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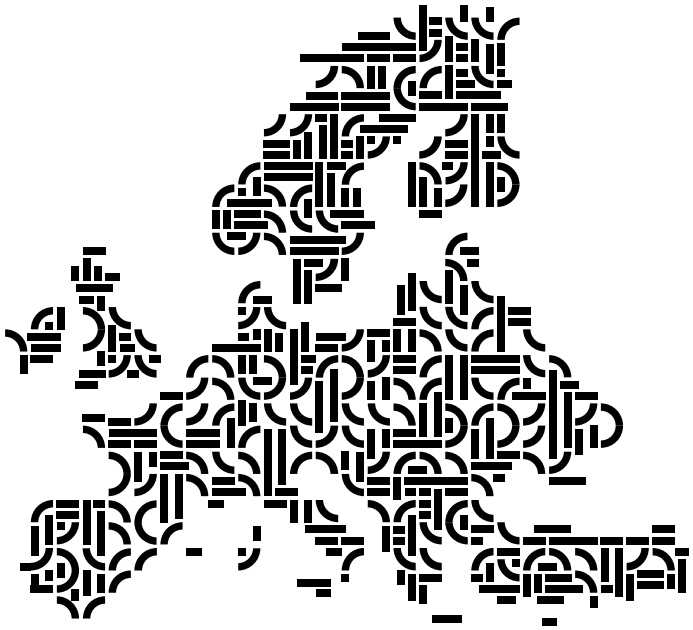

EELISA

European University

Shared definition of EELISA profile

Deliverable 2.6

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EELISA Partners

Number	Role	Name in original language	Name in English	Short name	Country
1	COO	Universidad Politécnica de Madrid	Technical University of Madrid	UPM	Spain
2	BEN	Budapesti Műszaki és Gazdaságtudományi Egyetem	Budapest University of Technology and Economics	BME	Hungary
3	BEN	École Nationale des Ponts et Chaussées	National School of Civil Engineering	PONTS ParisTech	France
4	BEN	Friedrich-Alexander-Universität Erlangen-Nürnberg	Friedrich-Alexander University Erlangen-Nürnberg	FAU	Germany
5	BEN	İstanbul Teknik Üniversitesi	Istanbul Technical University	ITU	Turkey
6	BEN	Scuola Normale Superiore	Higher Normal School	SNS	Italy
7	BEN	Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna	Sant'Anna School of Advanced Studies	SSSA	Italy
8	BEN	Universitatea Politehnica din Bucuresti	Politehnica University of Bucharest	UPB	Romania
9	BEN	Université Paris Sciences et Lettres	Université PSL	PSL	France
10	LTP	École Nationale Supérieure de Chimie de Paris	Paris National School of Chemical Engineering	CHIMIE ParisTech	France
11	LTP	École Nationale Supérieure des Mines de Paris	Paris National School of Mining Engineering	MINES ParisTech	France

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EXECUTIVE SUMMARY

The EELISA Alliance aims to develop a European engineer profile (EEP) that includes a set of skills that encompasses scientific, technical and more relational competencies, within the European context of diversity and mobility. In addition to the scientific and theoretical knowledge that belongs to their core competencies, the engineers will develop strong skills addresssing sustainability, interculturalism, and they will develop an innovation- oriented spirit adapted to the uncertainty and complexity of real- world situations.

1. BACKGROUND

The world needs more engineers and Europe provides a rich and diverse environment to train them. Among the universities of the EELISA Alliance, there is more than enough knowledge and experience to provide basic scientific and technical knowledge for different types of engineers, while stimulating shared values of sustainability and interculturalism, among other important transversal qualities. In this document, within the framework of the European Universities Initiative, which aims to improve and facilitate learning to solve complex problems in higher education, we propose four general “trademarks” of an EELISA European Engineer Profile (EELISA-EEP). In this context we refer to the ideal nature of a professional engineer entering the job market *via* any possible beginning career path, spanning the first 3 to 5 years after graduation.

