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RESEARCH ARTICLE

REVISED Fostering creativity in engineering education: The CEDE project and the design of a European e-learning platform

[version 3; peer review: 1 approved, 3 approved with reservations]

Cristina Prado-Acebo[1], Ana Ares-Pernas[1], Zuzana Palková[2,3], Hatice Uzuğ[4], Ramazan Kocatürk[4], Athanasios Angeioplastis[5], Alkiviadis Tsimpiris[5], Rossella Nocera[6], Antonio Sandoli[6]

[1]Universidade da Coruña, Campus Industrial de Ferrol, Escuela Universitaria de Diseño Industrial, Ferrol, A Coruña, 15403, Spain
[2]Slovak University of Agriculture in Nitra, Nitra, 949 76, Slovakia
[3]Institute of Technology and Business in České Budějovice, České Budějovice, 370 01, Slovakia
[4]Kocatürk Consulting, PınarMah, Kocaeli, 74217, Turkey
[5]International Hellenic University, Informatics and Telecommunications Engineering, Serres, 62124, Greece
[6]University of Molise, Department of Biosciences and Territory, Campobasso, 80266, Italy

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Abstract

Background

Engineering education increasingly requires creativity, critical thinking, digital competences, and problem-solving abilities alongside technical expertise. However, creativity remains insufficiently embedded in many engineering curricula. This study presents the Erasmus+ CEDE (Creative Engineering) project, which addresses this challenge through the development of a transnational framework aimed at fostering creativity and related transversal competences in engineering higher education.

Methods

The study adopted a Design-Based Research approach that combined comparative curriculum analysis, collaborative instructional design, and iterative stakeholder validation. Engineering curricula from five European countries (Spain, Italy, Greece, Turkey and Slovakia) were analysed to identify how creativity and related competences are currently addressed. Based on these findings, the consortium co-designed the CEDE framework, consisting of five complementary

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1. **Sahin Idil**, The Scientific and Technological Research Council of Türkiye (TÜBİTAK), Ankara, Turkey
2. **Ida Nugroho Saputro**, Sebelas Maret University, Surakarta, Indonesia
3. **Albert Albers**, Karlsruhe Institute of Technology, Karlsruhe, Germany
Annika Bastian, Karlsruhe Institute of Technology (KIT), IPEK – Institute of Product

modules delivered through a shared e-learning platform. The framework was subsequently evaluated through stakeholder round tables involving students, academics, university staff, professional associations, and industry representatives, whose feedback informed successive refinements of the modules and platform.

Results

The comparative analysis revealed substantial differences in the integration of creativity-related competences across engineering programmes, with creativity frequently addressed only implicitly or fragmented across curricula. Stakeholder validation confirmed the relevance and potential applicability of the CEDE framework, while also identifying improvement areas, including stronger practice-oriented activities, enhanced assessment strategies incorporating peer evaluation and reflective approaches, reinforcement of competences, and flexible pathways for curricular integration. These findings informed the final refinement of the framework and its associated learning resources.

Conclusions

The study contributes theoretically and practically to engineering education by proposing and empirically validating the CEDE framework, a transnational creativity-oriented model for the systematic integration of creativity, design thinking, digital thinking, and soft skills into engineering curricula. The results demonstrate the value of Design-Based Research for developing educational innovations that are evidence-informed and stakeholder-validated, offering a transferable framework for fostering creativity and transversal competences in diverse higher education contexts.

Plain Language summary

This article presents an European project called CEDE (Creative Engineering), which aims to improve how engineering is taught at university. The main idea is that today's engineers need more than technical knowledge: they also need creativity, critical thinking, teamwork, communication skills, and the ability to use digital tools responsibly.

To address this, universities from five European countries (Spain, Italy, Greece, Turkey and Slovakia) worked together to design a shared online course that can be easily added to different engineering degrees. The course is organised into five areas: critical thinking, design thinking, digital problem solving, digitalization and artificial intelligence, and soft skills. An e-learning platform was developed to deliver the content.

Students, teachers, and companies took part in evaluating the course

Engineering, Karlsruhe, Germany

4. **Sharon Guaman-Quintanilla**, Escuela Superior Politecnica del Litoral, ESPOL, i3lab Entrepreneurship and Innovation Center, Guayaqui, Ecuador

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and confirmed that it is useful, practical, and relevant to real professional needs. The project shows that creativity can be taught in a structured way and that doing so helps to prepare engineers to face today's complex technological and social challenges.

Keywords
Engineering education; Creativity; Critical thinking, Design thinking; Digital competences; Problem solving; Soft skills; E-learning.

This article is included in the Erasmus+ gateway.

Corresponding author: Cristina Prado-Acebo (cristina.prado.acebo@udc.es)

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REVISED **Amendments from Version 2**

This revised version substantially strengthens the manuscript in response to peer-review comments by reinforcing its research design, empirical evidence, theoretical contribution, and practical implications.

The abstract and introduction have been revised to better define the research gap, clarify the study objectives, and position the CEDE framework within current research on creativity in engineering education, Design Thinking and Design-Based Research (DBR). Recent literature has been incorporated throughout the manuscript to reflect the current state of knowledge.

The Methods section has been expanded to provide a more detailed description of the Design-Based Research methodology, including the iterative development process, research instruments, stakeholder questionnaire, data collection procedures and qualitative analysis. A new figure illustrating the DBR cycles has also been added.

The Results section has been substantially strengthened by incorporating additional empirical evidence from stakeholder validation activities conducted across all partner countries. In addition to the detailed University of A Coruña case study, the manuscript now includes a cross-partner synthesis of round tables and multiplier events, supported by new summary tables that present participant profiles, validation activities, feedback themes and educational implications. The scientific findings are now more clearly distinguished from the description of the educational modules.

The Discussion and Conclusions have been revised to clarify the theoretical contribution of the CEDE framework as a transferable transnational model for integrating creativity into engineering education. Practical implications, study limitations and future research directions have also been expanded. Finally, the conclusions have been reformulated to present a more cautious interpretation of the findings, emphasising stakeholder validation and the potential educational value of the framework rather than demonstrated learning effectiveness.

Any further responses from the reviewers can be found at the end of the article

1. Introduction

Engineering plays a central role in today's technology-driven society, shaping technological, industrial and social development. For this reason, professionals, not only with strong technical knowledge but also with creative, critical and digital competences, are required (Pusca & Northwood, 2019). Engineers create the objects and systems we use every day; they design systems, products and infrastructures that respond to increasingly complex global challenges, including digital transformation, sustainability, and rapid technological change. Therefore, they must be able to see things in a creative way, to recognize needs, and new ideas by thinking "out of the box" to solve problems from a creative point of view.

In this context, engineering practice requires not only solid technical knowledge but also a broad set of transversal competences, such as creativity, critical thinking, problem solving, digital competence and communication skills. These competences are essential for addressing problems, generating innovative solutions and adapting to evolving professional environments (Kuimova et al., 2017; Peroni, 2024). So, it is very important to teach and encourage creativity in engineering degrees and to develop programs that train on these competences. Recent literature consistently identify creativity as one of the key competences required for future engineers and emphasise that it should be explicitly integrated into engineering curricula through structured educational approaches rather than treated as an implicit outcome of technical training (Tekmen-Araci, 2024; Bertol et al., 2025).

However, creativity is still insufficiently integrated into many engineering curricula. The Erasmus+ project CEDE – Creative Engineering addresses this gap by promoting innovative educational approaches aimed to enhanced creativity and related transversal skills in engineering higher education.

Despite this growing demand, traditional engineering education has often prioritized technical content and analytical problem solving, leaving limited space for the systematic development of creative and transversal skills (Lawson, 2009). Creativity is frequently perceived as an innate ability or as a competence more closely associated with artistic disciplines rather than with engineering (Brown, 2008). As a result, creative approaches are often marginalized within engineering curricula or addressed in an implicit and fragmented manner. This gap between the competences required by society and industry (Florida, 2010; Beckman and Barry, 2007, p. 25) and those fostered in higher education has been widely recognized as a challenge for engineering education.

In recent years, educational research has highlighted the importance of integrating creativity into engineering programs (Kirillov et al., 2015) through active learning methodologies, interdisciplinary approaches and student-centered pedagogies. Promoting creative and reflective learning processes (McIntosh, 2010; Mentzer et al., 2015, p. 428), and encouraging students to think "outside the box", recognize needs and explore multiple solution paths (Dorst & Cross, 2001, p. 435), alignes engineering education more closely with real-world professional practice. Approaches such as design thinking, project-based learning and problem-based learning have shown potential to enhance students' creative capacities, critical thinking and engagement. At the same time, the rapid development of digital technologies has opened new opportunities for the design of flexible learning environments, including e-learning platforms that support collaborative, self-directed and experiential learning. However, the implementation of such approaches remains uneven across institutions and countries, particularly in non-core campuses and smaller universities.

Although previous research has demonstrated the potential of design thinking, project-based learning and creativity-focused pedagogies in engineering education ─and the effectiveness of structured creativity-oriented educational interventions in engineering programmes (Arifin & Mahmud, 2021)─, studies addressing the systematic integration of creativity through a transnational competence framework, validated across multiple European contexts and implemented through a shared digital platform, remain scarce.

Within this context, European cooperation projects offer a valuable framework for addressing common educational challenges and promoting innovation in higher education. Erasmus+ projects foster collaboration among institutions from different countries, enabling the exchange of experiences, the comparison of educational practices and the co-creation of shared educational resources. The CEDE – Creative Engineering project (2023–2025) was conceived in response to the need to strengthen creativity and related transversal skills in engineering education through a structured, collaborative and international approach.

The consortium involves higher education institutions from non core campuses and an external partner organisation (Spain, Italy, Greece, Turkey and Slovakia, the leader of the project), bringing together educators from different engineering disciplines and institutional contexts. A distinctive feature of the project is its focus on non-core campuses, which often face additional challenges in terms of resources, visibility and curricular innovation. By engaging partners from diverse geographical and educational contexts, the project seeks to develop a flexible framework that can be adapted to different engineering programs while addressing shared learning objectives.

This study contributes to engineering education research by:

- Proposing the CEDE framework for creativity-oriented engineering education.
- Demonstrating its development through an international DBR process.
- Providing empirical validation from multiple stakeholder groups.
- Offering a transferable model for curriculum innovation.

And to this end, the following research questions will be answered:

- RQ1. How is creativity currently integrated into engineering curricula across the participating European institutions?
- RQ2. How can a common creativity-oriented engineering module be designed through an international Design-Based Research process?
- RQ3. How do stakeholders evaluate the relevance, feasibility and curricular integration potential of the CEDE framework?

These research questions are aligned with current discussions on future engineering competences, which highlight creativity, digital literacy and interdisciplinary collaboration as essential capabilities for engineers working in rapidly evolving technological environments (Garcés et al., 2025; Hsu et al., 2025).

This research article presents the design, implementation and initial outcomes of the CEDE project, with a particular focus on the development of the European e-learning platform and the associated creative engineering modules. The study adopts a research-oriented perspective, combining comparative analysis, curricula design and participatory evaluation methods. The paper is structured as follows. First, the Methods section describes the different methodologies used on each stage of the project. The Results section presents the main findings of the comparative report and provides a concise overview of each module developed by the partner countries. Finally, the Conclusions and Discussion section reflects on the implications of the project for engineering education and outlines future directions for the integration and dissemination of creativity-focused educational initiatives.

2. Methods

2.1 Research design

The CEDE project adopts a qualitative and design-based research (DBR) approach (Laursen & Haase, 2019) aimed at the development, implementation and iterative refinement of an educational intervention in engineering higher education. Design-based research is particularly suitable for this study, as it enables the systematic integration of analysis, design, and evaluation processes in real educational settings.

The methodological process followed in this study is represented in Figure 1. Rather than adopting a linear development model, the CEDE project followed an iterative Design-Based Research approach (Cela-Ranilla et al., 2025; Mundy et al., 2024) in which analysis, design, implementation, stakeholder validation and refinement were interconnected. This approach was appropriate because the aim of the study was not only to describe an educational resource, but to develop, validate and refine a transferable framework for integrating creativity into engineering education.

The methodological framework is structured into several interrelated phases. First, a comparative curriculum analysis was conducted across partner institutions to identify how creativity-related competences and transversal skills are currently addressed in engineering programmes. Second, based on these findings, an instructional design phase was carried out, involving the co-creation of educational modules and the definition of their pedagogical structure. Third, a participatory evaluation phase was implemented through stakeholder engagement activities, including round tables with

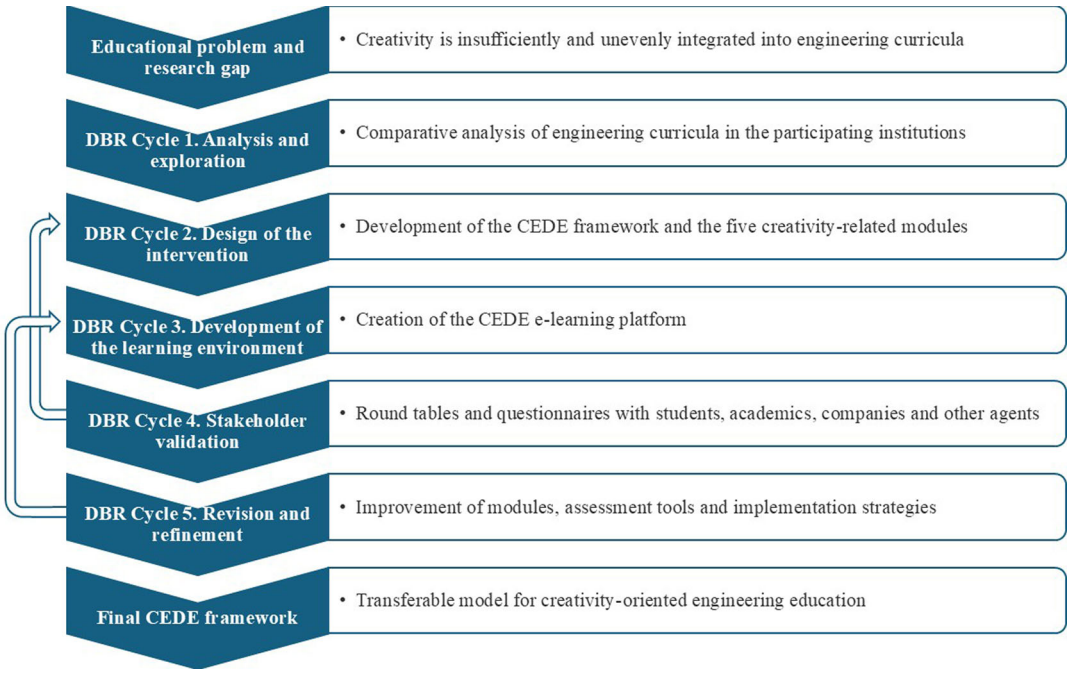


Figure 1. Design-based research process followed in the CEDE project. Each cycle informed the following stage. The comparative curriculum analysis provided the empirical basis for identifying the educational gap and defining the competence areas. The module design phase translated these findings into a structured educational intervention. The e-learning platform enabled the implementation of the modules in a flexible and transferable format. Finally, stakeholder feedback provided evidence for revising the contents, assessment tools and curricular integration strategies. In this way, the CEDE framework emerged from an iterative process of educational design, validation and refinement.

students, academic staff, professionals, and company representatives. Finally, these inputs informed the development and refinement of an e-learning platform designed to support the implementation of the modules.

Data sources included curriculum documents, a shared analysis template used by all partners, records and summaries from stakeholders round tables, and feedback collected during the developments and testing of the modules and platform. These data were analysed qualitatively, with a focus on identifying recurring themes, needs, and patterns that could inform the iterative design process.

The project was implemented between 2023 and 2025 within the framework of the Erasmus+ programme and involved five higher education institutions from Spain, Italy, Greece, Turkey and Slovakia. Participants include teachers from different engineering disciplines, educational researchers, institutional staff, and external stakeholders involved in different phases of the study.

