Received December 18, 2020, accepted February 2, 2021, date of publication February 15, 2021, date of current version February 24, 2021.
Digital Object Identifier 10.1109/ACCESS.2021.3059516

Teaching Soft Skills in Engineering Education: An European Perspective

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This work was supported by the Re-engineering Higher Education through Active Learning for Growth (HERA) project funded by the Erasmus+ program under Project 2019-1-EL01-KA203-062952.

ABSTRACT Higher Education engineering students need to be prepared to address sustainable solutions to the complex problems faced in this century. They should become proficient problem solvers, able to work in multidisciplinary teams, ready to adapt to new technologies, and able to acquire new knowledge and skills when needed. Usually known as soft skills, these competences play a key role in Engineering and have being taught in the last two decades, to a greater or lesser extent, using different methodologies and tools. This study reviews the promotion and teaching of soft skills in Higher Education across 5 European countries: Greece, Estonia, Denmark, Portugal and Spain. It provides an overview of best practices on these countries, focusing also on technological solutions to actually enable the development of soft skills. The purpose of this research is to shed some light about how soft skills are being taught presently and the difficulties involved in that process.

INDEX TERMS Higher engineering education, soft skills, best practices, employability.

I. INTRODUCTION

Higher Education (HE) engineering students will face complex personal and professional challenges such as sustainable management of natural resources, climate change mitigation, global health issues like the current COVID-19 pandemic, natural risk management, etc. [1]. Tackling these challenges requires a wide range of knowledge and skills from diverse subject areas, particularly Engineering and Economics, in order to achieve viable and sustainable solutions. In addition, skills such as digital literacy, independent and autonomous learning, openness to criticism, assertiveness or social interaction and empathy, generally known as soft skills, play a key role [2]. Thus, there is a growing interest in Europe on the development of soft skills in HE and, during the last two decades, educational curricula across Europe were introducing them at all levels, to a greater or lesser extent.

Despite this growing interest on the introduction of soft skills in the curricula, there is no common understanding about what skills are important, or how to teach or assess them. In fact, the way soft skills are being taught and assessed in different countries and educational institutions is very diverse [3] and this is an issue that should be addressed. Additionally, there are many variations on how soft skills are named, like 21st-century skills, general competencies, key competences, transversal competencies, etc. and it is also

The associate editor coordinating the review of this manuscript and approving it for publication was Meriel Huggard.

possible to find many variations in taxonomies for classifying soft skills: 21st century skills [4], skills you need [5], P21 framework [6], [7] cognitive skills [8], and new soft skills are continuously being suggested. This creates confusion and a lot of difficulties when we try to compare and relate skills in the different frameworks. For example, when we have to identify the most suitable or relevant skills for a particular field, the outcome may be different depending on the collection of soft skills taken as a reference.

Similarly, the pedagogical approaches to teach soft skills also exhibit a high degree of variability. It is generally accepted that soft skills cannot be learned passively, as raw knowledge acquisition. Students need to adopt an active role where they can experience their capabilities, strengths and weaknesses in relation to soft skills. As a result, many different approaches are being considered and described in the literature [9], usually as some kind of role-playing game, or involving a classroom debate. The ModEs project [10] identified different kinds of teaching strategies applied to soft skills, arranging them into three groups [3]: expository, guided and active strategies (cf. Table 1). These strategies can be observed on activities implemented by engineering departments to support soft skills development [11]:

- Capstone projects (thesis).
- Specific course implementation (e.g., Design Thinking, Experiment Design).
- Clinical pairing, internship, industrial training program.
- Competitions.
- Incorporation of soft skills in all courses.
- Partnership for interpersonal professional development with training schools outside the university.
- Multiple-solution problems with problem-based learning that require system-wide engagement.

TABLE 1. Learning Methodologies to Develop Soft Skills [3].

Expository	Guided	Active
Lecture	Discussion, debate	Brainstorming
Seminar	Workshop	Role play
Conference	Case study	Business game
Demonstration	Project work	Visits, journeys
	Simulation	Outdoor training
	Mentoring	Coaching

The heterogeneity around soft-skills is also observed in relation to their integration in the curriculum. Many times, soft skills are included through the whole curriculum, but not in any specific subject or module. Curricula usually show several courses where some soft skills are trained and assessed, despite in many cases there is not a clear definition about how it is done. A minority of institutions have formal practices such as curricular units integrated in the official curricula [12]. The E-QUA (Erasmus Quality Hosting Framework) project, whose purpose is to map the various mobility models in Europe [13], outlines the situation regarding soft skills in European universities. From their analysis, only eight out of twenty-eight universities offer a soft skills development program and the developed skills are mostly operative skills, intellectual / practical / relational / managerial skills, personal skills and thought skills.

From a technical perspective, it is also interesting to consider the use of information and communication technologies (ICT) to support teaching and learning. During the last years, many different ideas were proposed, as web applications, games, simulations and even virtual or augmented reality (VR, AR) solutions (cf. Sect. IV.F).

Taking into account the broad heterogeneity and diversity around the integration of soft skills teaching in engineering, this article introduces an overview of these issues in the European HE context, and particularly in the project partner countries: Denmark, Estonia, Greece, Portugal and Spain. The goal of this study, developed in the scope of the HERA project [14], is to shed some light on 3 main questions:

- What soft skills are being considered in Engineering and Economics HE?
- What practices are being considered to teach soft skills?
- How can ICT-based tools be used to support soft skills teaching and learning?

In the next section we identify the most relevant soft skills for Engineering, as well as the students' perception on the importance of soft skills. Section III presents some examples of best practices performed in the HERA partner countries and Sect. IV is dedicated to the most relevant ICT solutions found in this research. Finally, Sect. V presents the discussion and conclusions of this review.

II. SOFT SKILLS IN ENGINEERING

As mentioned above, there is a wide range of soft skills, classified according to different taxonomies, and, sometimes, even with different names for a similar set of skills [4]. One of the main tasks in the HERA project was to identify an effective and efficient response in a real-world scenario for engineers working on a complex project within an interdisciplinary team.

The process started with an analysis of the personal characteristics needed in an engineer nowadays, through the review of existing frameworks (21st century skills, skills you need, P21 framework), and soft skills sources proposed in the scientific literature. This process led to select 44 general characteristics or abilities, from which 18 were considered as fundamental:

- Formal, basic knowledge in their field.
- Ability to integrate of knowledge from diverse thematic areas.
- Collaboration, sometimes in multidisciplinary teams.
- Open-mindedness.
- High-level thinking.
- Critical, analytical and innovative thinking.
- Independent and autonomous learning.
- Problem-solving.
- Ability to prioritize.

- Ability to assess information, particularly when coming from diverse sources.
- Ability to follow systemic design processes.
- Implementation and validation of solutions from the perspective of end-users.
- Ability to analyze the factors that contribute to an undesired situation.
- Design and evaluation of alternative interventions towards solving a problem.
- Implementation and assessment of the effectiveness of a solution.
- Integrate and transfer knowledge to the real world.
- Work with limited resources.
- Presentation skills.

The analysis and review of these requirements by HERA experts, based on the existing soft skills found in the mentioned sources, resulted in the grouping of the skills in 5 categories (cf. Appendix I):

1) Technical skills that comprise skills out of the standard engineering curriculum related to technical aspects.
2) Metacognitive skills are those related to the management and improvement of the cognitive process. They are related to the soft skills that help an individual to excel independently of their learning path.
3) Intrapersonal skills are those related to one's inner characteristics and also one's attitude towards things, ranging from creativity or adaptability to self-discipline or perseverance.
4) Interpersonal skills are skills that improve one's capabilities to work with others. These skills are related to the ability of an individual to collaborate in a group, to communicate effectively, to understand the needs of others, to transfer knowledge to the real world, etc.
5) Problem-solving skills are those that help to identify the source of a problem and find a suitable and effective solution. These skills are related to the ability of an individual to motivate others, to communicate effectively, to plan and prioritize, and to see a project through to completion.

To know the students' point of view about these soft skills, a survey was conducted by means of a questionnaire aiming at establishing student understanding and perception about the selected 44 soft skills. The survey also contemplated the way in which they are taught. Thus, it consisted of two parts, being the first one dedicated to the skills and the second part to the pedagogical methods implemented to teach them. The questionnaire was answered by 184 last-year students in the HERA partner countries. The size of the sample was around 30% of the total number of eligible students, and the distribution per country is double in Spain and Greece than at the other 3 countries. Answers were collected using an on-line form, from March 5th to April 29th, 2020.

A. PERCEIVED IMPORTANCE OF SOFT SKILLS

Students were asked to provide input on the importance of the 44 soft skills selected for their future professional and personal life after they finish their education. The skills were grouped in the 5 categories enumerated above and rated in terms of perceived importance using a 5-point Likert scale, with 1 corresponding to "not important" and 5 to "very important". Students also could select "I don't know" which explains why the sum is not equal for all skills.