While many national and international organisations define learning outcomes for different types of engineers, we emphasize the notion of a general Profile which incorporates one of the main goals of the 35-year-old Erasmus program, training in fundamental skills while working on shared values and visions in a multicultural landscape. This deliverable builds on this knowledge and discussion groups held in EELISA, providing some new ideas for a Profile. Mastering technical disciplines and science-based processes and phenomena is essential, but society now demands that we integrate the technical, environmental, and social dimensions as well. Engineers face new challenges in a global society where multiple professional practices can be required to tackle global issues, while respecting local specificities. The EELISA engineer can play a pioneering role in a new industry based on research and innovation and ensure Europe's sovereignty.

To do so, training provided to European engineers should be based on a new system which would be a hybrid or *sui generis* educational system different from existing ones. By training European engineers, higher education institutions will also be in capacity to attract and host more international students and get additional prestige. So, the concept of an EELISA-EEP can increase the visibility and the position of Europe in the world.

ELISSA-EEP can be defined as the attributes, skills, lived experience and attitudes that make a graduate in engineering most adapted to the needs of employers in 2030. They will be more prepared to conduct his/her professional activity within a sphere of certain values and with a clear knowledge of societal challenges and goals. From a personal perspective, the EELISA-EEP can also be described by the type of mind-set students are trained to adopt, modes of thinking that cannot be reproduced or replicated by machines.

2. SCOPE

This document summarizes the efforts within Work Package 2 to define the EELISA-EEP, based on a survey and a review of current proposals, as well as several formal workshops and more informal meetings with Alliance participants. To satisfy the demands for economic development within the framework of a sustainable and responsible recovery, EELISA engineers first need to acquire specialized scientific and technical knowledge, along with training in concepts related to sustainability, interculturalism and inclusiveness and business and social skills. In what follows we present the methodology for data collection (Section 2), and a summary of the results from the survey (Section 3). Section 4 provides a review of the relevant literature within the framework of the training concepts mentioned above, and Section 5 places these concepts within a European framework, defining the core ideals for the EELISA-EEP.

3. METHODOLOGY

Two surveys were undertaken, a literature review was performed and one online workshop was organized, among different members of Work package 2 and beyond to discuss the profile. The first survey consisted in a series of questions (See Annex 1) which were placed online and sent to different stakeholders. The second survey consisted in hiring a consultancy firm to interview nine European leaders working at companies in Europe. Two main questions were asked, 1) What characteristics should the engineer of the future have? and 2) What is the set of skills that he/she should develop to face a professional development for being a leader for future generations? Further details of both surveys can be found in Annex 1.

For the literature review, we used the Web of Science to find recent papers regarding education in Engineering, especially related to some of the main profile topics that emerged from the surveys. We also consulted several partners to learn more about the views of different national and international academic societies, accreditation agencies and professions associations, especially in what regards the engineer of the future, more associated with a general profile that for specific engineering fields.

Lastly, one workshop was held in April 2022 to discuss traits of the EELISA-EEP with members of WP2 and to share drafts and ideas about the current document. The outline of the workshop and main conclusions are in Annex 1.

4. SURVEY AND INTERVIEWS ON EELISA-EEP

4.1. Web survey

A total of 75 people participated in the web survey, 16% of which were from outside the EELISA members. Approximately 37% were professors or research staff from universities and more than half were students (55%). Most of the respondents felt an interest in obtaining an European degree, although students were less keen on obtaining a European engineering degree instead of a national one, underlining that the view is more of an additional degree than a substitution of local degrees.

Regarding the learning outcomes of scientific and technical knowledge, most respondents (above 70%) mentioned to be adaptable to current and future real-life changes and to be able to analyse and synthesize complex problems, and to design, implement and validate innovative methods, products and solutions.

Related to learning outcomes on social and environmental issues, respondents were more interested in outcomes related to “ethical responsibilities” and “societal and environmental consequences of developed solutions”.

Regarding business and management skills, respondents mostly underlined the ability to communicate (with specialists and non-specialists), team working skills, as well as curiosity and pragmatism. Responses about intercultural skills were more varied but mostly centred around the ability to work with different nationalities and master several languages.

When asked about what types of innovative teaching methods could be used for different learning outcomes based on the EURACE accreditation system the responses were also quite varied but the word cloud analysis suggests the following pairing: knowledge and understanding (practise), engineer design (solutions), research (studies), engineering practise (real projects), making judgements (learning by projects), communication and team-working (team work).

Regarding the opinion on what students are looking for in terms of a future job, the main words used were “design”, “international” and “responsible”. Finally, the main other learning outcome that respondents found important was “communication”.

