SING for GREEN

WP3 T1 Develop the SING for Green curriculum

SING for GREEN Curriculum Structure and Competence Units Framework

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1st	31/07/2024	EWF	Draft version
2nd	06/08/2024	EWF	Adjustment for the 1st working session
3rd	18/09/2024	EWF	Adjustment for the subsequent working session
4th	20/11/2024	EWF	Conclusion of the CUs
5th	13/01/2025	EWF	Draft report for validation
6th	01/04/2025	EWF	Adjustments based on feedback
7th	16/05/2025	All	Adjustments after the Train the Trainers

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Table of Contents

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1. Executive Summary

The SING for GREEN project seeks to create a specialised curriculum that integrates sustainable skills within the Design for Additive Manufacturing (AM) profile, supporting the green transition and aligning industry requirements with training objectives. This initiative is timely and essential, given the growing demand for sustainable production practices driven by the growing of European regulations.

The curriculum was designed using a structured methodology with 3 pillars:

- Desk Research
- Interviews with industry in AM and with Higher Education institutions
- Focus Group for consolidation

The Desk Research provided a very comprehensive overview of the topics that directly impact the possible changes in the Design for AM curriculum, from the technological, political and educational points of view.

The interviews, conducted in the industry in AM in Europe, in a total of 17 experts from companies and 18 HE institutions, allowed the mapping of potential needs felt in the shopfloor, regarding the profile of Design for AM.

Following a Focus Group, met 25 experts from around Europe, from Academia to Industry, to reflect on the main conclusions from the Desk Research and Interviews, the outcome of this event was a set of recommendations and insights that were essential to start the revision of the curriculum for the Design for Additive Manufacturing profile.

The findings highlighted the following topics as essential:

AM technologies and processes, which include understanding how specific technologies work and the use of sustainable materials and processes.

Materials knowledge, focusing on understanding different materials and promoting material recycling and resource efficiency.

Product lifecycle and environmental impact, covering life cycle assessment (LCA), understanding the product lifecycle, and conducting environmental impact assessments.

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Economic and marketing benefits of sustainability, emphasising elements of sustainability and energy conservation.

Design aspects, including generative design and topology optimisation.

The next step involved mapping the existing qualifications for Designers within the International Additive Manufacturing Qualification System and cross-referencing the covered topics to prevent duplication and influence potential progression within the system. With this analysis completed, the SING for GREEN project was well-positioned to proceed with the curriculum design phase.

The design phase included the creation of two competence units, or modules, independent from each other, including detailed knowledge and expected outcomes, providing transparency to all the players in the training process.

The SING for GREEN curriculum will allow Designers in AM to improve their competencies and become well-prepared to face the demands of Sustainability.

The Curriculum Structure and Competence Units Framework represents the first outcome of the curriculum, which is now ready for preparing the training resources (WP3 T2 and T3) and being tested during the pilot phase in WP4.

After the pilots, with the project's conclusion, three levels of exploitation are expected. On an immediate level, the guidelines will be ready for approval in the IAMQS system and then be deployed in the system, all over the recognised and harmonised training centres. The guidelines and the training resources will also be made available and ready for implementation in each partner training organisation, finally, it will also be available for all training organisations that find in the SING for GREEN project an opportunity to capitalise their training portfolio and become an active actor in the green transition.

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2 Introduction

The transparency, flexibility and mutual recognition of qualifications across EU countries and beyond within industry and education have been the motivation for the creation and implementation of several instruments all over Europe. These efforts emphasise the continuous improvement of educational and training standards throughout all levels of qualifications. The SING for GREEN project aligns with this objective by using the European Qualifications Framework (EQF) as a reference point in its curriculum development process.

The curriculum design in SING for GREEN follows a structured methodology, used by EWF, ensuring consistency and clarity across qualifications. Each qualification is modular in nature, composed of distinct Competence Units. These units are defined by specific Learning Outcomes, which describe the essential knowledge and skills required for each module or competence unit.