Figure 1 shows the average of the questionnaire responses of participants for each skill in the 5 categories:

- Technical skills. The higher-rated skills were "digital literacy", "global awareness" and "information and media literacy". "Ethics" and "engineering knowledge" are slightly below the mean, and "financial literacy", and "health and wellness" obtained the lowest scores.
- Metacognitive skills. "Willingness to learn" and "critical and analytical thinking" were the most valued by the students, while "evaluating information from diverse sources" got the lowest score in this category. However, all the listed metacognitive skills were considered important, as discussed below (cf. Sect. III).
- Intrapersonal skills. "Open-mindedness" and "openness to others' ideas and thoughts" were deemed as the most relevant while "assertiveness" was considered the least important. Other skills perceived as desirable include "openness to criticism and feedback", "flexibility and adaptability", "sense of quality of work", "planning", "ability to prioritize" and "creativity" while, to a slightly lesser degree, the skills "self-discipline", "perseverance", "initiative", "self-direction", and finally "being positive".
- Interpersonal skills. "Collaboration and teamwork" skills were considered highly important while "presentation skills" were perceived as the least relevant. Additional skills include "being a listener", "oral and written communication", "transferring knowledge to the real world", "social interaction and empathy", and "leadership".
- Problem solving skills. The general term "problem-solving skills" was naturally the highest rated as it encompasses all others. Other skills that were considered important include "providing clarity", "implementing and assessing the effectiveness of a solution", "project management", "time management", "designing and evaluating alternative solutions", and "analysis of the factors that contribute to an unwanted situation". Less significant but still with scores close to the mean of the whole set were "working with limited resources" and "following a systemic design process".

Figure 2 shows the average result, maximum and minimum scores and standard deviation for each category. The highest-rated category was metacognitive skills, with an average rating of 4.28 and the lowest standard deviation, with 0.11, showing their agreement on metacognitive skills being the most relevant for them. Intrapersonal skills and problem-solving skills follow with an average of 4.12. However, the dispersion of the values is higher, being 0.19 and

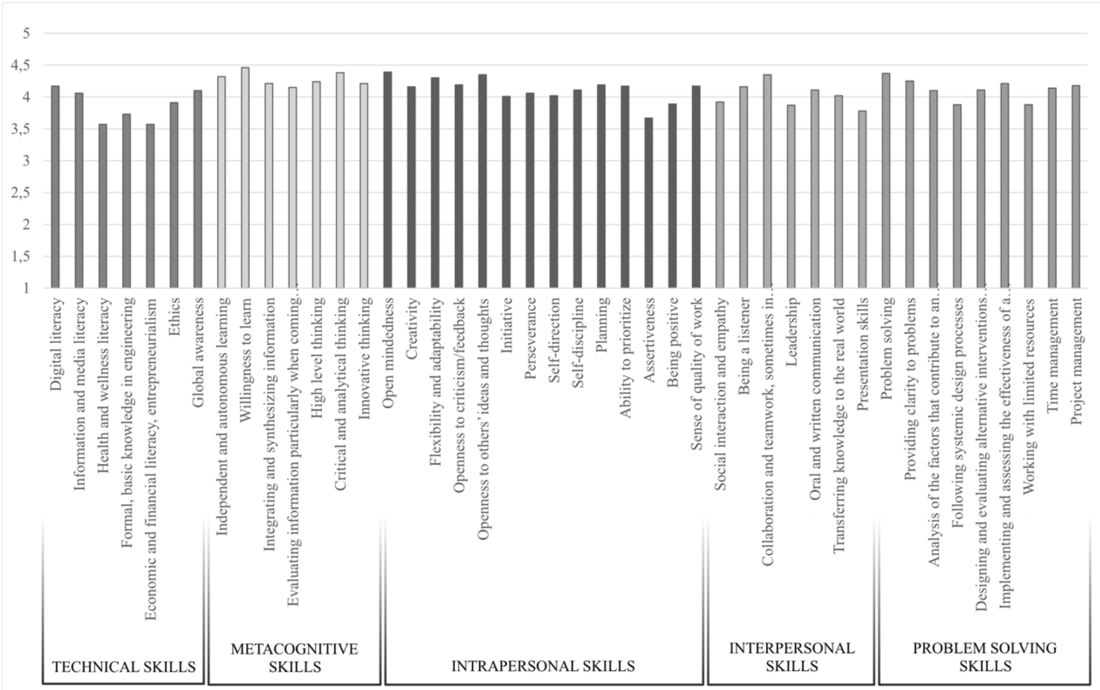

FIGURE 1. Average of perceived importance score (1–5) for each skill.

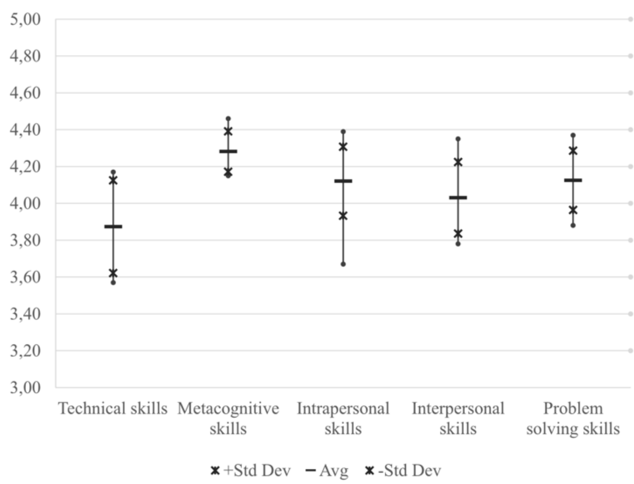

FIGURE 2. Average for each skill category with standard deviation and extreme values.

0.16 respectively. Interpersonal skills obtained a 4.03 average rating with a standard deviation of 0.19. Technical skills got the lowest score with 3.87, showing also the highest standard deviation, being 0.25. It is interesting to observe how students value more metacognitive, intrapersonal and problem-solving skills than technical ones.

B. SUITABILITY OF PEDAGOGICAL METHODS

The second part of the questionnaire focused on students' perceptions of the pedagogical methods used to teach soft skills. Students were asked if they thought that the current educational system allowed individuals to develop the skills that they consider to be important in their academic and future professional careers. Students mostly tended to provide a negative answer (45%) although the number of undecided students was equally high (41%). Only 14% responded positively.

Subsequently, students were asked to indicate which of the emerging pedagogical methodologies they believed that were suitable for developing the skills sought by industry. The proposed methodologies were:

- Problem/project-based learning that involves educational activities in which students are challenged to solve a problem or to develop a project, often open-ended and non-trivial, using knowledge from diverse subjects in the curriculum thus simulating how knowledge is used in the real world.
- Thinking-based learning that aims to develop better thinkers. Its goal is to lead to better lives outside of school. Thinking-based learning focuses on critical and creative thinking. It involves making decisions, solving problems, making predictions, evaluating information, etc. Thinking-based learning aims to transform classrooms so that the acquired knowledge has a positive impact on students beyond the classroom.
- Design thinking that allows the introduction of solutions to complex problems and the more accurate addressing of user needs through a process that enables the identification of real needs, as opposed to perceived ones. Design thinking involves a process of empathy towards understanding the experiences and feelings of

users when exposed to a particular solution, problem statement definition using user input and designer perspective, brainstorming, and prototyping of potential solutions in a manner that allows their use by involved individuals and the generation of feedback.

- Competency-based learning that focuses on knowledge development in a manner that allows learners to use it in real-world situations. It revolves around the development of educational activities that promote competences that can be measured against real-world standards. In this context, each competence is an individual learning outcome. Students work on a specific competency at a time. Competences are viewed as units that are part of broader learning objectives. Students must master each competence before focusing on the next.
- Cooperative learning that encourages students to work together toward achieving specific goals. This method is the opposite of broadly used educational approaches based on student competition. In cooperative learning the education sets up educational activities in a manner that requires student interaction and collaboration to be achieved. Students work in small groups for maximizing their benefits from the learning process as well as the benefits of others.
- Blended learning that integrates diverse educational methods, including traditional instruction, digital experimentation, site visits, and others that combined provide an active learning experience for students that more effectively addresses learning goals.
- Gamification that refers to the use of gaming elements in contexts other than entertainment. These include learning, training, crisis management, research, etc. Gamification elements may include rewards, recognition, a sense of mission, clear goals, a sense of affiliation, feedback, etc. In learning, well-designed gamification may lead to the achievement of educational goals when gaming elements are integrated into practices in a manner that promotes the learning process.
- Flipped classroom that aims at the higher engagement of students through blended, active learning approaches. In a flipped classroom, the teacher provides students with educational material before the lecture. Students review the material and use the classroom time to resolve questions, work on practical exercises, or to engage in other activities that traditionally may be considered as homework. The teacher plays the role of a mentor. Flipped classroom allows for more effective use of classroom time and encourages students to take responsibility for their learning.

