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DesignSmart

MODULE 4

Digital Tools for Eco-Design: CAD, 3D, and Virtual Prototyping



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Lesson Plan

Module purpose: This module equips VET providers and trainers to deliver practical learning on how CAD, 3D design, and virtual prototyping can support eco-design in fashion. Trainers will guide learners in developing digital garment designs, testing design variations, assessing virtual prototypes, and identifying opportunities to reduce material waste and the need for physical samples.

Relevant topics:

- CAD and 3D design tools for sustainable fashion
- Digital sampling and virtual twin concepts
- 3D material simulation and fit visualisation
- Linking digital tools with eco-design processes
- Digital rendering and rapid prototyping technologies (including 3D printing applications)

EQF Level: 5

Estimated Learning Time: 5/6 hours

Learning Outcomes: After completing this topic, learners will:

Knowledge

- Possess comprehensive, specialised knowledge of CAD/3D modelling software and the integration of digital prototyping workflows with sustainability objectives.
- Understand digital twin concepts and 3D material simulation technologies used to visualise fit and drape without physical resources.
- Maintain an awareness of current software capabilities, technical limitations, and emerging technologies like AI and 3D printing within the fashion tech sector.
- Comprehend the relationship between digital iteration and resource conservation, specifically how virtual sampling minimises material waste.

Skills

- Create high-fidelity digital prototypes using 2D pattern design and 3D modelling software to replace traditional physical samples.
- Execute 3D simulations and virtual fit assessments to analyse garment behaviour and accelerate the design iteration process.
- Conduct evidence-based comparisons between physical and digital sampling efficiency to optimise studio workflows.
- Utilise digital rendering and rapid prototyping tools (including 3D printing) to bridge the gap between virtual design and business feasibility.
- Integrate AI and digital tools into existing design pipelines as interconnected systems rather than standalone technologies.

Responsibility & Autonomy

- Exercising management and supervision in digital design contexts, remaining adaptable to evolving technological landscapes.
- Taking responsibility for the implementation of digital prototyping practices within professional teams to meet eco-design targets.
- Evaluating efficiency gains and resource savings to justify the transition from physical to digital sampling processes.
- Guiding and mentoring others in the adoption of digital tools, ensuring that sustainability remains a core driver of the design workflow.

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Topics and Sub-topics/Learning activities	Duration	Training methods used	Materials used	Suggestions for implementation
Ice-breaking activity Ice-breaking activity: "The Circular Mystery Bag." Learners identify the "circular potential" of a random item (e.g., a leather scrap, a poly-blend shirt).	15 min	Peer Learning & Discussion	Images of garments (physical vs digital), PPT	Trainer shows 3 examples (physical sample / 3D garment / rendered image). Learners must guess and explain differences. • What do you think this item is made of? • Is this product physical or digital? • Which step of the process created the most waste? • Could this product be designed digitally instead? • Which version do you think is more sustainable and why? • What is the main difference between a prototype and a digital model? • Where do you see unnecessary steps?
Pre evaluation The scope of the pre-evaluation activity is to test learners' familiarity with and knowledge of the key themes. 3-4 closed questions will be used in a multiple-choice and/or true-or-false quiz. The trainer will ask learners to complete the quiz, followed by a short discussion of the answers.	10 min	Quiz + Discussion	Mentimeter or similar tool to collect feedback	Quiz Questions (example 3–4): 1. What is a digital twin? A. A physical prototype of a garment **B. A virtual representation of a product** C. A marketing image D. A recycled version of a garment

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Topics and Sub-topics/Learning activities	Duration	Training methods used	Materials used	Suggestions for implementation
				2. Which stage creates the most waste? A. Sketching **B. Physical sampling** C. Marketing D. Packaging 3. What is CAD used for? A. Sewing garments **B. Digital pattern design** C. Selling products D. Fabric dyeing 4. How can digital tools reduce waste? A. Increasing production **B. Reducing physical samples** C. Faster shipping D. Producing more variations Discussion Questions: • Why did you choose this answer? • Where do you think waste happens? • Do you already use digital tools?
Instruction to Module 4 – Digital Tools for Eco-Design	10 min	Interactive Lecture & Q&A	PPT (Intro slides)	Trainer introduces key concepts: digital design, sustainability, eco-

