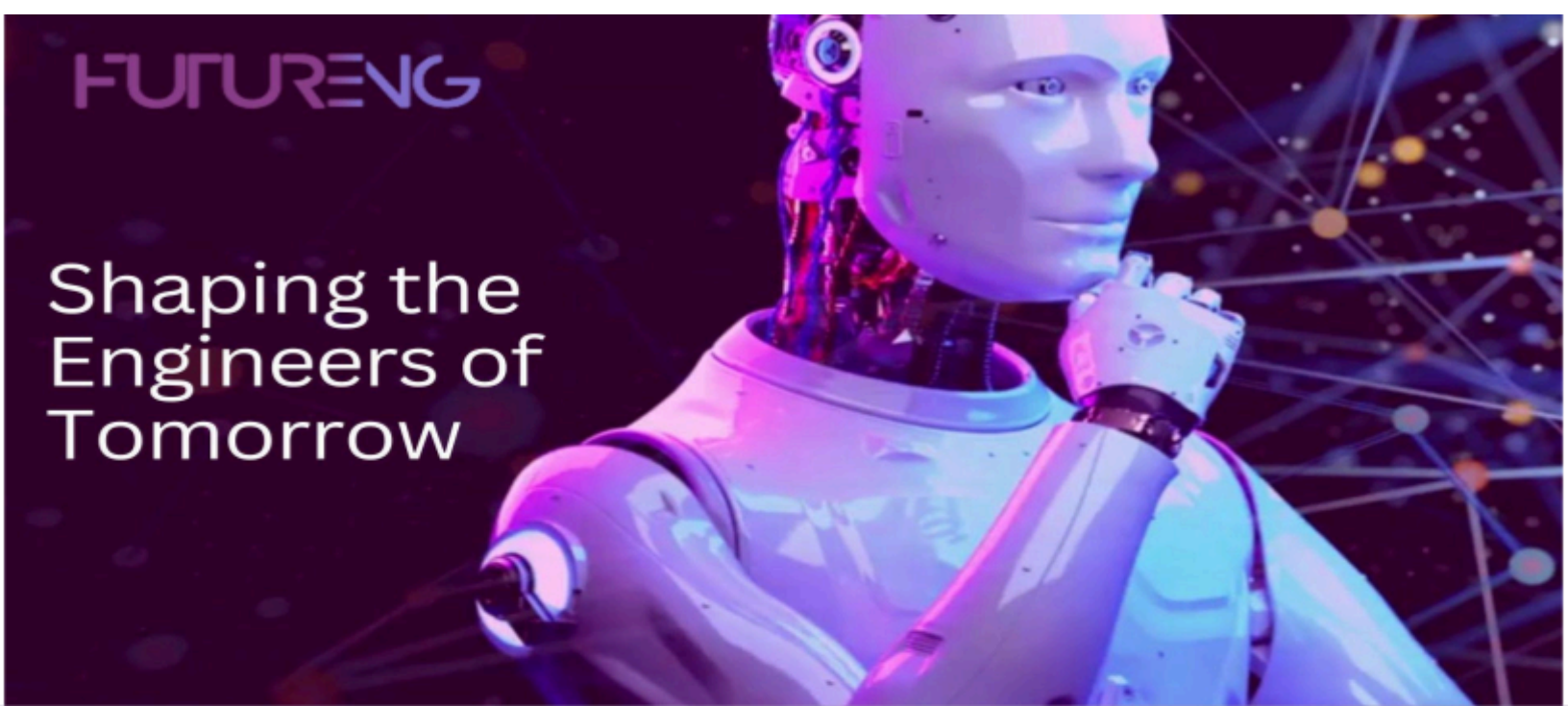




FUTURENG

Shaping the Engineers of Tomorrow

Deliverable R3: Guide for Educators Integrating Industry 5.0 E-learning and Web Quests into Engineering Curricula



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Contents

Chapter 1 - Guide for Educators: Integrating Industry 5.0 E-learning and Web Quests into Engineering Curricula.....	6
1 Introduction.....	7
2 Audience of the E-Learning Modules.....	7
2.1 Level assessment and content suitability.....	9
2.2 What can you do with the students?.....	10
3 Pedagogical Framework.....	12
3.1 The FuturENG training model - structure, learning objectives of the MOOC & Toolbox... 12	
3.1.1 Learning Approaches and Tools.....	13
3.1.2 Learning Objectives.....	13
3.1.3 What is a WebQuest?.....	13
3.1.4 How to use WebQuests effectively?.....	14
3.2 Module 1: Introduction to the Tech Essentials MOOC.....	17
3.2.1 MOOC.....	18
3.3 Module 2: Deep Tech enablers for Industry 5.0.....	19
3.3.1 MOOC.....	20
3.3.2 Web Quests.....	21
3.4 Module 3: AI for Industry 5.0.....	22
3.4.1 MOOC.....	23
3.4.2 Web Quests.....	25
3.5 Module 4: Twin transition enablers.....	25
3.5.1 MOOC.....	26
3.5.2 Web Quests.....	28
3.6 Module 5: Social, environmental and ethical implications.....	29
3.6.1 MOOC.....	30
3.6.2 Web Quests.....	31
4 Integration Models.....	32
5 Micro Credentials and the FuturENG Open badges System.....	32

5.1	Why the Market is Shifting Towards Microcredentials.....	32
5.2	Benefits for Students.....	33
5.3	Benefits for Educators.....	33
5.4	EU approach.....	34
5.4.1	EU Digital Education Action Plan (2021-2027).....	34
5.4.2	European Skills Agenda (2020).....	35
5.4.3	European Commission Pilot Projects.....	35
5.4.4	European Centre for the Development of Vocational Training (Cedefop).....	35
5.4.5	EU Funding Programs.....	36
5.4.6	European Qualifications Framework (EQF) and the European Credit Transfer and Accumulation System (ECTS).....	36
5.4.7	EU Policy Initiatives on Lifelong Learning.....	36
5.4.8	European Digital Education Hub (EDEH).....	37
5.5	Badges and Micro-credentials.....	37
5.5.1	Badges Explained.....	37
5.5.2	Microcredentials Explained.....	37
5.5.3	Relationship Between Badges and Microcredentials.....	38
5.5.4	How Badges and Microcredentials Help Learners and Educators.....	39
5.5.5	Examples of Platforms Using Badges and Microcredentials Together.....	40
5.6	The futurEng badge system.....	40
6	Using the Platform from the Teacher Perspective.....	42
7	Assessment Strategies.....	43
7.1	Assessment Strategies for the MOOC.....	43
7.2	Assessment Strategies for the Web Quests.....	43
8	Faculty Training Checklist.....	45
9	The FuturEng Experience.....	45
10	References:.....	47
Chapter 2 - Roadmap for Integrating Industry 5.0 E-learning and Web Quests into Engineering Curricula.....		1
1	Executive Summary.....	2
1	The Vision: Industry 5.0 and Engineering Education.....	2

2	Stakeholders and Target Users.....	3
3	Strategic Integration Phases.....	4
3.1	Registering and approving a new study module.....	5
3.1.1	Register and Approve the First and Second Cycle Study Modules and Micromodules.....	6
3.1.2	Prepare and Register a New First and/or Second Cycle Module.....	7
3.1.3	Approve a First and/or Second Cycle Module.....	9
3.1.4	Formal information for registering a new module.....	11
3.1.5	Requirements for e-course content.....	13
3.1.6	FuturEng course description.....	18
3.2	Offering Content as Microcredentials.....	20
3.2.1	Preparation - Strategic Alignment.....	21
3.2.2	Development - Curriculum and Structure Compliance.....	21
3.2.3	Certification — Portability and Recognition Procedures.....	22
3.2.4	Quality Assurance.....	23
3.3	Exploiting Hybrids of FuturEng Content.....	26
3.3.1	Preparation — Strategic Alignment.....	27
3.3.2	Development — Hybrid Curriculum and Structure Compliance.....	27
3.3.3	Validation — Governance and Quality Assurance.....	28
3.3.4	Delivery — Recognition and Portability.....	29
3.3.5	Benefits of the Hybrid Approach.....	30
4	Roadmap Timeline.....	31
4.1.1	2025–2026 (Pilot Phase).....	31
4.1.2	2027 (Expansion Phase).....	31
4.1.3	2028 onwards (Scaling and Consolidation).....	31
5	Conclusion.....	33



Chapter 1 - Guide for Educators: Integrating Industry 5.0 E-learning and Web Quests into Engineering Curricula

1 Introduction

This guide supports educators in using Industry 5.0-aligned e-learning materials and web quests to modernize engineering curricula. These resources foster human-centric, sustainable, and resilient competencies necessary for future-oriented engineering practices.

The Aim of this Guide is

- To equip HEI educators in technical disciplines with a thorough step-by-step plan and guidelines on how to use the FuturENG MOOC and Toolbox to teach complex technical concepts and achieve maximum learning effect.
- To enable HEI educators to integrate CBL within their teaching approach and thus contribute to raising the attractiveness of engineering/STEM programmes.
- To enable HEI educators to further promote the application of challenge-based learning in engineering/STEM curricula by creating their own webquests.
- Learn how to use the FuturEng Platform with the Role of a Teacher

2 Audience of the E-Learning Modules

The Tech Essentials MOOC has been designed primarily for higher education students in engineering and STEM-related fields, including mechanical, electrical, civil, environmental, industrial management, and computer science disciplines. Its content aligns best with EQF Level 6, making it suitable for undergraduates *who already possess foundational technical knowledge* and are ready to engage with emerging technologies, sustainability concepts, and interdisciplinary problem-solving.

Beyond the primary target group, the MOOC is also relevant for Vocational Education and Training (VET) learners and lifelong learners, who may seek practical upskilling or reskilling opportunities in technology, engineering, or industrial applications.

The MOOC has been created with versatility in mind incorporating modular design that enables you, as the educator, to tailor the learning path to learners with varying levels of prior knowledge, from VET learners to bachelor's students or professionals seeking advanced knowledge. The lessons and their respective quizzes result in a varied curriculum, allowing you to adjust the content to prior knowledge, professional background, and learning goals. It is designed as a tool that empowers both learners and educators and can be used as a self-learning tool as well as part of a teacher's learning toolkit.

As the flexibility of the Tech Essentials MOOC responds to a range of learners, higher education students (EQF Level 6), for example, can benefit from the full suite of modules, gaining foundational knowledge in emerging technologies, AI, deep tech, sustainability, and ethical considerations, which supports not only their technical, but also their transversal skill development. VET learners (EQF Level 4/5) and lifelong learners can selectively engage with modules or lessons most relevant to their skills and career goals, using the lesson-level quizzes to

identify gaps in knowledge and focus their learning. Through this modular approach, the MOOC ensures that each learner, regardless of background, acquires knowledge and practical competencies aligned with their field of study or professional objectives. It further supports learners in navigating complex work environments, collaborating effectively, and enhancing personal and professional development, standing as an example that upskilling in the era of digital and green economy entails growth in soft skills applied in a cross-disciplinary approach.

Target Audience	EQF Level	Recommended Modules	Learning Focus
HE Students (Engineering/STEM)	6	All Modules + WebQuests	Integration of deep tech, sustainability, and Industry 5.0
VET Learners	5	Modules 1-3	Applied knowledge, foundational digital and green skills
Lifelong Learners / Professionals	5 to 6	Flexible, by interest	Reskilling, twin transition, professional advancement

Table 1. Target Audience and Module suggestion

Module	Relevant Fields	Learning Focus Overview	EQF Level
Module 1: Introduction to Future Engineering	All STEM fields	Overview of Industry 5.0, course orientation, interdisciplinary thinking	5 to 6
Module 2: Deep Tech Enablers	Mechanical, Electrical, IT	AR/VR, robotics, 3D printing, blockchain	5 to 6
Module 3: AI for Industry 5.0	Computer Science, IT, Industrial Management	AI methods, computer vision, big data, prompt engineering	6
Module 4: Twin Transition Enablers	Environmental, Industrial Management, Civil	Circular economy, eco-design, sustainable business models	6
Module 5: Social, Environmental, Ethical Implications	All STEM fields	Ethics, social responsibility, cybersecurity, environmental awareness	5 to 6

Table 2. Module Relevance by Field and Level

2.1 Level assessment and content suitability

As an educator, you play a central role in maximizing the effectiveness of the MOOC and your support towards personalized learning remains essential. Think of the MOOC as a toolbox in which many instruments are stored. Their particular use is based on the previous knowledge, understanding and unique needs of the learners, as well as your teaching goals.

In order to determine which content of the modules is most suitable for upskilling and further knowledge building, you can use the quizzes offered at lesson level for each module. At the **start of the module**, they can function as an orientation tool, and knowledge checker to assess students' prior understanding of the topic at hand and thus helps you guide the selection and pacing of lessons. When the student has completed the quiz, you can use the results to decide

whether to go through the lessons in full, shorten them, or skip one or focus further on another. Conversely, if students struggle with the quiz, it highlights knowledge or skill gaps, signaling that the lesson should be delivered in full to build a solid foundation. This tactic can free up time for deeper discussion, practical exercises, or collaborative activities.

Quizzes can also be used after the whole module is completed to evaluate achievement and information retention before moving onto the next one and the respective WebQuests. Thus, quizzes serve as checkpoints to evaluate understanding and retention, helping students consolidate their learning before progressing.

Another way you can use the quizzes is as an orientation and motivation tool. You can present them as a challenge for the students to explore and examine what they do not yet know, to further push motivation for learning. Quiz results allow learners to consciously focus on those lessons, which are most relevant to their skills and experience, creating adaptive, individualized learning paths (Cigdem et al., 2017). Do not underestimate the power of the quizzes. They can maximize efficiency, encourage self-directed learning, and support differentiated instruction, ensuring each student engages with content that is both challenging to their learning skills and relevant to their field of study and future professional development.

The utilization of the quizzes as a method for evaluation and direction not only builds technical knowledge but also fosters key **soft skills** - reflection, problem-solving, and independent learning - essential qualities for future engineers navigating complex, interdisciplinary environments (Salmon, 2013).

2.2 What can you do with the students?

As you guide students through the Tech Essentials MOOC, your role is not just to deliver content but to orchestrate a learning environment that aligns students' expectations, scaffolds their growth, and highlights the interdisciplinary nature of engineering in the age of Industry 5.0. From day one, we suggest you engage your students in an open conversation exploring together what they hope to gain, where they feel strong, what they recognize as their knowledge gaps, and how the MOOC content relates to their academic or professional goals. Studies in engineering education show that when students' expectations are misaligned - for example, when they believe the learning process will deliver one set of learning outcomes, but the teacher emphasizes another - disengagement and lack of attention increase (Stappenbelt and Basu, 2019). It is in your power to set the tone of the whole upskilling process and create a powerful learning environment through understanding student needs, optimizing classroom design, integrating technology thoughtfully through the FuturEng Tech Essentials MOOC, and set the tone for cultivating a positive learning culture, which safely engages in continuous reflection and improvement (Sinakou, et al., 2019).

Powerful Learning Environment domain	Phrases
Expectation Setting	"Here's what you will learn, here's what I expect of you, here's how we'll work together." "Let's agree on the outcomes and responsibilities before we begin."
Goal Alignment	"Let's identify your goals and challenges before we start." "What do you hope to achieve by the end of this module?"
Relevance	"How does this connect to your field or experience?" "Where have you seen this applied in real-world settings?"
Interdisciplinary Awareness	"Think about how this knowledge interacts with other disciplines." "Which skills from other fields could help solve this problem?"
Reflective Practice	"Try it, make mistakes, and reflect on what you've learned." "What would you do differently next time?"
Collaborative Learning	"Work with your peers to solve this challenge together." "Share your ideas with us and give feedback to others, we are eager to know"
Self-Assessment	"Check your understanding before moving on." "Which areas do you feel confident in, and which need more practice?"
Critical Thinking	"Let's discuss different perspectives and approaches." "What assumptions are we making here, and are they valid?"
Real-World Application	"Where could these skills apply in real-world scenarios?" "How would you implement this solution in a professional context?"
Lifelong Learning	"Track your progress and reflect on your growth." "What new skills do you want to develop next?"

Table 3. Educators' Powerful Learning Environment Glossary

Next in importance is articulating the interdisciplinary nature of the Tech Essentials MOOC. As today's engineering problems do not sit neatly in a single domain, they demand the integration of deep tech (AR/VR, robotics, AI), digital systems, sustainability, and ethical reflection. Research by Beddoes (2020) shows that for engineering students to truly develop interdisciplinary teamwork competence, they need more than technical content, namely they require structured

practices that help them level disciplinary differences, align shared mental models, and coordinate across fields. You can reflect this in class by forming mixed-discipline teams, running short “discipline mapping” exercises (e.g., “what does a computer scientist bring to this problem, what does a civil engineer bring?”), and framing each module not only as a technical skill set but as part of a broader ecosystem of engineering, society, and sustainability.

For instance, begin the course by asking students to individually write down one personal goal, one expectation of the MOOC, and one apprehension. Then facilitate a discussion to surface common themes, clarify alignments (“this module will address that goal, but you will be responsible for this part”), and note how the lessons will cross technical, digital, and green domains. In module transitions, revisit that landscape: show students how Lesson 2.4 (Advanced robotics) builds on Lesson 2.3 (3D printing) and ties into Module 4’s eco-design content. Thus, you help students see the thread of interdisciplinarity in action.

Expectation alignment combined with interdisciplinary awareness sets the stage for a learning journey that is purposeful, connected, and forward-looking. Being mindful and harnessing the potency of powerful learning environments enables not only the acquisition of technical knowledge but also the ability to collaborate across domains, reflect on yours and your students’ role in sustainable innovation, and engage in engineering with a systems thinking mindset. You will be set to go!