Figure 3 provides a summary of the students' responses on a 5-point Likert scale, with 1 corresponding to ''not suited'' and 5 to ''totally suited''. Results are presented from higher to lower score to facilitate reading.

According to questionnaire respondents, ''problem-based learning'' was the most suitable educational approach in engineering and economics, followed closely by ''thinking-based learning'', ''design thinking'' and ''competency-based learning''. ''Cooperative learning'', ''gamification'' and ''flipped classroom'' were perceived as the least adequate. Students also provided some qualitative comments on educational design:

- ''Deploy combinations of the pedagogical methods proposed''.
- ''Introduce feedback mechanisms in learning''.
- ''Ensure flexibility in assessing student progress''.
- ''Change assessment methods as exams favor results over knowledge acquisition''.

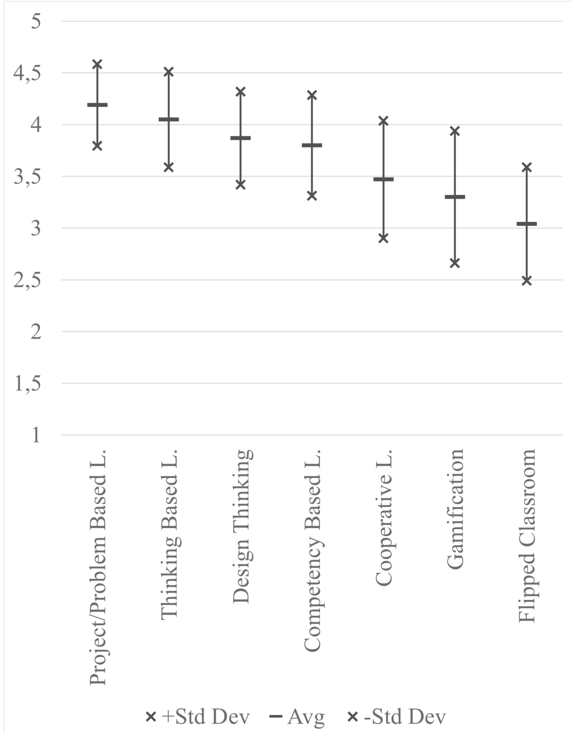

FIGURE 3. Summary of questionnaire response on emerging pedagogical methodologies suitable for soft skills.

III. BEST PRACTICES

This section introduces best practices in HE engineering that address to some extent the need for building desirable soft skills. For that, HERA project partners compiled and reviewed existing practices in Greece, Estonia, Portugal, Spain, and Denmark to ensure that the information gathered had a wide European footprint and is relevant from an European perspective.

The process to identify the best practices was performed separately at each country considering actual existing curricula. Searches were performed mainly in national journals and conferences of the e-learning and educational domains, but researchers' direct knowledge about practices was also used in some cases. The period of time considered was the last 10 years, from 2010 to 2020, which corresponds to the adoption of the Bologna model in all the countries.

The criteria utilized to identify best practices were:

- Being effective and successful. A candidate best practice was proven to produce effective results towards achieving a goal. It was successfully applied resulting in positive impact on individuals or organizations.
- Being socially sustainable. A best practice addresses current needs of interested parties and can be sustainably deployed in the future without compromising high-level objectives and goals.
- Being technically feasible. A ''best practice'' is technically feasible if it can be effortlessly integrated into existing practices with reasonable effort and resources.
- Being replicable and adaptable: A ''best practice'' can be replicated with adaptations to a range of situations with positive results.

From the 22 best practices identified, almost half of them (10), are based or focused on problem-based learning (PBL), usually combined with approaches involving active learning (4) and teamwork (3), while 4 use a project-based learning methodology. Also, 9 of them are based on some form of active learning approach. Most representative best practices are introduced below.

A. PROBLEM-BASED LEARNING

Problem-solving teaching support resources at the Universidad Politécnica de Madrid, Spain [15]. This initiative was launched in 2013 to support teachers in the development of problem-solving, as many teachers were not familiar with such methods. The methodology proposed was learning by doing, presenting students with practical, meaningful and contextualized problems to solve. The problems selected were in line with the difficulty level of related course activities and with the students' future careers, being more advanced than simple exercises and involving non-directive, motivating statements that facilitated the formation and development of concepts. As a strategy for teaching problem-solving competence, the coordinators of the activity chose the original procedure proposed by Pólya [16]. The reason for this selection is that the proposed method is a very general strategy that can be easily adapted to typical problems in diverse fields of knowledge. The strategy is structured in 4 steps: problem comprehension, planning the solving process, implementation of the plan and assessment of both the solution and the procedure. Activity coordinators developed a set of generic rules based on Pólya's work for guiding the students on the main aspects of problem-solving. The resulting procedure can be applied to any problem regardless of its complexity or the solution approach selected. Each of the identified problem-solving aspects can be evaluated and allocated from 1 to 4 points according to different criteria. The problems introduced to students may differ significantly depending on the subject and the year of studies. To compensate for that, the activity coordinators divided problem-solving competences in 4 levels, one for each year of study. Each level involves its own procedure with different rules, which are always based on the basic set of rules described above.

Problem-based learning at an undergraduate Management degree at the University of Minho, Portugal [17]. In this case, a problem-based learning approach was introduced into the capstone ''Business Case'' course trying to support student's skills development while working in a host company. Its main goal is that student teams integrate the knowledge and skills developed throughout the degree and apply them to a real given management problem or ''Business Case'', following a problem-based learning approach. Student teams work on the problem presented by host companies in a self-directed way. Teams are instructor-selected in order to reproduce a real workplace situation. A set of criteria is used, such as gender, language, computer skills, etc., to achieve heterogeneity within teams and homogeneity across teams, and ensuring concurrent meeting times. Teams define their own schedule and member roles, organize their work and manage communications and interactions with the company. Each team is assigned a tutor, who supervises the team's progress, monitoring how students interact, discuss the problem, seek information and make decisions. Teams work on average 12 hours per week for 15 weeks. Students follow an iterative approach towards analyzing the problem, deciding which aspects to address and developing a solution. In each step students collect the information they need through research and then analyze, evaluate, and synthesize this information in a manner that is relevant to the case. At the end of the activity, students present sustainable recommendations based on appropriate business analyses and defend their decisions to the class. This process enables students to develop and use transferable skills including information-researching, problem-solving, communication and argumentation skills for working with colleagues, educators, and industry. These interpersonal skills are developed through negotiation and dispute resolution among team members and with external parties, for example industry players. Upon completion of the activities students deliver a report and present their work to the company that introduced the learning task. Furthermore, students evaluate themselves and their teams through peer assessment processes. Results show that the development of transferable skills is explained by interaction with the tutor and the host company, and by having defined teamwork rules. Satisfaction is explained by skills development as well as factors relating to assessment, and understanding how organizations work.

Combining the Internet of things (IOT) with natural sciences at Tallinn University, Estonia [18]. In spring 2018, the Internet of Things course at School of Digital Technologies was combined with the Institute of Ecology activities to create a three-section aquarium named EcoKit: Ecological Waste Water Treatment Kit. The implementation took place at Findhorn and included sensors and data compiled from internet sources. During the course, students were organized in 3-member teams each team selected a plant or EcoKit aquarium as a field of research. Vegetation was planted in each section of the EcoKit and each team added their sensors. The teams measured several different parameters, such as the humidity of the soil, height of plants, temperature and light, water temperature, water level, and turbidity. They added a live camera, pumps, and lights, all of which were controllable from a website and operated in real-time. Students visualized all data on the internet. In the end, all teams published their work on a designated website, where all data could be seen and correlations could be established. In addition, students posted their assignments on a Facebook group were all the others, including other teachers and interested personnel, could see the results of their work.

Education Technologies course at University of Thessaly, Greece [19]. The course focuses on the deployment of technology as an educational tool in lifelong learning contexts. It analyses traditional and emerging learning methodologies including collaborative learning, explorative learning, active learning, mobile learning, problem-based learning, project-based learning, active learning, game-based learning, etc. It focuses on how technology, and most importantly information technology, can be combined with emerging pedagogies towards the enhancement of learning processes and experiences in formal, informal, and non-formal learning. The course focuses also on how technology can contribute, in combination with pedagogical models, towards the development of basic, transversal skills including analytical thinking, critical thinking, entrepreneurial thinking, problem-solving, ability to work in a team, etc.

During the course, students are exposed to active learning and problem-based learning in the contexts of formal projects, in which they have to:

- Design educational scenarios for integration into a learning game that targets engineering HE and aims to build skills for the real world. For each scenario, students are challenged to describe the educational objectives, the skills expected to be developed, and the gameplay and experience of the users that contributes to the achievement of educational goals.
- Design PBL activities for engineering education that deploy digital technology to promote exploration, experimentation, and collaboration.
- Research topics related to digital services for educational purposes and research activities related to technology in education.