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Topics and Sub-topics/Learning activities	Duration	Training methods used	Materials used	Suggestions for implementation
The facilitator will introduce the learners to module 4				design. Ask learners what tools they already know. Connect to SME reality. • What digital tools do you know? • Have you ever used CAD or 3D tools? • What does eco-design mean? • Where can designers reduce impact? • What challenges do SMEs face?
Topic 1 – CAD and 3D design tools for sustainable fashion	30 min	Demonstration-Based Learning + Guided Practice	CAD screenshots, short video, PPT	Trainer shows how patterns are created and optimised. Highlight waste reduction. • Where do you see waste reduction? • How many samples could be avoided? • What happens if a mistake is found? • Is digital faster? Why? • Can accuracy improve?
Topic 2 – Digital sampling and virtual twin concepts	30 min	Case-Based Learning + Demo	Digital garment example, PPT, Case Study	Show a digital garment modification. Introduce the digital twin concept. Link to reduced sampling. • What is the difference between digital and physical samples? • Which steps can be eliminated? • How many iterations are possible digitally?

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Topics and Sub-topics/Learning activities	Duration	Training methods used	Materials used	Suggestions for implementation
				• Would you trust a digital sample? Why? • How does this help communication?
Topic 3 – 3D material simulation and fit visualisation	30 min	Demonstration + Guided Analysis	Simulation video, avatar example	Show fabric simulation and fit. Highlight impact on returns and waste. • Where do you see fitting problems? • Which areas are too tight/loose? • Would customers return this? • How does fit affect sustainability? • Can simulation reduce returns?
Topic 4 – Linking digital tools with eco-design processes	30 min	Interactive Lecture + Problem-Based Learning	PPT (eco-design), checklist	Explain eco-design principles. Connect to lifecycle thinking. • When is impact defined? • What would you change in materials? • How can design reduce waste? • Can digital tools support eco-design? • What happens if sustainability is ignored?
Topic 5 – Digital rendering and rapid prototyping (3D printing)	30 min	Interactive Lecture + Discussion	PPT + examples	Explain AI for forecasting and demand. Discuss overproduction. • Do we need physical samples for marketing? • How can rendering replace photography? • Why is overproduction a problem?

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Topics and Sub-topics/Learning activities	Duration	Training methods used	Materials used	Suggestions for implementation
				• What happens to unsold products? • Can AI predict demand? • What are the risks of AI? • Can technology alone solve sustainability?
Practical activity - Digital Eco-Design Prototype Task	90 min	Hands-on / Simulation / Design	Software/templates / worksheet	Learners redesign a garment using digital tools, applying eco-design. Deliverable: before/after comparison + explanation. • Where is waste in this design? • What would you change first? • Is the design too complex? • Can it be simplified? • Can digital tools replace a step? • How does your redesign reduce impact? • Why did you choose this solution? • What impact does it have? • Is it realistic for SMEs? • What would be the next step?
Assessment (post-evaluation) The scope of the post-evaluation activity is to explore the extent to which learners understood the unit's concepts and acquired the specific learning objectives. 4-6 closed questions will be used in a	15 min	Project-Based & Quiz Assessment	Short quiz and Reflective Learning Log	The trainer should ask learners to respond to the quiz, and a short discussion on the answers will follow. Quiz Questions (4–6): 1. What is the main benefit of digital prototyping?