3 Pedagogical Framework

3.1 The FuturENG training model - structure, learning objectives of the MOOC & Toolbox.

The FuturENG Tech Essentials MOOC is an interactive learning journey aligned around an active learning pedagogical framework. It is a blend of structured e-learning modules, lesson-level quizzes and module level WebQuests (challenge-based activities to foster active learning across both technical and transversal trajectories). The MOOC develops Industry 5.0-ready skills in AI, robotics, IoT, data analytics, etc. while promoting self-directed, reflective, and interdisciplinary learning through essential transversal skills such as collaboration, ethical reasoning, systems thinking, and sustainability awareness. The course mimics the real-life combination of technical and soft skills much sought after in the skillset of emerging engineers and tech-specialists. Just as the FUTURENG project itself, the Tech Essentials MOOC shows how modern industries function - now more than ever the blend of technical expertise with soft skills is the winning combination that tackles problems, enables collaboration across disciplines, and navigates interconnected challenges. In essence, the MOOC enables learners from the engineering and tech professions for the very kinds of tasks and scenarios they will encounter in the professional world.

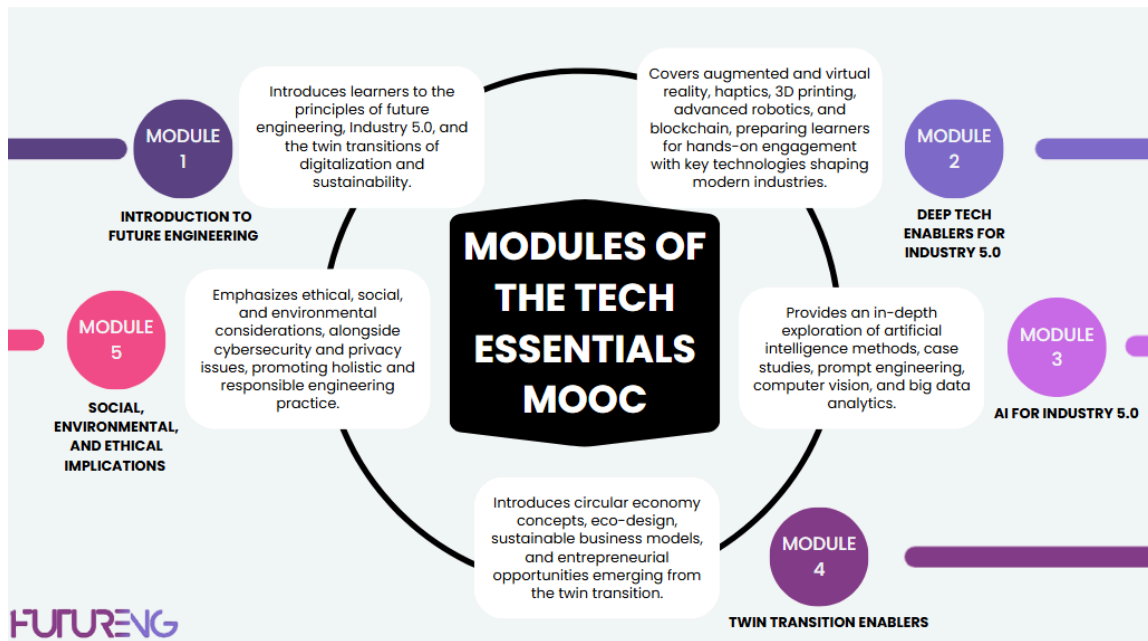


Figure 1. Tech Essentials MOOC Module structure

3.1.1 Learning Approaches and Tools

The MOOC supports active learning through multiple approaches – the lectures and interactive lessons deliver foundational knowledge and conceptual frameworks. On the level of evaluation, lesson-level quizzes and the final tests on the modules operate as diagnostic tools, enabling students to assess prior knowledge, monitor progress, and select learning paths that suit their level and interests. And lastly, the WebQuests and project-based exercises promote problem-solving, critical thinking, and collaboration, often in group settings.

3.1.2 Learning Objectives

Each e-learning lesson and WebQuest is explicitly mapped to a combination of:

- **Technical Skills:** AI, robotics, IoT, data analytics, human-machine interfaces.
- **Transversal Skills:** Collaboration, ethics, systems thinking, sustainability awareness.

The course design allows flexibility for learners to select lessons or WebQuests that best match their prior knowledge and professional needs, with the sole purpose of promoting adaptive and individualized learning paths.

3.1.3 What is a WebQuest?

WebQuests are your *pedagogical lever* - they transform knowledge into action. WebQuests are structured, challenge-based activities in which students investigate authentic real-world problems to gain knowledge, develop skills, and achieve a deeper understanding of the studied

topic (McNulty et al., 2006). Each WebQuest follows a clear structure - Introduction, Task, Process, Conclusion, and Learning Outcomes - that guides learners through exploration, analysis, and creative problem-solving.

Depending on the task design, these activities cultivate a broad range of competencies, including teamwork, critical and creative thinking, research literacy, and communication skills. Moreover, by engaging students in learning-by-doing, WebQuests promote experiential understanding and create positive, long-term cognitive connections to the content.

In the FuturENG project, the WebQuests are deliberately designed to nurture transversal, digital, and green skills, while encouraging students to apply cross-disciplinary technical knowledge drawn from the MOOC thus promoting the ability to tackle real-world scenarios using deep tech and AI concepts while simultaneously evaluating multiple approaches and designing innovative solutions.

3.1.4 How to use WebQuests effectively?

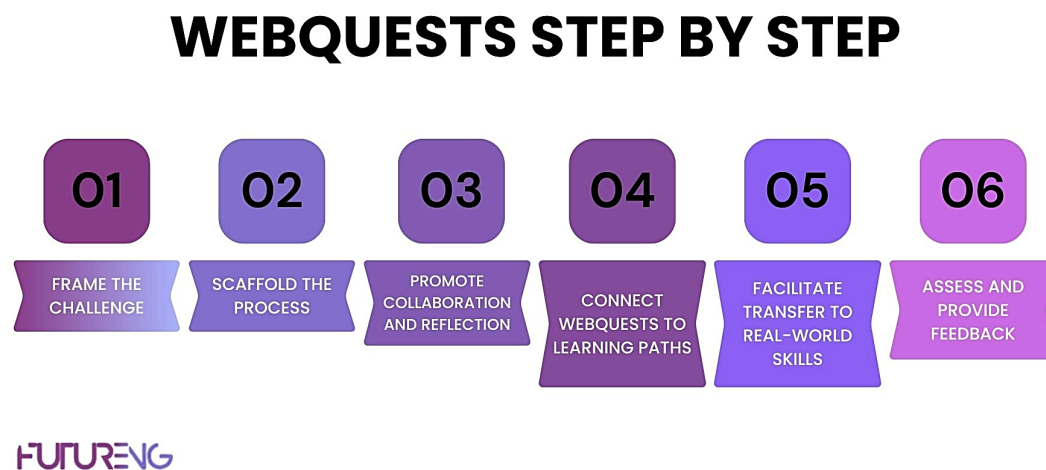


Figure 2. Process model for using WebQuests

1. How to frame the challenge?

Begin each WebQuest by clearly explaining the purpose, expected outcomes, and how it relates to the broader MOOC content. Emphasize the interdisciplinary nature of the task so students see the connection between technical skills (AI, robotics, IoT) and transversal competencies (collaboration, ethical reasoning, sustainability awareness).

2. How to scaffold the process?

WebQuests include a structured sequence - Introduction, Task, Process, Conclusion, and Learning Outcomes. As an educator, you can guide students through these stages as you help them interpret the task and plan their approach; suggest resources or research strategies for the Process stage and facilitate reflection at the Conclusion stage to reinforce learning.

3. How to promote collaboration and reflection?

Organize students into interdisciplinary teams to maximize the benefits of peer learning. Encourage them to share ideas, discuss multiple solutions, and evaluate the impact of their decisions from technical, ethical, and environmental perspectives.

4. How to connect WebQuests to learning paths?

Use lesson-level quizzes to identify gaps or strengths in student knowledge before assigning a WebQuest. This allows you to personalize the experience, ensuring students engage with challenges that are appropriate for their skill level while still pushing them to stretch their abilities.

5. How to facilitate transfer to real-world skills?

Guide students to link the outcomes of each WebQuest to practical engineering scenarios. Discuss how the problem-solving, systems thinking, and interdisciplinary collaboration practiced in WebQuest reflect the real-world demands of Industry 5.0.

6. How to assess and provide feedback?

WebQuests provide opportunities for formative assessment. Give timely, specific feedback on both technical solutions and the application of transversal skills. Recognize achievements through micro-credentials or badges to motivate engagement and reflection.

Corresponding Module	WebQuest
Module 2	WebQuest 1: Exploring Deep Tech Enablers for Industry 5.0
Deep Tech enablers for Industry 5.0	WebQuest 2: AI and Machine Learning in Industry 5.0
	WebQuest 3: Smart Industries: Harnessing IoT and Edge Computing
Module 3	WebQuest 4: Exploring Human-Robot Collaboration
AI for Industry 5.0	WebQuest 5: Mastering Prompt Engineering in AI Systems
Module 4	WebQuest 6: Harnessing Digitalization for a Sustainable Future
Twin Transition Enablers	WebQuest 7: Twin Transition Architects: Building Sustainable Business Models
Module 5	WebQuest 8: From Innovation to Impact: Social & Environmental Side of Disruptive Technologies
Social, Environmental, Ethical Implications	WebQuest 9: Guardians of the Digital World: Crafting Solutions for a Secure Digital Landscape

Table 4. WebQuests list

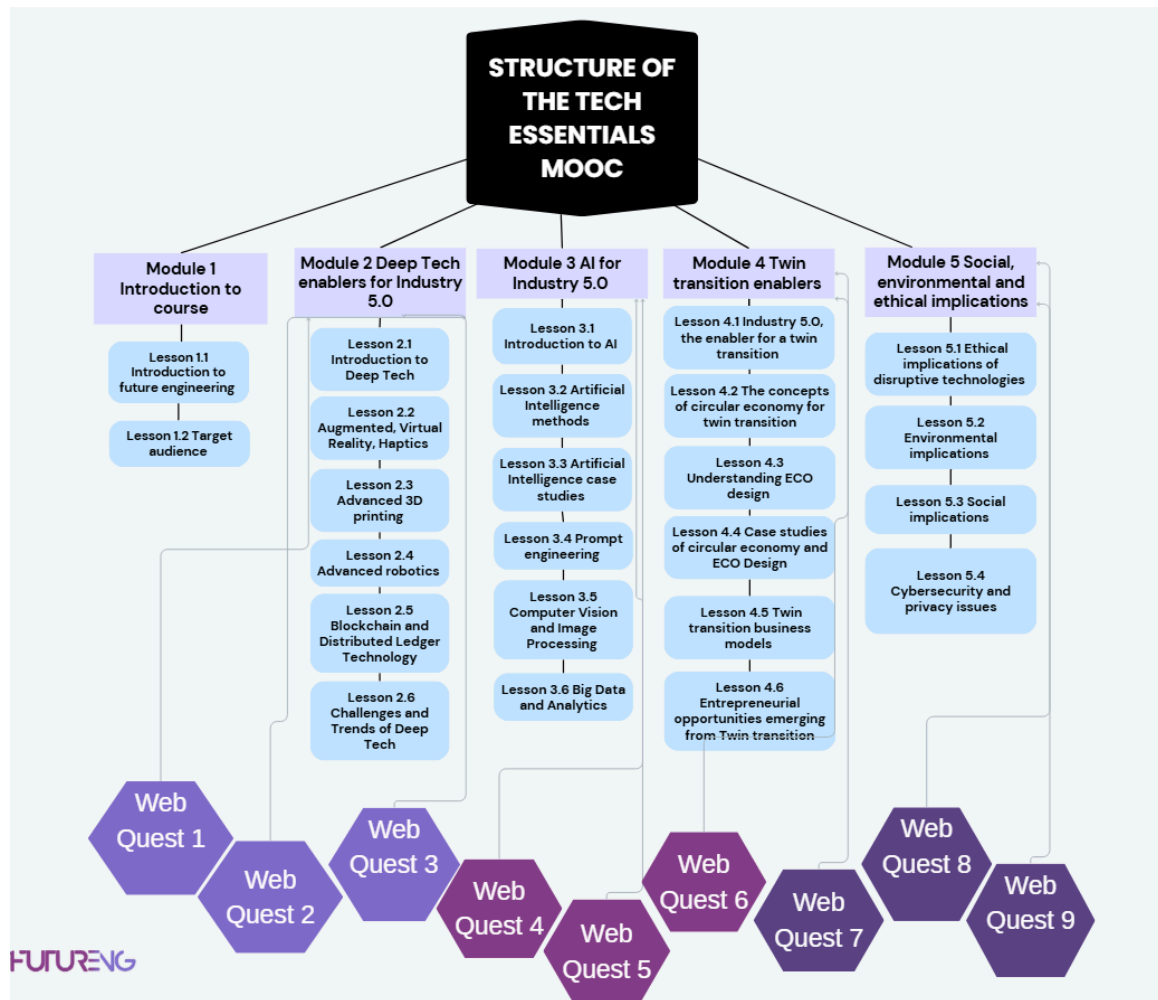


Figure 3. Tech essentials MOOC content diagram

3.2 Module 1: Introduction to the Tech Essentials MOOC

Why is it Important:

Module 1 establishes the foundational understanding necessary to navigate and comprehend the subsequent modules of the *Tech Essentials MOOC*. In an era defined by the rapid evolution of *Industry 4.0* towards *Industry 5.0*, learners require not only technical literacy but also a conceptual grasp of sustainability, ethics, and human-centric innovation (European Commission, 2021). The introduction of the fundamental principles of the *twin transition*—the simultaneous advancement of digitalisation and sustainability—ensures that learners can contextualise emerging technologies within broader societal and environmental frameworks (Breque, De Nul & Petridis, 2021).

Moreover, early exposure to key European strategies such as the *European Green Deal* and *Digital Decade Policy Programme* cultivates awareness of how engineering and technology are

interlinked with Europe's goals for resilience, inclusiveness, and sustainable growth (European Commission, 2020; 2022). Understanding these frameworks prepares students to become adaptive, ethically aware professionals capable of leveraging technology for societal benefit.

Module 1 is a structured entry point to guide learners' baseline understanding, enabling informed progression through the course. It supports competency-based education, connecting the structured learning pathway ahead with future modules' deeper exploration of deep tech, AI, and sustainability.

Structure of the Module:

Module 1 consists of two lessons that aim to provide a foundation for understanding the key concepts that shape the future of engineering. Lesson 1.1 – Introduction to Future Engineering covers the key topics shaping modern engineering, including the transition from Industry 4.0 to 5.0, the EU Green Deal, digital transformation, the twin transition, and the concepts of Industry 5.0 and Society 5.0. The lesson also addresses practical guidance on navigating the course and understanding the intended audience. While, Lesson 1.2 – Target Audience focuses on identifying who benefits most from the course, detailing primary profiles such as higher education engineering and STEM students, and highlighting other potential users including VET and lifelong learners.

Together, these lessons set the stage for deeper exploration in subsequent modules, ensuring learners start with a clear understanding of both the course content and its purpose.



3.2.1 MOOC

Module 1 – Introduction to the Tech Essentials MOOC serves as the foundation for the entire course. It introduces the main themes and target audience, fostering an understanding of the course's purpose and its relevance for engineering, STEM, and lifelong learners.

Lesson 1.1 – Introduction to Future Engineering

The lesson supports a comprehensive understanding of the main aim of the MOOC, the benefits for enrolling in it and what it enables with regards to knowledge dissemination and upskilling. To introduce main concepts such as Twin Transition and Green Transitions, principles of circular economy and Digital Transition for a rapidly evolving world.

Lesson 1.2 – Target Audience

The aim of this lesson is to identify the primary and secondary target audiences of the *Tech Essentials MOOC* and explain its relevance to those. To help learners understand who the course is designed for—primarily higher education students in engineering and STEM—and why it is also valuable and valid for upskilling of vocational and lifelong learners.

3.3 Module 2: Deep Tech enablers for Industry 5.0

Why is it Important:

Deep Technologies are key drivers of industrial transformation, sustainable development, and human-centered automation. Understanding them is essential for future engineers and professionals to remain competitive in the workforce. To do that, this module begins with an overview of Deep Tech, providing students with comprehensive knowledge of its key concepts, applications and challenges. Being aware of these transformations is crucial to building resilient, efficient, and sustainable systems aligned with Industry 5.0 and the Twin Transition (European Commission, 2022).

Throughout this module, students will gather an awareness of the current developments in immersive technologies and how they, through several applications, are currently shaping human interaction with digital environments (OECD, 2025).

With the example of Advanced 3D printing and Advanced robotics, the module addresses the impact of automation and data integration in driving innovation, improving efficiency, and reducing the environmental impact of production systems. (World Economic Forum, 2023). Students will also explore the fundamentals of distributed ledger and blockchain technologies, gaining knowledge of the potential they can bring to more secure, transparent, and efficient operations across industries. (European Blockchain Observatory, 2023; OECD, 2024).

To finalize, a landscape view of Deep Tech trends, hype cycles, and innovation challenges, supports learners in their ability to distinguish short-lived technologies from long-term advancements (Gartner, 2024). By combining conceptual understanding of these innovative technologies with an awareness of its applications, risks, and societal implications, this module provides students with the knowledge and the soft skills—creativity, critical thinking, and problem-solving—needed to responsibly harness Deep Tech for sustainable and human-centered innovation (Breque, De Nul & Petridis, 2021).

Structure of the Module:

This module consists of six lessons, supported by video recordings, slides, and complementary materials. After every lesson, students complete a short quiz of three questions to assess their understanding. At the end of the module, students take a final test with 18 questions. Additionally, the module includes four webquest assignments designed to promote research, critical thinking, and real-world application of the knowledge acquired.



3.3.1 MOOC

Lessons included:

Lesson 1 – Deep Technologies: Introduction and Concepts

This opening lesson provides a foundational understanding of Deep Tech, defining its core characteristics and explaining how they differ from other innovation domains. Learners are introduced to the main Deep Tech fields — such as AI, robotics, advanced materials, and quantum computing- and explore their role in addressing global challenges and driving industrial transformation. Concrete examples illustrate real-world applications of Deep Tech in sectors such as agriculture, health, transport and energy.

