PROPOSAL FOR A SUSTAINABLE COMPETENCY FRAMEWORK FOR ENGINEERING STUDENTS

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Abstract

In this article, we present our approach to integrating sustainability principles into engineering education. This is achieved by offering Open Educational Resources (OER) at three levels: basic, advanced, and integrated or proficiency. This is intended to help educators and institutions to best suit their specific programs and classes.

To define the framework underpinning the program, a comprehensive set of competencies has been developed to guide the integration of sustainability into engineering curricula across all disciplines. Twelve competencies have been created based on the UNESCO and EU Recommendations for Engineering Education on Sustainability and on our findings from a study of the status of higher education institutions in Europe and the demands posed by real-world challenges. This competency framework, supported by a set of skills and knowledge and understanding, and driven through consistent pedagogies, offers a coherent roadmap for preparing professionals who can actively contribute to the achievement of the SDGs, embedding systems thinking, the inclusion of diverse knowledge systems, responsible innovation, and collective action. This approach is the goal of the EESF project (Enginering Education for a Sustainable Future), an international collaboration, funded by the European Union, Erasmus +.

This article presents the process of refining the sustainable competencies to twelve, organizing them into four blocks or modules: Holistic Engineering for Impact: Integrating Systems Thinking, Social Responsibility, and a Multidisciplinary Approach; Transversal Skills for Leadership in Sustainable Engineering; Life Cycle Analysis; and Innovation for Global Challenges. Our goal is to offer diverse, ready-to-use resources that any teacher can use as microlearning integrated into regular classrooms for any subject. The discussion presents the key elements considered and the interdisciplinary work carried out with the contributions of the project partners.

Keywords: Sustainable Competencies, Sustainable Engineering, SDGs, OERs for Engineering.

1 INTRODUCTION

The European Union is committed to transforming the social, economic, and productive systems toward a sustainable model within the framework of the 2030 Agenda for Sustainable Development, which includes the 17 Sustainable Development Goals (SDGs). The European Green Deal [1], a strategy aimed at making the EU a climate-neutral, sustainable, and prosperous economy by 2050, identifies education as a key sector that must undergo comprehensive change. To this end, the EU has developed the GreenComp sustainability competency framework [2], which establishes the principles that should inspire education at all levels. Ideally, this process should lead to a unified and consistent approach to education across Europe. In this context, UNESCO has created a reference framework for higher education in engineering, outlining the sustainability competencies that engineers must develop [3].

Research on the integration of sustainability into education highlights the need to strengthen students' ability to discuss sustainability, embracing the complexity of the issues and diverse perspectives. Beyond to communication skills, it is also essential to reinforce transversal competencies such as leadership and project management [4][5][6][7][8].

The nature of sustainability challenges demands holistic integration across disciplines, whether through collaborative interdisciplinary efforts or multidisciplinary training that provides students with a broad and balanced understanding of the issues [9][10].

Advancing teaching methodologies and promoting greater student engagement with sustainability through real-world practical activities is essential [6][11]. Collaboration between universities, companies, non-

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governmental organizations, and institutions has yielded promising results in helping students become aware of the opportunities offered by sustainability and fostering greater social commitment [12].

Within European engineering schools, initiatives have emerged both at the institutional level and among faculty members. In some cases, curricula have incorporated the need to establish connections between student activities and the SDGs. The creation of courses addressing sustainability topics has proven to be a valuable approach, yielding positive outcomes in engineering disciplines [5][6]. However, a well-structured framework that can be adopted by engineering schools across all European countries has yet to be developed [13][14].

The EESF project aims to create a training package suitable for integrating sustainability into higher engineering education, applicable across all specialties and throughout Europe. This package is delivered by undergraduate educators and integrated into regular classroom instruction using Open Educational Resources (OERs).

This paper presents the development of a methodological framework for sustainability training in European higher engineering schools, designed in a versatile format compatible with teaching and learning processes, aligned with the OER model and the European Higher Education Area.

2 METHODOLOGY

To achieve the objectives of this research, a multi-stage methodology was followed to acquire a theorical foundations and empirical insights, ensuring that the proposed framework is robust, representative and aligned with the needs of European engineering education. The methodology follows a 4 steps structure:

Literature Review: A literature review was conducted to identify existing initiatives related to sustainability in engineering education. These include university activities, the creation of dedicated institutional units, and classroom activities aimed at embedding sustainability into learning process

Interviews: A total of fifty interviews were conducted with individuals holding positions in the professional and academic fields. Participants included faculty members, academic managers, accreditation agency officials, and executives from companies working in the field of sustainability and ecological transition. The interviewees came from various engineering fields to ensure sufficiently representative results.