2.2 Comparative analysis of engineering curricula

The first methodological phase consisted of a comparative curriculum analysis aimed at examining how creativity and related transversal competences are addressed in existing engineering degree programmes at the partner universities. Each institution analysed a selection of engineering programmes at institutional and national level, focusing on the presence of learning outcomes, courses, and learning activities explicitly or implicitly related to creativity, critical thinking, problem solving, digital competences and soft skills.

To ensure comparability across countries, all partners agreed on a common analysis template, which includes criteria related to (i) the explicit inclusion of transversal competences in programme learning outcomes, (ii) the integration of these competences within courses and teaching practices, and (iii) the assessment approaches used. This template guided the systematic collection of data across institutions.

The collected data included qualitative descriptions of curricular structures, teaching methodologies and assessment practices, as well as contextual information regarding institutional frameworks, constraints and opportunities. The analysis followed a collaborative and iterative process, in which partner institutions contributed their findings to a shared dataset, enabling cross-case comparison and the identification of recurring patterns.

The results of this phase were synthesised into a comparative report, which served as the empirical basis for the subsequent instructional design phase, informing both the definition of the module structure and the selection of key competences to be addressed.

2.3 Design of the common creative engineering module

Based on the findings of the comparative analysis, a common complementary module was designed with the objective of fostering creativity and transversal skills in engineering students. The module was conceived as a flexible and adaptable structure that could be integrated into different engineering programmes at an early stage of the curriculum.

The module is organised into five thematic areas, each coordinated and developed by one partner country:

1. Critical Thinking: Introduction to Creative Engineering (Italy)
2. Design Thinking: Creative Engineering Methods (Spain)
3. Digital Thinking: Problem Solving (Turkey)
4. Digital Thinking: Digitalisation and Artificial Intelligence (Greece)
5. Soft Skills (Slovakia)

For each thematic area, the responsible partner designed the learning content, teaching methodology and assessment strategy. A competency-based approach was adopted, with clearly defined learning outcomes aligned with creativity-related competences. Regular consortium meetings were held to ensure coherence across modules and to harmonise pedagogical approaches.

2.4 Development of the E-learning platform

To support the delivery of the common module, an e-learning platform was developed as a central element of the project. The platform was designed to facilitate flexible access to learning materials, interactive activities and assessment tools. It supports self-directed learning, collaborative tasks and project-based activities, allowing students to engage with the content at their own pace.

The platform hosts the five modules and provides a structured learning pathway, including theoretical content, practical exercises, tests, case studies and project work. Particular attention was paid to usability, accessibility and adaptability to different institutional contexts. The platform also integrates assessment and monitoring tools to track students' progress in the development of creative competences.

2.5 Assessment tools and monitoring of creative competences

To evaluate and monitor the development of creative competences, a total of fifteen assessment tools were selected and designed within the project, with three tools associated with each module. These tools include a combination of formative and summative assessment methods, such as knowledge tests, portfolios, project work, presentations, self-assessment and peer assessment activities.

The assessment framework aims to capture multiple dimensions of creativity and transversal skills, including ideation, problem analysis, solution development, collaboration and communication. The design of the assessment tools was aligned with the learning outcomes of each module and adapted to the online learning environment.

2.6 Round table, stakeholder feedback and iterative improvement

A key methodological component of the project was the organisation of round tables aimed at evaluating the e-learning platform and its contents. These activities were conducted across the five participant countries and involved a diverse group of stakeholders, including students, academic staff, university staff, professionals and representatives from companies in the engineering sector.

During the round tables, participants were invited to explore the platform, review the modules and provide structured feedback on aspects such as relevance, clarity, usability, pedagogical value and alignment with professional needs. Data collection combined guided group discussions and questionnaire-based input, allowing both open qualitative insights and structured responses to be gathered.

The analysis followed a collaborative cross-institutional process, in which partner institutions synthesised their results and identified common patterns across contexts. While some variability was observed due to institutional and national differences, the feedback showed consistent trends regarding the perceived relevance of transversal competences and the value of integrating creativity-oriented approaches into engineering education.

The results were used to iteratively refine the modules, assessment tools, and platform functionalities. In line with the design-based research approach, this feedback loop supported the progressive adjustment of the educational intervention to stakeholder needs.

For illustrative purposes, selected results are presented in more detail for the University of A Coruña case, while the overall findings reflect shared patterns identified across partner institutions. This is acknowledged as a limitation in terms of the level of detail available for each context.

2.6.1 Research instruments

The main research instrument used for the stakeholder validation phase was a structured questionnaire specifically developed within the CEDE project to evaluate the relevance, quality, and feasibility of the proposed educational framework (Table 1). The questionnaire was administered through Microsoft Forms during the round-table sessions and combined closed-ended and open-ended questions.

The instrument was designed collaboratively by the international project consortium and aligned with the objectives of the CEDE framework. It included items covering six core dimensions (Table 2): (1) adequacy of theoretical content, (2) suitability of practical activities, (3) appropriateness of assessment tools, (4) adequacy of workload and scheduling, (5) usefulness of the e-learning platform, and (6) relevance of the proposed competences and possibilities for curricular integration. In addition, participants provided demographic and stakeholder-profile information.

Table 1. Research instruments.

Instrument	Purpose	Participants	Indicators
Comparative curriculum analysis template	Analyse creativity integration in curricula	Partner institutions	Learning outcomes, teaching methodologies, assessment practices, creativity-related competences
Stakeholder questionnaire	Validate CEDE framework	Students, faculty, companies, associations	Relevance, usability, assessment adequacy, workload, curricular integration
Round-table discussion guide	Collect qualitative feedback	Stakeholders	Strengths, weaknesses, improvement proposals, implementation barriers

Table 2. Correlation between questionnaire items and the dimensions analysed.

Dimension	Question
Content adequacy	Q2
Activities	Q3
Assessment	Q4
Schedule	Q5
Platform	Q6
Competences	Q7
Curriculum integration	Q8

To ensure content validity, the questionnaire was reviewed by representatives from all partner institutions, including experts in engineering education, curriculum design, and creativity development. The review process verified that the items adequately represented the dimensions under investigation and were consistent across the participating countries.

The questionnaire generated both quantitative and qualitative data. Closed-ended questions provided descriptive information regarding stakeholder perceptions, while open-ended responses allowed participants to justify their evaluations and propose improvements. Qualitative responses were analysed through thematic analysis, identifying recurring themes, recommendations, and concerns. These themes were subsequently discussed by the consortium and used to refine the modules and the e-learning platform.

The complete survey instrument, including all questionnaire items and evaluation dimensions, has been deposited in Zenodo as supplementary material and can be consulted by researchers interested in replicating or adapting the instrument for similar studies in engineering education.

2.6.2 Qualitative data analysis

Qualitative data obtained from the stakeholder round tables and open-ended questionnaire responses were analysed using an inductive thematic analysis approach.

The analysis was conducted in five stages (Table 3). First, all responses were reviewed repeatedly to achieve data familiarisation. Second, researchers identified meaningful statements and generated initial codes related to content adequacy, practical activities, assessment methods, platform usability, competence development and curricular integration. Third, similar codes were grouped into broader themes representing common stakeholder concerns and recommendations. Fourth, the emerging themes were reviewed and discussed among project partners to ensure consistency of interpretation. Finally, consensus was reached regarding the final thematic categories and their implications for module refinement.

To enhance the credibility of the analysis, coding and interpretation were reviewed by several members of the research consortium. The resulting themes were subsequently used to guide revisions of the CEDE modules, assessment tools and implementation strategies.

Table 3. Qualitative analysis process.

Stage	Description
Familiarisation	Repeated reading of stakeholder responses
Coding	Identification of relevant ideas and suggestions
Categorisation	Grouping of codes into themes
Review	Discussion among project partners
Interpretation	Identification of implications for module improvement

2.7 Dissemination

The final methodological phase focused on the dissemination of the project results and the iterative improvement of the developed materials. Dissemination activities included multiplier events, participation in congress, presentations at academic and professional forums, media, social nets and the sharing of resources within the partner institutions.

3. Results

3.1 Results of the comparative analysis of engineering curricula

Engineering curricula vary significantly across different institutions and countries, influenced by factors such as industrial needs, educational policies, and cultural priorities (Arnold, 2016). A comparative analysis of the curriculum reveals distinct approaches to teaching and skill acquisition in engineering disciplines. In this project the key aspects of engineering curricula from various regions have been outlined before defining the E-learning platform.

From a general standpoint, key differences among the curricula were analysed regarding a) Duration and Structure, b) Emphasis on Practical Experience, c) Project-Based Curriculum.

Moreover, all the aspects related to the course organizations in various countries involved in the CEDE project – such as duration, focus area, project-based learning, interdisciplinarity and accreditation – were analysed and compared.

The comparisons showed a marked trend toward incorporating more digital skills and sustainability into engineering curricula. Universities worldwide are beginning to integrate topics like artificial intelligence, renewable energy systems, and data analytics, reflecting industry demands and global challenges.

The comparative curriculum in engineering courses highlights the diversity in educational strategies and priorities worldwide. Understanding these differences can help prospective students choose the program that aligns best with their career goals and interests, while also providing insights into how different regions prepare their engineering graduates for the global workforce.

3.2 Results of the E-learning platform and the modules developed by each partner country

The modules developed by each partner institution constitute one of the main outcomes of the CEDE project. This section presents their structure and pedagogical orientation, with a focus on how they operationalise the competence framework identified through the comparative curriculum analysis and respond to the needs highlighted during the stakeholder feedback phase.

While the level of detail provided for each module may appear extensive, this reflects the project's design-based approach, in which educational interventions are iteratively developed, documented, and refined. The descriptions therefore aim not only to present the modules, but also to illustrate how creativity and transversal competences are embedded into engineering education through concrete pedagogical design.

The modules share a common structure—combining conceptual foundations, applied methodologies, and project-based learning—while allowing adaptation to specific disciplinary and institutional contexts. The following subsections highlight the main features of each module and their contribution to the overall CEDE framework.

3.2.1 Critical thinking: Introduction to creative engineering (Italy)

Creativity is often associated with the arts, but creativity is needed everywhere, and it plays a crucial role in engineering as well. Engineers must always find solution to real world problems. They need to think of creative ways to come up with

solutions. Creativity allows engineers to deal with new problems and new applications combined with existing and traditional methods and techniques.

Creative engineering is the place where innovation meets practicality, and imagination drives progress. In this dynamic field, engineers blend their technical expertise with a dash of creativity to solve complex problems, design groundbreaking products, and shape the future of technology. It transcends traditional boundaries, encompassing diverse disciplines such as mechanical, electrical, software, and aerospace engineering, among others. It thrives on the intersection of art and science, encouraging engineers to think outside the box and push the limits of what's possible.

In summary, creativity is a vital component of engineering that fuels innovation, drives problem-solving, and enables engineers to develop novel and impactful solutions to complex challenges. By embracing creativity, engineers can unlock new possibilities, drive progress, and make a positive impact on society and the world at large.

The aim of the competence unit is to develop a comprehensive set of skills that enable engineers to have a comprehensive vision of the basic concepts of the creative engineering, allowing them to acquire the basic competences to face the subsequent modules. It encompasses a wide range of topics, spanning from fundamental principles to advanced techniques.

The first part of the module involves "Defining creativity". It is a nuanced task, as it encompasses various aspects and can manifest differently depending on the context. However, at its core, creativity can be understood as the ability to generate novel and valuable ideas, solutions, or outcomes.

The unit covers various problem-solving techniques and strategies relevant to creative engineering, as described in the following:

1. Novelty: Generating ideas, solutions, or outcomes that are original and new, ranging from entirely unprecedented concepts to innovative combinations of existing elements.

2. Value: Producing ideas or solutions that are meaningful, useful, or impactful in some way. The value of creative outputs can be subjective and context-dependent.

3. Problem-solving: Approaching challenges with an open mind, exploring multiple perspectives, and generating unconventional solutions.

4. Flexibility: Flexibility in thinking, willing to entertain diverse ideas and perspectives. They are not bound by conventional or rigid thinking patterns and are open to exploring alternative approaches.

5. Originality: Building upon existing ideas or concepts, it also requires a degree of originality. Creative individuals bring their unique insights, experiences, and perspectives to the creative process, resulting in outputs that reflect their individuality.

6. Expression: Creativity it encompasses artistic expression and innovation in areas such as literature, music, art, and design. Creative expression allows individuals to communicate emotions, ideas, and experiences in novel and engaging ways.

7. Process-oriented: Creativity is often viewed as a process rather than a fixed trait. It involves engaging in activities such as brainstorming, experimentation, iteration, and reflection to generate and refine creative ideas and solutions.

8. Context-dependence: The perception of creativity can vary depending on cultural, social, and disciplinary contexts. What is considered creative in one context may not be perceived as such in another. Additionally, the criteria for evaluating creativity may differ across domains.

The core unit number two engages the "Creativity in engineering". The creative process involves several steps. The first level includes the definition of the question or the problem. The process goes further involving all ideas and concepts associated to the problem. By following these steps described in the following and leveraging creative thinking techniques, engineers can navigate the complexities of engineering challenges and develop innovative solutions that address the needs of society, industry, and the environment.

The unit covers various problem-solving techniques and strategies relevant to creative engineering, as described in the following:

1. Identifying the Problem: The first step in the creative process is to clearly define the problem or challenge that needs to be addressed. This involves understanding the requirements, constraints, and objectives of the project, as well as gathering relevant information and data.

2. Research and Exploration: Enable the engineers capable to conduct research and explore existing solutions, technologies, and methodologies related to the problem at hand. This helps them gain insights, identify best practices, and understand the current state of the art in the field.

3. Brainstorming and Idea Generation: Brainstorming sessions are conducted to generate a wide range of ideas, concepts, and potential solutions. Engineers leverage creative thinking techniques such as free association, mind mapping, and lateral thinking to explore diverse possibilities and generate novel insights.

4. Concept Development: Once a pool of ideas has been generated, engineers evaluate and refine them to develop more concrete concepts and proposals. This may involve sketching, prototyping, or modeling to visualize and communicate ideas effectively.

5. Problem-solving: Enable the engineers to approach to problems from different angles, consider unconventional solutions, and develop innovative strategies to address them effectively.

6. Innovative Design: Engineers must devise innovative solutions that meet specific requirements while considering factors such as functionality, efficiency, safety, and cost-effectiveness. Creativity allows engineers to explore novel concepts, integrate new technologies, and push the limits of design possibilities.

7. Optimization and Efficiency: Creativity as a tool for optimizing existing processes, systems, and products. Engineers continually seek ways to improve efficiency, enhance performance, and reduce waste through creative problem-solving and innovation. This may involve redesigning components, reconfiguring processes, or implementing new technologies.

8. Refinement and Optimization: The design is refined and optimized based on the feedback obtained during prototyping and testing. Engineers iterate on the design, making adjustments, improvements, and optimizations to enhance performance, functionality, and usability.

9. Interdisciplinary Collaboration: Many engineering projects require collaboration across multiple disciplines, such as mechanical, electrical, software, and materials engineering. Creativity enables engineers to communicate effectively across disciplinary boundaries, leverage diverse expertise, and integrate different perspectives to develop holistic solutions.

10. Risk Management: Creativity is integral to managing risks in engineering projects. Engineers must anticipate potential challenges, identify vulnerabilities, and develop creative strategies to mitigate risks effectively. This may involve contingency planning, scenario analysis, and innovative approaches to ensure project success.

11. Sustainability and Environmental Responsibility: In today's world, sustainability and environmental considerations are paramount in engineering design and decision-making. Creativity enables engineers to develop eco-friendly solutions, minimize environmental impact, and promote sustainable practices through innovative design, materials selection, and energy-efficient technologies.

12. Continuous Improvement and Innovation: Creativity drives continuous improvement and innovation in engineering. Engineers are constantly seeking ways to push the boundaries of what is possible, develop new technologies, and pioneer groundbreaking solutions to address evolving needs and challenges.

13. Human-Centered Design: Creativity is essential for human-centered design, which focuses on creating products, systems, and experiences that prioritize the needs, preferences, and capabilities of end-users. Engineers leverage creative thinking to empathize with users, anticipate their requirements, and design solutions that enhance usability, accessibility, and user satisfaction.

14. Reflection and Learning: After the completion of the project, engineers will reflect on the creative process, evaluate the outcomes, and identify lessons learned. This reflection helps them gain insights, improve their skills, and apply their experiences to future projects.