To ensure alignment with the most up-to-date educational standards, SING for GREEN uses CEDEFOP's (2023)[1] definitions for key Vocational Education and Training (VET) concepts, summarised as follows:

Qualification – A formal certification or credential earned upon demonstrating the required knowledge, skills, and competencies for a specific professional role. Qualifications include the necessary job requirements and are organised into profiles and corresponding curricula that outline the educational or training activities needed to achieve them.

Competence Unit – A distinct component of a qualification that includes a specific set of learning outcomes. Each unit can be assessed independently, offering learners flexibility in how they build their skills and progress through the curriculum.

Learning Outcomes – Statements detailing what a learner is expected to know, understand, and be capable of doing after completing a learning activity or course. These outcomes focus on knowledge acquisition, skill development, and the level of autonomy a learner is expected to achieve.

[1] https://www.cedefop.europa.eu/en/tools/vet-glossary

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Workload – An estimation of the time required for a learner to complete all activities necessary to meet the learning outcomes. This includes lectures, hands-on exercises, project work, and independent study in structured educational settings.

The SING for GREEN curriculum focuses on embedding sustainability skills into the Design for Additive Manufacturing profile. By structuring the curriculum around Competence Units, learners can pursue training in a modular and flexible manner. This approach allows for personalised learning pathways, enabling participants to acquire competencies relevant to their professional goals and the evolving needs of the industry.

3 The SING for GREEN Curriculum

The following section describes the working progress and outcomes of the new Competence Units for the Design of Additive Manufacturing profile, at Expert Level, in alignment with EQF level 7.

To capacitate all partners for the task of designing a curriculum, the University of Brunel and EWF provided a Workshop dedicated to Learning Outcomes (Annexe 1 – LO Workshop supporting materials)

The workshop focused on introducing Learning Outcomes and Concepts related to designing a Competence Unit.

The design of Competence Units is a critical step in creating an effective curriculum. For the SING for GREEN project, this process ensures that sustainability skills are integrated into the Design for Additive Manufacturing profile. The primary goal is to provide learners with modular and flexible learning opportunities that reflect industry needs and environmental best practices.

The process for designing Competence Units in SING for GREEN follows a structured methodology, focusing on clarity, relevance, and flexibility. This approach includes several key phases:

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Defining Learning Outcomes

Each Competence Unit begins with clearly defined learning outcomes. These outcomes specify what learners are expected to know, understand, and be able to do upon completing the unit. The learning outcomes are categorised into three main areas (CEDEFOP; Council of the European Union, 2017):

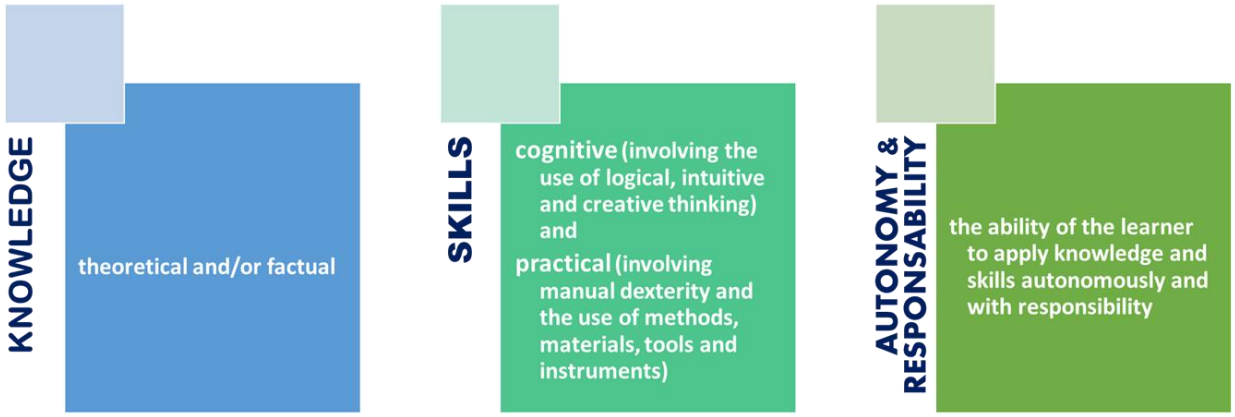

Figure 1 - Learning Outcomes main areas

When designing a Competence Unit using the learning outcomes methodology, learners are placed at the center of the learning process. The Learning Outcomes allow a clear definition of how the learning experience impacts learners, and what is expected and relevant for the learner to gain at the end of the learning process.