The interviews were conducted either in person or online video call. A structured set of questions was applied, focusing on the current situation and recommendations to foster change. Three different survey models were developed and used, depending on the interviewee's professional profile. Project partners dedicated to research and teaching conducted the interviews in their respective countries

Validation: After data collection, the interview data underwent a review and validation process carried out by a fifth project partner who had not participated in the interviews, ensuring objectivity and consistency.

Collaborative Work: Collaborative sessions were organized to synthesize the findings and define the main guidelines for the development of the OERs. These sessions drew on the results of both the literature review and the interviews, ensuring that the resources were grounded in evidence and reflected diverse perspectives.

3 RESULTS

In this section, we present the current state of sustainability education in a relevant sample of European higher engineering schools.

There is a need to advance in standardizing both training and assessment in sustainability. To this end, a fundamental aspect is the creation of a framework of competencies, skills, and knowledge, together with appropriate pedagogical methodologies (hybrid, in-person, online) and active learning (such a learning pyramid). This approach allows these competencies to be incorporated into existing curricula within the processes of curriculum modification, as they are structured with the same framework and format.

3.1 Key topics for the implementation of a framework for OERs

The EESF project has conducted an extensive review of current practices and approaches for integrating sustainability into engineering education, with the participation of project partners dedicated to research and teaching. Academic literature has shown that teachers, companies, students, governments, and associations all have an interest in ensuring that higher engineering education takes steps to integrate sustainability into their programs and courses.

This conclusion has been reinforced by the results of the surveys. From the perspective of academia, companies, and quality accreditation agencies, it has been possible to specify the real needs of the engineering sector and the current profile of graduates in relation to those needs.

Our research not only addressed the current situation but also gathered information on how to improve the current state and optimally integrate sustainability mindsets, skills, knowledge, and competencies into engineering education, as well as the challenges to achieving this.

The results of this phase are collected in the Engineering Education for Sustainable Future: Discovery Report [15] and have been summarized in the following findings:

Current irregular implementation:

This occurs especially at the undergraduate level, although many universities offer master's degrees specializing in sustainability within various engineering fields. Some institutions, such as Atlantic Technological University (ATU) in Ireland or Université d'Aix Marseille in France, and faculty members have reported that while sustainability is integrated into their modules, this integration is not intentional or systematic across all courses. At Universidad Politécnica de Madrid (UPM), the institution actively embeds sustainability across student activities, teaching, and environmental improvements in various facilities.

Incomplete sustainability training among graduates:

From the employers' perspective, it has been reported that sustainability training among graduates is incomplete. Engineering associations call for greater standardization of training and emphasize the importance of real-world experiences.

Resistance to change:

Institutions are resistant to making changes in curricula. Additionally, interviewed professors agree on the lack of specific funding to support sustainability initiatives. Based on the current situation and considering the results of the literature review on best practices in sustainability education in engineering, a series of work streams have been established to develop the OERs. The final recommendations obtained in the EESF project from this review establish several key points to be considered.

Develop Sustainability-Oriented Mindsets in Students

First, there is a need to articulate sustainability training models that place the development of a sustainable mindset at the center, an attitude sustained through ethical decisions and systems thinking with a multidisciplinary approach. This sustainable mindset enables the identification of relationships between society and engineering. Around this core, technical and leadership skills must be developed. Specific knowledge areas related to sustainability that should be incorporated into training are also identified.

Integrate Comprehensive Sustainability Knowledge Across Engineering Curricula

Second, a broad base of knowledge is required regarding the environment, economic and business responsibility, and social responsibility. This set of skills and knowledge is important not only in each domain but also in their interrelationships.

Train Students in Sustainability-Related Skills

Third, it is necessary to equip students with skills such as data analysis, simulation tools, Life Cycle Analysis, and energy efficiency, in alignment with sustainability principles and the SDGs.

3.2 Integrating Sustainability into Engineering Education: Defining the Principles of a Comprehensive Competency Framework

Given the acceleration of global challenges—climate change, resource depletion, social inequality, and environmental degradation—engineering education must evolve to prepare professionals capable of designing solutions that are not only technically sound but also ethically responsible and environmentally sustainable. To achieve this, a comprehensive set of competencies has been developed to guide the integration of sustainability into engineering curricula across all disciplines.