4.2. Interviews

The results from the in-depth interviews of nine senior managers in leading European companies suggest that the specialized knowledge of current engineer graduates in Europe is excellent and should be maintained at a high level, including basic science skills. Most respondents found it difficult to predict the qualities required of engineers in the future, mostly due to uncertainties

related to technological change. On the other hand, for the future they suggested improvements in three main fields: sustainability, interculturalism and inclusiveness, and business and social skills. For a full report of the findings of this survey see Annex 1.

4.2.1. Sustainability

According to our surveys, engineers should have the knowledge and the mentality that is needed to overcome different sustainability challenges. Younger generations seem well prepared. These were not seen as primary skills but rather as a necessary awareness and philosophy to motivate engineers to excel at their work. This could be further promoted by increased cooperation between companies and students during their studies, on state-of-the-art technological solutions to sustainability issues.

4.2.2. Interculturalism and inclusiveness

In general, European students have had some exposure to other countries and cultures, having studied abroad through different mobility schemes, but in some countries (e.g., France and Spain), the level of English language could be improved. Regarding inclusiveness, for some companies it is difficult to reach a gender balance but the incorporation of women is promoted and several interviewees mentioned that including more women in their workforce can create better working conditions.

4.2.3. Business and social skills

Current and future engineers require stronger training in management skills, including human interaction/communication, entrepreneurship, finance and leadership. Although these skills can be acquired on the job, the overall feeling is that more of these subjects could be included in the degree programs. Engineers should be better trained to understand decision making in a company, under uncertain situations and to be prepared to react quickly about adopting new technologies. In the future engineers will probably need to learn to be more flexible, acquire new knowledge quickly and respond to unexpected situations. A better knowledge in economic viability (handling finance) of project would be welcome. When managing a project, engineers should also consider how the end client will use the proposed solution.

Social and communication skills could be improved by considering the knowledge of other people (inside a company) and by improving empathy. Engineers, especially those in leadership positions, need to know how to adapt their communication with stakeholders (higher authorities, other companies, social communities). This goes hand in hand with a good general culture in various fields (economic, political, cultural, etc.).

5. REVIEWING RECENT DEVELOPMENTS

5.1. Scientific studies

A simple search in the Web of Science for “engineer education” provides more the 160,000 results, which can be categorized into several fields, most notably Education related to Scientific Disciplines and Educational Research (see Figure 1). An in depth review of such a vast amount of literature is beyond the scope of this deliverable but a more detailed look at some of the most recent papers is pertinent.