To support the clear definition of the expected outcomes, it was used Bloom's Taxonomy. This tool provides a hierarchical structure for categorising cognitive skills and knowledge acquisition. This tool is essential for designing the learning activities and the assessment process.

Bloom's Taxonomy underwent a significant revision (2021) to emphasise a more dynamic and learner-centred approach to education. Unlike the original taxonomy, which used static nouns to describe cognitive levels (e.g., knowledge, comprehension, application), the revised taxonomy employs action verbs—Remembering, Understanding, Applying, Analysing, Evaluating, and Creating—to reflect the active cognitive processes learners engage in during learning. This change shifts the focus from mere acquisition of knowledge to the application and transformation of knowledge in various contexts.

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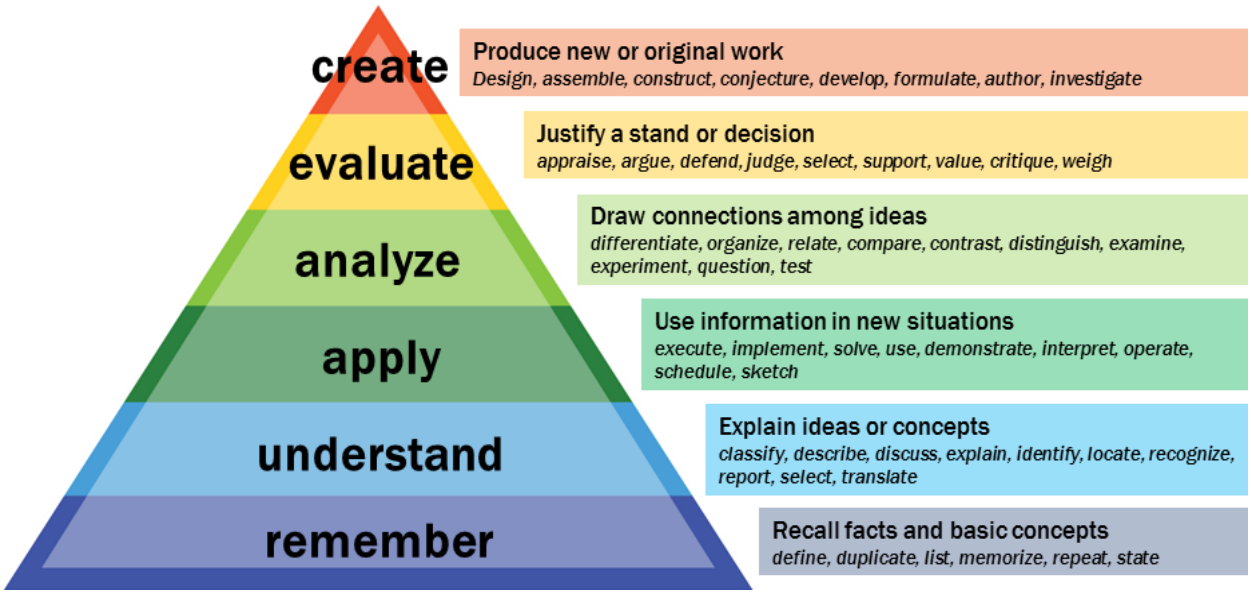

Figure 2 - Bloom's Taxonomy

When developing a curriculum, the knowledge and skills learners are expected to acquire (learning outcomes) are systematically organized into Competence Units. The SING for GREEN curriculum is designed around Competence Units that can be independently assessed and validated, offering greater flexibility in the learning process. Each Competence Unit is further divided into subunits, each focusing on specific areas of application with clearly defined learning outcomes, ensuring a targeted and comprehensive learning experience.