At the core of this framework is the ability to understand and reduce the carbon footprint associated with energy systems. Engineers must be able to evaluate energy sources not only in terms of efficiency and cost but also from the perspective of environmental impact, applying fundamental energy principles and comparative analyses. This understanding extends to the transportation sector, where engineers are called upon to innovate in logistics, mobility, and tourism systems to reduce emissions and improve sustainability.

Equally crucial is the ability to design sustainable and resilient infrastructures and urban environments. This involves anticipating climate change risks, promoting distributed renewable energy systems, implementing circular supply chains, and integrating nature-based solutions. These approaches require a deep understanding of the life cycle of products and processes. Engineers must master Life Cycle Assessment (LCA) methodologies, be able to quantify environmental impacts, and incorporate risk analysis to ensure long-term sustainability.

Resource efficiency is another pillar of this competency framework. Engineers must be trained to optimize energy use and material selection, integrating renewable resources and sustainable manufacturing practices that prioritize durability, recyclability, and minimal environmental impact. These technical skills must be complemented by the ability to manage projects with a focus on sustainability: strategic planning, risk mitigation, and alignment of initiatives with relevant policies, regulations, and certifications.

In addition to technical expertise, engineers must also develop leadership skills to drive transitions toward sustainability within organizations. This includes ethical decision-making, the implementation of corporate social responsibility (CSR) strategies, and an understanding of the financial and business dimensions of sustainability. Strategic foresight becomes essential, as engineers must anticipate long-term trends, assess geopolitical and economic influences, and develop adaptive strategies to ensure resilience in a constantly changing world.

A systemic approach is fundamental in this educational model. Engineers must recognize the interdependence of environmental, social, and economic systems, designing solutions that respect planetary boundaries and acknowledge the finite nature of resources. Ethical and social responsibility must be present in every decision, ensuring that engineering practices promote environmental justice, equity, and accountability.

Finally, a truly global and inclusive perspective is essential. Engineers must be able to integrate cultural and multidisciplinary perspectives, including indigenous knowledge systems, to develop contextually relevant and globally applicable solutions. This holistic approach ensures that sustainability is not considered an add-on but a central element of engineering practice.

The integration of these interconnected topics into engineering education represents a transformative shift toward sustainability. By incorporating this framework into curricula, institutions can train engineers who are not only technically competent but also visionary, responsible, and capable of leading the transition toward a more sustainable and equitable future.

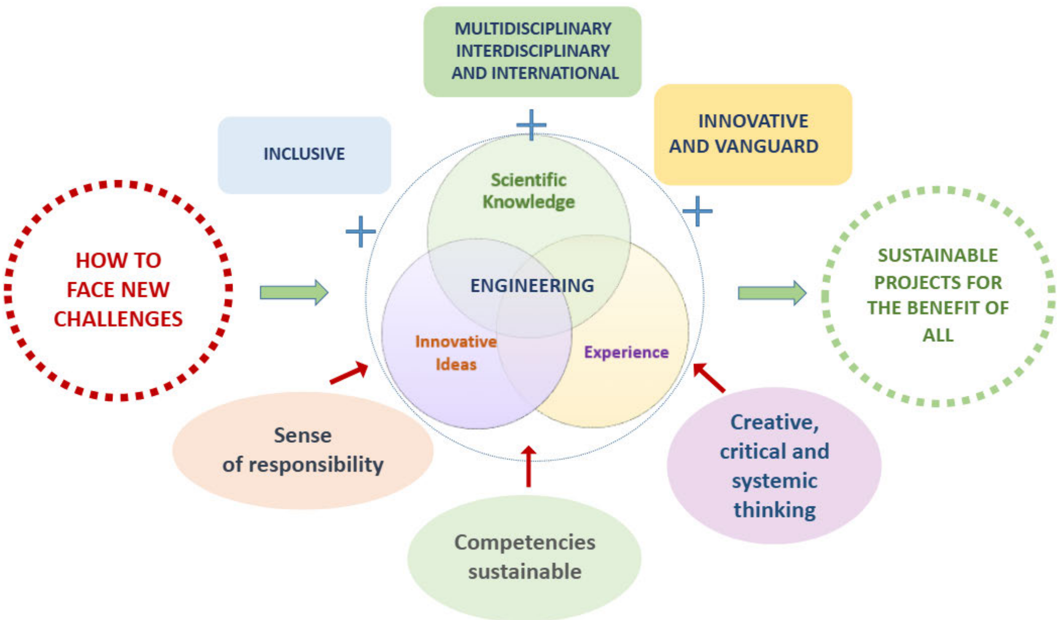

Figure 1. This diagram is the driving force of the proposal and brings together the results of the entire first phase of "discovery and research," including the report drawn up based on the interviews. Source: author