The last part of the module involves the "Creation of a project", based on team-working to bring diversity of background and expertise together. In the realm of Creative Engineering, the creation of a project begins with a unique blend of innovation and practical problem-solving. Engineers leverage their technical knowledge and artistic vision to develop solutions that address specific needs or challenges. This process often starts with brainstorming sessions where diverse ideas are generated, followed by concept development and prototyping. Teams incorporate feedback and iteration to refine their designs, ensuring both functionality and aesthetic appeal. Throughout the project, collaboration across disciplines—such as design, engineering, and user experience—is crucial, fostering an environment where creativity thrives. Ultimately, the successful realization of a project in Creative Engineering not only showcases technical expertise but also inspires new ways to think about and engage with technology in everyday life.

This final step is organised in different sub-fields:

1. Introduction to Creative Engineering: Overview of Creative Engineering, with definitions and significance. Historical Context about sey developments in engineering and design. Case Studies: Examples of successful creative engineering projects.

2. Ideation and Brainstorming: Techniques for Ideation such as mind mapping, SCAMPER, and role-playing. Collaborative Brainstorming creating group dynamics and idea generation. Evaluating ideas through criteria for assessing feasibility and innovation.

3. Design Thinking Process: Understanding user needs, conducting interviews and surveys and defining problem statements. Prototyping Techniques: Low fidelity vs. high-fidelity prototypes.

4. Technical Skills Development. It involves basic engineering principles such as introduction to materials and methodologies and development of experiments. It is required the use of software tools for students, i.e., overview of CAD, simulation software, and project management tools.

5. Project Management in Creative Engineering. It is aimed at developing planning and organization, setting goals, timelines, and budgeting. The team work dynamically, defining roles and collaboration in project teams, iterative design and feedback and the importance of testing and refining ideas.

6. Presentation and Communication Skills. It involves the development of effective communication techniques for presenting ideas clearly and the visual design using visuals to enhance presentations and projects. Moreover, storytelling in engineering is learned, crafting compelling narratives for project pitches.

7. Sustainability and ethics in engineering: sustainable design practices. Here are learned the principles of eco-friendly engineering, ethical considerations about the responsibility and impact of engineering solutions, and future trends in emerging technologies and their potential effects on society.

8. Final Presentation: Showcasing the project to peers and instructors. These submodules can guide students through various key aspects of Creative Engineering, helping them build a comprehensive skill set.

This module illustrates how creativity can be explicitly structured within engineering education, addressing gaps identified in the initial curriculum analysis and aligning with the competence framework proposed by the CEDE project.

3.2.2 Design thinking: Creative engineering methods (Spain)

The aim of this competence unit and its associated learning outcomes is to equip students with the necessary skills and knowledge to manage design thinking and creative engineering methods in their future work as engineers, to work collaboratively in multidisciplinary teams and to apply creativity in the design of new products and services. The module addresses the need to connect technical knowledge with innovative thinking processes, enabling students to approach engineering challenges from a user-centred, iterative and solution-oriented perspective.

This module was designed in response to the results of the comparative analysis, which revealed that while problem-solving is a core component of engineering education, explicit training in creative methodologies and design thinking is often limited or fragmented. The Spanish partner therefore developed a module that integrates creativity directly into engineering practice, positioning design thinking not as an auxiliary skill (Cross, 1982, p. 223; Buchanan, 1992) but as a structured methodology applicable to real engineering contexts. Recent evidence also supports the contribution of design thinking to the development of sustainable innovation competences and interdisciplinary problem solving in engineering education (Esquicha-Tejada et al., 2026).

The module is organised into three interrelated sections that progressively guide students from conceptual understanding to practical application, ensuring a coherent learning progression from theory to practice. This structure reflects the underlying philosophy of design thinking as a holistic and iterative approach to problem solving in engineering contexts.

The first section focuses on the definition and theoretical foundations of design thinking (Rowe, 1987; Dorst, 2011, p. 521; Laursen & Haase, 2019; Mosely et al., 2018, p. 177). Students are introduced to the origins, principles and relevance of design thinking within engineering and innovation processes. Emphasis is placed on understanding design thinking as an iterative and non-linear approach (Luchs et al., 2016, p. 8; Luka, 2020, p. 65) that integrates empathy, problem definition, ideation, prototyping and evaluation. Through this introduction, students develop awareness of the importance of understanding user needs, contextual constraints and societal impact when designing engineering solutions.

Design thinking is presented as a human-centred approach to innovation that integrates analytical and creative processes to address complex and ill-defined problems (Brown, 2008; Razzouk & Shute, 2012, p. 330). Within the module, design ─one of the most effective approaches for fostering creativity and innovation in engineering education (Deng et al., 2026; Wilson et al., 2024)─ thinking is defined as a structured methodology that combines empathy, creativity and rationality to meet user needs while respecting technical, economic and contextual constraints. Students are introduced to design thinking as an approach that goes beyond traditional linear problem-solving models, emphasising iteration, feedback and continuous refinement.

Particular attention is given to the design thinking process, commonly described through five interconnected phases: empathy, problem definition, ideation, prototyping and testing (Henriksen et al., 2017). In addition, students are introduced to different design thinking methodologies and frameworks, each with its own structure and emphasis, allowing them to develop a global overview of the process (Brown and Wyatt, 2010; Tschimmel, 2012; Lawson, 2004). This comparative perspective enables students to adapt and tailor the design thinking approach to the specific needs of their project, their team composition and the context in which the engineering challenge is situated (Cross, 2001, p. 49–50; Koro & Tanggaard, 2022). Students explore each phase in detail, understanding that these stages are not sequential steps but rather flexible and iterative components of a dynamic process.

In the empathy phase, students learn techniques for understanding users, stakeholders and contexts, such as observation, interviews and user profiling. This phase is used to highlight the importance of incorporating social, ethical and environmental considerations into engineering design.

The problem definition phase focuses on synthesising insights gathered during empathy activities to formulate clear and meaningful problem statements. Students are trained to reframe technical challenges from a user-centred perspective, learning how the formulation of the problem directly influences the quality and creativity of potential solutions. This phase encourages critical thinking and reflection, helping students move beyond predefined problem statements.

In the ideation phase, students are introduced to divergent thinking techniques aimed at generating a wide range of possible solutions. Creativity is framed not as spontaneous inspiration but as a skill that can be developed through structured methods. Emphasis is placed on creating an open and collaborative environment that encourages risk-taking and the suspension of premature judgement. The module highlights the value of quantity, diversity and originality of ideas as a foundation for innovation in engineering design.

The prototyping and testing phases are presented as essential mechanisms for learning through making and experimentation. Students learn that prototypes do not need to be fully functional technical solutions but can take the form of sketches, mock-ups, simulations or conceptual models. These phases reinforce the idea that failure and iteration are integral parts of the design process, fostering resilience and adaptability—key competences for future engineers.

The second section of the module concentrates on creative engineering methods and tools that support and operationalise the design thinking process. This section provides students with a repertoire of structured techniques that can be systematically applied within engineering projects to enhance creativity and innovation (Engel, 2018). Methods for idea generation, such as brainstorming and other creative problem-solving techniques (Goria, 2017; Hatcher et al., 2018; Liedtka & Ogilvie, 2011; Wade & Piccinini, 2020), are introduced and practised within a controlled framework to ensure productive collaboration (Dunne and Martin, 2006) and effective outcomes.

Beyond idea generation, the module addresses tools for concept development, evaluation, selection and refinement. Students are trained to analyse and compare alternative solutions based on technical feasibility, user needs and contextual constraints. These methods are contextualised within engineering scenarios to ensure their applicability and relevance, allowing students to understand how creativity can be systematically integrated into technical design and rigorous engineering decision-making processes, rather than relying solely on intuition, filling the perceived gap between creativity and technical rationality.

All creative engineering methods are contextualised through examples and practical exercises drawn from engineering scenarios. This contextualisation ensures that students perceive creativity as an integral part of engineering practice rather than as an abstract or peripheral competence. By applying these methods to discipline-specific problems, students develop confidence in using creative approaches within their future professional environments.

The third section of the module is dedicated to the development of a technical project, which constitutes the central learning activity and the main evidence of competence acquisition. This project-based learning component ─that combined with design thinking enhances students' engagement, creativity, teamwork and engineering problem-solving competences (Jiang & Pang, 2023; Au & Goonetilleke, 2025)─ requires students to work collaboratively in teams to address a real or realistic engineering challenge by applying design thinking principles and creative engineering methods. The project serves as a synthesis of the knowledge, skills and attitudes developed throughout the module.

During the project, students are required to define the problem, analyse technical and contextual constraints, generate and evaluate alternative solutions and justify their design decisions. The emphasis is placed not only on the final solution but also on the design process itself. Students are encouraged to document their decisions, reflect on iterations and demonstrate how user needs and creativity have informed their engineering choices.

This section fosters a range of transversal competences in addition to creativity, including teamwork, communication, critical thinking and decision-making skills, reflecting the complexity of professional engineering practice. The collaborative nature of the project shows professional engineering practice, where solutions are typically developed in multidisciplinary teams and require negotiation, coordination and shared responsibility. By engaging in this project-based experience, students gain insight into the complexity of real-world engineering challenges and the value of creative, user-centred approaches.

From a methodological perspective, the module adopts an active and student-centred learning approach. Teaching strategies combine short theoretical inputs with practical activities, collaborative work and guided reflection. Project-based learning serves as the core methodology, supported by complementary techniques such as brainstorming sessions, group discussions, debates and flipped classroom elements. This pedagogical approach encourages students to take an active role in their learning process, promoting engagement, motivation and deeper understanding.

The e-learning platform plays a key role in the implementation of the module. All learning materials, activities and assessment tasks are delivered through the platform, enabling flexible access and supporting both synchronous and asynchronous learning. The digital environment facilitates collaboration among students, provides spaces for sharing ideas and project outcomes, and supports continuous interaction between students and instructors. The use of an online platform also allows the module to be easily integrated into different engineering programmes and institutional contexts.

Assessment in the Design Thinking module is closely aligned with the targeted learning outcomes and creative competences. Three complementary assessment tools are used to capture different dimensions of student learning. First, a test associated with the theoretical content evaluates students' understanding of design thinking concepts and creative engineering methods. Second, a portfolio corresponding to the technical project documents the design process, including problem definition, ideation, decision-making and final outcomes. This portfolio-based assessment allows for the evaluation of creativity as a process rather than solely as a final product. Third, students present their projects through an online presentation, which assesses communication skills, teamwork and the ability to justify and reflect on creative solutions.

To ensure transparency and consistency, assessment criteria are defined through detailed rubrics that are shared with students in advance. The evaluation framework also incorporates elements of self-assessment and peer assessment, encouraging students to reflect critically on their own learning and on the contributions of their team members. This reflective dimension is particularly relevant for the development of creative and transversal competences.

Overall, the Design Thinking: Creative Engineering Methods module developed by the Spanish partner represents a comprehensive and practice-oriented approach to fostering creativity in engineering education. By integrating theoretical foundations, creative methodologies, project-based learning and aligned assessment within an e-learning environment, the module demonstrates how design thinking can be effectively embedded in engineering curricula. These findings are also consistent with qualitative evidence showing that creativity can be effectively developed in engineering students through explicit educational interventions and structured design methodologies (Bertol-Gros et al., 2025).

The results suggest that this approach may contribute to enhancing students' creative capacity, collaborative skills and readiness to address complex engineering challenges, although further empirical validation in different institutional contexts would be required.

3.2.3 Digital thinking: Problem solving (Turkey)

The module Digital Thinking: Problem Solving, developed by the Turkish partner, addresses the need—identified in the comparative curriculum analysis—to strengthen the explicit development of structured problem-solving competences within engineering education. Although problem solving is a core element of engineering curricula, the analysis revealed that it is often approached from a predominantly technical perspective, with limited integration of creative and reflective dimensions.

In response, this module conceptualises problem solving as a transversal competence that combines analytical reasoning, creativity, ethical awareness, and practical application. Its structure reflects the CEDE competence framework and is designed to guide students from problem identification to solution implementation and reflection through a structured and iterative process.

The first section, "Understanding the Challenge", focuses on the definition and theoretical foundations of creative engineering problem solving. Students are introduced to the significance of problem-solving methodologies, distinguishing between finding any solution and finding the best solution within specific constraints. Emphasis is placed on the initial phase of problem identification, where students learn to recognize technical limitations, system failures, and emerging societal needs.

Key analytical tools are central to this phase. Students acquire the skills to apply SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) to identify internal and external factors affecting a project. Furthermore, Root Cause Analysis is taught as a critical technique to trace problems to their fundamental sources rather than merely addressing symptoms. Through the analysis of real-world engineering challenges, students develop the competence to define key elements and constraints, ensuring a deep understanding of the context before attempting to solve the problem.

The second section, "Creative Ideation and Solution Development", shifts the focus to the generation of innovative solutions. This unit is designed to instill the essential skills required to generate groundbreaking ideas and craft effective prototypes. Ideation is framed as a creative process of generating, developing, and communicating new ideas without immediate constraints.

Students are introduced to diverse ideation techniques such as Brainstorming, Mind Mapping, and SCAMPER (Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, Reverse). These methods are practiced within a collaborative environment to encourage divergent thinking. Following ideation, the module emphasizes Prototyping as a pivotal stage in transitioning from theoretical concepts to tangible applications. Students engage in hands-on activities, utilizing materials and tools, ranging from modelling clay to 3D printing and CAD software, to visualize and refine their design concepts. This phase allows for the evaluation of solutions based on criteria such as feasibility, cost-effectiveness, scalability, and innovation.

The third section, "Implementation and Reflection", is dedicated to the practical execution of engineering projects and the continuous improvement of professional practice. This unit covers the fundamentals of project management, requiring students to create comprehensive project plans, timelines, and resource assessments.

Beyond technical implementation, this section fosters a strong ethical framework. Students are trained to recognize and discuss the ethical implications of their engineering decisions, applying ethical decision-making frameworks to real-world scenarios. The module concludes with a focus on Reflective Practice, encouraging students to critically review their problem-solving journeys, identify areas for improvement, and develop strategies for continuous professional development. Emerging technologies, such as Artificial Intelligence (AI) and Machine Learning (ML), are also explored for their potential to optimize designs and predict outcomes, ensuring students are prepared for future engineering landscapes. Similarly, recent studies highlight the need to systematically develop and assess digital competences in higher education to prepare graduates for Industry 5.0 environments (Pelaez-Sanchez et al., 2024; Mejías-Acosta et al., 2024).

From a methodological perspective, the module adopts an active and student-centred learning approach aligned with CEDE design-based framework. Teaching strategies combine theoretical inputs with problem-based and collaborative activities, enabling students to engage with real-world scenarios and iteratively refine their problem-solving strategies. Collaborative learning is integral, realized through interactive workshops where students work in teams to apply SWOT analysis, brainstorm ideas, and develop prototypes. Simulation-based learning is also utilized, allowing students to engage with realistic project planning scenarios and computer-based problem-solving exercises.

Assessment is aligned with the defined learning outcomes and aims to capture different dimensions of competence development. A combination of continuous assessment and a final theoretical-practical test is used to evaluate students' ability to apply problem-solving methodologies and justify their decisions. Reflective tools, such as learning journals, are incorporated to support critical thinking and self-assessment.

Overall, this module illustrates how structured problem-solving approaches can be integrated with creativity and reflective practice in engineering education. In line with the findings of the comparative analysis and stakeholder feedback, it offers a coherent framework for addressing complex engineering challenges, although further empirical evaluation would be required to assess its impact on student learning outcomes.

3.2.4 Digital thinking: Digitalisation and artificial intelligence (Greece)

The module Digital Thinking: Digitalisation and Artificial Intelligence, developed by the International Hellenic University (IHU) within the CEDE project, addresses the need—identified in the comparative curriculum analysis—to strengthen the integration of digitalisation and artificial intelligence within engineering education. While these topics are increasingly incorporated into curricula, the analysis indicated that they are often addressed in a fragmented and tool-oriented manner, with limited integration of transversal competences such as creativity, critical thinking, and ethical awareness (Provost & Fawcett, 2013; Sammut & Webb, 2017).