In the SING for GREEN project, the combination of defined actions and corresponding performance criteria establishes the complexity and depth required to determine the appropriate EQF level for each Competence Unit. Learning Outcomes are systematically broken down into three key dimensions: knowledge application, practical application, and competencies as statements of what learners know, understand and can perform in line with EQF descriptors.

This approach ensures that performance expectations are transparent and measurable, enhancing clarity for both learners and trainers. It clearly defines the performance requirements and assessment criteria, reinforces a learner-centred approach and improves the comparability of qualifications across various learning providers and systems. This, in turn, promotes mutual recognition of qualifications, making it easier for learners to progress through different educational pathways.

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Finally, the adoption of the European Qualifications Framework (EQF) within SING for GREEN supports greater mobility for trainees and professionals across Europe by facilitating the recognition of qualifications beyond national boundaries. The EQF acts as a common reference framework, enabling education and training institutions, employers, and individuals to compare qualifications across different systems. The framework is grounded in Learning Outcomes (LOs) and structured around three main descriptors: Knowledge, Skills and Autonomy and Responsibility (Attitudes).

Industry often faces challenges in interpreting educational taxonomies, which can hinder effective communication between educational institutions and employers. To address this, the EWF system offers a matrix that aligns EQF levels with terminology and descriptors commonly used and understood in the industry. This alignment facilitates clearer understanding and promotes stronger collaboration between the education and industrial sectors.

KNOWLEDGE	SKILLS	AUTONOMY AND RESPONSIBILITY	FIELD OF ACTIVITIY JOINING	FIELD OF ACTIVITIY AM	EWF LEVEL JOINING	EWF LEVEL AM	EQF LEVEL
Knowledge at the most advanced frontier in the field of additive manufacturing and at the interface between other manufacturing fields.	Highly advanced and specialised skills and techniques, including synthesis and evaluation required to solve critical problems in research and/or innovation applied in additive manufacturing technology. Extend and redefine existing knowledge or professional practice when applying additive manufacturing processes.	Demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes including research at the forefront of additive manufacturing.	-	-	N.A	N.A	8
Highly specialised and forefront knowledge including original thinking, research and critical assessment of theory, principles and applicability of additive manufacturing processes.	Highly specialised problem-solving skills including critical and original evaluation, allowing to define or develop the best technical and economical solutions, when applying additive manufacturing processes, in complex and unpredictable conditions.	Manage and transform additive manufacturing processes in a highly complex context. Fully responsible for the definition and revision of additive manufacturing personnel's tasks.	Engineer		ADVANCED (COMPREHENSIVE)	EXPERT	7
Advanced knowledge and critical understanding of the theory, principles and applicability of additive manufacturing processes.	Advanced problem-solving skills including critical evaluation, allowing to choose the proper technical and economical solutions, when applying additive manufacturing processes, in complex and unpredictable conditions.	Manage the applications of additive manufacturing processes in a highly complex context. Act autonomously in decision making and definition in the definition of the additive manufacturing personnel's tasks.	Coordinator Technologist	Designer Process Engineer Coordinator		ADVANCED	6

Figure 3 - Alignment Matrix: EQF Levels and Industry-Relevant Competencies

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This alignment with EQF ensures that the SING for GREEN curriculum meets European standards, providing learners with qualifications that are both widely recognised and valuable in the evolving field of sustainable additive manufacturing.

4 The SING for GREEN Competence Units

To provide a clear and structured visualisation of the SING for GREEN curriculum, which focuses on embedding sustainability competencies into the Design for Additive Manufacturing (AM) profile, the contents of the theoretical Modules/Competence Units are presented in terms of the following components:

Learning Outcomes – Clearly defined in terms of knowledge, skills, and competencies, as outlined by EQF descriptors. These outcomes specify what learners are expected to know and be able to do upon completion of each Module/Competence Unit.