To complete their work, students are challenged to deploy active learning for understanding the needs of the target groups concerning specific educational objectives and themes, designing a learning solution that involves digital technology for enriching student experiences and contributing to the achievement of learning goals, and proposing methods for validating the scaffolding of knowledge. Students present their work in the classroom for the benefit of all and get evaluated by their peers.

E-learning as part of the problem-based learning at Aalborg University (AAU) in Denmark [20]. AAU has a long tradition in using PBL for all courses and projects. Generally, the process of PBL on courses and projects allows students to exercise the contextual elements of a curriculum as well as the training of soft skills in team-work, critical thinking, communication, etc. One element which is essential for learning and understanding the challenges and principles of PBL is to discuss with peers and learn in that way.

However, experience sharing is often happening in confined communities, on informal IT-platforms, which means that many students never realize that they may have the same kind of challenges, and some learning opportunities are lost. The soft skills which are being exercised and trained for in projects focus in particular on cross-cultural skills, critical and inventive thinking, knowledge sharing and co-creating knowledge. A web platform was developed and introduced to students at several degree programs (e.g., computer science) in the Faculty of Technology and Design, AAU. The platform provided possibilities for students to ask and answer questions, comment on others contributions, and upvote and downvote questions and answers in the system.

Despite the students being used to digital platforms, it turned out that they were less willing to use a new one. Many students envisioned this as just one more thing they should do and therefore not shared so many experiences or questions. Sharing of experiences across different degree programs challenged the wordings and the perception of what was being said. It caused misunderstandings and miscommunication. As such, the web-platform pushed students to learn more aspects of inter-cultural communication, however, to support the development of these inter-cultural skills, access to a web platform must be followed up by physical meetings and supervised commenting.

B. PROJECT-BASED LEARNING

Project-based learning in the 1st year of an Industrial Engineering and Management Integrated Master program (IMIEM) at the University of Minho, Portugal [21]. This experience was introduced in 2005 for the implementation of interdisciplinary projects. It contrasted with the students' prior learning experiences in earlier education levels, and represented a shift on the educational design that departed from traditional lecture-based instruction, in which learning is more passive. Its implementation relied on a group of lecturers who taught 1^{st}-year courses and volunteered to build the required structure and provide the operational support for the implementation of the project. Subsequent editions relied on a wider team of lecturers, who mostly focused on selected Project Supporting Courses, and on staff acting as tutors and on researchers, forming the coordination team of the project. In the academic year 2012-2013 a reformulation of the IEM curricula provided the opportunity to adapt the structure of the program to Project-based Learning by creating the Integrated Project in Industrial Engineering and Management course. The proposed learning approach grew from there and is now in its 14th edition. This wide implementation time frame allowed the consolidation of the model for enriched effectiveness. This initiative also promotes the interaction with companies, trying to create contexts that contribute to increase students' motivation, solid technical competences, and at the same time a range of transversal competencies necessary for the professional performance in Engineering and Industrial Management. Currently, in addition to the final master's project taking place in the 10th semester, the IMIEM curriculum presents interdisciplinary projects in three moments of the course, specifically in the 1st, 7th and 8th semesters. These projects, in addition to their interdisciplinary approach, are characterized by the relationship with professional engineering practice through problems for which student teams have to find solutions during the semester with the support of the contents of the curricular units and the respective teachers and tutors. The project stands out as being one of the most significant experiences during the initial training of students of IMIEM.

Project-based learning to prepare IT students for an Industry Career at the Bragança Polytechnic, Portugal [22]. This initiative involved students from BSc, MSc, and PhD degrees in Computing in developing a software project required by a real client. The teaching staff is responsible for creating an environment that enhances communications, teamwork, management, and engineering skills in the students involved. The real-world project approach to teaching software engineering was successful so far. It helped to motivate teams and to encourage the development of higher quality products by them. The teams took seriously the importance of the problems that they were helping to solve. The approach teaches inexperienced graduate students many principles of software engineering and software verification and validation that they could apply to their future jobs and subsequent courses. This initiative started in 2009 and over the past four years there were, approximately, 1.000 students involved in the four educational syllabuses.

A project-based course at the Telecommunications Engineering bachelor degree at the University of Vigo, Spain [23]. Since 2013, this subject involves students working in teams of 4–6 members trying to provide a feasible solution to a real-world problem. They must develop some kind of technology-based prototype with a minimum functionality, as a minimum viable product (MVP), that can be used to show their proposed solution and get feedback from end-users. The course lasts 14 weeks with students working around 20 hours per week. Students identify a real-world problem, analyze the issues involved and review the technology available and technical literature to propose a solution. Issues regarding social impact, legislation involved and sustainability have to be studied as well. The subject is structured as follows:

- Introductory activities. Lectures provide practical advice on skills such as oral and written presentation, and teamwork. Agile methodologies and Lean startup ideas are also explained as a suggestion to manage their projects.
- Mentored work. Partial review of the evolution of the different projects with short presentations and discussions, supervised by two faculty members. Each week, a one-hour meeting is scheduled between the team and its tutors.
- Project-based learning. This is the core of the course, in which student teams develop their projects working in close cooperation to achieve the objectives. It is recommended the creation of a web site, such as a wiki, blog, or similar, for each team to document and show the works developed during the term.
- Presentation. Every team must showcase its project in a final oral presentation and in two poster sessions known as LPRO Days. The oral presentation must include evidence of the work developed and achieved results. All members of the team have to show, explain, and get feedback on their prototypes in two open public poster sessions, one for all the faculty, students, and university personnel and an afternoon session open to local technology companies. This event is key for the success of the course because students like to show they need to get positive feedback. This became a main event in the school. Companies showed their involvement by proposing problems to be solved by students, and by providing feedback about the provided solutions. Some of these local companies award cash prizes to the best projects.

Summer practice in software engineering at Tallin University, Estonia [24]. All first-year informatics students are asked to form 4-member teams and solve a real-life problem. Problems are proposed by staff members, students, or other stakeholders outside the university who need some solutions. In this program, students developed online shops, games, IOT tasks such as a set of sensors to measure the quality of working spaces, robotic hands etc. The problem proposer acts as a customer during a 2-week intense study period in May or June. Students are challenged to offer the best solution they can. They have meetings with their team members and with customers, just like in real life, and try to work towards a mutual goal. Students are monitored by supervisors from different fields such as robotics, system administrators, multimedia, software engineers, designers, business managers, etc., depending on the nature of the project. Supervisors are located on campus so they can be reached as quickly as possible. Some funds are available for buying some of the required equipment, such as sensors, electrical elements, gadgets, assets etc. During the semester, students attend courses on different topics, and during the last two weeks of the semester, they have to physically be together and work on solutions. In the end, they compile a report about their work and defend it in front of a committee. The outcome is usually an applicable solution, although students do not always succeed. In that case, the experience is also valuable for them.

C. GAME-BASED LEARNING AND GAMIFICATION

The eCity Erasmus+ project [25]–[27] developed and validated a game platform, based on a city-development simulation engine, that stimulates the integration and continuous exploitation of problem-based learning. The platform was used by students from secondary and vocational schools, and higher education engineering schools. The methodology and game were extensively tested by 1.250 individuals from different countries. Participants initiated their engagement at the research stage, at which HE students and instructors contributed to problem definition, secondary education teachers helped to design the PBL methodology and secondary education students provided insight on the expectations from game-oriented learning.

Gamified learning environments at the Rey Juan Carlos University in Madrid, Spain [28]. The promoters of this initiative observed that the motivation of their students decreased as the complexity of courses increased. Thus, they transformed a course on Business Tax Regime from the bachelor degree on Business Administration into the tax game Re-Game. Teachers proposed a team game in which all members must be involved helping classmates to keep up without losing motivation. The method seeks to develop critical thinking and the search for consensus in proposed solutions. In Re-Game, each team was challenged to create a fictitious company and apply the knowledge acquired in the course to keep the company's tax obligations up to date. The game levels corresponded to those in the course syllabus. To pass each level, students had to individually prepare the content of each topic, perform a self-assessment test and pass the key test on the planned date. Students competed in teams performing practical training activities that contained exercises on the topic addressed. The level of difficulty increased gradually at each level due to the cumulative incorporation of fiscal elements. Each activity allowed students to earn points and collect badges depending on the number of points achieved. Rankings were published upon completion of each level. The highest-scoring teams received "excellence bonus".

