual reports, sustainability statements) and any observational data if feasible.

Next Steps: Transcribe replies (from audio, AI apps are available for free for 30' interviews) and translate them to English. SOFFA will collect all transcribed interviews to perform data analysis.

Apps for translation or translation:

- Riverside.fm
- Otter.ai
- DeepL
- https://www.ai-media.tv/knowledge-hub/insights/free-transcription-tools/

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