Detailed Knowledge – A comprehensive description of the knowledge level and qualifications each Module/Competence Unit addresses. This includes a breakdown of the key content areas covered under each subject title, ensuring alignment with sustainability principles and industry-specific needs.

Recommended Contact Hours – The minimum number of recommended contact hours required for each subject title, covering instructor-led sessions, hands-on activities, and group discussions.

Workload – An estimated total time learners typically need to achieve the specified learning outcomes. This includes a combination of theoretical instruction, independent study, practical exercises, and examination preparation. The time required for completing each Module/Competence Unit may vary depending on the learner's prior knowledge and individual learning pace.

Assessment Procedures – A description of the assessment methodologies used to evaluate learners' progress. These methodologies may include written tests, practical demonstrations, project presentations, and questionnaires, ensuring that assessments are aligned with both the learning outcomes and real-world applications in sustainable additive manufacturing.

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This structured approach ensures that the SING for GREEN curriculum provides learners with a well-rounded and transparent learning experience, tailored to meet the demands of the green transition in the manufacturing sector.

Pre-requisite Knowledge Requirements

To successfully attend the SING for GREEN competence Units, participants will need to have basic knowledge of engineering, manufacturing, and CAD. Familiarity with AM technologies, material science, optimisation, sustainability, and engineering software is beneficial. Prior exposure to design methodologies, structural analysis, and LCA aids in advanced topics.

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Competence Unit A - Additive Manufacturing Lifecycle Assessment and Sustainability

EQF Level 7 / EWF Proficiency Level Expertise **Competence Unit - Additive Manufacturing Lifecycle Assessment and Sustainability** **Subject Title**	**Recommended Contact Hours**	**Workload**
Sustainability tools	1	2
Business case definition	1,5	3
Sustainability databases, risks, and mitigation in data collection	1	2
Sustainability tools and databases in business case Applications	1	2
Case studies for "Comparing different processes, including traditional manufacturing and AM"	2,5	5
Total	**7**	
Workload	**14**	

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Learning Outcomes – Additive Manufacturing Lifecycle Assessment and Sustainability	
Knowledge	Highly specialised and forefront knowledge, including original thinking, research and critical assessment of theory, principles and applicability of: Sustainability tools. Methodologies for defining and evaluating business cases. Use and integration of sustainability databases and risk mitigation strategies in data collection for sustainability assessments.
Skills	At the end of this CU is expected that the learner will be able to: Select appropriate sustainability tools based on specific AM project requirements, aligning them with sustainability goals. Analyse the flow of activities in the assessment process, identifying critical decision points that influence the efficiency and sustainability of production. Evaluate potential risks related to the lack of data and its impact on sustainability assessment Justify the application of sustainability tools in different business cases.

Training Resources available:

- PowerPoint slides
- Case studies
- End-user manual for trainers
- Assessment exercises

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Competence Unit B - Sustainability-Driven Design Strategies in AM

EQF Level 7 / EWF Proficiency Level Expertise **CU Sustainability-Driven Design Strategies in AM** **Subject**	**Recommended Contact Hours**
Part Consolidation	1
Finite Element Analysis Fundamentals	1
Topology Optimization	5
Generative Design	4
Lattice Structures	3
Total	**14**
Workload	**28**

Learning Outcomes – Sustainability-Driven Design Strategies in AM	
Knowledge	Highly specialised and forefront knowledge, including original thinking, research and critical assessment of theory, principles and applicability of: - Part consolidation - Finite Element Analysis Fundamentals - Topology optimisation - Generative design - Lattice structures

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Skills	Analyse relationships between parts and assemblies for part consolidation Distinguish part design for traditional manufacturing from the part consolidation approach, from a sustainability perspective. Evaluate the benefits of using topology optimisation when compared with other traditional design approaches. Evaluate the benefits of using generative design when compared with other traditional design approaches. Distinguish generative design from topology optimisation when developing a part. Justify the use of different lattice structure types in the context of their applications. Justify the application of part consolidation, topology optimization, generative design and lattice structures for light weighting.