Design and Implementation of a Digital Games course at the University of Thessaly, Greece [29]. The course focuses on the design and implementation of digital games and covers topics that include the definition of games and play, characteristics of digital games, game taxonomies and game genres, understanding different groups of users, designing a game concept, designing elements of game worlds, designing a game story, designing game characters, designing the core mechanics of a game, understanding game dynamics and the experience of users, ensuring that a game is balanced according to the needs of users, introducing elements of chance, understanding the characteristics of on-line games, understanding the principles of creative play, developing marketing strategies, etc. The course is balanced between theory and practice. It includes weekly laboratory work that takes place in the computer labs of the Department of Electrical and Computer Engineering. At the beginning of the course, students follow tutorial examples as well as practical presentations of the functionality of popular game design platforms, such as Unity. Upon their completion, students use the lab to design and implement their games in teams. During lab sessions, students have the opportunity to collaborate with their peers towards game implementation, to get help on technical questions, and to receive guidance for a smooth implementation. Before implementing their game, students are summoned to present their game concept in class and receive feedback from their peers. At the end of the course, students showcase their working games in the classroom.

D. ASSESSMENT

Analyzing the level of acquisition of problem-solving skills in the Business Administration and Management Program in Badajoz and Seville, Spain [30]. This initiative from 2013 aimed to assess and analyze the level of acquisition of problem-solving skills through four courses in the curriculum using the Social Problem-Solving Inventory-Revised (SPSI-R) as measuring instrument. The implementation team worked with the problem-solving model proposed by D'Zurilla *et al.* [31]. In the Business Administration and Management studies context, the implementation team found a link between this problem-solving model and the different curricular objectives. Thus, they could see that certain subjects promote particular skills. For example, Introduction to Economics and Business Mathematics promotes the understanding and use of the scientific method and logical reasoning; Microeconomics focuses on training the student to analyze and respond to problems and others; Organizational Theory and Human Resources Management are diagnosis and solution-oriented; Advanced Management Accounting and others help in the identification, organization, use, and analysis of information sources, etc. The revised version of the SPSI-R was used as a psychometric instrument to measure the competence of individuals to solve problems. It is a self-report that measures the resolution of problems evaluating not only the level of capacity that a person may possess but also the strengths and weaknesses in the different key components of the process.

Peer evaluation and self-assessment of transversal competence teamwork at the Polytechnic University of Valencia, Spain [32]. This activity deploys since 2017 a set of resources, including quantitative methodologies, to evaluate teamwork and leadership transversal skills. Individuals are grouped in teams and carry out several practical activities. At the end of the semester, all participants must answer a questionnaire of 9 indicators related to teamwork and leadership, evaluating both their teammates and themselves. The questionnaires include aspects of activities, deadlines, prioritization, information, conciliation, agreements, interest, ideas, and encouragement. They also established the ideal profile of transversal competence, setting a reference value for each item. This is considered a best practice because it was applied successfully in a course on Human Resources Management from a bachelor degree in Management and Public Administration.

IV. ICT SOLUTIONS TO TEACH SOFT SKILLS

Soft skills ICT-based support was an active topic during recent years. Several ICT based services, commercial and non-commercial, can be found in the scientific literature which is or may be deployed in the context of HE for fostering the development of desirable skills [33]–[38]. Particularly in the context of Erasmus+ projects [36], [37], [49], [56], [63] there was a lot of interest in designing tools that facilitate the development of this kind of competences.

More broadly, ICT-based tools are usually involved in the teaching of university courses, often in the context of blended learning [51], [52]. Collaboration, communication, and productivity tools are usually used to enrich learning experiences. With their various functions, digital tools provide teachers with more opportunities to engage their students in interactions that are not available in the traditional classroom environment. They can be used to stimulate learning by doing and help students develop their skills. This study explored different kinds of ICT-based solutions that were used to support teaching and training of soft skills.

The next paragraphs include the results from a search for ICT-based tools used to support the teaching of soft-skills. The search was performed for the period 2010 to 2020, in the following databases: EBSCOhost Academic Search Complete, Emerald e-journals premier collection, Education Resources Information Center (ERIC), Google Scholar, IEEE Xplore, Science Direct, Scopus, SpringerLink, Taylor & Francis, and Wiley Online Library. Also, the Erasmus+ Project Results Platform was used. Search queries included the following terms and combinations: ''Soft skills'', ''21st-century skills'', ''P21 framework'', ''cognitive skills'', ''ICT-based tools'', ''Supporting tools'', ''Technology-based tools''. Results were filtered taking into account the reading of the abstracts and conclusions.

A. SERIOUS GAMES

The use of games to support the instruction of soft skills was acknowledged by existing literature [33]. Games have the main advantage over traditional education when used for training: they are focused on practice. Like in student-centered learning, games are focused on the players, in this case, learners, who have an active role. The learning process comes from solving situational problems controlled by the game. This exposition to different situations, challenges and problems with a practical approach make games able to enhance the development of soft skills. Besides, it is very common that these educational games for soft skills training involve role-playing [34], which makes them close to a simulation.

The Hotel Management Game [35] was used to study the capabilities of Game Based Learning (GBL) to improve soft skills. GBL is a concept structured around a learning process that uses a specific game as the main pedagogical tool. The game provides several contexts for learners to develop leadership, time management and team management skills through the activities for managing a hotel. It has four player roles: the marketing player, the front office player, the housekeeping player and the food and beverage player. The simulation provides realistic scenarios and situations that the players have to tackle collaboratively while doing their own tasks, like strategic and financial planning, requesting funds, proposing upgrades and expansions, solving problems and crises.

The DEVELOP project [36] created a serious game to measure and train leadership competences. In this game, the player is immersed in a realistic workplace context with virtual team members. The interactions with the virtual team are used to identify the player's preferred leadership style. Players also complete a questionnaire to capture their self-perception as leaders. After completing the leadership journey, the game shows a report that provides insight into leadership self-perceptions compared to leadership styles based on players' decisions during the simulation.

In the ModEs project [37], a serious game prototype was implemented aimed at the development of communication, negotiation, and teamwork skills. The approach taken to develop the serious game included 3 different pedagogical concepts: exploratory, experiential and game-based learning. These concepts reflect the lack of existing research linking pedagogical elements to both learning requirements and technical features.

Similarly, there exist companies that work with serious games to support soft skills training in the corporate sector, like GameLearn, a Spanish company [38]. Recently, the company produced Echo, a serious formative game about coaching in which the student assumes the role of a trainer to help an important public figure launch an international treaty to eradicate plastic from the ocean. Players test their skills and abilities during three real training sessions in which they helps their clients define objectives, analyze reality, explore alternatives, and outline an action plan.

B. SIMULATIONS

A simulation is a simplified representation of the real world in which a problem is defined by a set of inputs and outputs and the relationships between them [39]. The use of simulations and simulation-based learning was extensively explored as an appropriate approach to teach soft skills, including large classes [40].

Enterprise simulations were used as an educational tool to support the development of soft skills [41]. Group performance, group dynamics, team member satisfaction and personal growth activities were aspects included in the simulation, which comprised a set of organizational activities.

Schutt *et al.* [42] presented a digital role play simulation for teaching healthcare soft skills. In this work, students play the role of a doctor that interacts via text with a virtual patient, an AIML chatterbot that reacts and recognizes specific diagnostic questions from students. The proposal features an editable conversation tree that allows course administrators to prompt, record, and score student's responses. Administrators can also select ''reaction'' animations that play immediately after a student made a selection and ''idle'' animations that reflect the mood of the patient. Available reaction animations include ''happy'', ''sad'', ''yes'', ''no'', ''angry'', and ''confused''. Idle animations include ''disengaged'', ''neutral'', and ''engaged''.

Bareli & Naso [43] describe what the authors define as the gold standard for soft skills training: a simulation in disaster preparedness and relief. The work uses the Laerdal Medical SimMan 3G patient simulator to provide a full-scale high-fidelity simulation in which teams of rescues are required to proceed with different phases.

Levant *et al.* [44] analyzed the role of business simulations in the development of a selection of 11 soft skills. Business games are regularly used in higher education as learning tools in management, strategy, and finance training [45]. Difficulty and realism levels vary ranging from introductory management games to advanced simulations. This way, we can find general simulations that enable students to address the main issues involved in managing a business with a very limited number of variables, more in-depth games designed to develop a specific area of corporate management, such as marketing or accounting, and simulations in which participants receive more variables to immerse them in a complex environment intended to represent the real life of the organization. Some business simulations are based on team work [46], representing real-life management situations in which several departments of a business interact to make decisions, enabling students to build soft skills. Finally, the S-Cube project explored the use of online-role-play to promote soft skills development [47].

C. GAMIFICATION

The integration of game elements into online courses ws also proposed to facilitate the teaching of soft skills, introducing engaging and fun factors. This process involves game elements or game-design techniques such as scores, achievements, challenges, progress bar, and leaderboards. Online learning platforms, such as Moodle, include plugins with numerous gamification elements that can be used to gamify online courses.

In [48] Dochie *et al.* describe an online course named ''Skill Generator Assessment Game'' focused on developing soft skills combining gamification and scenario-based learning. The proposal includes a traditional online learning part based on course presentations and a game-like assessment, aimed at creating a game-like experience, using interactive content and scenario-based learning to simulate the game experience. Other gamification elements such as points and leaderboards are included.