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Topics and Sub-topics/Learning activities	Duration	Training methods used	Materials used	Suggestions for implementation
multiple choice and/or true or false quiz.				A. Increasing the number of physical samples **B. Reducing material waste** C. Increasing production costs D. Slowing down the design process 2. What is a digital twin? A. A physical duplicate of a garment B. A marketing image of a product **C. A virtual model that simulates a real product** D. A recycled version of a garment 3. What does CAD allow in fashion design? A. Manual sewing of garments **B. Digital pattern creation and modification** C. Fabric dyeing processes D. Retail product management 4. Why is 3D simulation useful in fashion? A. To create marketing campaigns **B. To test garment fit and behaviour** C. To increase production speed only D. To reduce labour costs 5. What is one of the main causes of overproduction?

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Topics and Sub-topics/Learning activities	Duration	Training methods used	Materials used	Suggestions for implementation
				A. Too much automation **B. Poor demand forecasting** C. High-quality materials D. Digital design tools 6. What is eco-design? A. Designing products only for fast production B. Designing products focused only on aesthetics **C. Designing products to reduce environmental impact** D. Designing products for luxury markets only Reflection Questions: • What did you learn today? • How can this reduce waste? • What would you apply in real work?
Wrap-up The trainer asks each learner to share one "actionable recommendation" they will take back	10 min	Collaborative Summary	Peer-reviewed mini-reports	Each learner shares 1 actionable idea for applying digital tools in real work context (SME or personal project). • What is one thing you learned? • What will you apply? • What would you change in your workflow? • How can you reduce waste in your work? • What digital tool was most useful?

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Case Study: Reducing Physical Sampling through 3D Digital Prototyping in a Fashion SME

Country: **Italy**

Main Content including the following:

Background

- **Company/context description:**

A small Italian fashion SME specialising in casualwear collections produces seasonal garments for local and international buyers. The company operates within a traditional design and development framework, characterised by manual patternmaking processes, physical prototyping, and iterative sample validation.

Design and production activities are distributed across a network of local suppliers and external manufacturers, which requires continuous communication and coordination throughout the development cycle. As is common among many SMEs in the Italian fashion ecosystem, they did not initially integrate digital tools into the workflow, and design decisions relied heavily on physical testing rather than simulation.

This operational structure reflects broader trends identified in the National Report, where SMEs are often characterised by strong craftsmanship but limited digitalisation, leading to inefficiencies in resource use and longer product development cycles.

- **Initial problem or challenge:**

The company produces an average of 4–6 physical samples per garment during the design and development phase. Each prototype requires fabric, trims, labour, and transportation between stakeholders, creating cumulative environmental and economic impacts.

This workflow led to several critical issues:

- high material waste due to discarded samples
- increased production and development costs
- extended lead times, reducing responsiveness to market demand
- inefficiencies in communication with suppliers, often requiring additional iterations

These challenges are consistent with findings from the National Report, where SMEs identified sampling processes as one of the main sources of inefficiency and environmental impact within the product development phase.

The Challenge

- **What sustainability/digital issue is addressed?**

The company faces a dual challenge that combines both environmental and operational dimensions.

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1. **Environmental issue**: The repeated production of physical samples generates significant textile waste and consumes resources such as water, energy, and raw materials. This contributes to the overall environmental impact of the product before it even reaches production.
2. **Operational issue**: The reliance on physical prototyping slows down decision-making processes and increases costs. Each modification requires the creation of a new sample, limiting flexibility and extending development timelines.

   The core challenge is therefore to reduce the number of physical prototypes while maintaining design accuracy, product quality, and effective collaboration across stakeholders. This requires a shift from a purely material-based workflow to a hybrid model that integrates digital tools.

Actions Taken

- **Step 1 - Introduction of CAD and 3D tools**

The company initiated a gradual transition toward digital design by introducing CAD software for pattern development. This allowed designers to create and modify patterns digitally, improving precision and reducing the need for manual adjustments.

At the same time, the company began experimenting with 3D garment simulation tools, enabling designers to visualise garments in a virtual environment. Designers could analyse proportions, structure, and overall aesthetics without producing physical samples.

This first step required investment in both software and training, as designers needed to develop new competencies related to digital workflows and simulation tools.