Lesson 2 - Immersive Technologies

The lesson introduces learners to Virtual Reality (AR), and Mixed Reality (MR). It explores immersive technologies' key concepts, their educational and industrial applications, and the ways they enhance human interaction with digital environments. By the end of the lesson, students will be able to describe virtual, augmented, and haptic technologies, understand the main building blocks of these immersive technologies, and identify the devices that can be used to solve real-world challenges. The lesson encourages students to stay informed on the rapid expansion of immersive technology applications in different industry sectors.

Lesson 3 – Advanced 3D Printing

This lesson supports address 3D printing as a cornerstone of innovation in the digital fabrication realm. It introduces 3D printing core principles, main printing methods and materials, and latest advancements. Learners examine examples of 3D printing applications in areas such as patient care, consumer product design, and address the future direction of 3D printing as a convergence point of innovation, customization, and sustainability.

Lesson 4 – Advanced Robotics

The fourth lesson of the module gives an in-depth look at advanced robotics. It begins with the historical context, and the differences between advanced and conventional robotics systems. Learners explore how robots operate, equipment, capabilities, advantages and limitations.

Learners are then introduced to five key applications of advanced robotics: 1. Collaborative robots; 2. Motorized exoskeletons; 3. Automated guided vehicles, and 4. Drones. Students analyze the benefits of these applications for efficiency and precision, and productivity, while also addressing challenges related to safety, ethics, and workforce adaptation.

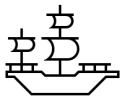
Lesson 5 – Distributed Ledger & Blockchain Technologies

This lesson introduces learners to blockchain and distributed ledger systems. It begins by explaining the key features of blockchain, fundamental algorithms, and procedures behind the technology. Learners explore the three generations of blockchain, examining how each phase expanded its applications. Later, practical uses and applications of these technologies are discussed - supply chain management, smart contracts, and data security. The lesson concludes with a critical look at regulatory, scalability, and sustainability challenges

Lesson 6 – Hype Cycles, Challenges, and Trends of Deep Tech

The final lesson integrates the concepts from previous modules, focusing on technology adoption cycles, emerging trends, and barriers to the implementation of Deep Tech. Learners analyze various hype cycles, explore emerging trends in this field, using tools such as the Impact Radar 2024.

They are encouraged to critically reflect on how organizations can navigate uncertainty, balance innovation with risk, and prepare for the ethical and societal implications of rapid technological transformation.



3.3.2 Web Quests

Web Quests Included:

Exploring Deep Tech Enablers For Industry 5.0: The Future Of Innovation Starts Here!

In this webquest students demonstrate their understanding of emerging technologies by proposing a viable and innovative integrating strategy solution for an industry context. To do this, they are encouraged to understand the main deep tech drivers of this industrial transformation, distinguishing Industry 5.0 from 4.0 and critically reflect on the opportunities and challenges associated with adopting these technologies.

Smart Industries: Harnessing IoT and Edge Computing for Transformation

In this task, students create an informative poster that synthesizes essential information on IoT (Internet of Things) and Edge Computing, focusing on their transformative potential for data management, operational efficiency, and system security in modern industries. To do this, students research how IoT devices work and present real-world industrial applications that demonstrate the capabilities and impact of these technologies.

Exploring The Future of Human-Robot Collaboration

In this task, students create an informative poster that synthesizes essential information on IoT (Internet of Things) and Edge Computing, focusing on their transformative potential for data management, operational efficiency, and system security in modern industries. To do this, students research how IoT devices work and present real-world industrial applications that demonstrate the capabilities and impact of these technologies.

AI Machine Learning in Industry 5.0: Evolution or Revolution?

To consolidate knowledge in advanced robotics and human-robot collaboration, this webquest asks students to investigate and conceptually apply the principles of these interactions. Students research safety protocols, design considerations, and ethical frameworks for an industry-specific application of a collaborative robot (cobot). Further, students are expected to describe the collaborative robotic system tasks and assistance functions, its impact on human workers, and related safety, efficiency, and sustainability considerations.

3.4 Module 3: AI for Industry 5.0

Why is it Important:

This course module provides students with a comprehensive understanding of the rapidly evolving field of Artificial Intelligence (AI) and its profound impact across various engineering domains. By delving into the fundamental concepts, students gain a solid foundation that enables them to understand AI's significance, its core components, and recognize both its potential and limitations. This foundational knowledge is essential for preparing students to innovate and responsibly implement AI solutions in real-world engineering contexts.

Furthermore, the module explores the main AI methods—such as machine learning, deep learning, natural language processing, and computer vision—equipping students with the technical skills necessary to analyze, develop, and apply these advanced techniques (Crowley, 2021). This technical competence is crucial in today's data-driven world, where AI technologies are integral to solving complex problems across industries. The inclusion of case studies demonstrating successful AI applications helps students connect theoretical knowledge to practical outcomes, illustrating how AI can address specific engineering challenges.

An emphasis on Prompt Engineering highlights the strategic importance of effective communication with AI systems, especially in the context of Industry 5.0. This skill enhances operational efficiency, reduces costs, and promotes ethical AI development, positioning students as future leaders capable of guiding responsible AI integration (Kalyanakrishnan, 2023). Additionally, the module's focus on image processing and computer vision introduces students to technologies that underpin numerous innovative applications, from autonomous vehicles to medical diagnostics (Kolesnikova, 2023).

Finally, understanding Big Data and Analytics is important for managing and extracting value from the vast amounts of data generated in modern industry. By learning about the main implementation features used by leading companies, students acquire essential insights into data-driven decision-making and technological deployment at scale (Marr, 2016). Overall, this module provides students with the knowledge, skills, and strategic perspectives necessary to thrive in an increasingly AI-centric world, making it a vital component of contemporary engineering education.

Structure of the Module:

Module 3 is structured to provide a comprehensive learning experience through six lessons, each delivered via text materials and video recordings with slides. After completing each lesson, students are required to take a short test consisting of three questions that assess their understanding of the lesson content. At the end of the entire module, students have to complete a graded final test with 18 questions, designed to evaluate their overall grasp of the material covered across all lessons. Additionally, the module includes two WebQuest assignments: the first focuses on exploring and critically analyzing the roles of Artificial Intelligence (AI) and Machine Learning (ML) within the context of Industry 5.0, while the second encourages students to learn the principles of prompt engineering and develop skills to effectively guide AI outputs through carefully crafted instructions.



3.4.1 MOOC

Lessons included:

Lesson 3.1. Introduction to AI

In this lesson, students are introduced to the field of Artificial Intelligence (AI) and its significance in engineering. The lesson explores the concept of AI, its main components, and its application in a variety of engineering domains. Students learn to distinguish between Weak AI and Strong AI, and can provide examples of applications for both types. In addition, the key components of an AI system, including input data, algorithms, models, and outputs of predictions or decisions, are presented. The lesson material addresses common challenges and limitations in AI, including data quality, interpretability, and ethical issues. At the end of the lesson, students are encouraged to apply critical thinking to address the challenges of AI and recognize the importance of staying up-to-date on the role of AI in the future of engineering.

Lesson 3.2. Artificial Intelligence methods

The lesson provides a comprehensive overview of various artificial intelligence (AI) methods, focusing on machine learning, deep learning, natural language processing (NLP), and computer vision. Students learn about the fundamental concepts and techniques within each category. The importance and applications of each method are highlighted, from enhancing industry efficiency to enabling personalized recommendations and understanding human language. Students gain a deeper understanding of the diverse methodologies used to imbue machines with cognitive capabilities, empowering them to navigate the dynamic landscape of AI methods and comprehend their wide-ranging applications and implications.

Lesson 3.3. Artificial Intelligence case studies

The lesson explores a variety of case studies that demonstrate how Artificial Intelligence (AI) is transforming various industries and fields related to engineering. Students can deepen their understanding of AI and its significance in engineering, as the lesson discusses how this revolutionary technology is shaping the current and future landscape. The lesson discusses the

broader context of how AI is transforming various industries and presents specific case studies that highlight successful applications of AI in engineering-related fields such as manufacturing, healthcare, finance, and transportation. In addition, lesson material demonstrates how AI technologies have been applied to address specific engineering challenges or improve existing processes. Students can learn to distinguish the main AI technologies involved in each case study, such as machine learning algorithms, natural language processing or computer vision. By the end of the lesson, students are encouraged to promote the identification of the problem-solving aspects of each case study among their peers and to emphasize the importance of collaboration between engineers and experts from other domains to drive innovation and progress.

Lesson 3.4. Prompt engineering

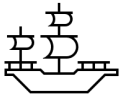
This lecture delves into the concept of Prompt Engineering and its pivotal role in shaping the future of artificial intelligence applications within Industry 5.0. Students explore the basics of prompt crafting, its benefits, applications, and ethical considerations. Through engaging discussions and examples, learners will understand how optimized prompts can drive efficiency, innovation, and significant cost savings across various AI applications.

Lesson 3.5. Computer Vision and Image Processing

This lesson talks about different image formats and their conversion, because, in computer vision, it is important to enhance the raw images into a refined version of itself. Students discover that such operations make it more suitable for analysis, laying the groundwork for deeper interpretation, including by computer vision systems. It is a necessary preprocessing step in numerous computer vision applications, including face recognition, object identification, and image compression. The lesson introduces different fields of computer vision applications and provides several cases of computer vision that have been put into practice.

Lesson 3.6. Big Data and Analytics

In this lesson, students learn about the key characteristics of Big Data, its potential benefits for companies, and how it creates value. The lesson introduces ten essential requirements to enhance the value of Big Data within an organization. These include using the right methods to access Big Data and combining data intelligently with suitable solutions. It is also important to ensure that all employees can access Big Data easily and that users can quickly find the data they need. Promoting collaboration is crucial for driving innovation, while creating an agile analysis environment helps meet the needs of everyone involved. Providing access to analysis tools from any device and location is essential for flexibility, and implementing scalable solutions ensures that the system can grow alongside the company. Using flexible platforms that can adapt to future technologies is also recommended. Lastly, employing data integration technologies enables the implementation of DataOps, streamlining data management and operations. Additionally, the lesson covers a 4-step model for data visualization and processing, requirements for the platform and analysis tools, and the technical solutions needed for implementation.



3.4.2 Web Quests

Web Quests Included:

AI And Machine Learning in Industry 5.0: Evolution or Revolution?

This WebQuest explores the transformative role of Artificial Intelligence (AI) and Machine Learning (ML) in shaping Industry 5.0. Students will investigate the different types of AI and ML, their applications in modern manufacturing and innovation, and the opportunities they present—such as intelligent automation and integration with emerging technologies. Additionally, it prompts learners to critically analyze the ethical and technical challenges associated with adopting these technologies. The core goal is to evaluate whether AI and ML represent a simple evolution of existing systems or a revolutionary change in how industries operate and humans interact with machines. Students will prepare to debate this question, developing well-founded arguments and broadening their understanding of industry transformation.

Mastering Prompt Engineering In AI Systems

This WebQuest introduces prompt engineering, a crucial skill in AI and Natural Language Processing (NLP). It focuses on learning how to craft effective instructions that guide AI systems like ChatGPT to produce accurate and relevant results. In the context of Industry 5.0, where human-AI collaboration aims for sustainable and human-centered innovation, mastering prompt engineering ensures ethical, responsible, and efficient AI interactions. The activity will cover the principles of prompt design, its role in AI communication, ethical considerations, and its application in real-world industrial settings.

3.5 Module 4: Twin transition enablers

Why is it Important:

This module introduces students to the Twin Transition, which merges digital transformation and sustainability to build the foundations of Industry 5.0. It focuses on how industrial innovation, circular economy models, and ecological design principles work together to drive a competitive yet environmentally responsible future.

By exploring the technological, economic, and social enablers of the twin transition, students will understand how industries can simultaneously advance productivity and sustainability. The module emphasizes the interconnection between digitalization, eco-innovation, and business transformation, ensuring that learners can translate theory into impactful strategies aligned with the European Green Deal and the Sustainable Development Goals (SDGs).

Students will also engage with case studies, frameworks, and entrepreneurial examples to understand how circular economy principles, eco design strategies, and new business models enable sustainable growth and innovation. The module equips participants with the necessary

knowledge, analytical skills, and mindset to act as catalysts for change — shaping a future where digital innovation supports ecological resilience and economic opportunity.

Structure of the Module

Module 4 consists of six lectures, each delivered through video presentations, accompanying slide decks, and reading materials.

After each lecture, students complete a short test (3 questions) to assess their comprehension.

Upon finishing all lessons, participants complete a final graded test (18 questions) evaluating their understanding of the Twin Transition enablers.



Two WebQuests are also included to encourage independent research, collaboration, and applied analysis of real-world twin transition practices.

3.5.1 MOOC

Lessons included:

Lecture 4.1. Industry 5.0 – The Enabler for a Twin Transition

This lecture introduces Industry 5.0 as the paradigm that bridges human-centric innovation, advanced technology, and environmental sustainability. Students explore how Industry 5.0 extends beyond automation and efficiency to re-humanize production, emphasizing collaboration between people and intelligent systems. The session examines how cobots, AI-driven analytics, additive manufacturing, and smart energy management can simultaneously boost productivity and reduce environmental footprints.

Through European policy frameworks such as the Green Deal and the Digital Europe Programme, learners identify the institutional mechanisms supporting this transition. By the end of the lecture, students will understand how Industry 5.0 acts as the strategic and cultural backbone of the twin transition, transforming factories into adaptive, sustainable ecosystems.

Lecture 4.2. The Concepts of Circular Economy for Twin Transition

This lecture provides a structured understanding of the Circular Economy (CE) as an essential driver of sustainable industrial transformation. It explores the shift from a linear *take-make-dispose* model to a regenerative one focused on resource efficiency, closed-loop systems, and extended product lifecycles.

Students analyze the butterfly diagram developed by the Ellen MacArthur Foundation and examine how CE strategies—remanufacturing, reuse, refurbishment, and recycling—are integrated into digital infrastructures through IoT-enabled tracking and predictive analytics.

Case examples from manufacturing, packaging, and energy sectors demonstrate how circularity leads to measurable reductions in carbon emissions and raw-material dependency. Learners reflect on how data-driven circularity creates economic resilience and aligns with both green and digital priorities.

Lecture 4.3. Understanding ECO Design

This lecture focuses on the principles and practices of ECO Design, emphasizing design thinking as a catalyst for sustainability. Students learn how environmental considerations can be embedded from the earliest stages of product conception—covering materials selection, modularity, reparability, recyclability, and end-of-life management.

Interactive examples illustrate the use of digital twins, lifecycle-assessment (LCA) software, and eco-impact modeling to optimize product design. Learners also evaluate EU directives such as Ecodesign Directive 2009/125/EC and emerging standards promoting sustainable product frameworks.

By the end of this session, students will be able to connect eco-design principles with circular-economy goals, articulating how responsible design choices directly contribute to the twin transition.

Lecture 4.4. Case Studies of Circular Economy and ECO Design

Building on the theoretical foundation of previous lessons, this lecture immerses students in real-world applications of circular economy and eco-design principles. The session presents diverse case studies from European SMEs and multinational corporations that have successfully adopted resource-efficient manufacturing, product-service systems, and cradle-to-cradle design.

Each case explores the catalysts, challenges, and outcomes of transition—highlighting economic gains, stakeholder engagement, and measurable sustainability metrics.

Students conduct critical analyses of these cases, comparing strategies and identifying replicable success factors. The activity encourages learners to bridge academic insight and industrial practice, reinforcing the multidisciplinary nature of the twin transition.

Lecture 4.5. Twin Transition Business Models

This lecture examines how business innovation serves as an operational engine for the twin transition. Students study emerging models such as Product-as-a-Service (PaaS), industrial symbiosis networks, green digital platforms, and carbon-neutral supply chains.

Through frameworks like the Triple Bottom Line and Value Creation Canvas, learners evaluate how organizations can create simultaneous economic, environmental, and social value. The

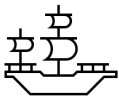
lecture also explores how digital technologies (blockchain for traceability, AI for predictive maintenance, and IoT for resource optimization) enhance transparency and efficiency in these models.

By the end, students gain a strategic understanding of how to design and scale sustainable business models, ensuring competitiveness in the age of Industry 5.0.

Lecture 4.6. Entrepreneurial Opportunities Emerging from Twin Transition

The concluding lecture positions the twin transition as a launchpad for entrepreneurship and innovation. Students explore how new market niches emerge from sustainability-driven policies, carbon-neutral targets, and consumer demand for responsible products.

Topics include green start-up ecosystems, access to EU innovation funding (Horizon Europe, LIFE Programme), and sustainable finance mechanisms that de-risk early-stage ventures. Learners examine case profiles of entrepreneurs leveraging digital platforms and circular business ideas to achieve impact at scale.



This session also emphasizes the soft-skills dimension—resilience, creativity, systems thinking, and ethical leadership—preparing students to become change agents who can translate sustainability challenges into profitable, regenerative opportunities.

3.5.2 Web Quests

Web Quests Included:

Harnessing Digitalization for a Sustainable Future: Exploring the Twin Transition

This WebQuest invites students to explore how digital technologies—including the Internet of Things (IoT), Artificial Intelligence (AI), Big Data, and blockchain—are accelerating sustainability goals across multiple industries. Learners will analyze real-world examples of companies that have successfully integrated digital innovation with green practices to reduce waste, optimize energy use, and improve circularity.

Through guided research and peer discussion, students will evaluate how data-driven decision-making supports environmental management, resource tracking, and carbon reduction initiatives. The exercise supports develop an integrated understanding of how the digital and green transitions reinforce one another, preparing students to identify synergies and challenges within the European Twin Transition agenda.

Twin Transition Architects: Building Sustainable Business Models for the Future

In this WebQuest, students act as strategic consultants tasked with designing a sustainable, digitally enabled business model for an organization of their choice. Using the principles of circular economy, eco design, and Industry 5.0, learners will create a framework that balances innovation, profitability, and ecological responsibility.