D. LEARNING ENVIRONMENTS

Besides all the proposals based on games and simulations, other approaches based on learning environments with support for soft skills were proposed in recent years.

The SKILLS+ project [49] developed an e-learning platform focused on soft skills [50] that includes different types of learning resources and tools to support reading resources: videos, real-world examples, tips and tricks, and self-reflective exercises. The learning space is linked to a storyline of an old clipper roaming around a ''Sea of Knowledge'', where treasures are hidden in different islands. These treasures are the skills that enable the learner to navigate effectively, work well with others, and achieve goals. Despite this introduction of the skills, the learning space does not involve any kind of game.

The DEVELOP project [36] created a Personalized Learning Environment (PLE) for employees, people managers, and strategic HR in medium and large companies who want to receive career guidance and actively develop their career. The environment provides assessment of social capital and transversal competencies such as leadership, communication, critical thinking, and more, helping employees to discover their strengths. The DEVELOP Social Learning Tool, a part of the PLE, facilitates self-directed informal learning and competency development supported by a learning community. The tool offers various features to guide and motivate the user to apply knowledge in practice. A coach can use the Social Learning Tool to prepare learning activities around a certain transversal competency. An activity consists of several small tasks or challenges on which learners can work alone or supported by a community of practice, whenever this occurs in their daily work. The end product of the project is intended to be a for-profit tool for medium and large companies, yet to be released.

Mokwa-Tarnowska *et al.* [51] describes a blended learning experience based on Web 2.0 applications to develop collaborative projects for enhancing soft skills. The project involved Civil Engineering students who worked collaboratively in groups of 3-4 individuals for 3 weeks. Students had to prepare an interactive multimedia poster on accidental discoveries or inventions, compile specifications on an artifact they had to invent and advertise, and devise future applications for virtual reality (VR) and augmented reality (AR) and base their solution on collected data. The tools used for this project include a selection of collaborative authoring tools and a brainstorming app: Moodle wiki, Thinglink, Mural, Quip and Ease.ly. All the work done by the students had to be presented and discussed in class.

The Evalsoft system proposed by García-García *et al.* [52] focuses on promoting the learning and assessment of teamwork skills through online environments. It is based on a blended learning approach that integrates games and role-playing with problem-based and collaborative learning design. Teams of 3–5 students collaboratively execute a series of tasks working towards solving a problem, taking turns in leading the team for each assignment. Teams are self-organized and self-regulated under their teacher's guidance and each student is assigned a functional role for each specific task. Groups are heterogeneous internally and are formed based on each student's learning style using Vermunt's Learning Styles Inventory in order to achieve self-regulated teams, but homogeneous in relation to other groups for ensuring balance and effectiveness.

E. MOOCS

Massive open online courses (MOOCs) are also used to support the development of soft skills. MOOCs are mainly based on the delivery of video content and on the performance of continuous assessment activities, but hands-on activities and learning by doing based on real-life cases can also be found [53]. Collaborative assignments and peer evaluation are other typical activities in MOOCs [54].

It is possible to find MOOCs that focus specifically on different kinds of soft skills. Learning, innovation, communication, critical thinking and problem-solving are skills covered to a great extent. The extensive focus of MOOCs on these skills is the result of them being some of the most desired competences in the labor market [55]. To life and career skills, MOOCs in the business and management field focus on the development of leadership and responsibility, initiative and self-direction, and productivity and accountability competencies.

The eLene4work project [56] is focused on the selection and definition of soft skills, including digital soft skills. It proposes activities and practical tools for fostering the development of student skills through MOOCs and Open Educational Resources (OERs).

Puhek & Strmšek [57] analyzed MOOCs in the field of lifelong learning skills for the 21st century with emphasis on transversal competences. In total, 829 MOOCs were analyzed regarding the ability to build transversal skills. The MOOCs considered in the analysis were hosted on 39 different platforms, although Coursera, edX, FutureLearn, Canvas, OpenSAP and NovoEd hosted 84.3% of all analyzed MOOCs.

F. VIRTUAL AND AUGMENTED REALITY

The use of Virtual Reality (VR) and Augmented Reality (AR) technologies as training tools for the development of soft skills is still in its early stages. Existing projects based on VR and AR are, to the best of our knowledge, research projects not used in educational settings. However, the possibilities of VR and AR to immerse students in realistic situations make them attractive to study new approaches.

Górski *et al.* (2018) [58] discuss development and test procedures of VR systems for building soft skills. Specifically, they present the Virtual Quality Toolbox, a VR solution that allows employees of small and micro-production companies to effectively gain knowledge on the application of quality management tools in practice. The toolbox content is introduced by a virtual character, the production master. Building working experience on a selected tool requires users to perform activities in an actual production environment, including listening to a coordinator, locating objects, or performing a set of actions with them, actions and situations that can be well represented in VR.

Hickman & Akdere [59] developed experiential case studies involving VR simulation modules that immerse students in intercultural leadership scenarios. The simulations were recorded through 360-degree cameras capturing real actors and also using computer-generated characters.

Pinzón-Cristancho *et al.* [60] presented an educational strategy based on gamification for the development of soft skills among engineering students through the simulation of product development processes in a VR environment. The activity was based on the popular game Second Life. Its virtual environment allowed the representation of conditions very close to the ones implemented in industry, promoting positive interactions among students and encouraging them to take action and overcome apathy and fear. This approach resulted in very positive perceptions.

Finally, Rafiq & Hashim [61] described an English language teaching AR game that also supports the development of 21st-century skills.

G. ASSESSMENT

According to recent research, the assessment of soft skills can also be supported by ICT tools. The Measuring and Assessing Soft Skills [62] project outlined the importance of using different approaches to assess different groups of people.

O'Connor *et al.* introduced in [63] the results of the Grading Soft Skills (GRASS) project, focused on representing learners' soft skills in a quantitative, measurable way to enable skills' formal validation and recognition [64]. It proposes a technological infrastructure to allow educators to continuously support, observe, assess, and acknowledge the development of student's soft skills. The infrastructure is based on self-assessment, peer observation, and teacher evaluation. The key point is to try to balance, weight, and triangulate the objective and subjective evidence of soft skill acquisition ensuring the validity and reliability of the accreditation of soft skills. The proposed technological infrastructure is based on the accreditation of soft skills with digital badges using the BadgeOS plugin for WordPress. This plugin can be bi-directionally associated with Credly [65], a solution to share credentials. This enables the sharing of badges via professional and social media platforms. Also, details of the badge earners and the requirements for achieving a badge can be stored as metadata within the same file to support transparency.

V. DISCUSSION

According to the results introduced in Sect. II, students agree on the high importance of soft skills and on the need for active methods to acquire them. They value more the importance of soft skills such as meta-cognitive, intrapersonal or problem solving, than technical skills. This perception is justified because it is commonly accepted by students, especially those in the last years of their studies, or those enrolled in graduate programs, that technical skills are an integral part of their education as engineers and are not perceived as ''traversal'' or ''soft''.

They also acknowledge the existence of a variety of pedagogical methods to teach and learn soft skills. However, they tend to value most those with which they are more familiar or more intuitive, such as those directly involving teamwork or those that are applied, at least in part, in regular course activities (e.g. making decisions, solving problems,

TABLE 2. List of Selected Skills for the Technical Skills Category.

Skill	Description	Justification
Digital literacy	Ability to find, evaluate, and compose clear information through writing and other media on various digital platforms.	Digital skills are required for performing everyday activities, using specialized software, communicating, presenting, and more.
Information and media literacy	Ability to show and make informed judgments as users of information and media as well as to become skillful creators and producers of information and media messages.	Students and professionals use media and the internet as a source of information. The ability to evaluate information from diverse sources in significant in synthesizing solutions. Furthermore, as content creators, students need to understand concepts related to media presence and safety on the internet.
Health and wellness literacy	Ability to obtain, process, and understand basic health information and services needed to make appropriate health decisions.	Developing solutions to business and societal challenges requires the analysis of problems from diverse viewpoints, such as technical, societal, economic, and health. Wellness literacy is a necessary skill for effective problem analysis and solution design.
Formal, basic knowledge in engineering	Knowledge and ability to apply the fundamental concepts of STEM required for following an engineering career.	Formal engineering knowledge is key to synthesizing solutions to related challenges. This is the knowledge that is developed through formal educational HE curricula.
Economic and financial literacy, entrepreneurialism	Knowledge and ability to apply the fundamental concepts of math, economics, business, and others required to follow an economics career.	Theoretical economics knowledge developed by formal HE economics curricula is key to solving related problems. It is the basis for developing a successful career in the field.
Ethics	Ability to understand, apply and assess the moral principles that govern a person's behavior or the conducting of an academic and/or professional activity.	Ethics is an important dimension when analyzing a problem and needs to be take into consideration when designing human centered solutions that benefit individuals and communities.
Global Awareness	Ability to understand, respect, and work well with people from diverse cultures.	Modern challenges need to be addressed with both a local and global perspective. Today's interconnected world requires solutions that work for all. In addition, today's business environment is multicultural; in this environment individuals need to work harmoniously with peers from diverse cultural, educational, and economic backgrounds.

or making predictions thinking-based learning). On the other side, more innovative methodologies, that might be perceived as subverting the lecturing standards, such as gamification or flipped classroom, still generate some reluctance even among students.