In response to these findings, the IHU module conceptualises digitalisation and AI as socio-technical phenomena that fundamentally reshape industries, organisations, and everyday life, rather than as isolated technological domains. The main objective of the module is to foster digital thinking as a transversal competence that integrates technical understanding, analytical reasoning, creativity, and reflective judgement. This pedagogical orientation is consistent with contemporary perspectives in data science and AI education, which emphasise interpretability, contextual understanding, and responsible application of digital technologies (Kelleher et al., 2015; Provost & Fawcett, 2013).

The module is designed as a complementary learning unit that can be integrated into existing engineering programmes at an early or intermediate stage of study. It is delivered through the CEDE e-learning platform and structured into six sessions of two hours each (12 hours in total), allowing flexible implementation according to institutional needs.

The learning outcomes of the module are aligned with the CEDE competence framework and focus on the development of digital, analytical, and creative competences relevant to contemporary engineering practice. Upon successful completion of the module, students are expected to:

- Understand fundamental concepts of digitalisation and artificial intelligence and their historical evolution (Bishop, 2006; Sammut & Webb, 2017).
- Analyse the role of data as a core resource in digital transformation processes (Han et al., 2011; Provost & Fawcett, 2013).
- Apply basic data analytics and data visualisation techniques to support problem solving and decision making (Han et al., 2011; Kelleher et al., 2015).

- Distinguish between different types of AI systems and learning algorithms and evaluate their applications across sectors (Bishop, 2006; Pedregosa et al., 2011).

- Critically assess ethical, societal, and professional implications of AI and digital technologies (Sammut & Webb, 2017).

- Integrate digital and AI-driven approaches into business and engineering contexts in a creative and responsible manner (Provost & Fawcett, 2013).

These learning outcomes reflect the module's emphasis on digital thinking as a competence that extends beyond technical skills to include critical analysis, creativity, and ethical awareness, thereby preparing future engineers for complex, data-driven professional environments.

The module is organised into six interrelated sessions that progressively guide students from conceptual understanding to applied and reflective engagement with digitalisation and artificial intelligence. This structure ensures coherent learning progression by integrating theoretical foundations, practical activities, and critical reflection, supporting the development of digital thinking as a transversal engineering competence.

The first session introduces the core concepts of digitalisation and artificial intelligence, including key definitions, historical developments, and the growing relevance of digital technologies in contemporary society (Bishop, 2006; Sammut & Webb, 2017), reflecting the growing importance attributed to artificial intelligence and digital transformation within contemporary engineering education (Zhang et al., 2024; Liu et al., 2025). Digitalisation is presented as a transformative process that reshapes economic sectors, organisational models, and professional practices.

The second session focuses on digital thinking and digital transformation. Students explore established frameworks and models for analysing organisational change in digital contexts, with case-based discussions highlighting the importance of critically evaluating technological adoption beyond purely technical considerations (Provost & Fawcett, 2013).

The third session addresses the central role of data in digital transformation processes. Through hands-on activities on the CEDE e-learning platform, students work with structured and unstructured datasets and engage in data analytics and visualisation tasks using tools such as Orange Data Mining (Han et al., 2011; Orange Data Mining Team, 2023). These activities strengthen data literacy, model evaluation skills, and evidence-based reasoning (Kelleher et al., 2015).

Building on this analytical foundation, the fourth session introduces principles and applications of artificial intelligence. Students examine distinctions between machine learning and deep learning and engage in applied case studies comparing supervised learning algorithms using evaluation metrics such as accuracy, precision, recall, and AUC (Bishop, 2006; Pedregosa et al., 2011). This applied focus supports transparent and responsible interpretation of AI model performance.

The fifth session focuses on the integration of digitalisation and AI within organisational and business contexts. Digital business models, data-driven strategies, and AI-enabled innovation are examined to illustrate creative and strategic applications of digital technologies in professional practice (Provost & Fawcett, 2013).

The final session adopts a forward-looking and reflective perspective by exploring emerging technologies and future trends alongside ethical, societal, and professional challenges related to digitalisation and artificial intelligence. This session reinforces responsible and critical engagement with digital technologies, consistent with contemporary debates on the societal impact of AI (Sammut & Webb, 2017).

The module adopts an active, student-centred, and competence-oriented pedagogical approach aligned with the CEDE methodology. Teaching strategies combine short theoretical inputs with case studies, guided discussions, practical exercises, and collaborative activities. Emphasis is placed on linking abstract concepts to real-world engineering and business scenarios, thereby supporting experiential and applied learning (Kelleher et al., 2015).

The CEDE e-learning platform supports both synchronous and asynchronous learning by providing structured access to learning materials, multimedia resources, practical exercises, and assessment activities. Hands-on activities, particularly in data analytics and AI sessions, engage students with commonly used digital tools such as spreadsheets, data visualisation platforms, and introductory analytics environments (Han et al., 2011; Orange Data Mining Team, 2023).

Assessment in the module follows a competence-based and learning-outcome-oriented approach aligned with the defined learning outcomes. A knowledge-based test evaluates students' understanding of key concepts related to digitalisation, data analytics, and artificial intelligence (Bishop, 2006). A practical assignment or portfolio documents students' engagement with data analysis, visualisation, or AI-related case studies, enabling assessment of applied competences and creative problem solving (Pedregosa et al., 2011). Reflective activities, such as short reports or discussion contributions, assess students' ability to critically evaluate ethical and societal implications of digital technologies (Sammut & Webb, 2017).

Formative self-assessment tools are embedded throughout the module, including structured questionnaires and reflective journals that support students in evaluating their understanding of digitalisation, data analytics, and AI concepts. Quizzes, scenario analyses, and applied projects promote continuous reflection and competence development, reinforcing digital thinking as a transversal engineering competence.

Overall, the Digital Thinking: Digitalisation and Artificial Intelligence module contributes a critical dimension to the CEDE framework by integrating technical understanding with critical thinking, creativity, and ethical reflection. Initial implementation feedback suggests that digital thinking can be introduced and developed within an e-learning environment and that students value approaches that connect digital technologies with real-world challenges and societal implications (Provost & Fawcett, 2013; Sammut & Webb, 2017).

3.2.5 Soft skills (Slovakia)

The Soft Skills module, developed by the Slovak partner, focuses on communication as a core transversal competence that underpins creativity, collaboration, and innovation in engineering education. Findings from the comparative curriculum analysis conducted within the CEDE project indicate that, while engineering curricula traditionally emphasise technical knowledge, analytical reasoning, and problem-solving, communication competences are often treated as secondary or implicitly embedded within technical courses.

The comparative analysis conducted within the CEDE project revealed that, in many engineering programmes, soft skills—particularly communication skills—are insufficiently structured, rarely assessed explicitly, and often left to be developed informally through project work. This gap is especially critical in creative engineering contexts, where innovation emerges through interaction, dialogue, negotiation, and shared understanding. In response, the Slovak partner designed a comprehensive Soft Skills module with a strong emphasis on communication for creative engineering, positioning communication not as an auxiliary competence but as a foundational element of creative and innovative engineering practice.

The module conceptualises communication as a multidimensional competence encompassing written, verbal, interpersonal, and digital communication skills, as well as ethical and responsible communication. Its main objective is to equip engineering students with the ability to communicate complex technical ideas effectively, collaborate within diverse teams, and present innovative solutions in a clear, persuasive, and socially responsible manner.

Communication is framed as a dynamic process that enables creativity by facilitating idea generation, critical discussion, feedback, and shared problem-solving. In creative engineering, where solutions often arise from interdisciplinary interaction and iterative design processes, effective communication becomes a key enabler of innovation. The module therefore aims to develop students' capacity to express ideas clearly, listen actively, adapt messages to different audiences, and engage constructively in collaborative and professional contexts.

The module is structured into three main thematic blocks, each addressing a specific dimension of communication in creative engineering practice. The content is designed to progress from foundational communication skills to advanced applications in professional and innovation-oriented contexts.

The first block introduces communication skills as a cornerstone of creative engineering. Students explore the role of communication in engineering projects, design thinking processes, and innovation ecosystems. Emphasis is placed on understanding communication as more than the transmission of information; it is presented as a relational and interpretative process that builds shared meaning, trust, and collaboration among team members and stakeholders.

A key focus is placed on the ability to translate technical concepts into language accessible to non-technical audiences. Engineers frequently interact with managers, clients, investors, policymakers, and the general public, and their capacity to explain ideas clearly can significantly influence decision-making and project success. Students learn strategies for

avoiding excessive technical jargon, using analogies and storytelling, and highlighting the relevance and benefits of engineering solutions rather than focusing solely on technical details.

Active listening is introduced as an essential communication skill in creative engineering. Through guided exercises, students learn how to solicit and incorporate feedback, recognise different perspectives, and engage in constructive dialogue. Active listening is framed as a prerequisite for effective collaboration, conflict prevention, and continuous improvement within engineering teams.

The module also emphasises the use of visual communication techniques—such as sketches, diagrams, prototypes, graphs, and infographics—as powerful tools for conveying complex ideas. Visualisation is presented as a bridge between disciplines, enabling engineers to communicate concepts efficiently and support collaborative decision-making processes.

The second block focuses on effective written and verbal communication in engineering contexts. Written communication is presented as a permanent and strategic component of engineering work, essential for documenting ideas, decisions, and processes. Students are introduced to principles of clarity, precision, structure, and conciseness in technical writing. Particular attention is given to audience-oriented writing, encouraging students to adapt tone, style, and level of detail according to the intended recipients.

The module addresses different forms of written communication relevant to engineering practice, including technical reports, emails, project documentation, and proposals. Students learn how to organise information logically, use headings and visual elements effectively, and ensure accuracy and consistency. Ethical considerations, such as proper attribution of sources and avoidance of misleading statements, are integrated into the discussion of written communication.

Verbal communication is explored as a critical skill for teamwork, leadership, and professional interaction. Students examine elements such as clarity of expression, tone of voice, non-verbal communication, and confidence in delivery. The module highlights the role of verbal communication in mitigating conflicts, enhancing motivation, and fostering innovation within teams. Through practical activities, students develop skills in explaining ideas orally, participating in discussions, and providing constructive feedback.

Public speaking and presentation skills form a key component of this block. Engineers are increasingly required to present ideas in academic, industrial, and entrepreneurial settings. The module introduces principles of effective presentation design, audience engagement, and storytelling. Students learn how to structure presentations logically, use visual aids responsibly, and adapt their delivery to different contexts.

The third block addresses interpersonal communication, collaboration, and ethical responsibility in engineering communication. Students explore how professional relationships are built on trust, respect, transparency, and accountability. The module emphasises that strong interpersonal communication skills are essential for effective teamwork and for creating an environment conducive to creativity and innovation.

Collaboration is presented as a necessity rather than an option in modern engineering practice. Students analyse the dynamics of multidisciplinary teams and learn strategies for effective coordination, role clarification, and shared decision-making. Conflict resolution and negotiation techniques are introduced, highlighting conflicts as natural and potentially productive elements of team interaction when managed constructively. Students practise techniques such as active listening, reframing, and win–win negotiation approaches.

Cross-cultural communication is addressed as a critical competence in global engineering environments. Students examine how cultural differences can influence communication styles, decision-making, and collaboration. The module promotes cultural awareness, empathy, and adaptability as key attributes for engineers working in diverse teams and international contexts.

Ethical and responsible communication is integrated throughout the module. Students are introduced to principles of honesty, accuracy, transparency, and respect in technical communication. Issues related to confidentiality, data protection, and responsible dissemination of information are discussed, particularly in relation to digital communication tools and public presentations. Engineers' societal responsibility to communicate risks, limitations, and uncertainties clearly is emphasised, reinforcing the link between ethical communication and professional integrity.

From a methodological perspective, the Soft Skills module adopts an experiential, student-centred, and reflective learning approach, in line with the CEDE design-based framework. Teaching strategies combine short theoretical inputs with interactive activities, role-playing scenarios, case studies, group discussions, and guided reflection. This approach aligns with the broader CEDE philosophy of learning by doing and supports the development of communication skills through practice and feedback.

Role-playing exercises are a central pedagogical tool within the module. Students engage in simulated scenarios such as team conflicts, stakeholder meetings, technical explanations for non-expert audiences, and startup pitching sessions. These activities allow students to experiment with different communication strategies, reflect on their effectiveness, and develop confidence in real-world communication situations.

The e-learning platform plays a crucial role in delivering the module. All learning materials, exercises, and assessment tasks are hosted on the platform, enabling flexible access and supporting both synchronous and asynchronous learning. Online discussion forums and collaborative tools facilitate peer interaction and collective learning, while reflective tasks support individual learning trajectories.

Assessment within the Soft Skills module is aligned with the competence-based framework of the CEDE project. Three complementary assessment tools are used to capture different dimensions of communication competence development. A reflective self-assessment questionnaire encourages students to evaluate their communication strengths, learning progress, and areas for improvement. A group-based task assesses interpersonal communication and collaboration skills within team activities. Finally, a presentation-based assessment evaluates students' ability to articulate ideas clearly, structure arguments, and communicate professionally in oral form.

Assessment criteria are defined through transparent rubrics shared with students in advance. The emphasis is placed on both process and outcomes, reinforcing the understanding of communication skills as competencies that develop over time through practice, reflection, and feedback.

Overall, the Soft Skills: Communication for Creative Engineering module provides a structured approach to integrating communication competences into engineering education. It illustrates how communication can be explicitly addressed as a transversal competence within the CEDE framework.

In line with the findings from the comparative analysis and stakeholder feedback, the module highlights the relevance of communication skills for creative and collaborative engineering practice. While the results indicate its alignment with identified needs, further implementation and evaluation would be required to assess its impact on student learning outcomes.

3.2.6 Overall outcomes of the module development

The development of the 5 modules represents the implementation of the needs identified during the comparative curriculum analysis regarding the explicit integration of creativity into engineering education. Although the initial analysis revealed important differences in the explicit integration of creativity across the participating institutions, the consortium developed a common curriculum that addresses these gaps through complementary competence units covering critical thinking, design thinking, digital thinking and soft skills (Table 4).

A significant outcome of the project is the establishment of a common pedagogical architecture shared by all modules. The adoption of a shared pedagogical architecture is consistent with recent proposals advocating educational ecosystems based on design thinking and collaborative curriculum innovation (Berglund, 2024). Despite addressing different competence domains, each unit follows the same instructional design principles, including competence-based learning, active learning methodologies, project-oriented activities and student-centred learning.

This common structure facilitates implementation across different engineering programmes while allowing institutions sufficient flexibility to adapt the content to their own curricular context and disciplinary needs. These outcomes reinforce recent recommendations advocating creativity-centred engineering education capable of responding to the challenges of digital transformation and sustainable development (Hsu et al., 2025). Beyond serving as a repository of teaching materials, the platform facilitates collaboration, autonomous learning and the dissemination of the CEDE educational framework among higher education institutions.

Table 4. Summary of the educational outputs developed within the CEDE project.

Module	Educational need identified during the comparative analysis	Main educational outcome	Assessment tools developed	Targeted competence
Critical Thinking: Introduction to Creative Engineering (Italy)	Limited explicit development of critical and creative reasoning in engineering curricula	Competence unit introducing critical thinking as the foundation of creative engineering	Test + Reflective activities + Project creation	Critical thinking and creative reasoning
Design Thinking: Creative Engineering Methods (Spain)	Limited integration of structured creativity methodologies into engineering education	Three-part module introducing design thinking, creative engineering methods and project-based application	Test + Portfolio + Project presentation	Design thinking and creative problem solving
Digital Thinking: Problem Solving (Turkey)	Need for structured approaches to solving complex engineering problems	Competence unit focused on digital thinking and systematic problem-solving methodologies	Test + Case study challenge + Case study analysis	Analytical and creative problem solving
Digital Thinking: Digitalisation and Artificial Intelligence (Greece)	Growing demand for digital competences and AI literacy in engineering practice	Module introducing digital transformation and artificial intelligence in engineering contexts	Test + Case study + Scenario Analysis Exercise	Digital competence and AI awareness
Soft Skills (Slovakia)	Need to strengthen interpersonal and professional competences alongside technical knowledge	Competence unit focused on communication, teamwork, leadership and professional development	Test + Group-based task + Oral presentation	Communication, teamwork and professional skills

Table 5. Findings.