3.3 Framework of Twelve Competencies, Skills, and Knowledge

Competencies are defined as “articulated sets of knowledge, capacities, skills, dispositions, attitudes, and aptitudes that allow EEFS consortium to understand and analyze problems or situations, and to act coherently and effectively, individually or collectively, in specific contexts”[16].

They are assessed through learning outcomes and demonstrated by the ability to apply knowledge, skills, and personal, social, professional, and methodological abilities in work or study situations, as well as in professional and personal development. Competencies are inherent to individuals and are continuously developed through professional practice and lifelong learning.

Competencies and learning outcomes, which are sometimes used interchangeably, are the starting point and the core of any teaching process, as they define what we want the student to achieve at the educational level.

Therefore, learning outcomes are statements of what a student is expected to know, understand, and/or be able to demonstrate [17]

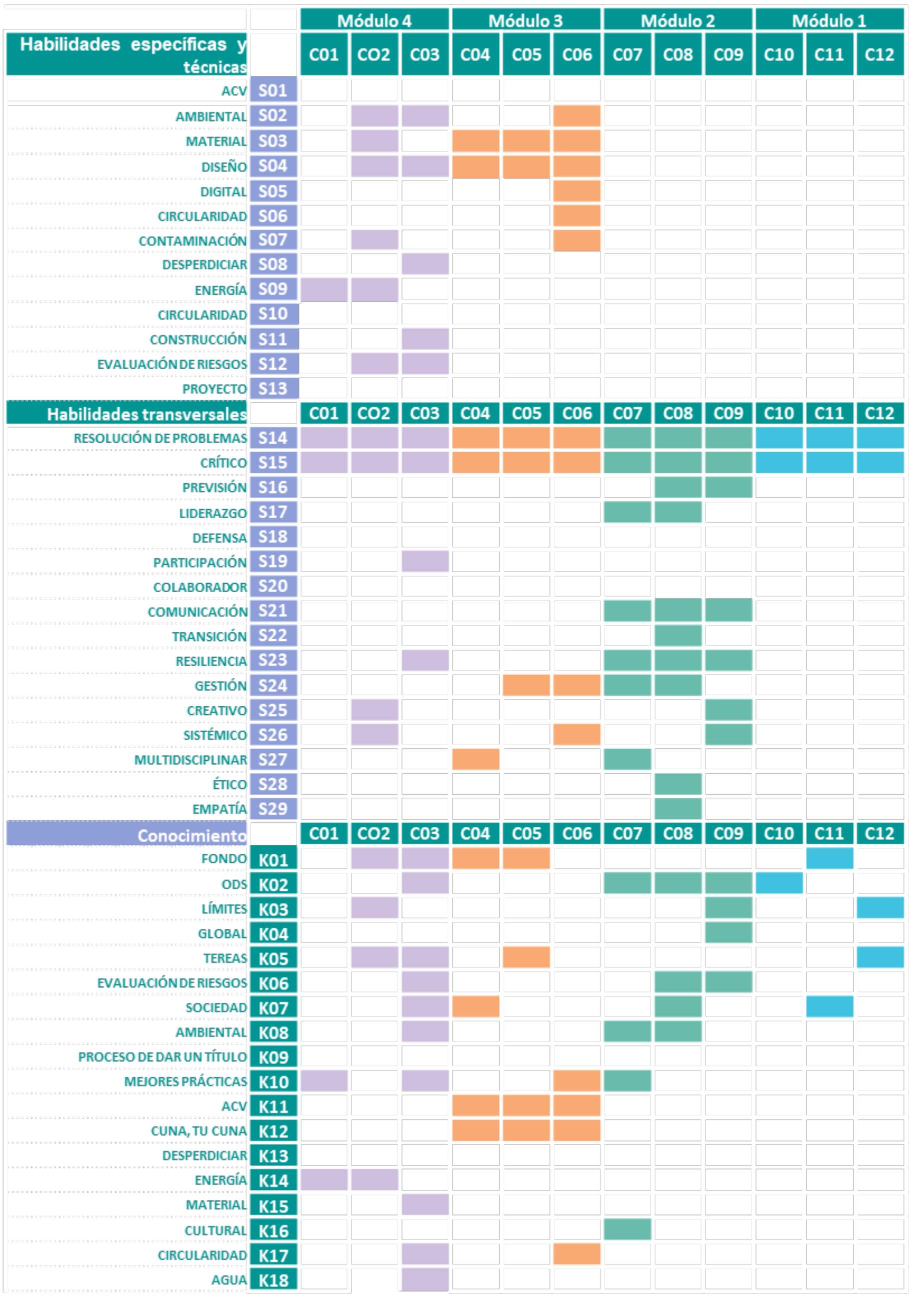

Figure 2. Competencies Matrix., Engineering Education for a Sustainable Future, EESF

The choice of the appropriate verb in the competency is essential, as it will determine the level of complexity the student will face and, therefore, the expected level of training. To achieve this, it is necessary to consider the educational level in order to adjust the depth and complexity of the proposed activities, as well as the time available for their development. Training evolves over time, not only in scope but also in complexity. Therefore, a first-year student is not the same as one about to present their Final Degree Project. A series of knowledge areas related to Sustainability and Engineering have been selected, allowing for a different approach. The same has been done with competencies, which have been divided into transversal and specific or technical. The set of designed competencies aims to cover technical, organizational, leadership, and awareness aspects. The twelve proposed competencies can be transversal to all engineering fields, as the topics addressed are of interest in any area. For this reason, these competencies could be applied to any curricular structure in higher education. As already explained, these competencies, together with the skills to be developed and the knowledge to be acquired, are a tool designed both to complement regulated instruction in engineering andto integrate into current curricula.