The number and quality of the actual best practices found in the five countries of the study indicate that it is possible to effectively teach soft skills, but this is a topic that has to be addressed specifically and not taken for granted. As discussed, similar practices are explored in different countries. Nevertheless, they need to be considered more as isolated experiences and not as generally adopted practices.

From what was observed in the best practices, many initiatives involve the use of games and simulations that enable the development of situations where learners can experience the application of soft skills. These games can be used in a wide variety of learning scenarios, from classroom settings to online courses. However, the development of these games implies a high cost from a technical point of view and they tend to be very specific, with each game focusing on some particular skills. Using games in instructional processes may require some level of technical preparation by instructors for their effective integration with other activities such as debates, analyses, assessment, etc. Therefore, games are not directly transferable and scalable among educational institutions. Some attempts of developing games based on VR and AR technologies exist, but they are still at an early research stage.

There is also another group of ICT solutions that are used to support and promote soft skills in the context of classroom activities, namely gamified solutions and e-learning environments. In the former, gamification is used mainly to motivate students and engage them in learning and training. Soft skills are very different from typical formal knowledge and keeping learners motivated in soft skills development activities is a key point. In the latter case, tools such as

TABLE 3. List of Selected Skills for the Metacognitive Skills Category.

Independent and autonomous learning	Ability to learn independently and autonomously.	The ability to learn independently is one of the transversal competencies that individuals need to build in addition to formal knowledge and is necessary for developing knowledge throughout one's career as technological and business processes evolve. Other transversal competencies include critical and analytical thinking, collaboration capacity, communication skills, and more.
Willingness to learn	Readiness to know new things and to improve oneself.	Knowledge development is a process that to a great extent is based on internal motivation. Willingness to learn drives students to explore new knowledge and to develop knowledge through experience. Willingness to learn is also important in active learning methodologies, in which the responsibility for learning is to some degree transferred from the instructor to the student.
Integrating and synthesizing information	Ability to compare, combine and generate a consistent message based on multiple, sometimes conflicting, sources of information.	Synthesizing information that stems from diverse fields is the norm in problem-solving practices in the real world. Rarely in real life will a problem be solved by applying knowledge from a single field. Knowledge synthesis is a key transversal competency along with analytical and critical thinking. It is highly relevant in engineering and economics.
Evaluating information particularly when coming from diverse sources	Ability to analyze through critical thinking the reliability, validity, accuracy, timeliness, point of view, and bias of information sources.	In today's connected world, information does not only come from traditional resources, such as books. It comes from the internet, newspapers, TV, scientific articles, social media, and a lot more. The ability to evaluate information stemming from diverse sources is important in today's environment in which technology allows broad access.
High-level thinking	Ability to apply all the previous skills, namely analysis, evaluation, and synthesis/creation of new knowledge.	High-level thinking involves the capacity of individuals to evaluate information, apply it, and create new knowledge by synthesizing old. High order thinking skills are desirable in the industry as opposed to traditional learning skills related to memorization of information. High order thinking allows individuals to create solutions to real-world challenges through research, analysis, synthesis, collaboration, and integration of knowledge and information.
Critical and analytical thinking	Ability to break down complex information into fundamental parts and assess and judge that information.	Analytical and critical thinking is a transversal competency that helps individuals solve problems independently of sector. Analytical and critical thinking is important both in education and in business. It is the basis of high order thinking activities in which students and professionals build new knowledge from old.
Innovative thinking	Ability to look at problems or situations from a fresh perspective that could provide "out-of-the-box" solutions.	Innovative thinking is a transversal learning capacity along with analytical and critical thinking. Innovative thinking is required to solve emerging 21st-century challenges that are complex and require entrepreneurial mindsets to be addressed.

collaboration, communication, and production facilities are used to support the development of student activities. These are not specific tools for the development of soft skills and, in many cases, they are used for other purposes as well, including the teaching of fundamental curricula knowledge.

Another ICT-related hot issue could be the introduction of data science in soft skills teaching and acquisition. For example, machine-learning algorithms could be used to analyze data obtained from the interaction of students with course management systems, social networks or project planning

TABLE 4. List of Selected Skills for the Intrapersonal Skills Category.

Open-mindedness	Ability to being receptive to a wide variety of ideas, arguments, and information.	Addressing pressing 21st-century challenges requires exploration, collaboration, and experimentation with ideas that are often "out-of-the-box". To introduce solutions that are human-centered and address real, as opposed to perceived needs of stakeholders. Engineers and economics need to have an open-minded while listening to stakeholders, and to be open to ideas that range from conventional to innovative to create a pool of potential solutions that will be evaluated for selecting the most viable one.
Creativity	Ability to perceive the environment, to find hidden patterns, to make connections between seemingly unrelated facts, and to generate solutions. Ability to turn new and imaginative ideas into reality.	Creativity, along with innovative, analytical, and critical thinking is a desirable transversal learning ability that allows individuals to introduce entrepreneurial solutions to complex real-world challenges. Creativity is a key ability in both engineering and economics, which are solution-oriented disciplines.
Flexibility and adaptability	Ability to adapt to changing circumstances and environments and to adopt new ideas and concepts.	Responding to change is important in an evolving technological and business environment. Agile design principles are inherent in engineering and aim at addressing evolving user requirements towards implementing solutions that address evolving needs. Change management processes are also important through protocols and practices that allow multidisciplinary teams to work together in an evolving environment.
Openness to criticism/feedback	Ability to accept negative feedback about oneself or one's work without reacting overly emotionally.	Problem-solving often takes place in groups, in which members collaborate and exchange ideas. In this groups environment it is important to both accept ideas without being overly critical but to also be able to accept criticism without overly reacting.
Openness to others' ideas and thoughts	Ability to be willing to consider ideas and opinions that are new or different from the own.	Being open to the ideas of others is a sign of good collaboration skills and of the ability to listen and take in information from diverse sources. In the context of brainstorming towards finding a solution, being open to the ideas of others, even if these are different from the own, is an important step towards creating a pool of potential solutions.
Initiative	Ability to assess and initiate things independently.	Leadership and the ability to initiate things is an ability that is as significant as being able to effectively collaborate in a group. Taking initiative and acting allows to put ideas into action and to implement solutions in both engineering and economics.
Perseverance	Ability to persist in a course of action, a purpose, a state, etc., especially despite difficulties, obstacles, or discouragement.	Effective implementers have the capacity to not only introduce innovative ideas but to take all the steps necessary for these ideas to turn into action. Innovation is important in solution design, but so is also implementation and hard work.
Self-direction	Ability to make own decisions and organizing your own work rather than being told what to do by others, such as managers, teachers, etc.	Self-motivation and self-direction are important both among students and professionals not only in educational contexts but also in business. The ability to work independently is a transversal competency that is as significant as working effectively in a group. Self-motivation is a capacity that can lead an individual to seek progress in academic and professional contexts throughout their career.

TABLE 4. ***(Continued.)*** **List of Selected Skills for the Intrapersonal Skills Category.**

Self-discipline	Ability to discipline oneself to set clear goals, and then to work towards them every day.	The ability to set clear goals and to see them through is another element of self-motivation and taking initiative. Along with perseverance, it enables individuals to set their own goals and to achieve them both individually and in a group.
Planning	Ability to accurately identify and organize systems and resources (including time) required to complete a task efficiently.	Ability to organize and plan project implementation is significant in all engineering principles as well as in economics projects.
Ability to prioritize	Ability to identify critical tasks and resources and to establish priorities systematically, differentiating between urgent, important, and unimportant processes.	Project management and implementation require the identification of tasks and their prioritization based on requirements. Engineering principles, such as computer science, typically reply on project implementation through the breaking down of activities into smaller tasks and the prioritization of those based on the desirability and urgency of features. Prioritization of tasks allows incremental delivery, which in turn enables users to have access to basic product functionality early on in the implementation.
Assertiveness	Ability to express thoughts, feelings and beliefs in direct, honest and appropriate ways.	Being part of a team involves the expression of opinions and thoughts, which facilitate brainstorming and evaluation processes towards reaching a desirable result.
Being positive	Ability to focus on the things that one can control.	A positive outlook is important in complex challenges for overcoming day to day development and the pressure of project implementation in the long term.
Sense of quality of work	Ability to analyze, judge, and critique a piece of work in such a way that leads to an improved version of that piece of work.	Quality assurance processes are part of every project implementation in engineering and economics. The ability to polish the result of a project to turn it into a final product that is ready for users is a key competency that is important to possess in a group.

tools to identify personality treats or skills already acquired to facilitate the learning of new skills or foster existing one. Besides, the blossoming of IoT solutions and the introduction of low-cost wearable sensor devices enable the capture of information about the physical status and mood of students to drive soft skill acquisition.