The task encourages the application of theoretical knowledge to practical business design—considering factors such as resource flows, digital traceability, renewable energy integration, and product-as-a-service models. Students will also assess potential funding opportunities under EU programmes (e.g., Horizon Europe, LIFE, or Green Deal initiatives), fostering entrepreneurial thinking and systems-level problem solving.

By the end, participants will have developed a realistic and ethically grounded blueprint for sustainable value creation aligned with the Twin Transition vision.

3.6 Module 5: Social, environmental and ethical implications

Why is it Important:

Module 5 addresses the social, environmental, and ethical dimensions of key enabling technologies, providing essential context for educators and learners to understand the broader impacts of emerging technologies. In today's digitally connected and environmentally constrained world, engineers and technologists are increasingly required to anticipate not only technical but also societal, environmental, and ethical consequences of their work (Floridi, 2019).

The module equips learners with awareness of ethical considerations related to artificial intelligence, including bias, fairness, discrimination, and the societal risks of misinformation and disinformation. It also introduces the EU AI Act as a regulatory framework guiding trustworthy and responsible AI deployment (European Commission, 2021).

Environmental implications are examined through the lens of the EU Green Deal and the circular economy, enabling students to critically analyze how key enabling technologies can either mitigate or exacerbate environmental challenges (European Environment Agency, 2024). Social impacts, such as workforce transformation, inclusivity, and digital equity, are discussed to ensure learners recognize the human-centric dimension of technological progress (OECD, 2024). Finally, cybersecurity and privacy considerations are addressed, providing practical knowledge on protecting sensitive information and ensuring responsible data management in digital projects.

Module 5 provides a roadmap for integrating these dimensions into learners' upskilling and further knowledge acquisition, helping them develop critical thinking and ethical reasoning on key topics, increasingly recognized as core competencies for the next generation of engineers and technology professionals (Breque, De Nul & Petridis, 2021).

Structure of the Module:

Module 5 begins with Ethical Implications of Disruptive Technologies (Lesson 5.1), which addresses AI bias, fairness, misinformation, and the EU AI Act, encouraging critical reflection on responsible technology use. Lesson 5.2 – Environmental Implications examines the impact of key enabling technologies on the environment, stakeholder roles, and circular economy principles aligned with the EU Green Deal. Lesson 5.3 – Social Implications focuses on workforce

transformation, inclusivity, accessibility, privacy, and the broader societal effects of technological change. The module concludes with Lesson 5.4 – Cybersecurity and Privacy Issues, highlighting common cyberthreats, protective measures, and responsible data management practices.

Each lesson includes formative quizzes, and the module concludes with a cumulative test, ensuring learners develop a holistic understanding of the social, environmental, and ethical dimensions of technology, preparing them for responsible and informed professional practice.

There are 2 webquests included in the end of the module - Webquest 8 - *From Innovation to Impact: The Social and Environmental Side of Disruptive Technologies* and Webquest 9 - *Guardians of the digital world: crafting solutions for a secure digital landscape*. Their main aim is to consolidate learning. Webquest 8 engages learners in team-based research on a chosen disruptive technology (AI, IoT, Big Data, Digital Twins, or Blockchain), exploring its



ethical, social, and environmental implications, and presenting actionable recommendations to a mock advisory panel. Webquest 9, focuses on cybersecurity and privacy, guiding learners to identify risks, develop a Cybersecurity Action Plan, and propose practical solutions to protect data in the digital era.

3.6.1 MOOC

Lessons Included

Lesson 5.1 – Ethical implications of disruptive technologies

The goal of lesson 5.1 is to raise learners’ awareness of the ethical implications of AI and other disruptive technologies, fostering critical thinking and responsible use of AI-powered tools. It develops an understanding of risks related to bias, discrimination, misinformation, and disinformation in students, while also becoming familiar with regulatory frameworks such as the EU AI Act. It encourages critical assessment, discussion, and making informed decisions regarding the ethical deployment and use of emerging technologies in professional contexts.

Lesson 5.2 – Environmental Implication

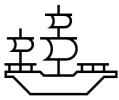
The goal of lesson 5.2 is to equip learners with the knowledge and critical thinking skills necessary to understand the environmental impact of key enabling technologies (KETs). Via this lesson, students can explore how emerging technologies interact with environmental sustainability, the EU Green Deal, and circular economy principles, while considering the roles of various stakeholders. It enables critical analysis of environmental challenges and opportunities, assessment of the sustainability of technological solutions, and proposing strategies that align technological development with ecological responsibility.

Lesson 5.3 – Social Implications

Lesson 5.3 supports learners with a comprehensive understanding of the social consequences of emerging and key enabling technologies. It equips students explore how technologies such as AI, Blockchain, IoT, Robotics, and Big Data transform society, the workforce, and organizational structures, while raising challenges related to ethics, inclusivity, accessibility, and work-life balance. Its goal is to help with the critical analysis of the societal impact of technological change, and the awareness of the need for upskilling and adaptability, and evaluation of the ethical and human-centered dimensions of digital transformation.

Lesson 5.4 - Cybersecurity and privacy issues

The goal of lesson 5.4 is to raise learners' awareness of cybersecurity threats and privacy challenges in digital systems, particularly those arising from the use of disruptive technologies such as AI and Big Data. It encourages students to explore common cyberthreats, vulnerabilities, and preventive measures, while learning the principles of the CIA triad and best practices for privacy protection. The lesson enables provide both the ability to recognize and understand cybersecurity risks, practical measures to safeguard sensitive information, and how to approach cybersecurity and privacy in professional and engineering contexts.



3.6.2 Web Quests

Web Quests Included:

From innovation to impact: the social and environmental side of disruptive technologies

This WebQuest invites students to investigate not just the possibilities but also the hidden consequences of emerging technologies on society and the environment. Divided into teams, participants select a technology such as AI, IoT, Big Data, or Digital Twins, and evaluate its ethical, social, and ecological impacts, including both potential benefits and risks. The dive deep helps them examine not only the benefits but also the surprising challenges that underpin the emergence of a technology and its social impact. A single prompt request to an AI can consume ten times the energy of a Google search, Digital Twins might unintentionally reinforce inequalities. Within the paradoxical values of technological advancement and ecological footprint, the teams would be able to synthesize their discoveries into a detailed report and a creative presentation, proposing actionable strategies to amplify positive impacts while addressing unforeseen risks. Beyond research and reporting, the quest encourages students to think like innovators and ethicists simultaneously so as to cultivate critical reflection on how rapid technological progress can be steered responsibly, thus training themselves to make decisions that could shape a more sustainable, equitable, and resilient future.

Guardians of the digital world: crafting solutions for a secure digital landscape

This WebQuest plunges students into the high-stakes world of digital security, where every click, app, and data stream carries both opportunity and risk. Students are challenged to consider the ethical dilemmas and societal impacts of digital life from personal privacy to corporate responsibility, fostering critical thinking and preparing them to navigate and protect an increasingly interconnected world as vigilant, proactive digital citizens. The participants step into the shoes of cybersecurity experts, investigating real-world threats like ransomware, phishing, and AI-driven vulnerabilities, while uncovering the hidden ways emerging technologies such as IoT and Big Data can be exploited. They then craft a detailed Cybersecurity Action Plan, blending research, strategy, and creativity, and present their proposals to a simulated executive board, defending their ideas under scrutiny.

4 Integration Models

Educators can adopt multiple integration models depending on institutional readiness and course design:

1. Supplemental Use

-  Use materials as optional or flipped-classroom content.
-  Asynchronous learning /self-paced) with Web-quests results presented in the classroom
-  Add papers in the topic, extra resources to the students based in teachers course

2. Modular Integration

-  Replace traditional lectures or labs with relevant e-learning or web quest modules.
-  Lectures can use separated modules according to the learning objectives of their courses.

3. Capstone Preparation

-  Use quests as skill-boosters prior to end-year projects.

4. Microcredential Pathways

-  Bundle materials into certified short courses or microcredentials.

5 Micro Credentials and the FuturENG Open badges System

Microcredentials refer to a form of certification that validates specific skills or knowledge acquired by an individual. They are often smaller, more targeted qualifications than traditional degrees or diplomas. Microcredentials can be earned through various methods, including online courses, workshops, or specific training programs, and they typically focus on particular competencies or skills within a field.

5.1 Why the Market is Shifting Towards Microcredentials

1. **Skill-Based Economy:** As industries evolve, there's a growing demand for specialized, up-to-date skills. Traditional degree programs often take years to complete and may not always align with the rapidly changing needs of the job market. Microcredentials provide a way for individuals to learn in-demand skills quickly and effectively.
2. **Lifelong Learning:** In today's fast-paced world, people are expected to continuously update their skillsets to remain competitive. Microcredentials offer a flexible and accessible way to do so, often through online platforms that allow learners to balance work, personal life, and education.
3. **Cost-Effectiveness:** Traditional degrees can be expensive and time-consuming. Microcredentials are typically more affordable, making education more accessible for a broader audience.
4. **Employer Demand:** Many employers value specific skills over formal degrees, especially in fields like technology, healthcare, and business. Microcredentials help to meet this demand by certifying a learner's proficiency in a specific area, giving them a competitive edge in the job market.
5. **Personalization of Learning:** Microcredentials allow individuals to tailor their learning journey to their specific career goals. Instead of taking a broad, generalized curriculum, learners can choose credentials that match their interests and desired expertise.

5.2 Benefits for Students

Students can benefit from this shift towards microcredentials. Microcredentials offer:

1. **Focused Learning:** Microcredentials are designed to help students acquire practical, relevant skills in specific areas. This leads to more targeted learning that directly applies to their career interests.
2. **Flexibility and Accessibility:** Many microcredential programs are offered online, allowing students to learn at their own pace and from anywhere in the world. This flexibility is crucial for working professionals or those who need to balance other commitments.

3. **Career Advancement:** Microcredentials can enhance a student's resume and make them more attractive to employers by demonstrating a commitment to professional growth and expertise in specific skills.
4. **Stackable Credentials:** Students can accumulate multiple microcredentials over time, building a comprehensive skill set that aligns with their career path. Some institutions and employers even allow stacking these credentials towards more formal qualifications or degrees.
5. **Affordability:** Since they tend to be shorter and more focused than traditional degrees, microcredentials are generally less expensive, making higher education more accessible to a wider audience.

5.3 Benefits for Educators

Educators can also benefit from this shift towards microcredentials since they can:

1. **Meet Industry Demand:** Educators can design programs that cater directly to the needs of employers and the skills gap in the market, helping students be more job-ready.
2. **Enhance Teaching Opportunities:** With the rise of online learning platforms and microcredential providers, educators have the opportunity to create and offer courses that target specific skills, often with a more global reach than traditional university-based teaching.
3. **Engage with Lifelong Learners:** Microcredentials enable educators to work with learners throughout their careers, creating an ongoing relationship between institutions and students as they continue to upskill.
4. **Customize Learning Paths:** Educators can offer a wide variety of programs that cater to diverse audiences, from beginners to advanced professionals, and even customize the content based on real-time feedback from learners and employers.
5. **Increase Collaboration with Industry:** Many microcredential programs are developed in partnership with employers, ensuring that the skills taught align with industry needs. Educators can collaborate more closely with businesses to develop curricula that meet the demands of the workforce.

The shift towards microcredentials reflects the increasing demand for accessible, flexible, and competency-based learning options that align with the needs of both students and employers.

5.4 EU approach

The European Union (EU) has taken several proactive steps to promote and integrate **micro-credentials** into its education systems, labor markets, and broader economic frameworks. These actions are aimed at enhancing the skills and employability of EU citizens, addressing skills gaps, and making education more flexible and accessible. Here are some of the key actions the EU has undertaken to promote micro-credentials:

5.4.1 EU Digital Education Action Plan (2021-2027)

The **Digital Education Action Plan (2021-2027)** includes a focus on digital skills, which aligns with the growth of micro-credentials. One of its main objectives is to encourage the development of high-quality digital education and to ensure that learning is flexible, accessible, and recognized across the EU. The plan highlights:

- **Quality Assurance:** The EU promotes quality standards for micro-credentials to ensure they are widely accepted and respected. This includes establishing mechanisms for recognizing and validating micro-credentials across borders within the EU.
- **Creating a Common Framework:** The EU is working on a common framework for micro-credentials, which can help institutions, employers, and learners better understand what these qualifications represent and how they can be used for career advancement or further learning.

5.4.2 European Skills Agenda (2020)

The **European Skills Agenda** is another key EU initiative aimed at addressing the EU's skills gaps, particularly in the context of digital transformation, green economy, and global competition. It has specific measures to encourage the development and uptake of micro-credentials, such as:

- **Promoting Micro-Credentials as an EU-wide Standard:** The agenda emphasizes micro-credentials as a tool to enhance lifelong learning and support individuals in continuously developing new skills in a rapidly changing job market.
- **Building a European Qualifications Framework (EQF):** One of the goals of the European Skills Agenda is to ensure that micro-credentials can be linked to the **European Qualifications Framework (EQF)**. This helps in making micro-credentials comparable and transferable across EU countries, thus enhancing their mobility and recognition.

5.4.3 European Commission Pilot Projects

The **European Commission** has been funding and promoting various pilot projects related to micro-credentials. These projects are designed to test innovative ways of validating and recognizing micro-credentials. Notable examples include:

- **Micro-credentials in Higher Education:** The EU is exploring how universities and other higher education institutions can offer and recognize micro-credentials in addition to traditional degrees. This includes defining what constitutes a micro-credential and determining how they will be assessed and validated across EU member states.
- **European Digital Credentials for Learning (EDC):** This initiative aims to create a framework for issuing and recognizing digital credentials for learning that can be linked to micro-credentials. The goal is to facilitate the portability and recognition of micro-credentials across borders.

5.4.4 European Centre for the Development of Vocational Training (Cedefop)

Cedefop, an EU agency that supports the development of vocational education and training (VET), plays a key role in promoting the use of micro-credentials within the context of vocational education. It does this through:

- **Research and Data:** Cedefop conducts research to assess the potential impact of micro-credentials on skills development, labor market participation, and the integration of education and training systems across Europe.
- **Collaborations:** Cedefop collaborates with national governments, industry, and educational institutions to develop frameworks and guidelines for micro-credentials, ensuring they are aligned with European labor market needs.

5.4.5 EU Funding Programs

The EU offers funding programs that support the development and adoption of micro-credentials across member states, particularly in the context of digital learning, adult education, and skills development. Some key programs include:

- **Erasmus+:** This program is traditionally known for supporting mobility, but it is increasingly funding projects related to lifelong learning and the development of micro-credentials. Erasmus+ supports partnerships between universities, vocational training centers, and businesses to develop joint micro-credential programs that enhance employability and adaptability.
- **Horizon Europe:** Horizon Europe funds research and innovation projects, and it has supported initiatives that explore the role of micro-credentials in skills development for emerging technologies, particularly in the areas of AI, digital transformation, and green energy.

5.4.6 European Qualifications Framework (EQF) and the European Credit Transfer and Accumulation System (ECTS)

The EU is working to better integrate **micro-credentials** into the **European Qualifications Framework (EQF)** and the **European Credit Transfer and Accumulation System (ECTS)**, which are tools that help to standardize and compare qualifications across EU countries. Specifically:

- **Linking Micro-Credentials to EQF Levels:** By aligning micro-credentials with the EQF, the EU aims to ensure they are recognized across different educational and professional systems. This alignment helps learners and employers better understand the value of micro-credentials.
- **Creating ECTS Points for Micro-Credentials:** ECTS, which is used to measure the workload of students in higher education, may be extended to cover micro-credentials, allowing learners to accumulate credits toward formal degrees or certifications.

5.4.7 EU Policy Initiatives on Lifelong Learning

The EU has adopted a **Lifelong Learning Strategy**, which emphasizes the importance of upskilling and reskilling throughout a person's career. Micro-credentials are a core part of this strategy, as they allow individuals to gain new, job-relevant skills quickly and efficiently without the need for long-term formal education programs.

- **Flexible Learning Pathways:** Micro-credentials are recognized as a key way to create flexible, modular learning pathways for people of all ages and backgrounds, allowing them to upskill and reskill throughout their careers.
- **Collaborations with Industry:** EU initiatives encourage collaboration between educational institutions and businesses to design micro-credentials that are closely aligned with labor market needs.

5.4.8 European Digital Education Hub (EDEH)

The **European Digital Education Hub** is a platform designed to facilitate collaboration across Europe on digital education initiatives. One of its goals is to improve access to micro-credentials and other forms of digital education, ensuring that learners in different EU countries can access high-quality, recognized qualifications.

5.5 Badges and Micro-credentials

Badges and **microcredentials** are both tools used to recognize and validate skills or achievements, but they differ in terms of depth, formality, and scope. However, they are closely related, and in many contexts, **badges** are used as part of the process for awarding **microcredentials**. Let's dive into the relationship between the two:

5.5.1 Badges Explained

A **badge** is a digital symbol or indicator that represents a specific achievement, skill, or competence earned by an individual. Badges are typically issued by organizations, institutions, or platforms as a way of recognizing and verifying a learner's accomplishment in a certain area. These are usually awarded for completing a specific task, finishing a course, mastering a skill, or passing an assessment.

- **Digital and Visual:** Badges are often represented as visual icons (images) that are displayed on online platforms, resumes, or portfolios.
- **Shorter-Term Achievements:** A badge can signify a narrower or more specific achievement. For example, earning a badge might indicate the completion of a particular online course, a project, or a module.
- **Stackable:** Badges can be stacked over time to indicate progress or cumulative learning, and they are often linked to **microcredentials** or **learning pathways**.

5.5.2 Microcredentials Explained

Microcredentials are more formal certifications that recognize a specific set of skills or knowledge, often earned through short-term, targeted learning programs. Microcredentials are typically linked to broader educational outcomes than badges and may include more rigorous assessments and a clear validation process. A microcredential can be earned after completing a structured course or program that demonstrates competence in a specific area.

- **Formal Certification:** Microcredentials usually come with more detailed records (such as a certificate or transcript) and might be linked to the **European Qualifications Framework (EQF)** or another standard.
- **Focused on Competence:** A microcredential is often issued after a learner has demonstrated mastery of a specific competency or skill in a given subject.
- **Higher Credibility:** Microcredentials are generally more recognized and can carry greater weight in professional or academic contexts compared to badges.