The framework of 12 competencies, 29 skills, and 18 knowledge areas, together with the list of 22 teaching methodologies or pedagogies, constitutes a tool for generating activities that can be adapted in the future to more specific or general interests.

Therefore, the EESF OER course is an example of the many possibilities available and will help teachers and students develop the desired sustainable mindset.

We now present, as the backbone of this proposal, the 12 competencies developed by our team:

CO1 MINIMIZING THE CARBON FOOTPRINT. Ability to qualitatively analyze the carbon footprint associated with different energy sources. Energy principles, comparison variables.

CO2 ENVIRONMENTAL EFFECTS OF TRANSPORTATION. Ability to apply engineering knowledge, experience, and innovation to transportation, logistics, freight transport, passenger transport, and tourism.

C03 SUSTAINABLE AND RESILIENT INFRASTRUCTURES AND CITIES. Ability to develop sustainable and resilient infrastructure and city models, identifying and understanding the risks posed by climate change, implementing sustainable mobility strategies, distributed renewable energy generation, circular supply chains, and nature-based solutions and forward-looking scenarios.

C04 IMPACTS OF PRODUCTS AND SERVICES. Ability to perform life cycle and environmental impact assessments, evaluating the environmental impact of products and processes, applying life cycle analysis (LCA) and carbon footprint calculations, and incorporating risk assessment methodologies to ensure sustainable engineering outcomes.

C05 ACV METHODOLOGY. Ability to understand methodologies such as the LCA methodology that determines the environmental impacts of products considering their life cycle, being able to identify the different phases and steps according to the ISO 14040:2006 series of standards.

C06 LCA AND ENVIRONMENTAL IMPACT ASSESSMENT. Ability to perform life cycle and environmental impact assessments by evaluating the environmental impact of products and processes considering their life cycle, applying the life cycle assessment (LCA) methodology, including carbon footprint calculations to ensure sustainable engineering results

C07 SUSTAINABLE PROJECT MANAGEMENT. Ability to manage sustainability-focused projects through strategic planning, risk mitigation, coordination of sustainability initiatives, and ensuring alignment with sustainability-related policies, regulations, and certifications.

C08 SUSTAINABLE TRANSITION LEADERSHIP. Ability to lead sustainability transitions by driving change in engineering organizations, making ethical decisions, implementing corporate social responsibility (CSR) frameworks, and understanding how sustainability connects to business and finance.