Finally, the assessment of soft skills deserves special attention. It is a hard part of teachers' work. Some projects and proposals describe methods for capturing data from teachers and peers and manage them to facilitate global assessment. ICT-tools can be helpful to support these tasks. The use of electronic badges was also considered as an appropriate tool through its gamification component. In any case, the complex part of these solutions seems to be more in the definition of the assessment framework, i.e., what information should be collected and which criteria should be used for assessing. New technologies such as analytics can play a good role supporting or performing automatic assessment, but the existing solutions are still at a research state.

VI. CONCLUSION

This study reviews the promotion and teaching of soft skills in engineering Higher Education across 5 European countries. Students' views about soft skills to master, best practices and ICT-based solutions are provided, offering a broad perspective of the current situation in Europe.

As a first main conclusion, it is clear that there is a great interest about the development of soft skills among higher engineering education institutions, which gained additional momentum in the last years in Europe as a consequence of the implementation of the European Higher Education Area consequence of the Bologna declaration [66]. In addition, the current situation also shows the existence of a variety of alternatives related to what soft skills to consider and about the best approaches and tools to support their development. In the article, we collected the most successful practices, such as problem and project-based, and game-based, but there exist many other approaches to develop soft skills in engineering curricula. Despite such a variety should not be considered as something negative by itself, we consider that further research is needed to be able to analyze, measure and compare the alternatives. Deeper scientific knowledge about the appropriateness of the different soft skills schemes, about the best teaching methods and ICT support, would be very valuable for better decision-making towards the re-engineering of higher education.

TABLE 5. List of Selected Skills for the Interpersonal Skills Category.

Social interaction and empathy	Ability to understand others feelings, ideas and actions and to communicate with them by providing them with your feelings, ideas and actions.	User centered solution design requires empathy on behalf of design team members to understand the real, as opposed to perceived, needs of users and the actual parameters of a given problem. Empathy allows designers to understand the experience and feelings of users when exposed to a solution and to define accurate problem statements, which in turn lead to solutions that more effectively address user needs.
Being a listener	Ability to consciously focus on the speaker message to be able to get a deep understanding of that message.	Similarly to exercising empathy, active listening is an ability that allows professionals to understand the viewpoints of their customers and their peers leading to effective collaboration and desirable results.
Collaboration and teamwork, sometimes in multidisciplinary teams	Ability to productively work with our persons on common tasks to reach a certain goal.	Business and societal challenges are rarely addressed individually. The solution to complex, 21st century challenges requires the collaboration of multidisciplinary teams the members of which collectively possess the required knowledge. Being able to effectively collaborate in multidisciplinary groups, to openly listen to the viewpoints of others, and to integrate knowledge is an ability that contributes to the synthesis of solutions.
Leadership	Ability to organize and motivate other people to reach a shared goal.	Leadership is one of the transversal competences that are desirable for addressing complex problems independently of thematic area. Leadership itself is a combination of skills, including communication, motivation, positivity, delegation, creativity, accepting and providing feedback, commitment, flexibility, and more.
Oral and written communication	Ability to communicate one's thoughts clearly and concisely, but also being able to create focus, energy, and passion.	Oral and written communication allows an individual to convey ideas clearly and concisely, to create focus, and to motivate. They are both significant skills related to leadership.
Transferring knowledge to the real world	Ability to apply the acquired knowledge, skills and competences in a different context or in a different way.	One of the key challenges of higher education today is to build among students' knowledge and skills in a manner that allows their transferability to the real world. The transferability of new knowledge contributes to the bridging of the gap between skills built in academia and those required by industry. Active learning fosters transferability through the development of knowledge in virtual or physical settings that simulate real-world scenarios.
Presentation skills	Ability to deliver information clearly and effectively to a specific audience.	Presentation skills are part of oral communication. They help an individual bring a message across. Effective presentation skills are desirable independently of the area of work. Most individuals at some point will need to professionally present ideas in front of an audience. Good presentation skills are typically considered to be part of leadership skill sets.

Among the variety of methods to teach soft skills, practice-based and collaboration-oriented ones are very relevant, such as problem-solving or project-based approaches. These usually involve the development of competences in a broad sense exposing students to complex challenges where the mastering of soft skills, particularly self-motivation and personal leadership skills [66], makes a big difference towards the achievement of a good performance. Engineering disciplines are particularly well-suited to integrate this kind of practices. Another option is the use of simulations and game-based approaches. This can be more appropriate to support the development of specific skills. It would be interesting to analyze both approaches, general and specific ones, studying the differences in terms of students' learning and appropriateness to be included in the curricula.

Related to the integration of soft skills in the engineering curricula, another main issue is assessment. Some best practices are described, but also in this case there is not a

TABLE 6. List of Selected Skills for the Problem-Solving Skills Category.

Problem-solving	Ability to understand a problem, use generic or ad hoc methods in an orderly manner to find solutions for that problem, identify the most suitable ones and test them.	Addressing the complex challenges of today requires high problem-solving skills. They are higher-order thinking skills that involve the most evolved function of the human brain. Addressing problems requires identifying an accurate problem statement, breaking down a problem into smaller parts, solving those, and synthesizing a solution from the results.
Providing clarity to problems	Ability to analyze a fuzzy problem and identify suitable objectives for solving that problem.	Problems found in complex projects, and often in simpler ones, may not always have a clear origin or pattern, or may even be hidden and leading to other issues, making it hard to identify them. The ability to analyze fuzzy problems and abnormal situations and being able to describe them is key to identify possible sources and ways to tackle the issues to find possible solutions.
Analysis of the factors that contribute to an unwanted situation	Ability to identify events, conditions or other aspects that created an immediate cause for an undesired situation.	Project management requires systematic planning and the ability to organize actions for addressing diverse situations. In particular for unwanted situations, the analysis of factors that could lead to undesirable states is significant for designing mitigation actions.
Following systemic design processes	Ability to understand and apply methods that combine systems thinking and human-centered design to cope with complex design projects.	Effective design of solutions requires knowledge of and the ability to apply systematic thinking towards the implementation of effective actions that address real stakeholder needs.
Designing and evaluating alternative interventions towards solving a problem	Ability to apply methods to conceive and evaluate potential solutions to solve a problem.	Designing alternative solutions is significant for many reasons. It allows teams to brainstorm, creating a pool of ideas towards the solution of a problem. It further allows teams to evaluate diverse implementation paths and to select a single or a limited number of solutions for prototyping and piloting, allowing the generation of feedback by stakeholders.
Implementing and assessing the effectiveness of a solution	Ability to implement the solution and evaluate the achieved results from an efficiency point of view.	The capacity to implement a solution is desirable in a team. It is the process of putting an idea to action and developing a final product, service, or intervention. Evaluation of the final result is also significant for ensuring that it complies with user requirements and user needs.
Working with limited resources	Ability to design a strategic plan and implement decisions to respond to changing circumstances and demands that lead to scarcity of resources.	Project management processes always require implementation within limited resources, including a financial budget, working with specific implementation teams, or others. The ability to navigate project implementation within limited resources is necessary for implementing a project in the real world.
Time management	Ability to plan and organize the division of time between specific activities.	Time is another limited resource, as projects must be implemented within specific timeframes that are determined by external conditions including market and industry evolution. Time management skills include the ability to setup a timeline for project implementation, to identify implementation milestones, and to take into account dependencies between implementation tasks.
Project management	Ability to plan, procure and execute a project with efficient use of all the resources.	The ability to manage the overall project implementation process, which includes time management, financial management, allocation of resources, observation of dependencies, collaboration, and more is significant for all young professionals entering the world of work.

general approach about how to perform it. Usually, multiple factors are taken into account depending on the pedagogical approach followed, peer assessment and self-assessment are considered, and assessment evidence are collected along the course. Therefore, it is a complex problem, and subjective to a certain extend. Also, at this point, it would be desirable to have available assessment instruments that were easily implementable and reproducible, that can provide precise evaluations about the level of soft skill mastering of a person. This would be also very important to allow us to objectively compare different approaches to support soft skills teaching.

APPENDIX I

This appendix introduces the list of skills for each skill category considered in the article, cf. Tables 2–6.

ACKNOWLEDGMENT

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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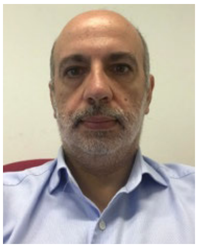

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