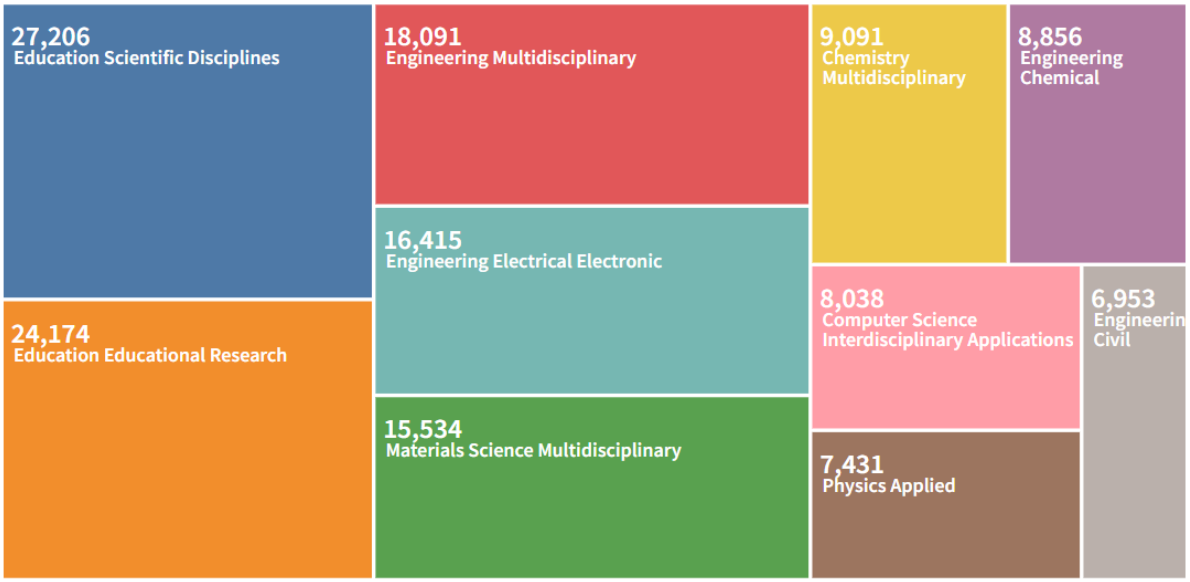

Figure 1 - Categorization of the 160783 papers on the Web of Science resulting from the search “engineer education”.

For example, there are no less than three impact journals that deal with engineering education, namely the *Journal of Engineering Education*, the *European Journal of Engineering Education* and the *International Journal of Engineering Education*. Among those, some recent articles include one by Magarian & Seering (2021). They conclude that engineers obtain, via their studies, a unifying work attribute that can be called “design responsibility”, which includes product efficacy and safety through governance of new or existing designs. Zhu et al. (2021) formalize very precisely the skills involved for engineers in a Chinese industrial context: 1) Sensemaking: analysing and understanding the current situation of the tasks in a project using a variety of data, 2) Relating: Relating involves leaders' skills of inquiry, advocacy, and connecting, all of which require leaders to understand other members' opinions, to take a stand and keep an open mind about alternatives, and to build a constructive relationship with the entire group, 3) Visioning: Visioning refers to setting up inspiring and attainable goals, articulating them to other group

members, and encouraging the members to achieve these common goals through feasible methods, 4) Inventing: Inventing entails creating, improving, and implementing processes, ways, and/or structures as needed to accomplish the vision."

Diaz-Lantada and Nuñez (2021), among others, recognize the importance of basic disciplines of science and technology. In their paper on "engineering for all", Diaz Lantada et al., (2016) specifically underline that theoretical focus on basic science and technology is a required first step and must be detailed in depth, to then be able to focus on more applied activities. Indeed, a thorough knowledge of the basics will also allow students to be more flexible in their applications later on.

5.2. International associations

Moving away from scientific papers and more into the realm of associations, the National Academy of Engineering, in their document on the Engineer of 2020, indicates that engineers need to develop analytical skills, practical ingenuity, creative capability, and leadership, along with other technical skills. That document urges the engineering profession to recognize what engineers can build for the future through a wide range of leadership roles in industry, government, and academia--not just through technical jobs. Professional leadership can be defined as the ability to provide a direction, a process, and a coordination to the members of an organization for the purpose of attaining the organization's goals. Similarly, the Royal Academy of Engineering suggest that future engineers should be equipped with creativity, innovation, and leadership to act as change agents in industry. They should address the demands of transformation from a labour-intensive to a knowledge- intensive economy.

On a European level, for example, Conference of European Schools for Advanced Engineering Education and Research (CESAER) has a Taskforce on Learning and teaching, which is developing a white paper on the engineer of the future in terms of advancing our understanding on how science and technology universities can provide future-proof, ground-breaking engineering education.

The European Society for Engineering Education (SEFI) has been actively advocating for quality of the engineering education since 1973. SEFI has a Special Interest Group named "Curriculum Development" working on the development of Engineering Education in Europe. In relation with the Engineer profile, the topics of interest are the integration of science and technology advancements in engineering education, or University-Industry Cooperation [7].

In a position paper on Developing Graduate Engineering Skills in 2016, SEFI supports the following key common issues within the formation and education of the engineer:

- Ability to adapt in a world changing fast
- Broaden the engineer in addition to providing a deep technical knowledge
- Embrace diversity in the students they attract and in the staff employed by higher engineering education institutions
- Engineering graduate mobility and engineering programme comparability are important elements of the quality of engineering education
- Due consideration must be given to how academics staff are equally evolving and supported as educators and how to enhance their ability to teach, coach, supervise and inspire student learning, and the development of an engineering identity within graduate engineers.
- Learning is for life as engineering education is not finished after first or second cycle
- Cultivate and strengthen the relationship and exchange of know-how between industry and academia

On a national level in France, for example, the Shift project is helping to refine the engineer for the 21st century, promoting activities such as a redefinition of the institutional strategies to integrate sustainability issues.