C09 SUSTAINABLE STRATEGIES AND STRATEGIC PLANNING. Ability to apply strategic foresight and scenario planning by analyzing long-term sustainability trends, anticipating risks, and integrating adaptive strategies into engineering projects, considering geopolitical and economic influences that shape sustainability policies, resource availability, and global market dynamics.

C10 INTERCONNECTED ENVIRONMENT, SOCIETY AND ECONOMY. Ability to apply systems thinking to sustainability engineering by recognizing and addressing the interconnections between environmental, social, and economic factors, while designing solutions that remain within planetary boundaries and consider the finite availability of resources.

C11 ETHICAL AND SOCIAL RESPONSIBILITY. Ability to integrate ethical and social responsibility into sustainability decisions, considering environmental justice, corporate responsibility, and social equity.

C12 CULTURAL AND MULTIDISCIPLINARY PERSPECTIVES. Ability to incorporate cultural and multidisciplinary perspectives into sustainability by integrating diverse viewpoints, including indigenous knowledge, to create globally relevant solutions.

3.4 Active Pedagogies Applicable to the EESF Project Framework

Learning to think and act sustainably in engineering depends not only on content but also on how it is delivered. Active methodologies transform students into individuals committed to problem-solving, ready to face real-world challenges with responsibility and vision.

Fostering a sustainable mindset in engineering requires more than simply transmitting technical knowledge; it requires a transformative pedagogical approach that places the student at the center of the learning process, appealing to their engagement, critical thinking, and ability to act ethically and responsibly. For this reason, the course has been designed from a methodological perspective aligned with the principles of meaningful learning, structured around twelve core competencies that address different dimensions of sustainability: energy, environment, urban, ethics, social, economic, and cultural.

This structure, already defined, is organized into four modules, each focused on three competencies, with activities divided into three progressive levels of complexity (basic, advanced, and integrative), in line with Bloom's taxonomy revised by Anderson and Krathwohl [18], which guides cognitive development from memorization and understanding to application, analysis, evaluation, and creation. Active learning methodologies have been prioritized, where students are not passive recipients of information but transform and actively apply it in real and challenging contexts. Consequently, the course offers resources such as case studies, analytical videos, supporting texts, infographics, and diagrams, with the aim of dedicating most of the course time to meaningful activities.

This approach is based on widely recognized pedagogical evidence. As represented in Edgar Dale's Cone of Experience [19], methods involving direct and active participation lead to deeper and longer-lasting understanding compared to approaches based solely on reading or listening.

Although Dale did not assign retention percentages to each level of the cone, his work was later reinterpreted according to Bloom's framework, particularly by Anderson and Krathwohl [16], who emphasize action, creativity, and critical judgment as advanced learning outcomes. Similarly, the well-known Active Learning Pyramid, popularized by educators such as Cody Blair, presents a hierarchy of teaching methods based on the degree of student participation. This model suggests that learning by doing, applying knowledge in real contexts, and teaching others are among the most effective strategies. The specific percentages often associated with these diagrams should be interpreted with caution, as they are not based on systematic empirical research. Their value lies in highlighting the importance of student-centred, contextualized, and participatory learning.

The use of active methodologies, therefore, not only improves learning in limited timeframes but also represents a strategic commitment to training professionals capable of leading change through learning by doing, reflecting, and collaborating.

3.5 EESF Project OERs

The objective of this EESF OER course, structured into four thematic modules, is to enable students to apply the knowledge and skills acquired during their training, adopting a sustainable mindset and a systemic vision to propose, solve, and develop engineering projects.

The list of 12 sustainable competencies, which combine technical knowledge with creativity and innovation, will facilitate the ability to solve complex and constantly evolving problems. This requires a sustainable mindset that contributes to achieving the SDGs.

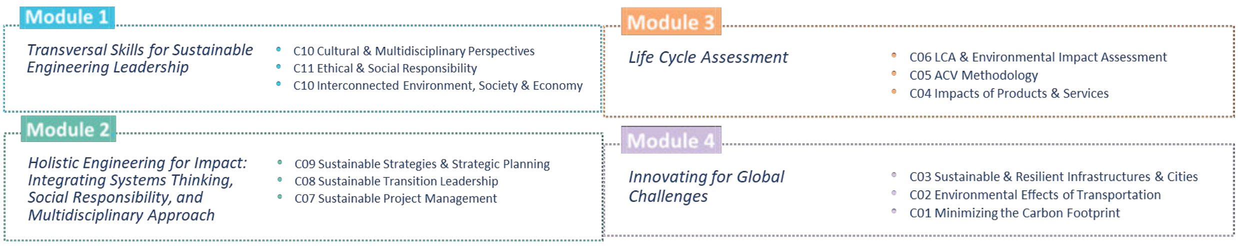

Figure 3. EESF OER Course. Composition of the four modules.