Finding	Evidence	Educational implication
Creativity is unevenly integrated across engineering curricula	Comparative analysis of partner universities	Need for a complementary competence-based framework
A common competence framework can be developed across different countries	Five jointly designed modules following a shared architecture	Transferable educational model
A common pedagogical architecture is applicable to different competence domains	All modules share learning outcomes, active methodologies and aligned assessment	Facilitates curricular integration
Stakeholder validation suggested the relevance of the framework	Feedback from students, teachers and industry representatives	Minor refinements introduced before final implementation

The main findings derived from the comparative analysis, the cross-partner module development process and the stakeholder validation are summarised in Table 5.

3.3 Results of the round table and stakeholder feedback

The validation of the CEDE training proposal was complemented through stakeholder round tables organised across the participating countries. These activities aimed to evaluate the relevance, feasibility and potential curricular integration of the developed modules and the associated e-learning platform. Stakeholders included academic staff, students, university representatives, professional associations and companies related to engineering education and practice.

For illustrative purposes, detailed results are first presented for the University of A Coruña case. This is followed by a cross-partner validation synthesis based on evidence gathered through round tables and multiplier events conducted by the other project partners.

3.3.1 UDC case

The round table took place at the Campus of Ferrol (University of A Coruña). In total, 18 participants attended, representing a deliberately diverse set of perspectives relevant to curricular adoption and employability. The participant profile distribution reported was: 1 academic responsible, 5 teaching staff, 3 companies, 5 student representatives, and 4 "others" (including engineering associations and other associations). In terms of composition and independence, the validation exercise was carried out by a group of professors from UDC who were not involved in the CEDE project, reinforcing the intention to gather external-to-the-project academic feedback. The round table also included students from the two engineering schools on the Ferrol Industrial Campus and representatives from engineering colleges/associations. From the non-academic stakeholder side, companies explicitly reported as participating in the testing process were MINT, Gasóleos San Marcos, Anta Norte, and Tecnopro Hispania.

The discussion "focused on the review and validation of five training modules for incorporation into the curricula of various engineering degrees across Europe". The round table was therefore framed not as an open-ended ideation workshop, but as a structured validation of (i) the adequacy of theoretical content, (ii) the balance between theory and practice, (iii) the suitability of assessment tools, (iv) scheduling/time allocation, (v) perceived usefulness of the web platform, (vi) coverage of competences, and (vii) feasibility of curricular integration.

To support a shared understanding, the organisers used a dedicated presentation that briefly introduced the CEDE project rationale—i.e., the need to teach and foster creativity in engineering education—and positioned CEDE as a multi-country Erasmus+ cooperation partnership. The slides also contextualised the five-module structure of "Creative engineering" (critical thinking, design thinking, digital thinking/problem solving, digitalisation & AI, and soft skills), explaining that each module was designed with content, methodology and evaluation components. This ensured that stakeholders could comment not only on topic relevance, but also on implementability and assessment design. Stakeholder feedback was captured through a structured questionnaire implemented in Microsoft Forms and also reproduced in the round table presentation The survey included an initial profiling question and seven content/implementation questions:

- Participant collective (Academic responsible/Teaching staff/Company/Engineering associations /Student representatives/Others).
- Whether additional theoretical questions should be added to the modules, and if yes, which ones.
- Whether additional activities should be included (or comments if not).
- Whether the evaluation tools are appropriate, and suggestions for additional ones if needed.
- Whether the schedule/time allocation is appropriate, and comments if not.
- Whether the webpage/platform is useful, including perceived drawbacks.
- Whether additional competences should be added, and which ones.
- Whether it would be possible to include the modules in the academic program, and if not, why.

This combination of (a) respondent profiling and (b) targeted questions on content, pedagogy, assessment and implementation feasibility produced feedback that could be directly mapped onto module redesign decisions and curricular integration strategies.

3.3.1.1 Overall results and key insights from stakeholder feedback

- Sufficiency of theoretical content (Q2)

Across respondents, the prevailing view was that the theoretical content is broadly sufficient. The round table report summarises that "most respondents believe the current theoretical content is sufficient," with one suggesting a

reinforcement via design thinking to better address complex contemporary contexts. This is consistent with qualitative comments in such as: *"I consider the theoretical part is enough, even extensive"* and *"They are in line with what the project proposes."*

However, one of the most substantive suggestions was to consider "the introduction of design thinking … emphasizing the current reality defined by VULCA-BANI contexts," connecting module framing to contemporary complexity and uncertainty. Another participant nuanced the need for additional theory by noting that, depending on the cohort, "students already have some kind of background or interest that can help lay the foundation for the module." Taken together, the feedback supports maintaining the existing theoretical backbone while allowing flexible adaptation depending on prior knowledge and local curricula.

- Need for additional activities and practice-oriented reinforcement (Q3)

A recurring theme was the desire to expand the practical component to strengthen application and skills development. The round table report notes that respondents suggested *"more extensive practical activities or internships"* to apply theoretical knowledge, while also acknowledging time constraints. This is mirrored by comments such as: *"I think the practical part should be a little more extensive … [but] I do not know what extent the students would have enough time to develop the projects during the hours indicated in the schedules"* and *"it would be feasible to implement internships in order to improve the acquisition of the skills."*

From an implementation standpoint, this feedback points to a trade-off that stakeholders explicitly recognised: increasing hands-on work can improve learning-by-doing outcomes, but it must be reconciled with timetable constraints and realistic student workload.

- Assessment design and integrity considerations (Q4)

While stakeholders generally considered the evaluation tools "appropriate," they provided several targeted recommendations. The round table report highlights proposals to: incorporate peer assessment, clarify portfolio requirements, use more reflective or reasoning-based questions to prevent misuse of AI tools, and consider alternative credentialing approaches such as open badges. Some recommendations are:

- "*Yes but we should include peer to peer assessment.*"

- A detailed critique notes that the "portfolio" concept may be confusing (a portfolio is usually built over time), and that "solving a challenge is the best way to internalize and put into practice" design thinking; the comment also proposes "the inclusion of an open badge system … encouraging students to self-assess," referencing experience from another Erasmus+ project ("Open Design and Manufacturing").

- Multiple participants raised concerns about online multiple-choice questionnaires being vulnerable to generative AI: one warns that students could "*pass all the questions to an artificial intelligence chat*," recommending questions that require a "high degree of student reasoning" or essay-based approaches when theoretical knowledge is assessed.

These comments are especially relevant for e-learning deployment: they do not reject quizzes outright, but they call for assessment redesign that protects academic integrity and better evaluates reasoning, reflection and authentic creative problem solving.

- Schedule and balance of emphases (Q5)

Stakeholders generally found the schedule appropriate, but feedback emphasised the importance of balancing breadth and depth and adapting timing to different cohorts. The round table report states that respondents "generally find the schedule appropriate," though some suggested adjustments to balance content depth, emphasise creativity over communication, and tailor timing based on prior knowledge and engineering focus.

The qualitative feedback provides texture to this: *"It looks like a tight schedule to cover a big topic, but the approach looks promising,"* and *"it might be necessary to place greater emphasis on the first part … or the second … depending on the type of engineering and prior knowledge."* One of the most pointed comments argued that *"communication skills*

have a great weight … Creativity and knowledge shall prevail over communication," warning that *"a wrong response well communicated can be dangerous, because [it can] transmit false trust to [the] general public."* This comment is important because it reframes "soft skills" not as an end in themselves, but as something that must be anchored in correctness, responsibility, and critical judgement—particularly relevant in technology-mediated contexts.

- Web platform usefulness (Q6)

For the question on the webpage/platform, results notes that *"It was no possible to answer this question."* As this is the only explicit outcome recorded for Q6 in the provided materials, conclusions about perceived platform usefulness must remain cautious: the available dataset does not contain evaluative responses, only the indication that it could not be answered. While no evaluative responses regarding platform usefulness were recorded in the UDC round table, positive feedback concerning platform usability and functionality was reported by other project partners.

- Competences to be added (Q7)

While one respondent considered the competences sufficient, others suggested reinforcing specific transversal and cognitive skills. The round table report identifies additions such as complex problem solving, empathy, testing and prototyping, and the ability to critically assess incorrect or AI-generated responses. This is consistent with direct comments: *"Ability to quickly check and judge incorrect solutions … detect AI-related bad responses,"* and *"The DT module could include … Complex Problem Solving … listening and empathy … focus on testing and prototyping for solution validation."*

These suggestions are coherent with the project's overarching aim to strengthen creative engineering profiles: stakeholders are effectively asking for competence framing that makes explicit the link between creativity, critical judgement, and validation practices (prototype/test), as well as human-centred skills (listening/empathy).

- Feasibility of curricular integration (Q8)

Finally, stakeholders were broadly optimistic about integrating the modules into academic programmes, but emphasised that the most realistic path is often flexible or optional integration rather than a one-size-fits-all compulsory subject. The round table report summarises that most respondents believe inclusion is possible, *"often as optional, complementary, or adaptable components,"* while noting challenges due to curriculum constraints and the need to develop transversal skills.

Qualitative statements reinforce this position: *"Yes … it would help students of more 'technical' engineering programs develop new skills,"* but also *"No … better if it's included in a non-compulsory activity program,"* and *"Yes, like an optional subject."* Several participants propose modular integration strategies: integrating single modules "as optional training courses that complement the academic program," or using the content as "basic training" that can serve as a foundation for later development across the programme, even while acknowledging implementation complexity. One respondent also suggested strengthening collaboration with companies or analysing success stories ("Collaborative module with companies or analysis of success stories").

3.3.2 Cross-partner validation evidence

In addition to the detailed stakeholder validation conducted at the University of A Coruña, partner institutions in Italy, Greece, Slovakia and Turkey organized round tables and/or multiplier events aimed at presenting the CEDE framework, gathering stakeholder feedback and assessing the relevance, feasibility and potential curricular integration of the proposed modules. The available evidence differed in format and level of detail across partners. Therefore, the cross-partner analysis was conducted as a structured synthesis of the available documentary evidence rather than as a fully standardized comparative statistical analysis. Nevertheless, the different activities provide complementary evidence regarding stakeholder perceptions of the CEDE framework across several European educational and professional contexts.

The Italian round table, organised by the University of Molise, involved representatives from higher education institutions, engineering associations, students and companies. Discussions focused on the integration of creativity, innovation, communication and transversal competences into engineering programmes, as well as on strengthening collaboration between universities and industry to improve graduate preparedness for future professional challenges.

Table 6. Cross-partner stakeholder validation activities documented in the CEDE project.

Country/ partner	Type of activity	Participants	Main focus or feedback	Main contribution
Spain (UDC)	Round table and dissemination activities	18 participants	Content, assessment, competences and curricular integration	Detailed qualitative validation
Italy (UNIMOL)	Round table and multiplier event	43 participants + >40	Creativity, innovation, communication and university–industry collaboration	Validation of the CEDE framework and transversal skills approach
Greece (IHU)	Round table	50 participants	Theory, activities, assessment, platform, competences and curricular integration	Structured stakeholder validation through questionnaire
Slovakia (SPU)	Round table and multiplier event	30 + 35 participants	Barriers to implementation, university–industry collaboration and teacher support/ Applicability of the CEDE learning model and educational outputs	Identification of implementation and institutional challenges/ Additional feedback on transferability and implementation
Turkey (Kocatürk Consulting)	Round table and multiplier	30 participants	Industry relevance, practical learning and curriculum development	Reinforcement of university–industry collaboration and practical approaches

The Greek round table, organised by the International Hellenic University, involved 50 participants, including students, university staff, engineers and company representatives. According to the aggregated results, most participants considered the existing theoretical content sufficient, while a large majority supported the inclusion of additional practical activities. The evaluation tools were generally regarded as appropriate and the CEDE platform received positive evaluations. Furthermore, most respondents considered the integration of the modules into academic programmes to be feasible. The accompanying qualitative feedback emphasised the value of applied learning activities, portfolio-based assessment, AI literacy and flexible curricular integration.

The Slovak round table focused on the barriers to implementing creativity and innovation in engineering curricula, the development of university–industry collaboration for fostering transversal competences, and the support required by teachers to teach communication, reflection and teamwork effectively. Participants highlighted the importance of practical experience, institutional readiness and real teaching conditions when introducing creativity-oriented educational content. A subsequent multiplier event provided additional opportunities to present the CEDE outputs and gather feedback regarding the relevance and applicability of the learning model within Slovak higher education and technical education contexts.

In Turkey, stakeholders highlighted the importance of strengthening practical and industry-oriented learning experiences through hands-on projects, workshops and seminars delivered by industry experts. Participants also recommended regular curriculum updates aligned with emerging technologies, enhanced faculty development in innovative teaching methodologies and stronger cooperation mechanisms between academia and industry to support curriculum design and implementation.

3.3.3 Synthesis

Across all partner activities, despite differences in the available documentation and data collection formats, several recurring themes emerged. Stakeholders consistently highlighted the relevance of creativity and transversal competences in engineering education, the need to reinforce practical and project-based learning activities, the importance of robust assessment approaches, the feasibility of flexible curricular integration models and the value of sustained university–industry collaboration. These findings complement the detailed UDC case study and provide broader evidence supporting the relevance, applicability and transferability of the CEDE framework across multiple European contexts.

Table 7. Key insights derived from the CEDE stakeholder validation activities.

Dimension evaluated	Main trend	Illustrative comments
Theoretical content	Largely sufficient	"The theoretical part is enough, even extensive"
Practical activities	Need for expansion	"The practical part should be more extensive"
Assessment tools	Appropriate, but improvements suggested	"Include peer assessment"; "Avoid AI-vulnerable quizzes"
Schedule	Generally appropriate	"Tight but promising"
Competences	Some additions suggested	"Complex problem solving"; "Empathy"
Curricular integration	Feasible with flexibility	"Optional or complementary modules"

Taken as a whole, the round table and survey responses validate the relevance of the CEDE modules while identifying concrete, actionable refinements (summarised in Table 7). First, the theoretical base is largely endorsed, with a targeted call to ensure the framing is robust for contemporary complexity (e.g., links to design thinking and complex problem contexts). Second, stakeholders consistently request stronger practice-oriented learning opportunities (expanded practical tasks and/or internships), but with awareness of schedule feasibility. Third, assessment design emerges as a critical area for improvement: respondents support adding peer assessment, clarifying portfolio/journal expectations, and redesigning quiz-based assessment to require reasoning and reduce vulnerability to generative AI misuse; open badges are proposed as a motivating complementary mechanism. Fourth, the schedule is seen as workable but may need adaptation by degree type and prior knowledge, and stakeholders highlight the need to preserve a clear hierarchy where creativity and correctness underpin communication. Finally, most stakeholders see curricular integration as feasible, particularly through flexible models such as optional subjects, complementary modules, or embedding selected units within existing courses—an approach aligned with the diversity of European engineering curricula.

4. Conclusions/discussion

The CEDE – Creative Engineering project provides a structured and collaborative approach to integrating creativity-related competences into engineering education through a coordinated, international and modular framework. The results of the project indicate the relevance and potential feasibility of such an approach, based on comparative curriculum analysis, instructional design, and participatory evaluation.

By incorporating design thinking, creative engineering methods, critical thinking, and digital thinking, the project proposes an approach aligned with the growing demand for engineers capable of addressing complex, real-world problems. The results suggest that fostering creativity through structured methodologies may support the development of both technical and transversal competences.

4.1 Key findings

The primary outcome of the CEDE project is the development of a common complementary module designed to foster creative engineering competences across diverse higher education contexts. The module is composed of five interconnected thematic areas—critical thinking, design thinking, digital problem solving, digitalisation and artificial intelligence, and soft skills—each addressing a specific dimension of creativity in engineering practice. Together, these modules form a coherent framework that supports the development of creativity as a transversal competence embedded within engineering education rather than as an isolated or optional component.