5.5.3 Relationship Between Badges and Microcredentials

While badges and microcredentials are distinct, they are often **interrelated** in the context of modern learning systems. Here's how:

1. Badges as Building Blocks of Microcredentials:

- In some systems, badges are awarded as smaller **achievements** or **steps** toward earning a microcredential. For example, you might receive badges for completing individual modules within a larger course, and after completing all the modules, you can earn a **microcredential** that certifies your overall mastery of a subject.
- **Stackable Badges:** Learners may accumulate multiple badges that, when combined, constitute a larger skill set. This cumulative process can then be formally recognized as a microcredential, especially if the learner meets the overall competency or assessment criteria.

2. Microcredentials Use Badges to Display Achievements:

- Many platforms issue **badges** to learners when they achieve specific milestones or competencies within a microcredential program. For example, a learner might complete a series of tasks in a course and earn badges for each task. Once all tasks are completed, the learner receives the microcredential.
- These badges are often **digitally verifiable**, meaning they include metadata that provides proof of the achievement and can be shared easily on platforms like LinkedIn or digital resumes.

3. Badges as an Informal or Supplemental Recognition:

- Badges can serve as a **supplementary** recognition of informal learning or achievement that may not require the full structure of a microcredential. For

example, someone might earn a badge for completing an online quiz or learning module, even if that doesn't add up to a full credential.

- In this case, badges are a **lighter, more accessible form of recognition**, but they may not carry the same weight or formality as a microcredential.

4. Flexibility and Recognition Across Platforms:

- One of the key advantages of badges is their **flexibility** and ability to be **integrated across different platforms**. Learners can earn badges from various sources (e.g., MOOCs, workshops, online courses) and display them in digital portfolios or social media profiles. Microcredentials, on the other hand, might be awarded in a more standardized or structured format, and while badges can be part of this process, microcredentials often come with more formal documentation.

Badges vs. Microcredentials: Key Differences

Aspect	Badges	Microcredentials
Purpose	Recognize small, specific achievements or skills	Certify a broader set of competencies or skills
Formality	Informal and often used as supplementary recognition	Formal certification recognized across systems
Scope	Narrower in scope, typically for individual tasks or modules	Covers a broader set of skills or competencies
Recognition	Less formal, often displayed on digital platforms	More formal, sometimes linked to academic or professional qualifications
Verification	May or may not be verified (depending on the issuing platform)	Typically involves a more rigorous verification process
Credentialing Process	Can be earned quickly and easily for specific tasks or knowledge	Involves completing a structured program or course with assessments
Stacking	Can be stacked together to create a larger portfolio of learning	Typically a stand-alone achievement, but can be part of a larger learning pathway

5.5.4 How Badges and Microcredentials Help Learners and Educators

- **For Learners:**

- **Badges** offer a quick way to showcase specific skills or milestones, making them useful for informal recognition or on-the-job learning.
- **Microcredentials** provide a more structured and comprehensive way to validate expertise in a field or subject, which can be more impactful for career advancement or academic purposes.
- Learners can **stack badges** to build up to a microcredential, giving them a clear path toward broader achievements.
- **For Educators:**
 - **Badges** are an easy-to-implement tool for recognizing incremental achievements and motivating learners throughout their educational journey.
 - **Microcredentials** are valuable for offering more formal, recognized qualifications that can be aligned with industry standards, helping to meet the growing demand for flexible, skill-based learning.
 - Educators can use **badges** as milestones that eventually lead to the awarding of a **microcredential**, providing a clear structure for learners to follow.

5.5.5 Examples of Platforms Using Badges and Microcredentials Together

- **Coursera, edX, and LinkedIn Learning:** These platforms often use **badges** as part of their microcredentialing system. For instance, a learner may earn badges for completing certain modules or assessments in a course, and upon completing the full course, they receive a **microcredential** that can be added to their resume or professional profile.
- **Open Badges Standard:** This is an open standard for digital badges developed by the Mozilla Foundation. It allows badges to be issued for a wide variety of learning achievements and includes detailed metadata to verify the achievement. Microcredentials can be built on top of this system by adding more formal learning criteria.

5.6 The futurEng badge system

The FuturEng online platform (<https://elearn-futureng.projectsgallery.eu/>) includes 5 Modules and 7 Web Quests.

MODULES:

- 🕒 Module 1: Introduction to course
- 🕒 Module 2: Deep Tech enablers for Industry 5.0
- 🕒 Module 3: AI for Industry 5.0
- 🕒 Module 4: Twin transition enablers

-  Module 4: Twin transition enablers
-  Module 5: Social, environmental and ethical implications

WEB QUESTS.

1. EXPLORING DEEP TECH ENABLERS FOR INDUSTRY 5.0: THE FUTURE OF INNOVATION STARTS HERE!
2. SMART INDUSTRIES: HARNESSING IOT AND EDGE COMPUTING FOR TRANSFORMATION
3. EXPLORING THE FUTURE OF HUMAN-ROBOT COLLABORATION
4. AI AND MACHINE LEARNING IN INDUSTRY 5.0: EVOLUTION OR REVOLUTION?
5. MASTERING PROMPT ENGINEERING IN AI SYSTEMS
6. HARNESSING DIGITALIZATION FOR A SUSTAINABLE FUTURE: EXPLORING THE TWIN TRANSITION
7. TWIN TRANSITION ARCHITECTS: BUILDING SUSTAINABLE BUSINESS MODELS FOR THE FUTURE

Students can create an account and automatically enroll in the course in their preferred language. The platform provides learning materials for each of the five modules, along with short quizzes at the end of each unit to assess their knowledge (excluding Module 1, which serves as an introduction). These quizzes are in learning mode, meaning the correct answer is shown after each question as the student moves on to the next one. There is no scoring in these quizzes.

At the end of modules 2, 3, 4, and 5, students can take a test. The test includes a scoring system, and a badge is awarded if the student achieves a score of 75% or higher. Please note, there is no penalty for incorrect answers

Name	Badge status	Criteria
 AI for Industry 5.0	Available to users	Complete: "SCORM package - Test: AI for Industry 5.0"
 Deep Tech enablers for Industry 5.0	Available to users	Complete: "SCORM package - Test on Deep Tech enablers for Industry 5.0"
 Social, environmental and ethical implications	Available to users	Complete: "SCORM package - Test: Social, environmental and ethical implications"
 Twin transition enablers	Available to users	Complete: "SCORM package - Test: Twin transition enablers"

Students can also submit tasks for the 7 online web quests, which can be scored by the teachers. For each web quest, students have the opportunity to earn an additional badge.

As a result, a student can earn a total of 11 badges. If all badges are obtained, the student will earn the **Micro-credential FutureEng**, and a certificate will be available for download.

6 Using the Platform from the Teacher Perspective

Teachers can create an account at <https://elearn-futureng.projectsgallery.eu/>. It is noted that by default the role assigned to anyone creating an account is student. The enrolled teacher must contact the platform administrator and request the Teacher Role. It is also noted that guidelines for Teachers for the web Quests are visible once the account created is assigned the Teacher role. These guidelines are not visible to students.

In the following pages the platform is explained in simple steps through a series of screen shots.

7 Assessment Strategies

FuturEng MOOC combines two complementary assessment strategies: traditional – formative and summative assessment of modules content– and performance-based assessment, through webquests.

7.1 Assessment Strategies for the MOOC

The module's assessment includes formative and summative assessments.

Formative Assessment is designed not as an assessment of learning, but *for* learning. It is typically composed of short and unlimited trial- quizzes as low-stakes assessment strategies that help learners self-monitor their progress. In general, these quizzes are built on the idea of retrieval practice (Roediger & Karpicke, 2006) – memory retention through recall. They also function to keep learners motivated, an essential aspect in online learning. They typically allow for multiple attempts, promoting persistence (Mastery Learning, Benjamin Bloom (1968) and a growth mindset (Dweck, 2006).

In FuturEng, the formative assessment is conducted at the end of each lesson through short quizzes consisting of 3-4 multiple choice questions or matching exercises, each worth 10 points. Learners have unlimited attempts.

Summative (final) assessment functions as an evidence of achievement (Black & William, 1998; Harlen 2007). It is recommended that the final questions are formulated according to Bloom's taxonomy of action verbs to effectively assess remembering and understanding.

In future, module level quizzes are administered at the end of all lessons in a module. These include 14 to 18 multiple choice questions and matching exercises, weighting 10 points each. Learners have a limit of 2 attempts.

This kind of assessment - composed of formative and summative approaches ensures the validity of learning and promotes the ongoing improvement of learners (Harlen, 2007)

7.2 Assessment Strategies for the Web Quests

WebQuests are rooted in constructivist teaching methods. They intend to develop problem-solving and critical thinking skills, while fostering the integration of technology into the teaching and learning process.

Webquests typically involve multi-faceted activities - research, analysis, presentation of information, team or individual work, project development and practical assignments. They often simulate real-world tasks and performances, reflecting inquiry-based approach to

knowledge construction, iterative and reflective processes. The process aims to support the transfer learning across different contexts.

As inquiry-based activities, WebQuests do not have 'right answers'. Instead, learners are encouraged to explore, reflect, and build their own understanding of the subjects in question. Consequently, the assessment of learners' performance must be flexible. One effective approach is to apply a rubric-based evaluation method, in which rubrics are aligned with intended learning outcomes. Rubrics should evaluate both the learner's performance and the tangible WebQuest's results.

In FuturEng, webquests vary in the type of expected output: ranging from presentation, report, debates to strategic proposal, business model/ plan or prototype/ demo. Each WebQuest, therefore, includes its own evaluation rubric. However, despite their diversity, all WebQuests share a similar assessment framework comprising three to four equally weighted criteria. These criteria include applied understanding; alignment with EQF level descriptors, transversal competences such as Ethics, sustainability, and human-centred technology, in alignment with Industry 5.0 principles and collaboration, communication, and presentation skills (i.e., ability to communicate ideas clearly and persuasively).

Accordingly, the assessment framework for FuturEng Webquests can be articulated into the following transversal rubrics:

- Research and innovation: Quality, Depth, and relevance of the output.
- Communication/ Presentation: clarity of expression
- Collaboration: teamwork dynamics
- Ethical and sustainable thinking: Human-centric and responsible technological principles

For each rubric, criteria and standards should be defined for the rating of the learner's performance. The final evaluation matrix would look like this:

Criterion	0 pts – Poor	2 pts – Average	4 pts – Good	6 pts – Excellent
1. Research & Innovation	Limited understanding; inaccurate or irrelevant work.	Basic understanding; little depth or originality.	Solid understanding; some creativity and relevance.	Deep, accurate, innovative work linked to real contexts.
2. Communication / Presentation	Unclear, disorganized, major errors.	Understandable, but lacks structure or clarity.	Clear and organized; appropriate visuals/media.	Clear, persuasive, well-designed, and engaging.

Criterion	0 pts – Poor	2 pts – Average	4 pts – Good	6 pts – Excellent
3. Collaboration	No or minimal participation	Inconsistent contribution or teamwork.	Regular participation and cooperation.	Active, respectful, and constructive teamwork.
4. Ethical & Sustainable Thinking	No ethical or sustainable awareness.	Mentions ethics/sustainability superficially.	Integrates some ethical or sustainable ideas	Strong ethical, sustainable, and human-centered approach.

Rating table:

Excellent	From 20 to 24 points
Good	From 13 to 19 points
Average	From 7 to 12 points
Poor	From 0 to 6 points

Finally, the rubric should be presented to learners before beginning the WebQuest to ensure transparency and shared understanding of the assessment process.

8 Faculty Training Checklist

To effectively deliver the materials, educators should be trained in:

- Basics of Industry 5.0 concepts
- Using the LMS platform and interactive tools
- Facilitating web quests and scenario-based learning
- Designing assessments aligned with learning outcomes
- Promoting student reflection and digital collaboration

9 The FuturEng Experience

The consortium of FuturEng compiled a comprehensive Experience report which supports document the testing and validation of the MOOC and the CBL Toolbox across the three partner universities, summarizing student feedback, pilot activities, and collaborative events that took place within the project lifespan, namely the digital hackathon and the LTTA in Portugal. The

report provides an evidence-based overview of how the project's tools supported the development of students' skills and informed improvements through co-creation and evaluation activities and serves as a key reference for understanding the project's progress and the practical impact of its results. Furthermore, it serves as proof for educators and institutions how innovative learning tools, such as the ones created within the FuturENG project, offer practical implementation examples that can be adapted for various engineering programs.

The complete version of this report is available as a freely downloadable resource on the FuturENG project [website homepage](#) (in section: Our Experience), or it can be directly accessed through the following link: [FuturEng Experience report](#).



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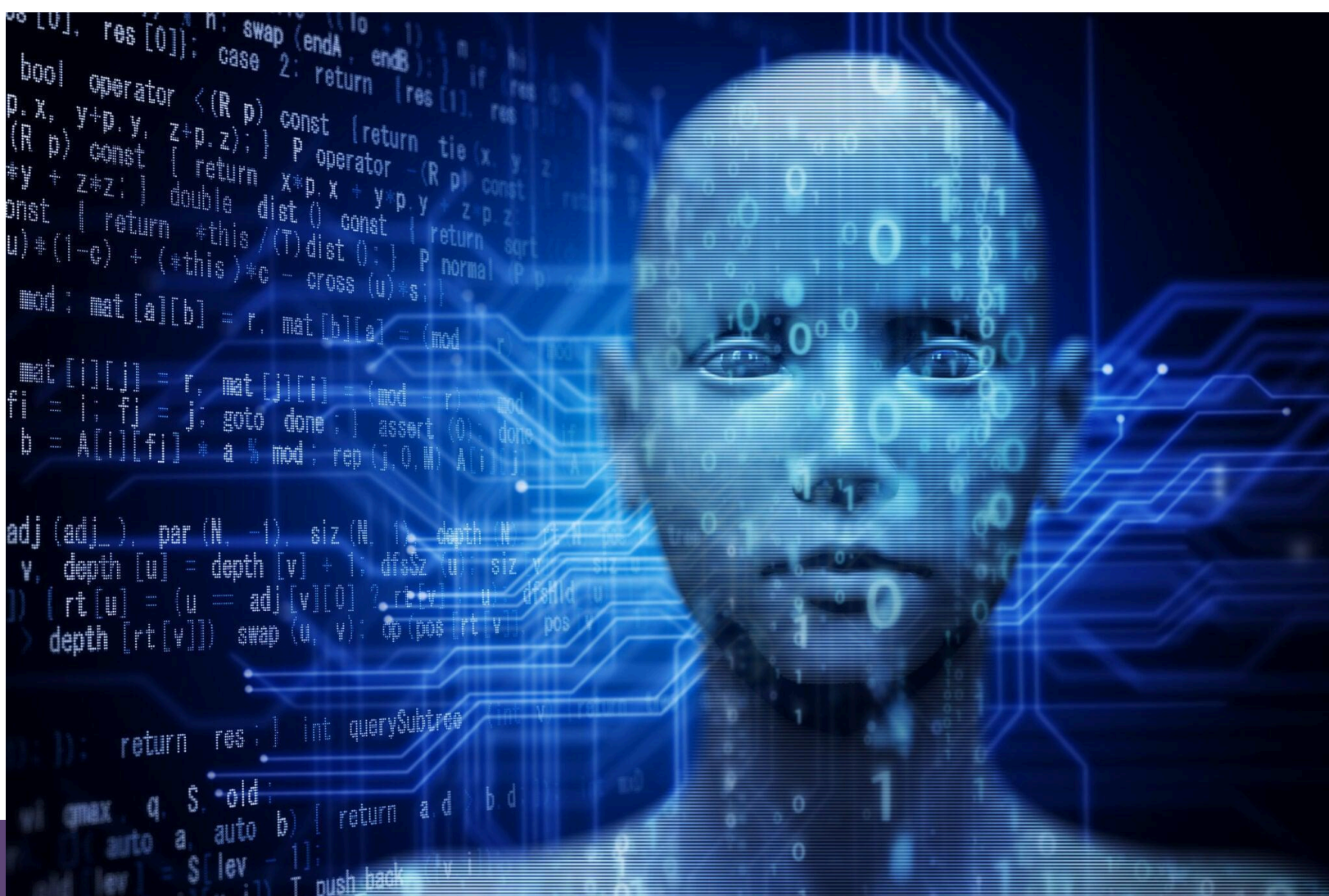
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Chapter 2 - Roadmap for Integrating Industry 5.0 E-learning and Web Quests into Engineering Curricula

1 Executive Summary

FuturEng is a European project that equips engineering education with the competences required for Industry 5.0 — a policy shift that calls for the use of advanced technologies in ways that prioritise people, environmental sustainability, and supply-chain resilience. The project provides ready-to-teach material covering artificial intelligence, secure data handling, blockchain, service-based business models, collaborative robots, and 3D printing. All learning content is mapped to the European Qualifications Framework and aligned with the 2022 Council Recommendation on micro-credentials, ensuring that every learning unit can be recognised across borders.

FuturEng enables three practical routes for learners. In the degree route, modules can be integrated into existing engineering programmes, enabling students to develop Industry 5.0 competences for credit. In the micro-credential route, short flexible courses allow practising engineers and learners from other fields to acquire focused skills and convert them into recognised credits later. In the workshop route, rapid-exposure activities such as hackathons and challenge sprints award badge-based recognition without requiring curriculum changes.

Teachers will receive targeted training that supports both technical instruction and the wider social and environmental aspects connected to Industry 5.0. Companies will contribute real data, equipment, and problem briefs, strengthening workplace relevance and creating direct talent pipelines. Quality assurance agencies and accreditation bodies will be involved throughout the process to ensure compliance with European standards for credit and recognition.