Training Resources available:

- PowerPoint slides
- Case studies
- End-user manual for trainers
- Assessment exercises

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5 - Annexe - Curriculum Design Work Plan

The following table summarises the work plan for WP3 T1.

Meeting/scope	Date & time/duration	Participants	Expected Output
Validation of topics (offline)	until 31/07	All	Matrix with possible topics for CUs ✅
1st working Session – Grouping the subjects (topics) by CU	W32 - 06/08 1hour duration	EWF + All	Number of CU Definition of the topics/expected learning outcomes Guidelines for the next sessions ✅
Individual Work Analyzing the CUs to avoid repetition - checking whether the topics identified by WP2 are covered in full or in part in the current CUs in the IAMQS system	Until 13/09	All	Matrix with a clear definition of needs ✅
Online Meeting	18/09	EWF + All	Clarification of the way forward: H1) Revise some CUs H2) Revise some CUs + create new CU **H3) Create new CU** Next steps ✅
2nd working session – Working on: Revision of: CU Template	09/10	**Group A** IDONIAL BRUNEL FA EWF **Group B**	CU A and CU B templates ✅

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LO approach/methodology		IDONIAL LATTICE MCC EWF	
3rd working session and subsequent Definition of knowledge and skills (Contact hours (teaching hours) Detailed Knowledge Assessment)	10/10 (at the pace of each group) developments of the CUs.	**Group A** IDONIAL BRUNEL FA EWF **Group B** IDONIAL LATTICE MCC EWF	1st draft of each CU ✅ Individual Homework
Working Session 5 –Working on: Drafts prepared Comments and validation	11/10 14/10 17/10 (at the pace of each group) developments of the CUs.	**Group A** IDONIAL BRUNEL FA EWF **Group B** IDONIAL LATTICE MCC EWF	1st version of the CU part ready for assembling ✅ Draft version of CU
Meeting	28/10	**EWF + All**	Comments and validation of the draft CU ready for peer review ✅
Working Session Individual work	20/11	**All**	Adjustments to CUs Ready for WP3T2 ✅
Adjustment of the CUs based on the development of the training materials and pilot's phase	To be defined, if needed	EWF + All	CUs in line with training materials

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Groups:

Group A	Group B
BRUNEL FA IDONIAL EWF	IDONIAL Lattice MCC EWF

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1st Working Session

Objectives:

- To grouping of subjects (topics) by CU
- To divide the partnership into smaller working groups

Toolbox:

WP3.1 Matrix Framework

Guidelines for the next sessions

Objectives:

- Working on definition of knowledge and skills; contact hours (teaching hours); detailed Knowledge; assessment

Toolbox:

The template - SING for GREEN CU Template.docx

To support the writing of the LO - Blooms Taxonomy.docx

The EWF's Levels of proficiency (aligned with EQF) EWF Systems Framework.JPG

The LO Workshop Learning Outcomes Workshop

SingforGreen- WP2 compiled results_BCA.docx

Before starting:

To design a competence unit we can adopt 2 approaches:

- Backward design approach
- Topic-driven design approach

Any of these will be correct if we ensure that the content meets the needs analysis and is result-focused and efficient.

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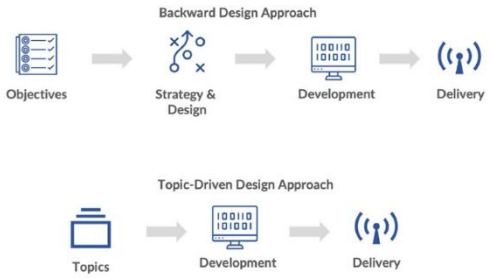

Figure 4 - Diagram Comparing Design Approaches

Source: Dodd, B. J. (2021). Curriculum Design Processes

The **Backward Design approach** is a method for creating educational curriculums that starts with the end goals or desired outcomes.