The comparative analysis of engineering curricula conducted at the initial stage of the project highlighted that while creativity is often mentioned in educational objectives, it is rarely explicitly embedded into the core curriculum. Also, it revealed significant variability in how creativity and transversal competences are addressed across institutions and countries. In many cases, creativity was present only implicitly or fragmented across courses, with limited use of active and student-centred methodologies. These findings confirmed the need for an explicit, structured and transferable educational intervention that prioritise creativity as a fundamental skill in engineering education.

The CEDE framework responds to this need by offering a flexible module that can be integrated into existing curricula at an early stage and adapted to different institutional and disciplinary contexts. Furthermore, the roundtable feedback from students, faculty, and industry stakeholders indicates that creativity-focused modules were perceived as highly beneficial for improving students' problem-solving abilities, teamwork skills, and capacity for innovation.

4.2 Discussion: Implications for engineering education

The integration of creativity and design thinking into engineering curricula represents a paradigm shift in the way we view the role of engineers. Traditionally, engineering education has focused heavily on technical knowledge and analytical skills, with creativity often regarded as a supplementary or non-essential component. However, as the demand for engineers capable of addressing complex, ill-defined problems continue to grow, it is becoming increasingly clear that creativity is no longer a luxury but a necessity.

From a pedagogical perspective, the results of the CEDE project highlight the importance of active, project-based and student-centred learning methodologies for the development of creative competences in engineering students. One of the main challenges identified throughout the project was the need for pedagogical approaches that balance creativity with the rigorous technical requirements of engineering education. The CEDE project suggests that creativity and technical skills can be integrated within engineering education, supporting more holistic approaches to problem solving. However, the process of integrating creative methodologies into traditional engineering courses is not without challenges. It requires both faculty and students to embrace new ways of thinking, often disrupting established teaching methods. Moreover, ensuring that creativity is evaluated in a meaningful and measurable way remains a critical challenge for educators.

Across all modules, creativity is approached as a competence that can be taught, practised and assessed through structured methodologies rather than as an innate or informal ability. The project provides preliminary evidence that creativity can be addressed and assessed through structured methodologies, that integrate critical thinking, design thinking, digital tools and soft skills.

The use of a shared e-learning platform emerges as a key enabler of this approach. The platform is designed to facilitate access to learning materials, support collaboration and reflection, and enable the integration of diverse assessment tools. It also provides a structure that support coherence across modules while allowing adaptation to different contexts. This balance between standardisation and flexibility is one of the strengths of the CEDE framework.

The development of appropriate assessment tools is essential for ensuring that students' creative competences are effectively monitored and evaluated. The development of fifteen assessment tools, aligned with learning outcomes and creative competences, responds to a recognised challenge in engineering education: the meaningful evaluation of creativity and transversal skills. By combining formative and summative approaches, it offers a structured framework for assessing both processes and outcomes.

Furthermore, the CEDE project highlighted the importance of cross-institutional and international collaboration in educational innovation. The engagement of five partner institutions across Europe allowed for a rich exchange of ideas, pedagogical strategies, and cultural perspectives on creativity in engineering education. This collaborative approach not only enriched the content and methodology of the creative engineering modules but also facilitated the development of an e-learning platform that can be easily adapted to different institutional contexts and engineering disciplines.

The development of the CEDE framework was informed by established research on Design Thinking, creativity in engineering education, and Design-Based Research (DBR). Design Thinking has been widely recognised as an effective approach for addressing complex problems through iterative, user-centred, and innovation-oriented processes (Brown, 2008; Razzouk & Shute, 2012). Furthermore, previous studies have highlighted the relevance of creativity as a core competence in engineering education, emphasizing its contribution to problem solving, innovation, and adaptability in rapidly changing professional environments (Pusca & Northwood, 2019; Peroni, 2024). Building on these foundations, the present study adopted a Design-Based Research approach, which combines the design of educational interventions with iterative cycles of implementation, evaluation, and refinement. This methodological perspective enabled the development and validation of the CEDE framework through a continuous interaction between theoretical principles, curriculum analysis, and stakeholder feedback, ensuring both educational relevance and practical applicability. In this context, stakeholder validation and comparative curriculum analysis constituted the primary sources of empirical evidence, allowing the framework to be refined and evaluated across diverse institutional and professional perspectives.

4.3 Dissemination of the Project

The project's dissemination strategy combined institutional communication, mass-media outreach, and community-facing events to ensure visibility at local, national, and EU levels across partner countries. Activities were coordinated through university channels, public events, and the project's own EU-wide social media presence, with documentation (posts, news items, videos) openly accessible.

UNIMOL implemented a dual track of public events and digital communication. A national, online multiplier event engaged stakeholders in creative engineering (>40 participants). Multiple Open Day activities in Campobasso showcased project outcomes to university audiences (>100–200 attendees). A Research Day in Isernia (>200 participants) further extended reach among students and staff. These were amplified through social media posts at institutional and project pages ensuring EU-level discovery and sustained visibility.

Spain prioritized institutional web and regional/national media to reach wider publics beyond academia. UDC's newsroom published multiple items summarizing project goals and meetings to a potential audience of >20,000 The project was continuously featured on campus social media with engagement metrics. Press coverage spanned local and national outlets The project also reached radio audiences. Finally, the project was presented in a national teaching innovation conference (XIGAID).

Dissemination in Slovakia combined large-scale fair presence and STEM engagement with students. The Agrokomplex 2024 fair in Nitra reached a general audience in the tens of thousands (>10,000). Additional STEM hackathon and workshops targeted the educational community (≈30–35 participants per activity). These actions were complemented by social media posts—in Slovak and English—announcing project meetings to national/EU audiences (e.g., Facebook items with bilingual coverage and links).

Greek dissemination activities focused on enhancing the visibility of project meetings and strengthening regional outreach through institutional and partner communication channels. Project meetings held in Serres were highlighted via campus communication platforms and were subsequently referenced in press notes issued by Spanish partners, illustrating effective cross-border information flows and the generation of lasting digital records of the project activities.

In Turkey, Kocatürk Consulting contributed concretely to the project's dissemination by actively participating in project meetings and providing content support for the promotion of project outputs. In particular, the partner shared information highlighting developments related to the e-learning platform through the consortium's communication channels and organised a round table event targeting key stakeholders (academics, engineering educators, university staff, students, and industry/SME representatives). Through this event, Kocatürk Consulting promoted the CEDE outputs and supported the practical use of the e-learning platform and creativity-focused modules, thereby fostering the uptake of the project results in Turkey and their integration into educational practices beyond the project period.

An English-language Facebook page functioned as a cross-partner hub for videos, meeting summaries, and poster highlights, extending discoverability across the Erasmus+ ecosystem. Collectively, these activities support a balanced portfolio: mass-event exposure (Italy, Slovakia), sustained digital amplification (Italy, Spain, EU page), institutional credibility via university newsrooms (Spain), and media corroboration (press and radio), meeting the typical Erasmus+ expectations of multi-level dissemination.

4.4 Lessons learned and future directions

Several key lessons emerged from the CEDE project, which may guide future efforts in integrating creativity into engineering education:

First, integrating creativity-focused modules into engineering curricula requires institutional commitment and coordination among teaching staff. While the modular and complementary nature of the CEDE framework facilitates integration, long-term sustainability depends on the willingness of institutions to embed such approaches within their educational strategies.

The success of creativity modules in different institutional contexts underscores the importance of adaptability. A one-size-fits-all approach is unlikely to work in diverse educational environments. The CEDE project's flexible, modular design allows for adjustments based on local curricula, institutional resources, and cultural contexts, ensuring that creativity-focused learning can be integrated effectively into a wide range of engineering programmes.

Second, the successful implementation of creative and student-centred methodologies highlights the need for continuous professional development for educators. Teaching creativity in engineering requires not only new tools and resources but also a shift in pedagogical mindset, moving from content transmission towards facilitation, guidance and reflection.

Third, the participatory evaluation process, particularly the round tables involving students, teachers, university staff, professionals and companies, was identified as a key element for ensuring the relevance and applicability of the developed modules, and it is critical for refining educational content and methodologies. The iterative nature of design

thinking aligns well with the need for continuous feedback in education, and this multi-stakeholder engagement strengthened the quality of the outcomes and reinforced the connection between higher education and professional practice.

Feedback from industry professionals has been instrumental in shaping the modules and ensuring their relevance to the skills needed in the workplace. Moving forward, stronger collaboration between universities and industry stakeholders is essential for developing curricula that address both academic and practical needs, fostering innovation and employability.

Looking forward, future work should focus on the long-term evaluation of the impact of the CEDE framework on student learning, employability and professional performance. The development of the e-learning platform has proven to be an effective tool for delivering the module content, fostering collaboration, and assessing student progress. However, further investment in e-learning technologies and resources is needed to expand the reach of such initiatives and ensure that all students, regardless of geographical location or institutional resources, have access to creative engineering education.

Expanding the use of the e-learning platform, integrating the modules into additional engineering programmes and strengthening collaboration with industry partners represent key directions for further development. In addition, future research could explore the scalability of the framework and its adaptation to other disciplines beyond engineering.

4.5 Limitations and Future research

Despite the promising results obtained, this study presents several limitations that should be acknowledged. First, although stakeholder validation involved participants from multiple countries and stakeholder groups, the available evidence was heterogeneous in format and depth across partner institutions, which may limit the generalisability of the findings. Second, the evidence generated is predominantly qualitative in nature, relying on stakeholder feedback, perceptions, and expert validation rather than large-scale quantitative analyses. Third, the study did not measure learning gains or changes in students' creative competences following implementation of the CEDE modules. Consequently, the findings primarily reflect stakeholders' perceptions regarding the relevance, feasibility, and potential value of the framework rather than its direct impact on educational outcomes. These limitations are consistent with the exploratory and developmental nature of the Design-Based Research approach adopted in this study.

Future research should focus on the longitudinal evaluation of the CEDE framework in different institutional and disciplinary contexts. In particular, further studies should examine the long-term impact of the modules on students' creativity, problem-solving abilities, transversal competences, and employability outcomes. The incorporation of larger samples, mixed-methods designs, and pre- and post-intervention assessments would provide stronger evidence regarding the effectiveness of the framework and contribute to a deeper understanding of how creativity-oriented educational innovations influence engineering education over time.

5. Conclusions

In conclusion, the CEDE project represents a structured and collaborative attempt to integrate creativity and innovative problem-solving methods into engineering education. This project contributes to the discussions by providing a transferable and evidence-informed framework for embedding creativity and transversal competences into engineering curricula.

From a practical perspective, the CEDE framework offers engineering educators a flexible and transferable model for integrating creativity-related competences into existing curricula through modular learning pathways, competence-based assessment strategies, and digital learning environments. The findings demonstrate that creativity, critical thinking, digital thinking, and soft skills can be systematically taught and assessed within engineering programmes while remaining adaptable to different institutional and disciplinary contexts.

From a theoretical perspective, this study contributes to engineering education research by proposing and validating a transnational framework that integrates creativity, design thinking, digital thinking, problem solving, artificial intelligence, and soft skills into a coherent competence-based model. By adopting a Design-Based Research approach, the study also advances understanding of how creativity-oriented educational innovations can be iteratively designed, evaluated, and refined through stakeholder participation, thereby strengthening the connection between educational theory and engineering education practice.

The findings suggest that structured methodologies such as design thinking and project-based learning may support the development of competences relevant for addressing complex engineering challenges. While the results indicate the relevance and perceived value of this approach, further implementation and longitudinal evaluation would be required to assess its impact on student learning and professional outcomes.

Continued development, dissemination and institutional support will be essential to ensure the sustainability of such initiatives. The lessons learned from the CEDE project will inform future educational practices and contribute to the evolution of engineering education towards more integrated, creative, and student-centred approaches.

Ethics and consent

In accordance with Spanish Law 14/2007 of 3 July on Biomedical Research, which limits its scope to biomedical research involving human participants or human biological material, as established in Articles 1 and 12 (https://www.boe.es/eli/es/l/2007/07/03/14/con), ethical approval is not required for this project. In addition, the Ethics Committee of the University of A Coruña indicated that projects not involving interventions on human beings or the use of biological samples of human origin are exempt from the requirement of formal ethical approval. As the CEDE project does not include such interventions, ethical approval was not required.

Nevertheless, all activities were conducted in full compliance with current regulations on personal data protection and information preservation. The handling of information was fully compliant with Organic Law 3/2018 of 5 December on the Protection of Personal Data and the Guarantee of Digital Rights, as well as with Law 37/2007 of 16 November on the reuse of public sector information, which regulates the reuse of research data generated by public institutions, provided that requirements relating to personal data protection, confidentiality, and intellectual property are respected.

(https://www.boe.es/eli/es/l/2007/11/16/37; https://www.boe.es/eli/es/lo/2018/12/05/3).

Furthermore, our approach is aligned with the European Commission Recommendation of 17 July 2012 on access to and preservation of scientific information (2012/417/EU), as revised and replaced by Commission Recommendation (EU) 2018/790, which promotes open access to and reuse of publicly funded research results within existing legal and ethical frameworks.

(https://www.boe.es/buscar/doc.php?id=DOUE-L-2012-81299, https://eur-lex.europa.eu/legal-content/ES/TXT/PDF/?uri=CELEX:32018H0790, https://eur-lex.europa.eu/eli/reco/2018/790/oj).

All participants in the round table were adults and were informed at the beginning of the session about the purpose of the study and the applicable data protection legislation. Informed consent was obtained from all participants involved in the activities described in the manuscript. Given the non-interventional and non-biomedical nature of the study, informed consent could have been obtained in a non-written (verbal) form, in accordance with standard practice for this type of research and in the absence of any legal requirement for written consent in this context. Nevertheless, written informed consent was in fact obtained from all participants: written consent forms authorizing the taking and use of photographs were signed; although photographs are not included in this article, consent was explicitly granted for their use for research and publication purposes.

Following the round table, participants completed a questionnaire. The qualitative data presented in this article were derived from anonymized responses, making it impossible to identify individual participants.

Data and software availability

The data supporting the findings of this study are originated from an anonymised stakeholder survey conducted during the CEDE project round table. All relevant aggregated data and qualitative feedback are presented within the article. Due to the nature of the data and in order to preserve participant's confidentiality, individual-level raw data are not publicly available.

Due to ethical restrictions and participant confidentiality, individual-level data from this study cannot be made publicly available.

Researchers wishing to access the data may submit a reasoned request to the corresponding author (cristina.prado.acebo@udc.es), providing a brief description of the intended use of the data. Access will be granted subject to approval by the institutional ethics committee and in accordance with applicable data protection legislation.

The training modules developed within the CEDE project and discussed in this study are publicly accessible through the project's e-learning platform at: http://cede-project.eu/.

Source data

All data supporting the results of this study are provided in aggregated and anonymised form within the article.

Underlying data

Zenodo: Spanish Round table results- CEDE project. https://doi.org/10.5281/zenodo.19354330 (Prado-Acebo & Ares-Pernas, 2026b).

The project contains the following underlying data:

- Spanish CEDE PROJECT SURVEY results.xlsx (Data Set)

Zenodo: Slovakia Multiplier event-CEDE project. https://doi.org/10.5281/zenodo.21594074 (Palková, 2026a).

The project contains the following underlying data:

- CEDE Multiplier event Slovakia.pdf (Report)

Zenodo: Slovakia Round Table results-CEDE project. https://doi.org/10.5281/zenodo.21594846 (Palková, 2026b).

The project contains the following underlying data:

- CEDE Round Table Report Slovakia.pdf (Report)

Zenodo: Italy Round table results-CEDE project. https://doi.org/10.5281/zenodo.21594681 (Sandoli, 2026).

The project contains the following underlying data:

- CEDE Round Table Report Italia.pdf (Report)

Zenodo: Turkey Round table results-CEDE project. https://doi.org/10.5281/zenodo.21595240 (Uzug & Kokatürk, 2026).

The project contains the following underlying data:

- CEDE Round Table Report Turkey.pdf (Report)

Zenodo: Greece Round table results-CEDE project. https://doi.org/10.5281/zenodo.21595368 (Angeioplastis & Tsimpiris, 2026a).

The project contains the following underlying data:

- IHU_Round_Table_Participant_Greece.pdf (Report)

Zenodo: Greece Round Table Raw Results. https://doi.org/10.5281/zenodo.21595659 (Angeioplastis & Tsimpiris, 2026b).