FuturEng starts with design and pilot activities in 2025–2026, followed by broader adoption by 2028 and ongoing incremental improvement. Progress will be monitored through indicators such as micro-credential uptake, learner mobility across Europe, and graduate outcomes in green and digital sectors. By integrating cutting-edge technology with strong sustainability and societal values, FuturEng supports the development of engineers who can design solutions that are not only innovative and efficient but also responsible and resilient.

1 The Vision: Industry 5.0 and Engineering Education

Industry 5.0 represents a shift towards industrial systems that enhance human well-being, protect the environment, and remain resilient to disruption (European Commission, 2021). It builds upon the technological progress of Industry 4.0, while placing a stronger focus on social and environmental outcomes. The need for skills that enable this transformation has become urgent, as noted in recent European policy reports (European Commission, 2024).

For engineering education, this transition requires strong technical foundations — including artificial intelligence, secure data management, blockchain, collaborative robotics, additive

manufacturing, and advanced analytics — while also embedding sustainability, ethics, and inclusivity (European Commission, 2021). Engineers must be able to evaluate the broader consequences of technology, adopt a life-cycle approach, and contribute to solution development that addresses climate, cyber-security, and supply-chain risks. They will increasingly work in service-based business models, such as Software-as-a-Service, Platform-as-a-Service, and Data-as-a-Service, that deliver value while respecting environmental limits (European Commission, 2024).

Meeting these expectations calls for modernised teaching and learning methods. Challenge-based approaches, including living lab environments, encourage multidisciplinary teamwork and rapid experimentation. Short, stackable learning units allow learners to acquire focused skills and demonstrate competence quickly. Micro-credentials aligned with European standards support flexible learning pathways, enabling students to upskill and reskill throughout their careers (Council of the EU, 2022). Collaboration across disciplines — for example, engineering students working with business, social science, and design students — helps them understand the human and organisational dimensions of innovation. Continuous professional development opportunities ensure that educators remain up to date with emerging tools and the societal questions they raise. Mobility windows and cross-border cooperation strengthen the flow of talent and knowledge across Europe (European Commission, 2024).

The following sections describe how FuturEng supports universities in implementing this vision. Through updated degree pathways, micro-credential offerings, and extracurricular innovation opportunities, the project supports equipping engineers to deliver solutions that are technically robust, sustainable, and aligned with Europe’s human-centric industrial future (European Commission, 2021).

2 Stakeholders and Target Users

Building FuturEng’s learning pathways around Industry 5.0 principles requires coordinated action from a wide community of stakeholders, each contributing distinct value to ensure successful implementation and long-term impact.

Students and other learners are central to the initiative. This includes full-time undergraduates, master’s and doctoral candidates, and professionals seeking to update their competences mid-career. Micro-credentials aligned with European quality and transparency standards provide flexible and portable recognition of learning, enabling individuals to acquire and stack skills in key enabling technologies such as artificial intelligence, blockchain and sustainable manufacturing (Council of the EU, 2022; European Commission, 2021).

Academic staff, programme directors and institutional quality teams drive curriculum innovation and safeguard academic standards. They will adapt syllabi, modernise assessment and embed

human-centric and sustainability perspectives within specialised engineering topics. European guidance emphasises early and continuous involvement of educators to ensure coherent learning outcomes aligned to recognised qualification frameworks (European Commission, 2024).

Industry partners — including technology providers, manufacturers and start-ups — contribute authentic contexts, datasets, facilities and challenge briefs. Their co-design role ensures that learning remains closely aligned with evolving workplace expectations and that Industry 5.0 competences translate directly into employability (European Commission, 2021).

Policy-makers, accreditation bodies and national agencies provide the regulatory foundation for curriculum flexibility, recognition and cross-border learner mobility. They ensure that academic and micro-credential pathways comply with the European Qualifications Framework and Lisbon Recognition Convention principles, maintaining trust and transparency across Europe (ENQA, 2015).

Finally, society and the wider economy benefit when engineering graduates develop solutions that enhance well-being, social inclusion and environmental responsibility — the core aims of Industry 5.0. By aligning the actions of all stakeholders, FuturEng contributes to Europe's green and digital transition while strengthening industrial resilience.

3 Strategic Integration Phases

To translate the Industry 5.0 vision into everyday learning, FuturEng will deploy its content through three complementary pathways that respond to different institutional needs while forming a single, scalable strategy for curriculum transformation (European Commission, 2024).

Pathway 1 — Full Curriculum Integration

FuturEng modules covering artificial intelligence, blockchain, big-data analytics, collaborative robotics, additive manufacturing and service-oriented business models will be embedded into existing accredited programmes. Learning outcomes will be mapped to EQF levels and ECTS standards to ensure inclusion within mainstream engineering education (European Commission, 2021).

Pathway 2 — Micro-Credentials for Flexible Upskilling

The same content will be offered as short, assessed and stackable learning units for professionals, students from other disciplines and alumni. Because these micro-credentials follow the 2022 Council Recommendation, they support fast recognition and labour-market relevance across Europe (Council of the EU, 2022).

Pathway 3 — Extracurricular and Co-Curricular Innovation

Weekend sprints, industry challenges, hackathons and Degree Plus experiences will provide hands-on engagement outside formal structures, recognised through digital badges and supporting rapid prototyping of new content in partnership with industry (OECD, 2023).

The subsections that follow outline the procedural, quality assurance and governance requirements for each pathway, ensuring that initial pilots progress toward sustainable, institution-wide adoption.

3.1 Registering and approving a new study module

Across Europe, university study programmes and their modules are subject to national quality assurance systems that operate within a shared European framework. The key reference is the *Standards and Guidelines for Quality Assurance in the European Higher Education Area* (ESG), first adopted in 2005 and revised in 2015. The ESG set out how institutions should assure the quality of their programmes internally and how external quality assurance agencies should evaluate them (ENQA, 2015). Implementing ESG-based quality assurance is a core obligation of the Bologna Process, which established the European Higher Education Area (EHEA). While the core principles are common, the detailed procedures vary between countries (European Commission, 2025).

When universities introduce new modules into established programmes, they normally follow an internal quality assurance process that mirrors, on a smaller scale, the approval of complete programmes. In line with the ESG standards for internal quality assurance, any curriculum modification — including the creation, revision, or removal of modules — must be properly planned, justified, and approved through institutional procedures. Typically, the initiative originates from an academic department or programme committee, which identifies a need arising from new research developments, labour-market needs, or feedback from students and external stakeholders. A module description is then drafted, outlining intended learning outcomes, content, assessment methods, and workload expressed in ECTS credits.

Once prepared, the proposal is reviewed for its alignment with the overall programme: the module level must correspond to the relevant qualifications framework, and the learning outcomes must meaningfully contribute to programme outcomes without overburdening students or duplicating existing teaching. In many systems, this alignment check is carried out by a faculty or university-level study programme committee and a quality assurance office, using templates and criteria derived from the ESG. Common areas of focus include student-centred learning, constructive alignment between teaching, learning and assessment, and the provision of clear information to learners.

Final approval is then granted by the appropriate decision-making body (e.g., a faculty board, senate, or equivalent). Minor updates may be handled fully within the institution and later reported during external review cycles. However, substantial changes — such as adding multiple new modules that significantly change the programme profile — may require notification to, or re-accreditation by, an external quality assurance agency. Regardless of classification, once implemented, modules are monitored through regular internal evaluations, including student feedback and performance indicators, and are reconsidered during cyclic programme reviews to ensure continuous improvement and coherence.

Guidance on quality management arrangements across national education systems, including links to related policy and regulatory documents, is provided on the European Commission's Eurydice platform (Eurydice, 2025).

To illustrate this process in practice, the following pages use the example of introducing a new module into a study programme at Kaunas University of Technology (KTU). Although procedures differ across national contexts, this case helps highlight the most typical steps, stakeholders, and key documents involved. It also demonstrates how the resources designed for a FuturEng course — including learning outcomes, syllabi, assessment schemes, and teaching materials — can be incorporated into established programme structures. The description draws on publicly available documents from the Kaunas University of Technology (Kaunas University of Technology, 2025).

The registration and approval of a study module is a structured process that ensures academic consistency and alignment with institutional and European expectations before inclusion in the official curriculum. A module is drafted, submitted, evaluated by relevant committees and experts, then approved and registered if it meets the necessary standards. Once approved, modules are valid for a defined period and later re-evaluated to maintain quality.

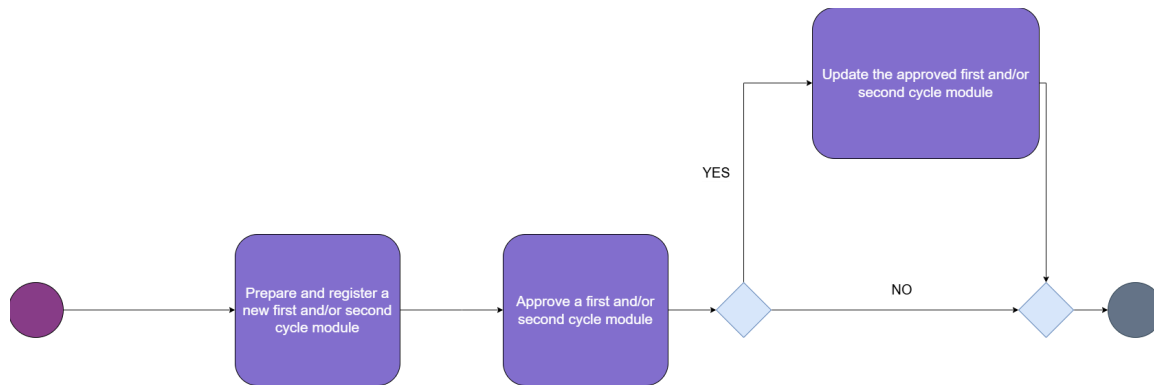
This section presents the detailed processes involved:

-  Framework for registering, approving and updating modules
-  Preparing and registering new modules (including detailed preparation, compliance checks, committee submission and registration)
-  Approving prepared modules (reviews, corrections, and re-approval of existing modules)

3.1.1 Register and Approve the First and Second Cycle Study Modules and Micromodules

This process provides the overall framework for creating, approving, and updating new study modules (Bachelor's, Master's, or micromodules). Every study module undergoes a formalised

process of creation, approval, and quality assurance before being added to the official academic curriculum.



Process steps:

1. The process begins when there is a need for a new study module or a revision of an existing one.
2. A new first- or second-cycle module is prepared by the responsible academic staff and registered in the university's Academic Information System (AIS).
3. The proposed module is submitted for approval by the relevant committees or bodies.
4. If approved, the module will be included in the official study offer and can be updated later.
5. If not approved, the module is either sent back for corrections, or the process ends without approval.
6. Approved modules may be updated when necessary, ensuring that changes are also subject to validation.

3.1.2 Prepare and Register a New First and/or Second Cycle Module

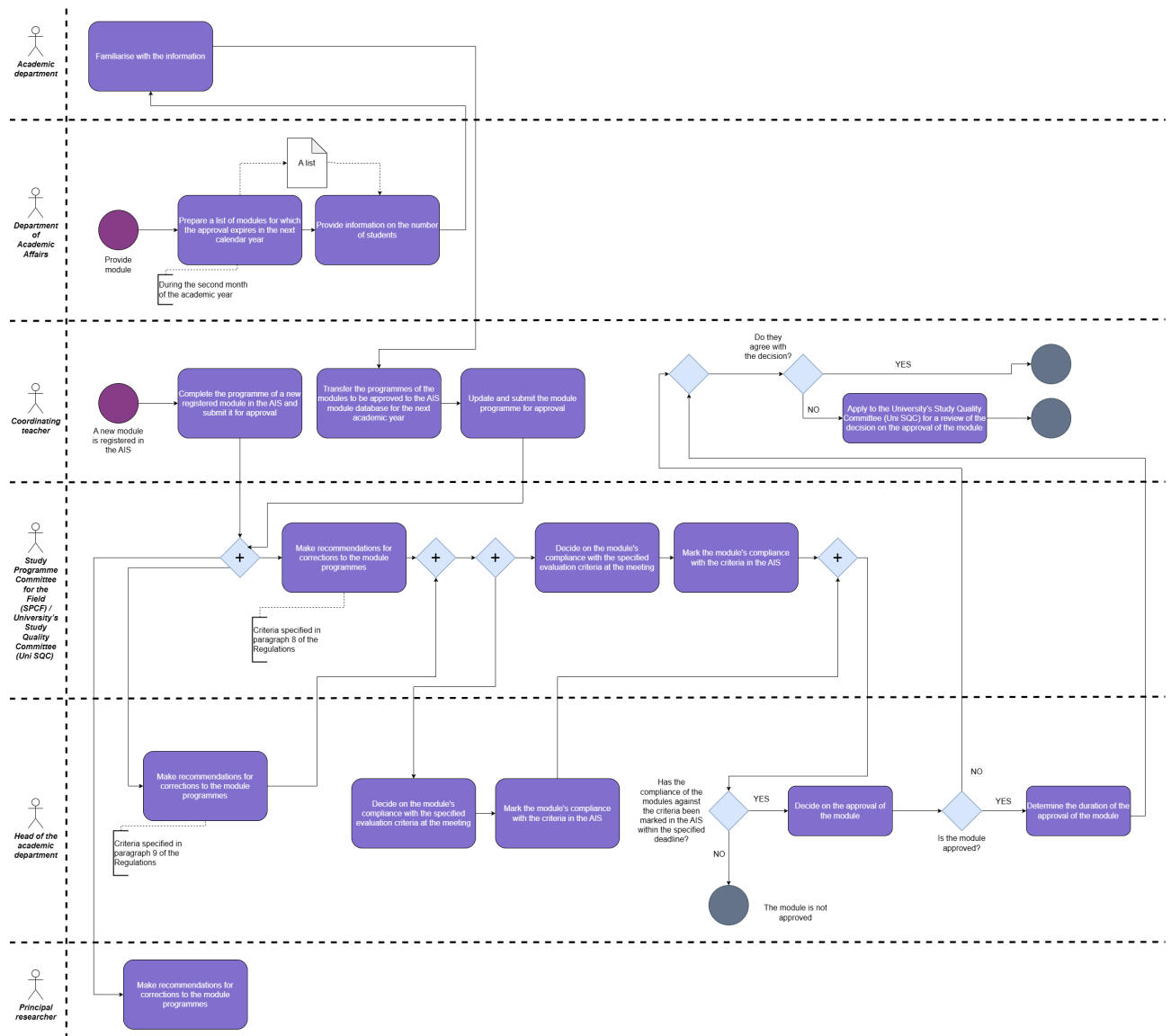
This process goes deeper into the practical steps of preparing a new module. The purpose is to ensure that new modules are systematically reviewed, meet academic standards, and are registered adequately before being offered to students.

1. Academic staff propose and prepare a draft of the new module according to established criteria (learning outcomes, workload, content, alignment with programme goals).
2. The draft is discussed at faculty or departmental meetings. Decisions are made on whether the draft is ready to proceed further.
3. If the proposal is not suitable, it is rejected.
4. If suitable, it is submitted for further evaluation at a higher level (see step 5).
5. The module is checked for compliance with university and national requirements (e.g., credit structure, content standards).
6. If non-compliant, then it is returned for correction.
7. If compliant, then it is submitted formally.

8. The draft new module is submitted to central committees (e.g., University Study Committee, RSMK) for consideration.
9. If approved, then the module is registered in the AIS.
10. If not approved, then the draft must be revised.
11. Once approval is granted, the module is formally registered in the Academic Information System.
12. At this point, the module becomes part of the official list of university modules, with its credit volume confirmed.

3.1.3 Approve a First and/or Second Cycle Module

This process describes how existing modules (already created and previously approved) are periodically reviewed, corrected if necessary, and re-approved. The purpose is to ensure that only high-quality, compliant modules remain in the study offer, thereby guaranteeing continuous quality assurance of the curriculum.



The process:

1. A list of modules due for approval in the upcoming academic year is prepared.
2. Additional information is gathered (e.g., number of students, demand, relevance).
3. The programme for the module has been completed and submitted to the AIS for review.
4. Committees or reviewers evaluate the module according to criteria (quality, relevance, compliance with regulations) and may provide recommendations for corrections.
5. If corrections are requested, the module is revised and resubmitted for review.
6. At the official meeting, compliance is assessed, and a decision is made regarding the approval of the module.
7. If compliant and of sufficient quality, then the approval is granted.

8. If not, then the module is either rejected or sent back for revisions.
9. If approved, the module is marked as compliant in AIS and included in the academic offer.
10. If not approved, then it may be returned for additional corrections or removed.
11. For approved modules, the validity/approval duration is specified (i.e., the number of years the module remains approved before re-evaluation is required).

3.1.4 Formal information for registering a new module

The module registration form used in the academic system captures all essential information required to ensure that a module is clearly defined and consistent with programme requirements. It includes the module title, prerequisites, aims, intended learning outcomes, content description, EQF level, syllabus structure, reference materials, language of instruction, and study mode. It also specifies the methods of organisation, assessment procedures, and approaches for evaluating independent learning and student achievement.

Once this information is approved, the instructor can create the corresponding course within the learning management system and upload the teaching and learning materials. The course content then undergoes a separate approval process using the criterion table outlined in Section 4.1.5.

Information for the academic system	Related to FuturEng?	Comments
1. General information:		
1.1. Module title	y	The FuturEng course title is “FuturEng: Shaping Engineers of Tomorrow”, but it is possible to adapt the title to a specific study programme.
1.2. Prerequisites for studies	y	Prerequisites are provided in the FuturEng course description.
1.3. Aim of the module	y	The aim of the module/course is provided in the FuturEng course description (see Goal).
1.4. Intended learning outcomes of the module, applied study, and assessment methods for student achievements	y	Intended outcomes are provided in the FuturEng course description (see Outcomes).