Start with the end: Start by identifying what we want learners to know and be able to do by the end of the CU.

The **Topic-Driven Design approach** is a more traditional way of creating educational curriculums that starts with the content or topics to be covered.

Start with Topics: In Topic-Driven Design, we start by listing the topics or content areas that need to be covered in the CU, and then list the desired outcomes.

In either case, after identifying the knowledge and skills, we will also:

Determine Evidence of Learning: This involves deciding what evidence will show that learners have achieved the learning goals. This could be through tests, projects, presentations, or other assessments.

Plan the Journey: This involves planning the lessons, activities, and materials that will guide learners to achieve the desired outcomes.

Assess Understanding: In education, assessments are given after teaching the content to see if learners have learned the material.

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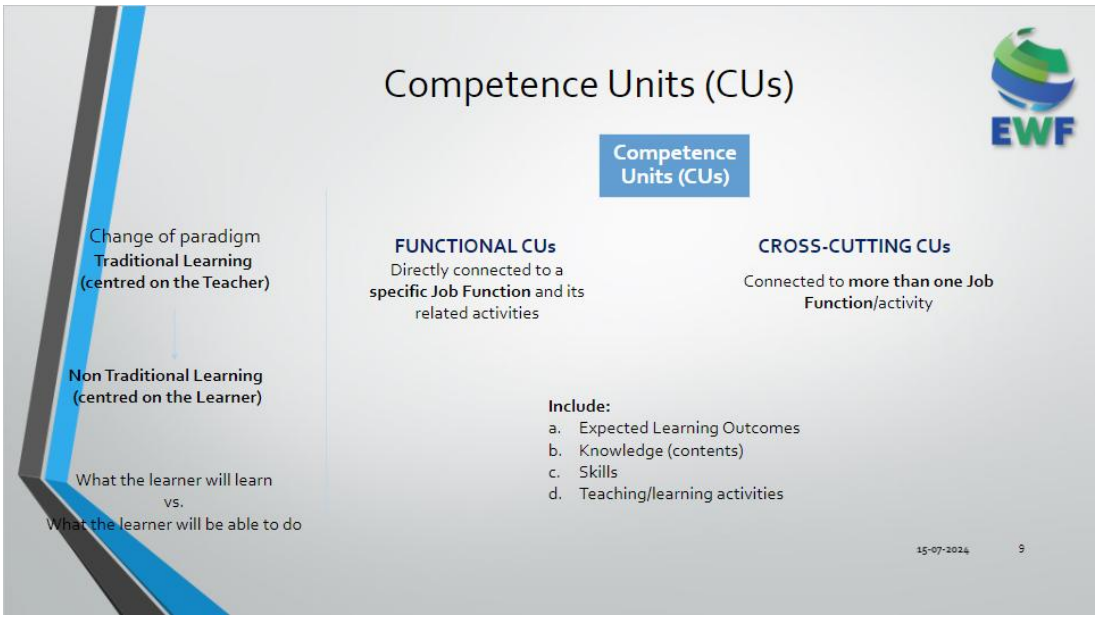

Figure 5 - LO Workshop PPT

Key Principles in the Design Process

The SING for GREEN project emphasizes several guiding principles throughout the design process:

Modularity: Competence Units are designed to be self-contained, enabling learners to complete units independently or in sequence, depending on their needs.

Flexibility: The curriculum accommodates diverse learning pathways, allowing learners to focus on specific areas of interest or professional relevance.

Sustainability Focus: All units incorporate sustainability concepts, preparing learners to contribute to the green transition in additive manufacturing.

Conclusion

The design of Competence Units for the SING for GREEN project ensures a structured yet adaptable curriculum, providing learners with the knowledge and skills necessary to meet industry demands while promoting sustainability. This comprehensive approach not only enhances learner engagement but also supports the broader goal of fostering sustainable innovation in additive manufacturing.

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