Step 2 - Implementation of digital sampling

After adopting digital design tools, the company moved to implement digital sampling. Physical prototypes were partially replaced with digital garments, which could be tested, modified, and validated in real time. This enabled:

- rapid adjustments to design elements such as shape, size, and material
- improved communication with suppliers through shared digital files
- reduction in the number of physical samples required

The company adopted a hybrid workflow, where digital prototypes were used for most iterations, while final validation was conducted through a limited number of physical samples.

- **Tools/methods used**

- CAD pattern design tools
- 3D garment simulation software
- Digital visualisation tools

Results

- **Environmental impact**

The adoption of digital prototyping led to measurable improvements in environmental performance:

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- reduction of physical samples by approximately 50–60%, significantly lowering material waste
- decreased fabric consumption during the sampling phase
- reduced transport requirements, leading to lower emissions

In addition, the company improved its ability to evaluate material usage early in the design phase, supporting more efficient resource management.

- **Business impact**

- From a business perspective, the transition resulted in several operational advantages:
- faster product development cycles, due to real-time modifications and reduced iteration time
- lower development costs, associated with reduced material usage and fewer physical samples
- improved communication between designers and suppliers, thanks to digital file sharing
- increased flexibility in responding to design changes and market demands

- **Lessons learned**

- Digital tools significantly reduce waste, but their effectiveness depends on proper training and integration into workflows
- Initial investments in technology and skills are necessary but can be offset by long-term savings
- Hybrid workflows, combining digital tools with limited physical validation, provide the most reliable results for SMEs
- Organisational change, including mindset and processes, is as important as technological adoption

Key Takeaways

- **3–5 practical insights:**

1. Digital sampling is one of the most effective strategies to reduce waste in fashion design
2. CAD and 3D tools improve both sustainability and efficiency
3. Transition requires training and mindset change
4. SMEs can benefit significantly from gradual digital integration
5. Combining digital and physical processes ensures reliability

Discussion Questions

- What would you do differently in this company?
- Can this digital workflow be applied in your own context?
- What barriers could prevent implementation (cost, skills, resistance)?
- Is full digitalisation realistic or should hybrid models be used?

Practical Exercise (optional)

- **Adapt the case to your context** (this could be translated into a practical activity)

Learners are asked to:

- imagine they work in the SME

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- design a new workflow using digital tools
- reduce sampling while maintaining quality

Expected Output

- short workflow diagram
- explanation of:
  - tools used
  - sustainability benefits

Best Practice: Integrated Digital Design and Sustainable Production in Nice Footwear Group

Type:

X Business practice X Technological solution ☐ Educational approach ☐ Policy

Content (Executive Snapshot):

Nice Footwear Group, an Italian company operating in the footwear sector in the Veneto region (close to the Riviera del Brenta district), represents a strong example of integrated innovation combining design, production, and sustainability. The company positions itself as a “partner for global brands”, managing the full product development process through multiple business units, including R&D, industrialisation, and production.

The practice integrates research-driven design, digital development processes, and structured production systems, allowing the company to anticipate trends, optimise workflows, and reduce inefficiencies.

This approach addresses key challenges typical of the footwear sector, such as long development cycles, over-reliance on physical prototyping, and fragmented communication between design and manufacturing phases.

It is considered a best practice because it demonstrates how a company can combine innovation, craftsmanship, and sustainability, creating a scalable model for SMEs transitioning toward digital and eco-conscious production.

The Challenge Addressed

- **What problem existed?**

Like many companies in the footwear sector, Nice Footwear operates in a highly competitive environment where speed, flexibility, and quality are essential. Traditional workflows in the sector often involve:

- multiple physical prototypes during development
- fragmented communication between design, R&D, and production
- inefficiencies in translating creative concepts into industrial processes

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These limitations can increase material use, extend time-to-market, and raise operational costs.