Information for the academic system	Related to FuturEng?	Comments
1.5. Description of the module	y	The module/course description is provided in the FuturEng module description (see Description).
1.6. Level of module	y	Bachelor's/master's/PhD level. The FuturEng project offers modules for all levels. The teacher should choose appropriate modules or topics from the course and control the depth of the materials and exercises.
1.7. Syllabus	y	The syllabus of the module/course is provided in the FuturEng course description (see Modules).
1.8. Procedure for knowledge and skills assessment	n	The teacher selects the procedure for knowledge and skill assessment in a similar form: the ten-grade scale and the cumulative evaluation system are applied. The module's final evaluation is the sum of the multiplications of the grades for the intermediate assessments and the final assessment, each multiplied by a weighting coefficient (a percentage component).
1.9. References	y	References are provided within lectures and their activities. Also, it is provided in the FuturEng course description.
1.10. Languages of instruction	y	The content is available in these languages: English, Lithuanian, Greek, Romanian, and Bulgarian.
1.11. Form of studies	y/n	The FuturEng course was created as a MOOC course, but it can be adapted to virtually any form of study.
1.12. Organisation method for studies	n	The FuturEng course does not dictate methods for studies.
1.13. Assessment of independent work	n	The FuturEng course does not dictate assessment of independent work, although

Information for the academic system	Related to FuturEng?	Comments
		there are guidelines for webquest assessment.
1.14. Assessment strategy for student achievements	n	The FuturEng course does not dictate an assessment strategy for student achievements.

3.1.5 Requirements for e-course content

The course evaluation form is a structured instrument used to assess the quality of e-courses that support study modules. Although each university uses its own version, the core criteria are generally comparable. The form is typically divided into sections such as general information, study materials, teaching and learning methods, student assessment, learner support, and information culture. These criteria ensure that the course is complete, pedagogically robust, and compliant with institutional standards.

The form helps reviewers verify alignment with the corresponding study module, the appropriateness and variety of teaching and assessment methods, opportunities for student engagement, and both the technical and stylistic quality of the course.

The table below provides an overview of the FuturEng course and indicates where detailed information can be accessed.

Criteria for the e-course of the study module	Related to FuturEng?	Comments
1. General information:		
1.1. Title, code, volume in credits of the study module, language of instruction, organisation method.	y	This information is provided in a course description.
1.2. Information about the teacher(s): name, surname, position, contact details, workplace, time, and method of individual consultations (on-campus (indicating location) or distance (specifying link)). In addition, a link to the teacher's profile on the University's website and/or other information requested by the teacher may be provided.	n	The lecturers provide the details themselves.

Criteria for the e-course of the study module	Related to FuturEng?	Comments
1.3. An annotation of the study module (in line with the study module programme (hereinafter – SMP) in the University's Academic Information System (hereinafter – AIS) and a link to the SMP in the University's AIS.	y	It is an annotation from the course description.
1.4. A presentation of the study module (in the form of slides, figures, video, audio, etc.) focusing on presenting the relevance of the study module.	y	There is a video in the FuturEng module 1 that presents a study module.
1.5. A plan for the delivery of the study module, including deadlines for topics and assessments (in line with the SMP), and participation (attendance) requirements (in line with the SMP).	n	The lecturer provides details in accordance with university regulations and their own preferences.
1.6. Substantial feedback comments based on the results of the module quality and teacher survey in the University's AIS, round tables, and discussion groups. It is recommended to give feedback comments annually, using a table containing the year of the module delivery, student suggestions, and the teacher's feedback comments.	n	The lecturer provides details in accordance with university regulations and their own preferences.
2. Study material:		
2.1. The required and additional literature used in the study module (online links, files, or information on physical/virtual availability of literature), and the sources of the literature are consistent with those specified in the SMP.	y	Additional literature, links, and files are presented in the FuturEng course.
2.2. Lecture material prepared by the teacher.	y	Course material is available for teachers to use in their modules.
2.3. Video material (may include video recordings of lectures) and illustrations.	y	The course contains a substantial amount of video material that can be reused in the course.
2.4. The expected learning outcomes for each topic.	y	Each lecture includes a description and outcomes.
2.5. Copyright requirements are met, and learning resources, both those produced by the teacher and the material by other authors used in the course, are properly described and cited.	y	Copyright info is provided in a separate file.
2.6. At least 3 different formats of learning resources are used (e.g., lecture slides, recordings, internet sources, handouts).	y	Video material, slides with text, internet sources, and web quests are provided in the FuturEng course.
3. Study methods:		

Criteria for the e-course of the study module	Related to FuturEng?	Comments
3.1. Synchronous work is applied according to the University's AIS timetable, and links are provided for accessing the synchronous distance classes.	n	The existing FuturEng course is not directly related to synchronous work. The teacher should relate FuturEng content to synchronous meetings.
3.2. Passive learning methods (for example, reading, watching videos, listening to audio recordings) are used.	y	The FuturEng course allows watching (and listening to) videos, provides text for readers, and slides (with comments) for visuals.
3.3. Active learning methods (for example, case studies, collaborative learning, teamwork, modelling, debates, design thinking, journaling, discussion, film/project making (production of video material), group/team projects) are used.	y	Provided webquests serve as the primary active learning method. It can be used in conjunction with case studies (presented in the webquest material), teamwork, collaboration, and discussion.
3.4. Methods of students' independent work (for example, tests, reflections, practice exercises) are used.	y	In the FuturEng course, there are tests for each lecture. Also, webquest material can be used for independent work.
3.5. Virtual collaborative boards (for example, "Miro", "Microsoft Whiteboard") and/or collaborative documents (for example, "Wiki") are used.	n	The FuturEng course itself does not include virtual boards. The lecturer should decide whether to use virtual boards and incorporate them into the learning environment.
3.6. Each activity is described in detail, specifying its purpose, procedure, and deadline, and the tools needed for completion.	y/n	The FuturEng course describes activities in detail that are not typically found in a standard study process (for example, webquests). The teachers themselves should set deadlines.
3.7. At least 3 different study methods are used for different assignments (for example, group project, individual project, project, laboratory works, practical assignments, seminar, readings).	n	The teachers themselves should decide on different assignments that may be supported by FuturEng material.
4. Evaluation of student achievements:		
4.1. The evaluation methods used are in line with those set out in the SMP.	n	The FuturEng course does not dictate evaluation methods, although evaluation criteria are provided in some activities, such as webquests.
4.2. The evaluation tools (assignments, activities) used allow the evaluation of the expected learning outcomes of the study module.	y	The FuturEng course includes tests that allow evaluation of the expected learning outcomes.
4.3. The information and communication technologies used ensure the academic integrity of students.	n	The teacher should select the information and communication

Criteria for the e-course of the study module	Related to FuturEng?	Comments
		technologies in accordance with university regulations.
4.4. The evaluation procedures and criteria are specified for each assignment/activity.	n	The teacher should select procedures and criteria specified for the assignment/activity in accordance with university regulations.
4.5. If a written work has to be submitted, it is subject to a similarity check using the "Turnitin" tool.	n	This requirement is specific to KTU and may differ for other universities.
4.6. Evaluation rubrics ("Moodle" or "Turnitin" tools) or an evaluation guide (text format) are used.	n	This requirement is specific to KTU and may differ for other universities.
4.7. The "Moodle" gradebook is used, and it is in line with the grading system defined in the SMP.	n	This requirement is specific to KTU and may differ for other universities.
4.8. Formative student evaluation tools are used to help students monitor their learning progress (for example, "Mentimeter", "Socrative", "Kahoot", etc.).	n	The teacher should select which formative student evaluation tools to use in accordance with university regulations.
4.9. Student self-assessment tools (for example, reflection, self-assessment tests, or questions) are used.	y	The FuturEng course includes tests for self-assessment activity.
4.10. "Moodle" measurement of student progress is used (mandatory for assessments, recommended for other activities).	n	The teacher should decide whether to use Moodle for the measurement of student progress in accordance with university regulations.
4.11. The use of student evaluation and self-assessment tools supports student learning (for example, if an answer is incorrect, instructions on what to read again, or an explanation of why the answer differs from the one the student gave).	y	The tests include self-assessment support with explanations.
4.12. At least 3 different methods are used for the evaluation of student achievements in different assignments (for example, examination, paper, semester paper, midterm examination, work portfolio, test).	n	The teacher should determine which methods to use for evaluating student achievements in accordance with university regulations.
5. Support for students:		
5.1. Recommendations on how to work with the study material.	y	There is a video in the FuturEng module 1 that presents how to work with study materials.
5.2. A description of the technical requirements for student participation in distance learning.	n	The teacher should determine and describe the technical requirements in accordance with university regulations. The FutureEng course should be available on the most

Criteria for the e-course of the study module	Related to FuturEng?	Comments
		common devices, such as PC, laptops, tablets, and smartphones.
5.3. Additional tools are used to encourage student involvement (for example, discussions and badges).	y	The FuturEng course includes discussions and badges.
5.4. At least 2 different methods of communication with students are used (for example, discussion forum, email consultations, face-to-face consultations).	y/n	The FuturEng course includes a discussion forum; however, the teacher should decide on the communication channels in accordance with university regulations.
6. Information culture:		
6.1. The overall appearance of the course is aesthetically pleasing and stylistically coherent.	y	The FuturEng course material is aesthetically pleasing and stylistically coherent. The quality was evaluated by conducting a peer review.
6.2. The structure of the course is based on the University's standard developed by the e-Learning Methodology Office. The structure of the course is arranged coherently, optionally by the topic of the study module, by subject, or by week. All parameters are in line with the SMP.	n	This requirement is specific to KTU and may differ for other universities and institutions. Teachers should adopt the FuturEng content in accordance with university regulations.
6.3. Textual, visual, or audio material is easily accessible and of good quality.	y	The quality of the FuturEng course material was validated through internal peer review.
6.4. The design of study materials and/or presentations produced by the teacher is coherent and consistent with the University's style guidelines. Each format of text or image resource produced by the teacher uses the University's logo and title. For student presentations, it is recommended to use the University's template.	n	This requirement is specific to KTU and may differ for other universities and institutions. Teachers should adopt the design of FuturEng content in accordance with university regulations.
6.5. Textual information is presented in the correct language without any errors in grammar, syntax, and/or style.	y	The FuturEng course language quality was validated by internal peer review.
6.6. Personalised, student-centred language is used, using active verb forms (for example, solve, use, assess).	y	The FuturEng course language is of good quality. It was validated by internal peer review.

3.1.6 FuturEng course description

Title	FuturEng: Shaping Engineers of Tomorrow	
Description	This course introduces the technologies and ideas behind Industry 5.0 and the twin transition, showing how digital innovation can support both people and the planet. You'll explore key deep-tech enablers - such as AI, immersive technologies (VR/AR), robotics, IoT, big data, and blockchain - with concrete examples from sectors including health, manufacturing, and transport. Along the way, you'll learn the basics of AI and data (how they work, where they fail, and why ethics and bias matter), and see how digital tools can power greener, more circular business models. Finally, you'll examine social impacts (jobs, skills, inclusion, well-being) and learn about the practical importance of cybersecurity and privacy so that you can discuss and apply deep tech in an informed, responsible way in your future work.	
Duration/ Workload	1-6 months	
Prerequisites	Basic digital literacy (using a computer, web browser, and online tools) and the ability to read and discuss course materials in English and the native language. No prior coding or advanced math is required.	
Goal	Enable students to understand and explain the main Industry 5.0 and deep-tech enablers (AI, data, immersive technologies, robotics, IoT, and blockchain), relate them to the digital-green twin transition, and critically assess their social, environmental, and ethical impacts to design responsible, human-centred engineering solutions.	
Outcomes	The outcomes are the elaborated competencies related to the goal. We use the EQF approach by defining outcomes using knowledge, skills and attitudes. These outcomes summarise all modules of the course. Find the descriptions of the outcomes in separate modules, if needed.	
	Knowledge	By the end of the course, students will be able to: • Explain the shift from Industry 4.0 to Industry 5.0 and Society 5.0, including the role of the twin transition (digital + green) and key EU policy frameworks such as the Green Deal and the Digital Decade. • Describe the main deep-tech enablers for Industry 5.0: AI, immersive technologies (VR/AR/MR), advanced 3D printing, advanced robotics, IoT/edge computing, blockchain/distributed ledgers, and big data/analytics, outlining their main applications, benefits and limitations in different sectors. • Distinguish core AI concepts and methods (e.g. weak vs. strong AI, ML, deep learning, NLP, computer vision), identify the key components of an AI system (data, models,

		outputs), and recognise common technical and ethical challenges such as data quality, bias and explainability. • Explain principles of circular economy, eco-design and twin-transition business models (e.g. product-as-a-service, industrial symbiosis), and how digital technologies support resource efficiency and low-carbon, circular value chains. • Summarise the main social, environmental, ethical, cybersecurity and privacy implications of disruptive technologies, including issues such as AI bias and discrimination, workforce transformation, digital inclusion, and the relevance of frameworks like the EU AI Act.
	Skills	By the end of the course, students will be able to: • Analyse real-world case studies and web-quest scenarios to assess how deep tech and AI contribute to Industry 5.0 goals, sustainability targets and organisational innovation. • Apply basic AI literacy in practice: identify suitable AI methods for a given problem, interpret AI system structures at a high level, and use prompt-engineering strategies to obtain more relevant and responsible outputs from AI tools. • Use systematic thinking to map how digital technologies, circular-economy strategies and policy drivers interact in twin-transition business models, and qualitatively evaluate environmental and economic implications. • Conduct structured, web-quest style research on emerging technologies (e.g. AI, IoT, robotics, blockchain), synthesise findings into posters, reports or presentations, and formulate evidence-based recommendations for organisations or stakeholders. • Identify social, ethical, environmental, cybersecurity and privacy risks in given scenarios and outline appropriate mitigation measures, action plans or design choices that support responsible, human-centred technology deployment.
	Attitudes	By the end of the course, students will: • Demonstrate curiosity and openness toward deep tech, AI and digital tools, while maintaining a critical mindset about hype, limitations and long-term impacts. • Value human-centric, ethical and inclusive approaches to engineering, recognising the importance of fairness, accessibility, wellbeing and digital equity when designing or applying new technologies. • Show a strong commitment to sustainability, appreciating how technological choices affect environmental outcomes and favouring solutions aligned with circular-economy and twin-transition principles. • Adopt a proactive, responsible stance on cybersecurity and privacy, treating protection of data and digital assets as a normal part of professional engineering practice.

		Exhibit a future-oriented, entrepreneurial and collaborative mindset—willing to work across disciplines, continuously update their skills, and act as change agents for sustainable, Industry 5.0-aligned innovation.
Modules	A course consists of five modules: Module 1 - Introduction to the course Module 2 - Deep Tech enablers for Industry 5.0 Module 3 - AI for Industry 5.0 Module 4 - Twin Transition enablers Module 5 - Social, environmental and ethical implications	

3.2 Offering Content as Microcredentials

Micro-credentials represent a flexible, market-responsive form of learning that supports rapid upskilling and reskilling in response to evolving competence needs (European Commission, 2022; OECD, 2023). As technological change accelerates, labour markets increasingly require specific skills that can be acquired quickly and updated frequently (Cedefop, 2023; OECD, 2021). Traditional higher education (HE) and vocational education and training (VET) systems often face lengthy approval cycles, making it difficult for them to respond at the required pace (EADTU, 2021).

Micro-credentials provide short, modular, and stackable learning opportunities that can be closely aligned with labour market demands (European Commission, 2022). Their rapid expansion, however, has resulted in a wide variety of models, formats, and certification systems (European Commission, 2022; ETF, 2023).

To improve comparability and recognition, recent efforts have focused on establishing shared principles for the design, implementation, and integration of micro-credentials. In 2022, the European Commission proposed an official definition:

a record of assessed learning outcomes based on a small volume of learning
(European Commission, 2022)

Since many micro-credentials originate from bottom-up initiatives outside formally recognised qualification systems, challenges remain regarding their quality assurance, credibility, and portability.

Recognition involves multiple actors — issuing organisations, learners, and stakeholder institutions such as HE providers, VET institutions, and employers (ETF, 2023). From an educational perspective, portability and stackability are critical; conversely, employers prioritise the reliability of micro-credentials in demonstrating relevant competences.

Although some countries are beginning to integrate micro-credentials into their formal qualifications systems, in most cases this development is still at an early stage (ETF, 2023). Nonetheless, several publications have proposed frameworks to support the adoption of micro-credentials. A commonly referenced roadmap treats provision and recognition as interconnected processes: designing micro-credentials with recognition principles in mind strengthens their acceptance later. The roadmap typically includes four stages: Preparation, Development, Certification, and Quality Assurance.

3.2.1 Preparation - Strategic Alignment

Before the development or adaptation of course content to a microcredential, issuing organisation should:

1. Define Microcredentials – establish a shared understanding of what constitutes a microcredential, clarifying its scope, target learners, intended outcomes, and credentialing format.
2. Ensure labour market relevance - Engage industry partners or employer representatives to validate the offer, ideally by aligning or through co-design of the learning content (ProToGo-YERUN, 2021).
3. Assure learner-centred focus - MCs should accommodate diverse learner profiles, enabling flexible participation alongside work and caring responsibilities (OECD, 2023). This generally entails designing blended or online learning formats.

3.2.2 Development - Curriculum and Structure Compliance

At the beginning of micro-credential development, two common approaches are used: unbundling existing study programmes or designing stand-alone courses.

Transparency and stackability

a. Define and publish learning outcomes

Learning outcomes should clearly describe what learners are expected to know, understand, and be able to do upon completion of the micro-credential (European Commission, 2022). They must align with the European Qualifications Framework (EQF) to ensure transparency in terms of knowledge, skills, and competences. Such alignment supports stackability across institutions and improves recognition by employers.

b. Credits and workload alignment

Micro-credentials should be aligned with established credit systems so they can be trusted and integrated into qualification frameworks. This facilitates learner progression between institutions and supports recognition for education and employment purposes (ETF, 2023).

Where formal credit transfer is not possible, documenting the workload — for example using ECTS or an equivalent system — strengthens transparency and credibility. One ECTS credit typically represents between 25 and 30 hours of total learning time. While there is no universal minimum, micro-credentials generally range from 1 ECTS to a volume smaller than a full degree (European Commission, 2020).