The project contains the following underlying data:

- IHU_CEDE_Round_Table_Responses Greece.xlsx (Data Set)

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

Extended data

The Creative Engineering (CEDE) project e-learning platform, which has been developed by the authors of this article and hosts the training modules described herein, is publicly available at: http://cede-project.eu/. The platform provides open access to the course structure and learning materials developed within the project.

Zenodo: Survey questions for the CEDE project round table. https://doi.org/10.5281/zenodo.19354517 (Prado-Acebo & Ares-Pernas, 2026a).

The project contains the following underlying data:

- CEDE PROJECT SURVEY.pdf (Survey Questions)

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

Software availability

No software was developed or used in this study.

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Open Peer Review

Current Peer Review Status: ✔ ? ? ?

Version 3

Reviewer Report 12 October 2026

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Sharon Guaman-Quintanilla
Escuela Superior Politecnica del Litoral, ESPOL, i3lab Entrepreneurship and Innovation Center, Guayaqui, Ecuador

Overall assessment
The topic is timely and relevant. Embedding creativity explicitly in engineering curricula, rather than leaving it as an implicit by-product of technical training, is a recognised need. The transnational, multi-stakeholder nature of the project is a genuine strength. The authors have responded seriously to the previous rounds of review: the research questions, DBR figure, instrument description, cross-partner synthesis and limitations section are clear improvements. The more cautious framing of learning effectiveness in Section 4.5 is also welcome.
I agree with the points raised by the previous reviewers, particularly Albers & Bastian on the definition of creativity, the missing curriculum analysis template, and the module descriptions. I do not repeat them here. My comments focus on four issues that, in my view, still limit the scientific soundness of the article:

- the extent to which the study actually fulfils a DBR design;
- the conceptual link between the five modules and creativity;
- how design thinking and creativity are facilitated and assessed in an online format;
- internal consistency between methods, results and conclusions.

1. The DBR claim needs to be substantiated with evidence of iteration and implementation.
DBR is characterised by iterative cycles of design, implementation in authentic learning settings, analysis and redesign. It produces two outputs: a refined intervention and transferable design principles (Anderson & Shattuck, 2012; McKenney & Reeves, 2019; Bakker, 2018). Figure 1 depicts feedback loops from Cycles 4 and 5 back to Cycles 2 and 3, but the manuscript does not document any iteration that actually took place. Table 5 mentions “minor refinements introduced before final implementation”, but readers cannot see what was changed.
I suggest the authors to:

(a) provide a traceable change log (e.g., a table) linking each stakeholder theme to the concrete design decision taken and the module element that was revised.

(b) state explicitly whether the modules have been implemented with students in any partner institution. Several statements imply implementation:

- "initial implementation feedback suggests…" (3.2.4);
- the platform "has proven to be an effective tool for delivering the module content, fostering collaboration, and assessing student progress" (4.4).
- If implementation took place, its data should be reported. If not, these statements should be removed, and the study should be described as the analysis and design phases of a DBR process with expert and stakeholder review, rather than a completed DBR cycle;

Please also check the methodological citation in Section 2.1. Laursen & Haase (2019) is cited as the reference for the "qualitative and design-based research (DBR) approach". That article compares design thinking with designerly thinking; it does not seem as a DBR methodology source.

2. RQ1 is not answered with data.

Section 3.1 is the only section that addresses RQ1, and it reports no findings from the curriculum analysis. It gives no number of programmes analysed per institution, no matrix of explicit and implicit presence of creativity-related learning outcomes, courses or assessment, and no examples. Its claims about global trends and about helping "prospective students choose the program" fall outside the scope of the study.

Yet the key conclusion, that creativity is "addressed only implicitly or fragmented", rests entirely on this analysis. Please provide:

- a summary table per institution or country with the criteria of the common template (explicit learning outcomes, courses, teaching methods, assessment);
- the comparative report itself as underlying or extended data.

Please also clarify which Turkish curricula were analysed. The Turkish partner seems like a consulting firm, and Section 2.1 states that the project "involved five higher education institutions", which contradicts the Introduction's description of an external partner organisation.

3. The conceptual model linking the five modules to creativity is missing.

The framework is presented as "creativity-oriented", but the manuscript does not explain how critical thinking, digitalisation and AI, or communication contribute to creativity. Nor does it say which dimension of creativity each module targets. Possible dimensions are person, process, product and press (Rhodes, 1961), or divergent and convergent thinking, problem finding and idea evaluation (Cropley, 2015; Daly, Mosyjowski & Seifert, 2014).

The previous reviewers asked for a definition of creativity; I would go further and ask for a constructive alignment matrix (Biggs). It would cross each module's learning outcomes, the creativity dimension addressed, the teaching activities and the assessment tool. Such a matrix would make the framework's coherence visible; expose overlaps, which are currently substantial. Ideation techniques such as brainstorming and SCAMPER, prototyping, and the DT process itself appear in Modules 1, 2 and 3; Module 1 contains a full "Design Thinking Process" sub-unit that duplicates Module 2; show where creativity is genuinely developed, e.g., in Module 4.

4. Facilitation of design thinking and creativity in an e-learning format is not addressed.

Design thinking is typically learned through team-based, coached, hands-on work on real problems with real users. The quality of facilitation is a critical and under-researched factor. The manuscript describes the platform's content but not how teaching happens. Please clarify:

- whether the modules are self-paced, blended or teacher-led;

- who facilitates, and with what preparation. The Slovak round table and Section 4.4 themselves point to teacher support as a key need;
- how teams are formed and how online teamwork is supported;
- whether students work with real users or problem owners;
- how prototyping and testing are carried out online.

If a facilitator guide exists, it should be described and shared. This is central to the claims of transferability and of curricular integration.

5. Assessment of creativity: description and consistency.
The article states that fifteen assessment tools were developed, three per module. However, the descriptions in Section 3.2 do not match Table 4. Please reconcile these. More importantly, explain how creativity itself is assessed, beyond knowledge tests. Established options exist, such as the AAC&U VALUE Creative Thinking rubric (Rhodes, 2010), the Consensual Assessment Technique (Amabile, 1982), or multi-source assessment combining self, peer and teacher ratings. Please justify why new tools were preferred over these, as Albers & Bastian also asked, and provide the rubrics as extended data. Since stakeholders flagged that online multiple-choice tests are vulnerable to generative AI, please also state whether and how this was addressed.

6. Stakeholder data should be reported with frequencies, not only qualitative descriptors.
Expressions such as “most participants”, “a large majority” or “generally appropriate” should be replaced or complemented by counts and percentages per item, per country and, where possible, per stakeholder group. This requires only descriptive statistics, but it is necessary for readers to judge the strength of the stakeholder validation.
To be clear, I am not asking the authors to reframe the study as a mixed-methods design; the qualitative DBR framing is appropriate for its aims. Reporting descriptive frequencies of the closed items would simply make the existing evidence transparent and allow readers to judge the strength of stakeholder agreement.

7. Inconsistency regarding the platform evaluation.
Section 2.6 states that participants were “invited to explore the platform”. However, at UDC, the most detailed case, the platform question (Q6) “was not possible to answer”. Please explain why. Was the platform not yet available, or was it not accessible during the session? The answer bears directly on how much the platform has been validated, and the conclusions about the platform should be adjusted accordingly.

8. Qualitative analysis procedure.
The analysis is described as inductive thematic analysis. However, the initial codes listed (content adequacy, activities, assessment, platform, competences, curricular integration) map one-to-one onto the questionnaire items, which suggests a deductive or framework analysis. Please clarify this and specify:

- who coded the data, and how many coders were involved;
- whether a codebook was used;
- how disagreements were resolved;
- how responses in different languages were translated and handled across partners;
- how the cross-partner “documentary synthesis” was conducted when the sources were reports rather than raw data.

9. Conclusions still overstate the evidence.
Section 4.5 correctly acknowledges that no learning outcomes were measured, but several statements elsewhere remain stronger than the data allow:

- "proposing and empirically validating the CEDE framework" (Abstract);
- "the findings demonstrate that creativity… can be systematically taught and assessed" (Conclusions);
- creativity-focused modules "were perceived as highly beneficial for improving students' problem-solving abilities, teamwork skills, and capacity for innovation" (4.1);
- the platform "has proven to be an effective tool" (4.4);
- "the project shows that creativity can be taught in a structured way and that doing so helps to prepare engineers" (Plain Language Summary).

The evidence supports stakeholder-perceived relevance and feasibility of a proposed framework, not validated effectiveness. Please align these statements with Section 4.5.

10. Availability of the e-learning platform and module materials.
The manuscript states that the training modules are "publicly accessible through the project's e-learning platform at http://cede-project.eu/", and this URL is listed as the main source of extended data. However, when I attempted to access it (11 October 2026, from different browsers), the domain could not be resolved (DNS error "NXDOMAIN"), so I was unable to examine the platform, the module materials or the assessment tools described in the article. This may be a temporary issue, but since the platform and modules are core outputs of the study, and the project ended in 2025, I recommend that the authors (a) verify and restore access to the platform, and (b) deposit the module materials, assessment rubrics, curriculum analysis template and comparative report in a persistent repository with a DOI (e.g., Zenodo, as already done for the round-table data), ideally under an open licence. Persistent deposit would also address the long-term sustainability of the project outputs discussed in Section 4.4, independently of the maintenance of the project website.

Minor points

- Table 2 is titled "Correlation between questionnaire items and the dimensions analysed"; "correspondence" or "mapping" would be more accurate. The text also mentions six dimensions while the table lists seven.
- The workload of each module (hours or ECTS) is reported only for Module 4 (12 hours). Since stakeholders evaluated the schedule (Q5), the time allocation of all modules should be reported.
- The ethics statement relies on Spanish legislation and the UDC Ethics Committee. Please clarify the basis for data collection in the other four countries.
- Some recent work on DT facilitation and on teaching creativity in engineering could strengthen the positioning.

Final thoughts
The CEDE framework is a valuable and practically useful outcome, and the article can make a sound contribution if it is positioned accurately. It is a well-documented account of the analysis, design and stakeholder-review phases of a DBR process. It should be supported by transparent curriculum analysis data, descriptive stakeholder statistics, an explicit link between the modules and creativity, and a traceable record of design iterations. Points 1, 2, 5, 6 and 9 are, in my view, essential. The others would substantially strengthen the manuscript.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and does the work have academic merit?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Design thinking in higher education; design thinking facilitation and instructional strategies; assessment of creativity, problem solving and teamwork from a multi-actor perspective; entrepreneurship education; faculty development for non-design facilitators.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 08 October 2026

https://doi.org/10.21956/openreseurope.26779.r79003

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Albert Albers
Karlsruhe Institute of Technology, Karlsruhe, Baden-Württemberg, Germany
Annika Bastian
Karlsruhe Institute of Technology (KIT), IPEK – Institute of Product Engineering, Karlsruhe, Baden-Württemberg, Germany

1) In Introduction paragraphs 5 and 6, sources for relevant information are missing.
2) The structure of the Introduction does not follow a clear line of argumentation that leads to your project and its results. The 4th paragraph repeats a lot of what has been said, and the entire introduction does not include an understanding of what you actually mean by creativity. It is a term with a variety of different definitions, and to introduce your work you should not start by why

it is needed but first by what it is, or means for your project. This might be information that you already stated for your grant agreement, but it is crucial for the readers of this results contribution here.
3) Placement of Figures. Figure 1 appears in the middle of a sentence. Please place each figure in an appropriate place after its introduction.
4) Content of Figure 1. Parts of the content of Figure 1 are repeated in the same way in the text. Please remove. Refer to the figure in the appropriate place in the text and let the Figure speak for itself. To do so, please give the columns a headline, e.g., Phases and Results.
5) The template mentioned in 2.2 is relevant for this contribution and should be included in the annex, since it is the data collection instrument to answer RQ1.
6) Please show the process of how the data was collected, where it was stored, and how it was synthesized in a figure: 1) collection via analysis template 2) introduction of data in shared data set (include platform or database) 3) analysis of recurring patterns and cross-case comparison (here we need the how) 4) synthesis into comparative report
7) Why was each module developed by a different partner?
8) Section 2.4 includes elements that are part of the results, not the methodology
9) Section 2.5 is missing details of how the assessment takes place and why new tools are developed and not existing tools integrated
10) 2.6.1 please define what makes the experts experts
11) 2.6.1 please include Zenodo DOI
12) Is the dissemination part of a methodology section of a research paper? This is very atypical
13) “Universities worldwide are beginning to integrate topics like artificial intelligence, renewable energy systems, and data analytics, reflecting industry demands and global challenges.” You are analyzing only the differences between the project partners; please ensure that you stay scientifically precise and do not overstate. If you want to keep this statement in the results section, you need to add a literature source here that states this clearly for more than the participating countries, and then include a literature review also in the methodology section. Alternatively, tone it down and make it sound like what it is: the trend you see among the partners.
14) Section 3.2 contains the long lines typical of AI —
15) 3.2.1 is completely missing sources. Even though this is your course program, the statements you make have sources. E.g., creativity is based on Stein 1953 and so on. You can’t state all of this in a scientific paper without giving the relevant sources.
16) SCAMPER is in module 1 and module 3 – looks like these two models were not so well coordinated
17) 3.2.4 It is unclear how students actually learn to be creative, apply creative thinking, or anything creativity-related in the Digitalisation module. Creativity is mentioned a few times, but how it is integrated and what students learn concerning creativity remains unclear.
18) 3.2.5 Please detail some of the strategies for avoiding technical jargon. Concepts in this section are introduced on an abstract level that makes it hard for the reader to understand what the students are actually taught. It is clear what they are supposed to learn, but not how. Which concepts are used, by whom, and why.
19) In 3.2.5, please use some graphical representation (e.g., for the different blocks) to break up the massive text block
20) 3.3.1 contains elements that need to be placed in the methodology section
21) 3.3.1.1 inconsistent display of citations: some cursive, others not
22) Placement of Table 6 is strange
23) Table 6 and its surrounding text are repetitive rather than complementary
24) The differences in data collection formats and available documentation are a limitation that

should be discussed in more detail
25) The dissemination part does not seem relevant to the research questions
26) 4.4, 4.5, and 5 are repetitive; please compress

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and does the work have academic merit?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Cultural influences on creativity in product engineering, creativity methods and method adaptation for distributed settings, distributed product engineering, engineering tools, methods and processes

We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.

Reviewer Report 26 August 2026

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Sahin Idil
The Scientific and Technological Research Council of Türkiye (TÜBİTAK), Ankara, Turkey

It is seen that the authors have made required revisions.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: My areas of expertise include STEM education, digital education, artificial intelligence in education, curriculum development, design thinking, project-based learning, and the development of transversal competences such as creativity, critical thinking, problem solving, collaboration, and communication. I am able to assess the article particularly in terms of its educational design, methodological clarity, curriculum relevance, e-learning approach, and contribution to engineering education.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 2

Reviewer Report 09 July 2026

https://doi.org/10.21956/openreseurope.26362.r76616

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Ida Nugroho Saputro
Sebelas Maret University, Surakarta, Central Java, Indonesia

Abstract
1.The abstract focuses more on describing the project activities than presenting the scientific findings of the study. Readers are not provided with clear information regarding what was measured, how the data were analyzed, and what the main findings are.
2.The novelty of the study is not explicitly stated. The authors should add one or two sentences explaining the unique contribution of this research compared with previous studies on creativity in engineering education.
3.The conclusion in the abstract is still too general. It should emphasize the study's contribution to both the theoretical development and practical implementation of engineering education.

Introduction
4.The introduction mainly explains the importance of creativity in engineering education but does not clearly identify the limitations of previous studies. The research gap should be presented more explicitly and critically.
5.The scientific contribution of the study has not been clearly articulated. The authors should explicitly state how this research advances existing knowledge.
6.The research objectives should be formulated as Research Questions (RQs) to provide a clearer direction for the study.