These competencies are organized into four thematic modules, offering teachers flexibility to implement them in the classroom. The course is designed to be completed through a series of structured activities within each module. Competencies are acquired through resources that address the proposed topics and activities, in which the student puts into practice the knowledge and skills necessary to achieve them.

		Activities	Minutes
Module	Competence 1	Level 1 Basic	15 - 30
		Level 2 Advanced	30 - 60
		Integration Activity	60 - 90
	Competence 2	Level 1 Basic	15 – 30
		Level 2 Advanced	30 – 60
		Integration Activity	60 – 90
	Competence 3	Level 1 Basic	15 – 30
		Level 2 Advanced	30 – 60
		Integration Activity	60 – 90

Figure 4. Composition of the OER Course, Engineering Education for a Sustainable Future, EESF

The proposed resources are simple and easy to integrate into existing curricula, requiring minimal additional time. Activities are structured in three pyramidal levels: Basic (Level 1), Advanced (Level 2), and Integrative (Level 3), with increasing time commitment and complexity at each level. This makes them an easy-to-implement learning tool thanks to their flexible scope. If the teacher or student has more time, they can also opt for the integrative activity, which allows the teacher to include content and activities in the subject they are teaching. Each activity includes references that allow both teachers and students to explore the topics in greater depth, depending on their time, interest, and curiosity. Educators can assess the completion of activities by their students, but the guide includes a brief questionnaire to be administered at the end of the Basic Level 1 activity for each competency.

3.6 Resources

The use of active methodologies not only improves learning in limited timeframes but also represents a strategic commitment to training professionals capable of leading change. Learning by doing, reflecting, and collaborating is now, more than ever, a necessary condition for engineering that truly contributes to a just and sustainable future.

In general, this methodological design seeks not only to facilitate the achievement of learning outcomes but also to foster an active, reflective, and transformative attitude in students. Only through authentic, participatory, and stimulating learning experiences will it be possible to advance toward engineering education aligned with the challenges of the 21st century, where the development of technical skills is accompanied by critical awareness and a strong commitment to sustainability.

The selection of specific methodologies for each activity is not arbitrary but responds to the type of competency being developed and the desired cognitive level. Thus, Level 1 (basic) activities are based on guided discovery, video analysis, or structured exercises; Level 2 (advanced) tasks use methods such as case studies, simulations, or challenge-based learning; while integrative activities are based on project-based learning (PBL), design thinking, and peer collaboration, allowing students to systematically apply their knowledge and skills in professional situations.

From our point of view, and as we have already explained, short-term learning (microlearning) requires more effective resources, so among all those mentioned, we believe that audiovisual materials, such as narrated videos and written summaries, are particulary helpful.

Each learning level of a competency (basic, advanced, and integrative) has its own resources and activities adapted to the time and complexity of the activity.

4 CONCLUSIONS

Research on the integration of sustainability into engineering education, as well as interviews with key stakeholders from academia and the professional world, demonstrates the potential for transforming engineering education to achieve the SDG goals. The research and interviews conducted within the

EESF project have made it possible to identify in detail a series of conditions for a valid line of work to create courses that address the unmet needs of engineering education.

It is necessary to articulate training models in sustainability that place the development of a sustainable mindset at the center; a broad base of knowledge is required regarding the environment, responsibility in economics and business, and social responsibility, as well as the skills to channel them into action; and it is essential to develop technical skills in data management, simulations, energy efficiency, Life Cycle Analysis, and related areas.

The experts interviewed consider the creation of parallel sustainability courses that complement regulated engineering education in sustainability topics, as well as real-world experiences and collaboration between companies and universities, to be effective and recommendable.

Furthermore, since it is necessary to move towards the integration of these parallel resources into curricula, this project has addressed this objective by creating and developing a competency reference framework that can be developed and interpreted for application to any engineering curriculum.