If credit alignment cannot be achieved, clarity remains essential — institutions should explicitly describe learning volume, learning outcomes, and assessment methods (ETF, 2023).

c. Design robust assessment strategies

Assessment is a defining feature of micro-credentials. Short learning experiences, including MOOCs, that issue non-assessed certificates do not meet the European definition of a micro-credential. Assessment strategies must:

-  Be published in advance
-  Align with the intended learning outcomes
-  Allow learners to demonstrate achievement levels
-  Follow recognised testing methodologies
-  Provide meaningful feedback to learners
-  Be applied consistently and fairly

When designing assessments, it is important to ensure validity by combining different methods, such as examinations, practical tasks, case studies, and portfolios, reflecting authentic workplace contexts (ETF, 2023; ProToGo-YERUN, 2021).

3.2.3 Certification — Portability and Recognition Procedures

To support recognition and portability, micro-credential providers must ensure that certificates are digitally verifiable, machine-readable, and interoperable across systems (ETF, 2023; microCredX, 2023).

3.2.3.1 *Standard Elements*

The Council Recommendation (Council of the EU, 2022) proposes a standardised presentation format for micro-credential certificates, including the following mandatory elements:

- Identification of the learner
- Title
- Country or region of the issuer
- Awarding body
- Date of issuance
- Learning outcomes
- Workload (in ECTS credits, where possible)
- EQF level
- Assessment method
- Mode of participation
- Quality assurance information

3.2.3.2 *Digital Verification*

To ensure authenticity, micro-credentials should include a digital signature, which verifies both the content and the identity of the issuing institution (ECampusOntario, 2021). It is recommended that micro-credentials adopt recognised data standards such as Open Badges, Comprehensive Learner Records, or European Learning Models, enabling credentials to be shared across interoperable platforms.

One example is the European Digital Credentials for Learning initiative, which applies structured data models compliant with European Learning Models and links credentials to the European Commission's accreditation database (ETF, 2023).

To support continuous improvement, verification procedures should incorporate feedback loops that inform future updates.

3.2.4 *Quality Assurance*

In line with European Commission recommendations (European Commission, 2022), micro-credentials should form part of institutional and external quality assurance processes. A comprehensive approach involves both:

- 🕒 Internal quality assurance — based on ESG principles, ensuring the overall quality of micro-credentials, course design, and learner feedback mechanisms (ETF, 2023)
- 🕒 External quality review — examining provider procedures and the effectiveness of the internal monitoring system

External verification should confirm that:

- ☆ Learning outcomes are clearly defined and applied
- ☆ Assessment reliably demonstrates achievement of those outcomes
- ☆ Feedback supports continuous improvement
- ☆ Relevant stakeholders are involved at each stage of development
- ☆ Courses are regularly evaluated
- ☆ Evaluation results are electronically accessible

Together, these mechanisms ensure that micro-credentials remain credible, trusted, and aligned with recognised qualification standards.

The following table summarizes the main steps for the design and implementation of microcredentials:

Phase	Action	Description
0. Preparation	Incorporate the MC initiative within the overall institution strategy.	Define the mc, clarifying its scope, target learners, and intended outcomes.
	Engage industry partners or employer representatives.	Design the program to be flexible and adaptable to changes in the labour market. Validate or co-design the learning content with external stakeholders to ensure labour market relevance.
1. Development	Define clear, measurable learning outcomes (los).	Ensure LOs are verifiable descriptions of knowledge, skills, and competences acquired. Capture the needs of industry and employers in the lo statements.
	Reference loss to standardized skill taxonomies.	Use descriptors like ESCO(european skills, competences, qualifications and occupations)

Phase	Action	Description
	Determine notional workload and credit alignment.	Use ECTS credits wherever possible for transparency and integration into qualification frameworks. Define the volume, typically ranging from 1 ects to less than a full degree (max 59 credits). If ECTS is infeasible, prioritise transparency regarding learning volume, outcomes, and assessment methods.
	Align to qualification framework (qf) levels.	Reference the learning experience to the NQF/EQF level (he levels 5-8 recommended).
	Design a valid assessment.	Non-assessed credentials (e.g., certificates of attendance) do not meet the standard eu definition. The assessment must be conducted against transparent and clearly defined criteria. Assessment must align with intended learning outcomes. Use methods such as projects, case studies, portfolios, or practical simulations that replicate authentic labour market scenarios. Publish assessment criteria and methods in advance.
2. Certification	Include all mandatory EU standard elements in the certified document.	The certified document must detail: learner id, title, awarding body, country/region of issuer, date of issuing, notional workload (in ects, wherever possible), and the type of quality assurance adopted.
	Issue micro-credentials as verifiable digital credentials.	Digital credentials must be machine-readable and interoperable across systems. Digitally sign credentials to ensure authenticity.
	Guarantee learner ownership and portability.	Credentials must be owned by the learner, shareable, and portable. Use structured data models (e.g., european learning model) to facilitate verification and portability.
	Publish the MC offer in accessible formats.	Ensure accessibility and effective outreach of information.

Phase	Action	Description
3. Recognition and value	If the MC documentation is transparent and complete, apply Standard Recognition Procedures.	MCs are in line with the Lisbon Recognition Convention (LRC) principles. This applies to MCs from HEIs and other entities whose standards are transparent
	If documentation is non-transparent, apply the recognition of prior learning (RPL) procedure.	The RPL/validation procedure is the default 'fallback' route for recognition when MCs lack transparent standard elements. This route is typically necessary for MCs issued by non-formal education providers
	Ensure recognition for employment purposes.	Collaborate with employers to secure recognition and acceptance.
4. Quality assurance	Implement Quality Assurance	QA procedures must be compatible with the ESG (Standards and Guidelines for QA in the EHEA

3.3 Exploiting Hybrids of FuturEng Content

The hybrid pathway provides a structured yet flexible approach for integrating FuturEng content into higher education, allowing institutions to respond quickly to labour-market changes while remaining compliant with European quality standards (ENQA, 2015; ESG, 2015). This pathway connects the pace of technological innovation with curriculum development cycles, ensuring that learners progressively build Industry 5.0 competences (European Commission, 2021; OECD, 2020).

Hybrid integration aligns with current European strategies that promote modularisation, stackability, and system-wide upskilling, ensuring that new learning can be implemented without large-scale programme restructuring (European Commission, 2022). It enables universities to test innovations on a small scale while maintaining clear pathways toward recognition, portability, and credit accumulation.

3.3.1 Preparation — Strategic Alignment

Before introducing hybrid components, institutions should:

-  Map FuturEng learning elements against existing curricula and strategic priorities
-  Engage internal stakeholders to determine curriculum ownership and workload implications

- ⌚ Consult employer and sector representatives to validate relevance and support co-design where possible (ProToGo–YERUN, 2021)
- ⌚ Ensure alignment with national and European frameworks such as EQF, Bologna Process transparency tools, and the Green Skills Agenda (European Commission, 2021b)

Strategic alignment ensures that hybrid delivery enhances — rather than fragments — programme coherence.

3.3.2 Development — Hybrid Curriculum and Structure Compliance

Hybrid integration can fall into three structural categories, each with distinct governance implications:

3.3.2.1 A) *Minor Changes*

Criteria:

- ⌚ No modification to learning outcomes
- ⌚ No change to credit value, level, or framework alignment
- ⌚ Only small shifts in delivery mode (e.g., increased blended elements)

Governance:

Department- or faculty-level approval (QAA, 2018)

Examples:

- ⌚ Inclusion of Industry 5.0 case studies in automation-focused modules
- ⌚ Short digital manufacturing practical activities

3.3.2.2 B) *Major Changes*

Criteria:

- ⌚ Learning outcomes revised and mapped to EQF and ESCO descriptors
- ⌚ Change to ECTS credit value or level
- ⌚ Module title updated to represent new scope

- ⌚ Significant delivery change (e.g., fully online transition)

Governance:

- ⌚ Programme validation including external expert review
- ⌚ Alignment with national qualifications frameworks
- ⌚ Quality assurance embedded from design stage (EQF Advisory Group, 2018)

Typical form:

- ⌚ Newly validated 5 ECTS interdisciplinary units
- ⌚ Stackable into micro-credentials or degree structures (European Commission, 2020)

3.3.2.3 C) Extracurricular Hybrids

Criteria:

- ⌚ Short-format learning offered outside formal programme structures
- ⌚ Non-formal paths leading to digital badges or recognition of prior learning (ETF, 2023)

Purpose:

- ⌚ Rapid piloting of FuturEng themes
- ⌚ Industry participation through hackathons, design sprints, and simulations (WEF, 2022)

3.3.3 Validation — Governance and Quality Assurance

Hybrid offerings must comply with institutional and European transparency principles:

- ⌚ Learning outcomes must be published, measurable, and assessable
- ⌚ Assessment must follow recognised standards and fairness requirements (EADTU, 2021)
- ⌚ Workload and notional hours clearly documented using ECTS conventions
- ⌚ Digital verification of achievements encouraged (microCredX, 2023)

Quality assurance involves:

- Internal QA — curriculum review, teaching evaluations, stakeholder feedback
- External QA — alignment with ESG and periodic audits (ENQA, 2015)

These mechanisms reinforce credibility, recognition, and learner mobility across Europe.

3.3.4 Delivery — Recognition and Portability

To protect learner progression and employment value:

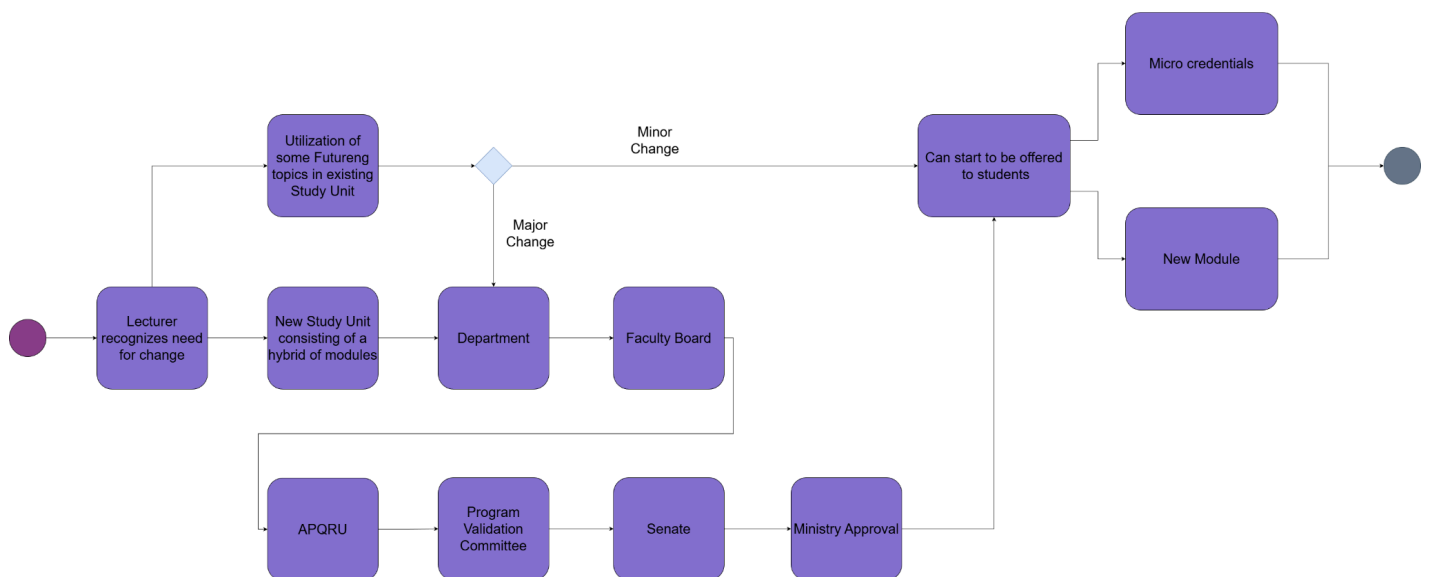
- Recognition should align with the Lisbon Recognition Convention principles
- Documentation must provide clear information on learning outcomes, assessment, workload, and EQF level (CIMEA, 2022)

Hybrid achievements can contribute directly to:

- Micro-credentials
- Recognition of prior learning (RPL)
- ECTS-accredited modules

Employer involvement in assessment and periodic review ensures continued relevance to labour-market needs (OECD, 2023).

Figure 4.3.5. Hybrid Pathway Curriculum Governance Decision Flow



This decision flow illustrates how FuturEng content may be introduced into higher education through either minor or major curriculum modifications.

When a lecturer identifies the need to embed FuturEng learning outcomes, the scale of change determines the pathway:

- Minor hybrid changes involve integrating elements of FuturEng into existing modules. These adjustments typically require only departmental or faculty-level approval before delivery to students.
- Major hybrid changes require the creation of a new module that integrates multiple FuturEng topics. This route must pass through formal quality assurance and institutional validation, including review by bodies such as the Department, Faculty Board, Programme Validation Committee, and Senate, and where applicable, approval by a national authority.

Successful approval through either route results in a recognised learning offer — either credit-bearing modules or stackable micro-credentials — aligned with European frameworks and recognition mechanisms.

3.3.5 Benefits of the Hybrid Approach

Stakeholder	Benefit
Students	Flexible access to Industry 5.0 competences and recognition through the accumulation of smaller learning blocks
Academics	A structured mechanism to innovate within established governance requirements
Industry	Early influence on talent development and access to learners with validated skills
Institutions	Scalable enhancement of programmes while maintaining ESG-aligned quality assurance

Hybrid pathways accelerate time-to-impact while ensuring long-term recognition, transparency, and sustainability.

4 Roadmap Timeline

The selected pathway will be implemented progressively, ensuring a balance between rapid innovation, rigorous quality assurance, and long-term sustainability.

4.1.1 2025–2026 (Pilot Phase)

- Launch short workshops, blended learning activities, and hackathons to provide early exposure to FuturEng content
- Embed selected FuturEng topics into existing modules as minor changes, enabling fast pilots without major curriculum restructuring
- Trial innovative assessment approaches such as case studies, prototype development, and reflective assignments
- Invite industry experts to contribute guest lectures that ensure immediate workplace relevance and strengthen collaboration with employers

4.1.2 2027 (Expansion Phase)

- Develop the first dedicated 5 ECTS interdisciplinary modules that combine multiple FuturEng themes into coherent courses
- Offer these modules both as degree-integrated study units and as standalone micro-credentials aligned with European qualification frameworks
- Increase industry participation in assessment, including co-evaluation of presentations, case studies, and project outcomes
- Expand blended and online delivery formats, supported by institutional and national quality assurance procedures

4.1.3 2028 onwards (Scaling and Consolidation)

- Roll out validated modules across a wider range of programmes and institutions, supporting cross-border portability through Erasmus+, EQF, and ECTS recognition
- Establish guest lectures and jointly developed industry challenge briefs as standard elements of hybrid modules
- Introduce long-term monitoring using pathway-specific indicators such as student participation, micro-credential uptake, cross-border learner mobility, and graduate employment in Industry 5.0 sectors
- Maintain continuous improvement through structured feedback from students, academic teams, industry representatives, and external reviewers

This phased roadmap ensures that FuturEng hybrid pathways evolve from low-risk pilots to validated modules and ultimately to sustainable, cross-border educational provision, while keeping industry engagement and assessment innovation central throughout.

4.1.3.1 Suggested Guidelines for institutions

Year / Phase	University Responsibilities (KPIs vary dependant on pathway chosen)	Expected Outcome
2025–2026 (Pilot Phase)	Deliver a minimum number of pilot workshops, hackathons, or challenge sprints embedding FuturEng content Update at least two existing study-units with FuturEng topics (minor changes) Ensure at least one extracurricular (e.g. badge-based activity) is launched Invite industry experts to contribute to at least one lecture or seminar	Students gain early exposure to Industry 5.0 Institutions test content relevance First industry-academia link established
2027 (Expansion Phase)	Develop and validate at least one new study-unit (approx. 5 ECTS) integrating FuturEng content Introduce at least two microcredentials aligned with EQF/ECTS Integrate guest industry experts in delivery or co-assessment of hybrid modules Expand assessment beyond exams to include projects, case studies, or prototypes	First wave of study-units formally embedded Microcredentials recognised across borders Students assessed on applied Industry 5.0 competences
2028 onwards (Scaling & Consolidation)	Ensure the adoption of at least five hybrid study-units across degree programmes	Widespread institutional adoption of FuturEng

Year / Phase	University Responsibilities (KPIs vary dependant on pathway chosen)	Expected Outcome
	Offer microcredentials to external learners and professionals beyond enrolled students	Lifelong learning pathways open for professionals
	Facilitate cross-border credit recognition and mobility for students completing FuturEng hybrids	Cross-border recognition secured
	Conduct graduate tracer studies to monitor outcomes in digital and green sectors	Evidence of graduates applying Industry 5.0 competences

5 Conclusion

The proposed pathways demonstrate how FuturEng content can be integrated into higher education in ways that are both flexible and robust. By distinguishing minor curriculum changes, which enable rapid piloting, from major changes that lead to validated study units and micro-credentials, the roadmap provides a phased approach that supports innovation while respecting academic standards.

Institutions play a central role in implementing this pathway. They are responsible for delivering pilot activities, updating existing modules, validating new hybrid courses, and ensuring that micro-credentials are recognised across borders. This responsibility extends beyond teaching, requiring the engagement of quality assurance teams, external reviewers, and national authorities to guarantee credibility and portability.

The involvement of industry — through guest lectures, co-designed challenges, and joint assessment — ensures that learners gain not only academic knowledge but also practical skills linked to real workplace needs. This direct connection with employers enhances graduate employability and strengthens confidence in the FuturEng framework.

By combining pilots, validated modules, micro-credentials, and extracurricular learning opportunities, institutions can offer learners a clear progression pathway: from initial exposure to Industry 5.0 competences, through stackable recognition, to fully credited study units embedded within degree programmes. This creates a sustainable ecosystem in which learning remains portable, industry-aligned, and continuously updated to reflect evolving technological and societal demands.

Through this approach, FuturEng prepares Europe's future engineers to design and deliver solutions that are not only technically advanced but also human-centred, environmentally responsible, and resilient to future challenges.

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