- **Why was it important to solve?**

The need to remain competitive in global markets, while also responding to increasing sustainability expectations, required a transformation of traditional workflows. In particular, it became essential to:

- improve integration between design and production
- reduce inefficiencies and waste
- accelerate product development cycles
- enhance responsiveness to market trends

- **What were the risks if not addressed?**

  - loss of competitiveness in international markets
  - inability to meet sustainability expectations from global brands
  - inefficiencies leading to higher costs
  - reduced innovation capacity

These risks are consistent with those identified in the National Report for SMEs in the fashion sector.

Innovation & Added Value

What makes this a best practice?

This case qualifies as a best practice because it integrates digitalisation, production, and sustainability at the system level.

Key elements of innovation:

1. Integrated business model

Nice Footwear operates through multiple interconnected units (design, R&D, production), creating a continuous workflow from concept to industrialisation.

2. Design and R&D driven approach

The company emphasises research and trend analysis to anticipate market needs and guide product development, reducing unnecessary iterations and improving efficiency.

3. Digital and industrial innovation

Although rooted in craftsmanship, the company integrates industrialization processes and structured development workflows, enabling better coordination and potentially reducing reliance on repeated physical sampling.

4. Sustainability integration

Sustainability is embedded in the company's vision, where innovation and responsibility coexist. This is reflected in:

- optimization of production processes
- focus on efficiency and resource use

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- reduction of unnecessary steps in development

5. Hybrid model (craft + digital)

Unlike purely industrial models, this approach maintains Italian craftsmanship while integrating digital and industrial processes, making it highly replicable in SME contexts.

Tools / Technologies Used

- 3D digital prototyping software
- CAD footwear design systems
- Augmented Reality (AR) technologies
- Virtual Reality (VR) systems
- Digital rendering and virtual visualisation tools
- Industry 4.0 digital workflow integration systems

Source:

www.nicefootwear.it

techartshoes.it/nicefootwear_prototipia_digitale

forbes.it/nicefootwear_R&D

Practical Activity: Digital Eco-Design Mini Prototype Redesign

Type:

X Hands-on ☐ AI-based X Analysis X Design X Simulation ☐ Other

Activity Objective:

This activity applies digital design and eco-design principles quickly and practically by redesigning an existing garment through a simplified digital workflow.

Learners will be guided to identify inefficiencies in a product (e.g. waste, fit issues, material use) and propose improvements using digital thinking and simulation logic, even without advanced software.

After the completion of this activity, learners will be able to:

- identify sustainability issues in a garment design
- apply eco-design principles at the design stage
- propose improvements using digital tools logic (CAD / 3D thinking)
- connect design decisions with environmental impact
- present a simple but structured design solution

Activity outline / Description of the activity:

Step1:

Learners are divided into small groups (2–3 people).

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Each group receives:

- a garment image (e.g. t-shirt / sneaker / jacket)
- or a simple digital mock-up (PPT / PDF / screenshot)
- a short worksheet

Task:

Learners must analyse the product and identify at least 2–3 critical issues, such as:

- excessive material use
- inefficient pattern layout
- poor fit (too tight/loose areas)
- unnecessary complexity
- potential overproduction risk

Tools used:

- worksheet (analysis template)
- visual slide or printed garment
- optional: simple digital viewer (no advanced CAD required)

Trainer role:

Guide learners by asking:

- *"Where do you see waste?"*
- *"What would you change before production?"*

Step2:

Learners must propose a mini redesign solution using digital logic.

Task:

Each group defines:

- at least 2 design improvements, such as:
  - reducing material usage
  - simplifying pattern structure
  - improving fit
  - replacing a component
- how a digital tool would support it (e.g. CAD, 3D simulation, digital sampling)

Output required:

- short sketch OR annotated image OR bullet explanation
- 2–3 sentences explaining:
  - what was changed
  - why it improves sustainability

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Trainer role:

Ask:

- *"How does your change reduce waste?"*
- *"Could this be tested digitally?"*

After the completion of this activity, you will be able to:

- analyse garments from a sustainability perspective
- apply eco-design thinking in early design stages
- understand how digital tools support decision-making
- connect design choices with real environmental impact
- develop structured solutions in a short time

Total time: 15-20 minutes

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