The application of this framework in an OER has made it possible to test the pedagogical model of the EESF project through various resources that, at this stage of the project, are in a pilot testing phase and will undergo a validation process before being shared with the rest of the university community.

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REFERENCES

[1] C. Fetting, “The European Green Deal,” ESDN Office, Vienna.

[2] G. Bianchi, U. Pisiotis, and M. Carbrera Giraldez, *GreenComp The European sustainability competence framework*, vol. 30955.

[3] A. Kolmos, “Engineering Education for the Future,” in *Engineering for Sustainable Development : Delivering on the Sustainable Development Goals*, UNESCO, 2021, pp. 121–128.

[4] T. Adams, S. Kishore Kumar, J. Goggins, and R. Manton, “Embedment of UN Sustainable Development Goals (SDG) within Engineering Degree Programmes,” 2020.

[5] U. Beagon and B. Bowe, “Understanding professional skills in engineering education: A phenomenographic study of faculty conceptions,” *Journal of engineering education*, vol. 112, no. 4, pp. 1109–1144, 2023.

[6] U. Beagon *et al.*, “Preparing engineering students for the challenges of the SDGs: what competences are required?,” *European Journal of Engineering Education*, vol. 48, no. 1, pp. 1–23, 2023.

[7] C. Desha, D. Rowe, and D. Hargreaves, “A review of progress and opportunities to foster development of sustainability-related competencies in engineering education,” *Australasian Journal of Engineering Education*, vol. 24, no. 2, pp. 61–73, 2019.

[8] R. Miñano Rubio, D. Uribe, A. Moreno-Romero, and S. Yáñez, “Embedding sustainability competences into engineering education. The case of informatics engineering and industrial engineering degree programs at Spanish universities,” *Sustainability*, vol. 11, no. 20, p. 5832, 2019.

[9] O. L. G. Quelhas *et al.*, “Engineering education and the development of competencies for sustainability,” *International Journal of Sustainability in Higher Education*, vol. 20, no. 4, pp. 614–629, 2019.

[10] R. A. Ramirez-Mendoza *et al.*, “Incorporating the sustainable development goals in engineering education,” *International Journal on Interactive Design and Manufacturing (IJIDeM)*, vol. 14, no. 3, pp. 739–745, 2020.

[11] O. Leifler and J.-E. Dahlin, “Curriculum integration of sustainability in engineering education–a national study of programme director perspectives,” *International Journal of Sustainability in Higher Education*, vol. 21, no. 5, pp. 877–894, 2020.

[12] A. R. Bielefeldt and M. Lima, “Service-learning and civic engagement as the basis for engineering design education,” *New innovations in engineering education and naval engineering*, pp. 17–36, 2019.

[13] W. Leal Filho, E. Pallant, A. Enete, B. Richter, and L. L. Brandli, “Planning and implementing sustainability in higher education institutions: an overview of the difficulties and potentials,” *International journal of sustainable development & world ecology*, vol. 25, no. 8, pp. 713–721, 2018.

[14] P. G. Serafini, J. M. de Moura, M. R. de Almeida, and J. F. D. de Rezende, “Sustainable development goals in higher education institutions: a systematic literature review,” *Journal of Cleaner Production*, vol. 370, p. 133473, 2022.

[15] “Engineering Education for a Sustainable Future: Discovery Report,” 2025. [Online]. Available: https://eesfproject.eu/resources/discovery-report-and-competence-research-report/

[16] ANECA, “Resultados de aprendizaje y procedimientos de aseguramiento de la calidad para la evaluación, certificación y acreditación de enseñanzas e instituciones Conforme al RD 640/2021 y al RD 822/2021. Documento complementario de la ‘Guía de apoyo para la redacción, puesta en práctica y evaluación de los resultados de aprendizaje’ publicada por ANECA en 2013,” 2022. [Online]. Available: https://www.aneca.es/documents/20123/63398/Informe_RA-V4.pdf/7106456d-b827-9424-d537-c8aabd71fd69?t=1662111636209.

[17] P. Tuning, “Tuning educational structures in Europe,” Informe final. Proyecto piloto. Fase, vol. 1, pp. 2004–2007, 2003.

[18] L. W. Anderson and D. R. Krathwohl, *A taxonomy for learning, teaching, and assessing: A revision of Bloom’s taxonomy of educational objectives: complete edition*. Addison Wesley Longman, Inc., 2001.

[19] E. Dale, “Audiovisual methods in teaching,” 1969.