Methodology
7.The description of the Design-Based Research (DBR) process is insufficiently detailed. The authors should systematically explain the design cycles, revision process, module development, and the relationships among each stage of the research.
8.Information about the research participants is incomplete. The manuscript should specify the total number of participants, participant characteristics, respondent types, and their distribution across the participating countries.
9.The qualitative data analysis procedures are not adequately described. The authors should explain the analytical techniques employed, the coding process, data validation procedures, and strategies used to ensure the credibility and trustworthiness of the findings.
10.The research instruments are not sufficiently described. More detailed information should be provided regarding the questionnaires, measurement indicators, and the development and validation of the instruments.

Results
11.The Results section is dominated by descriptions of the module content. Much of this section resembles documentation of instructional material development rather than the presentation of scientific research findings. The empirical results should be strengthened.
12.The empirical evidence presented is still limited. The authors are encouraged to provide supporting evidence through tables, figures, and quantitative or qualitative data that substantiate the findings.

Discussion
13.The discussion does not sufficiently relate the findings to existing theories or previous studies. The authors should explain whether the findings support, contradict, or extend previous research.
14.The theoretical contribution of the study is not clearly demonstrated. The authors should explain how the CEDE framework contributes to the advancement of engineering education theory.
15.Alternative interpretations of the findings are not discussed. The manuscript should acknowledge the study's limitations and consider other factors that may have influenced the results.

Conclusion
16.Some conclusions are stronger than the empirical evidence supports. Statements regarding the effectiveness of the platform should be presented more cautiously, as the study did not directly measure improvements in students' learning outcomes.
17.The practical implications of the study have not been explicitly discussed. The conclusion should clearly explain how the findings can be applied in engineering education practice.
18.The conclusion should clearly emphasize the study's contribution to the advancement of engineering education research and theory.
19.The references rely heavily on older literature. The authors are encouraged to incorporate more recent and relevant references published between 2023 and 2026 to strengthen the theoretical foundation and demonstrate the study's relevance to current research.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and does the work have academic merit?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Specializing in Technical and Vocational Education and Training (TVET) and Building Engineering Education, with expertise in developing innovative learning models, educational evaluation, and strengthening the competencies of vocational teachers. Research interests include learning innovation, curriculum development, and evidence-based approaches to improving the quality of vocational education

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 26 Jul 2026

Cristina Prado-Acebo

We would like to sincerely thank the reviewer for these valuable suggestions. In response to the reviewer's comments, we have substantially revised the manuscript to improve it.

1-3: We agree that the abstract overly emphasized project activities and underrepresented the research dimension. Accordingly, the abstract has been substantially revised to:

- explicitly describe the Design-Based Research (DBR) approach;
- specify the sources of empirical data (comparative curriculum analysis and stakeholder validation round tables);
- report the main findings derived from stakeholder feedback;
- highlight the novelty of the CEDE framework as a transnational creativity-oriented model for engineering education;
- strengthen the conclusion by emphasizing both theoretical and practical contributions.

4-6: Thank you for the comments regarding the introduction. The introduction has been revised to more explicitly identify limitations of previous studies and to clarify the existing research gap. Specifically, we now discuss the limited availability of structured and

transferable frameworks capable of integrating creativity systematically across engineering curricula and national contexts.

7: The DBR process has now been described in greater detail. A new subsection and figure have been incorporated, illustrating the iterative design cycles, refinement process, stakeholder feedback mechanisms and successive revisions leading to the final CEDE framework.

8. Detailed validation data are reported for the University of A Coruña round table because this was the most complete qualitative dataset available. However, in response to the reviewer´s concern, we have now incorporated additional cross-partner evidence from Italy, Greece, Slovakia and Turkey. Since the level of detail and format of the available documentation differed across partners, these data have been analysed as a structured documentary synthesis rather than as a fully standardised comparative statistical dataset. The revised manuscript now includes a new cross-partner validation subsection and a summary table describing the stakeholder activities, participant profiles, main feedback themes and implications for the refinement of the CEDE framework.

9. The procedure to analyse the qualitative data has now been explained.

10. Thank you for this important observation. We agree that the original manuscript did not provide sufficient detail regarding the research instruments. To address this limitation, we have substantially expanded the Methods section by describing the questionnaire design, the assessment dimensions evaluated, the structure of the stakeholder survey, participant profiles, data collection procedures, and the process used to analyse and validate stakeholder feedback. We also clarify how the survey items were derived from the project objectives and how the instruments were reviewed by the international consortium before implementation.

11-12. Thank you for the opportunity to highlight the scientific research findings and empirical results. The revised Results section now distinguished between the detailed UDC validation case and a broader cross-partner stakeholder validation synthesis. This addition strengthens the empirical dimension of the study by incorporating evidence from round tables and multiplier events conducted in Greece, Italy, Slovakia and Turkey, complementing the detailed qualitative finding obtained at UDC and reinforcing the transnational validation of the CEDE framework.

13. Thank you for this valuable suggestion. We agree that the empirical evidence should be presented more explicitly. In the revised manuscript, we have substantially strengthened the Results section by distinguishing between the detailed University of A Coruña validation case and a broader cross-partner stakeholder validation synthesis. In addition to the qualitative evidence obtained through the UDC round table, we now incorporate evidence derived from round tables and multiplier events conducted by partner institutions in Greece, Italy, Slovakia and Turkey. Although the level of detail and documentation format differed across partners, the available evidence was analysed through a structured synthesis that enabled the identification of common trends across countries. The revised Results section now presents both empirical findings and stakeholder-derived

recommendations in a more explicit manner. Across the participating countries, stakeholders consistently highlighted the relevance of creativity and transversal competences in engineering education, the need for more practice-oriented learning activities, the importance of robust assessment approaches, the feasibility of flexible curricular integration models, and the value of sustained university–industry collaboration. These findings are supported by stakeholder feedback obtained from students, academic staff, engineers, professional associations and company representatives involved in the validation activities. Furthermore, the empirical interpretation of these findings is framed within the Design-Based Research (DBR) approach adopted in the study. Rather than treating stakeholder feedback as a stand-alone evaluation exercise, the revised manuscript explicitly explains how this evidence informed successive cycles of refinement of the modules, assessment tools and e-learning platform. Consequently, the Results section now provides a clearer connection between empirical evidence, iterative design decisions and the final configuration of the CEDE framework.

14. Thank you for this important observation. We agree that the theoretical contribution should be stated more explicitly. In the revised manuscript, we have strengthened the Discussion and Conclusions sections to clarify how the CEDE framework contributes to engineering education theory. Specifically, the framework extends existing research on Design Thinking, Creativity in Engineering, and Design-Based Research by proposing a transnational and transferable model that integrates creativity, critical thinking, digital thinking, artificial intelligence, problem-solving, and soft skills within a single competence-based framework. Furthermore, the study demonstrates how creativity can be systematically embedded, assessed, and validated within engineering curricula through an iterative stakeholder-centred approach. Thus, the contribution of the study goes beyond the development of educational resources and provides a conceptual framework for the design and implementation of creativity-oriented engineering education initiatives in diverse higher education contexts.

15. Thank you for pointing that out. We have added a section on this topic: Limitations and Future Research.

16. Thank you for this important observation. We agree that some statements in the original manuscript could be interpreted as implying educational effectiveness beyond the evidence provided. In response, we have revised the Conclusions and Discussion sections to adopt a more cautious interpretation of the findings. Specifically, claims regarding the effectiveness of the CEDE platform and modules have been reformulated to emphasize stakeholder validation, perceived relevance, feasibility, and potential educational value rather than demonstrated improvements in student learning outcomes. We also explicitly acknowledge that the study did not measure learning gains or competence development through pre- and post-intervention assessments. Consequently, the findings should be interpreted as evidence supporting the acceptability and applicability of the CEDE framework rather than its direct impact on student performance. This limitation is now clearly discussed in the manuscript, and future research directions include longitudinal evaluations of learning outcomes and competence development.

17. Thank you for this valuable observation. We agree that the practical implications of the

study should be stated more explicitly. In the revised manuscript, we have expanded the Conclusions section to clarify how the findings can be applied in engineering education practice. Specifically, we emphasise that the CEDE framework provides a transferable and flexible model that can be integrated into existing engineering curricula through complementary modules, elective courses, or embedded learning activities. The framework offers educators a structured approach for teaching and assessing creativity, critical thinking, digital thinking, problem solving, and soft skills, supported by validated learning materials, assessment tools, and an e-learning platform. Furthermore, stakeholder feedback confirmed the feasibility and relevance of these components for engineering programmes in different institutional contexts.

18. Thank you for this important suggestion. We have revised the Conclusions and Discussion sections to highlight more clearly the study's contribution to engineering education research and theory. From a theoretical perspective, the CEDE framework advances existing research on creativity in engineering, Design Thinking, and Design-Based Research by proposing an integrated and transnational model that conceptualises creativity as a multidimensional competence combining critical thinking, design thinking, digital thinking, problem solving, artificial intelligence, and soft skills. The study also contributes methodological knowledge by demonstrating how educational innovations can be systematically designed, refined, and validated through iterative stakeholder engagement. Consequently, the contribution of the study extends beyond the development of educational resources and provides a conceptual framework for future research and implementation of creativity-oriented approaches in engineering education.

19. Thank you for the suggestion. We have updated the article with more recent and relevant references as indicated.

Competing Interests: No competing interests were disclosed.

Version 1

Reviewer Report 12 June 2026

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Sahin Idil
The Scientific and Technological Research Council of Türkiye (TÜBİTAK), Ankara, Turkey

The study focuses on five thematic areas: critical thinking, design thinking, digital problem solving, digitalisation and artificial intelligence, and soft skills. It also reports on a comparative curriculum

analysis and stakeholder feedback collected through round tables involving students, academic staff, professionals, and company representatives.

It is thought that the article addresses a timely and relevant topic. The integration of creativity, digital competencies, critical thinking, problem-solving, and soft skills into engineering curricula is highly important for contemporary engineering education. The international and collaborative nature of the CEDE project is a clear strength, and the development of concrete educational modules and an e-learning platform gives the work practical and pedagogical value. The manuscript is generally well organised and offers a useful contribution to discussions on curriculum innovation, transversal competences, and digitally supported learning environments in higher education.

The work is presented in general terms and cites relevant literature on creativity, design thinking, engineering education, digitalisation, artificial intelligence, and transversal competences. The study also has academic merit, particularly as a project-based and developmental contribution to engineering education. The qualitative and design-based orientation of the study is appropriate for the aims of developing, refining, and validating educational modules and an e-learning platform.

At the same time, several aspects could be clarified and strengthened to improve the article's scientific transparency, methodological robustness, and overall contribution.

First, the research design could be described more explicitly. The authors state that the project follows a qualitative and design-based research approach, which is suitable for the purpose of the study. However, the manuscript would benefit from a clearer explanation of the phases of the study, the data sources used in each phase, the participants involved, and the way in which evidence from the comparative analysis and stakeholder feedback informed the development or refinement of the modules and the platform. More explicit alignment between the research design, data sources, analysis procedures, and reported findings would strengthen the scientific structure of the manuscript.

Second, the comparative curriculum analysis could be presented in greater methodological detail. It would be useful to specify how many engineering programmes or curricula were analysed in each country or partner institution, what criteria were included in the common analysis template, how the data were collected and compared, and how the conclusions from this analysis were derived. At present, this part of the article is informative but relatively general. Providing more detail would increase the transparency, transferability, and potential replicability of the study.

Third, the stakeholder feedback section is valuable, but it could be made more systematic. The manuscript states that round tables were organised in the five participating countries, while the detailed results presented mainly refer to the University of A Coruña case. If the results from the other countries were similar, this should be supported with evidence, such as a cross-country synthesis, participant numbers for each country, comparable response patterns, or a summary table. Alternatively, the authors may clarify that the detailed evidence reported mainly reflects one institutional context and discuss this as a limitation. This would make the interpretation of the stakeholder validation more precise.

Fourth, the evaluation of the e-learning platform could be supported with additional evidence or

presented more cautiously. The platform is an important output of the CEDE project, and the article describes it as useful and pedagogically valuable. However, the empirical evidence supporting the platform's usability, effectiveness, or pedagogical impact appears limited. If usability data, student engagement data, learning analytics, platform testing results, or structured feedback specifically focused on the platform are available, they should be included. If such data are not yet available, the platform evaluation should be framed as preliminary and developmental rather than as evidence of effectiveness.

Fifth, the conclusions could be more closely aligned with the evidence presented. The project provides a promising and structured framework for integrating creativity-related competences into engineering education. However, the current evidence mainly concerns curriculum analysis, module development, and stakeholder validation. Therefore, claims about the demonstrated effectiveness of the modules or the development of student competences should be expressed carefully. Phrases such as "the findings suggest", "the project provides preliminary evidence", or "the framework may offer a feasible approach" would be more appropriate in some parts of the conclusion and discussion.

Sixth, the manuscript would benefit from minor language editing and a more consistently academic tone. Some sections, especially the descriptions of the modules, are highly descriptive and occasionally read more like a project report than a research article. These sections could be made more concise and analytical by linking the module descriptions more directly to the research aims, design process, stakeholder feedback, and findings. In addition, some broad or repetitive formulations could be revised to improve academic precision and reduce generality.

Regarding source data and reproducibility, the manuscript should more clearly indicate which datasets, instruments, templates, questionnaires, module materials, and feedback summaries are available and where they can be accessed. Since the study relies on curriculum analysis, module design, and stakeholder feedback, the availability of supporting materials is important for transparency and reproducibility. If some data cannot be shared due to privacy or institutional constraints, this should also be clearly explained.

The statistical analysis question is not applicable, as the study is primarily qualitative, design-based, and developmental rather than based on statistical testing.

In summary, I consider the article to be relevant, well-motivated, and valuable for the field of engineering education. Its main strengths are the international collaboration, the timely focus on creativity and transversal competences, and the practical development of educational modules and an e-learning platform. I recommend that the authors revise the manuscript by clarifying the research design, strengthening the methodological description, providing more systematic evidence from the stakeholder feedback, presenting the platform evaluation either with stronger evidence or with more cautious wording, and aligning the conclusions more closely with the data. These revisions would considerably strengthen the article's scientific transparency, methodological clarity, and contribution to the field.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and does the work have academic merit?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: My areas of expertise include STEM education, digital education, artificial intelligence in education, curriculum development, design thinking, project-based learning, and the development of transversal competences such as creativity, critical thinking, problem solving, collaboration, and communication. I am able to assess the article particularly in terms of its educational design, methodological clarity, curriculum relevance, e-learning approach, and contribution to engineering education.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 16 Jun 2026

Cristina Prado-Acebo

We would like to sincerely thank the reviewer for their thorough and constructive assessment of our manuscript, as well as for recognising the relevance and potential contribution of the CEDE project to engineering education. In response to the reviewer's comments, we have substantially revised the manuscript to improve its scientific transparency, methodological clarity, and alignment between evidence and conclusions.

1. First, we have strengthened the description of the research design by explicitly structuring the study according to a design-based research approach, clarifying its phases, data sources, participant groups, and the relationships between analysis, design, and evaluation processes.
2. Second, the methodological detail of the comparative curriculum analysis has been expanded, including a clearer description of the analysis template, criteria, data collection procedures, and cross-institutional comparison process.
3. Third, the stakeholder feedback section has been revised to provide a more systematic and transparent account. We have clarified the multi-country nature of the round tables, included a cross-institutional perspective, and explicitly acknowledged the level of detail available for specific case studies.

4. Fourth, we have carefully revised the sections related to the e-learning platform and module descriptions to adopt a more analytical and research-oriented tone. In line with the reviewer's suggestions, claims about effectiveness have been moderated, and the platform is now presented as a developmental and iterative outcome supported by initial feedback.
5. Fifth, the discussion and conclusions have been substantially refined to ensure that all claims are fully supported by the available evidence. We have adopted more cautious and precise formulations, emphasising that the findings provide preliminary evidence and a structured framework rather than definitive proof of effectiveness.
6. Finally, the manuscript has undergone language editing and restructuring to improve clarity, reduce redundancy, and ensure a consistent academic tone throughout. Additional information has also been included regarding data availability and supporting materials to enhance transparency and reproducibility. We believe that these revisions have significantly strengthened the manuscript and we are grateful to the reviewer for their valuable suggestions.

Competing Interests: No competing interests were disclosed.