Also on a national level, but in the Netherlands, the 4TU.Centre for Engineering Education is an initiative of the four universities of technology that connects and combines forces to contribute to social challenges, especially for educational innovation. In its Strategic plan 2022-2025, 4TU focuses on five topics, that can be grouped in some overarching themes as follows:

- Engineer of the future: Educating for responsible engineering/the ethical and responsible engineer, and entrepreneurial learning/academic entrepreneurship
- The future engineering education: Challenge-Based Learning with new forms of challenge-based learning (CBL) or challenge-based education and teaching excellence in engineering education: Diversification of career pathways

ICT enhanced education and the digitally literate engineer is linked to the two previous themes, and consist of two subtopics: a) ICT enhanced engineering education - Flexible and personal learning paths of learners, blended or online solutions for teaching and learning, especially for engineering specific activities such as lab education, excursions, collaboration in augmented or virtual reality, post Covid-19 hybrid education. (b) Digitally literate engineers: Digital literacy and information skills, using digital tools to design or test solutions, and digital collaboration; Industry 4.0, data security; the future role of computer science and mathematics; relevance of data security and privacy.

5.3. Sustainability

“The social responsibilities of engineers include human safety and environmental protection in engineering designs. … But it may extend further to include sustainability, pro bono work, social justice, and diversity…. The impact of the engineering education and broader college experiences on evolving notions of professional social responsibility in particular community engagement is an important feature. » (Bielefeldt, 2018).

Environmental considerations in the engineering design process have also been explicitly required for accredited engineering degrees under ENAEE (European Network for Accreditation of Engineering Education) and ABET (Accreditation Board for Engineering and Technology). It is mandatory to move from a concern for safety, human health and environment protection to a larger definition of sustainability including social justice and diversity. This includes comprehension of the impacts of engineering activity. Ethics and comprehension of the environmental impacts are already two separate knowledge outcomes required in the accreditation by the Washington Accord Program. It is also worth mentioning the evolution of companies towards a stronger integration of corporate social responsibility within their strategies.

5.4. Interculturalism in engineering: mobility

Intercultural competence is a complex competence made up of several sub-competences (knowledge, know-how and life skills – “savoirs, savoirs-faire et savoirs-être”), considering the learner like a responsible and autonomous social actor. More specifically, the aim is to communicate and interact in one or two foreign languages in national or international contexts and in formal or informal situations. This involves:

- mastering linguistic, professional and mediation skills;
- developing the skills of the engineer and the responsible and citizen manager;
- opening up to adapt in an intercultural, plurilingual and transdisciplinary world;
- broadening her/his general knowledge and scientific culture;
- adapting to a communication context in order to present a subject or a scientific and technical work.

Intercultural skills should go beyond communicating in one language but include mobilizing specific attitudes such as tolerance of ambiguity and an appreciation for cultural diversity and value multi- perspectivism. Often this involves improving communication skills to how to manage conflicts.

In the context of intercultural skills acquisition, implementing the virtuous spiral of learning leads to a first “internal” effect: intercultural reflexivity, which is the capacity to develop and relativize your own frame of reference and know how to develop empathy for the frame of reference of the

other. It then leads to a second “external” effect: knowing how to interact in a constructive way, which means knowing how to avoid violating cultural rules and ability to achieve values-based goals.

Different concepts like multiculturality or diversity can become important. Diversity opens the way to the discussion of different nationalities, societies, social backgrounds and ways of life that are probably more suitable. Working with diversity requires a curiosity and pragmatism that is not self-centred, recognizing the value of other systems and approaches. It is consistent with a more global and inclusive vision. It also shows an important retreat from a single frame of reference that guarantees a greater adaptability to changes of all kinds.

5.5. Business and communication skills

Leadership is a recurring key word for all engineering education. Engineers should be drivers of innovation in a changing global society. The shortest definition of leadership would be a *mixture of consensus building and decision – making*. However, the definition is not really standardized, and this appears as a difficulty for faculties and schools to introduce leadership in learning outcomes because it is poorly standardized and difficult to quantify.

This is a mixture of qualifications that contain abilities for interpersonal communication, teamwork, technical excellence, leadership knowledge, and visioning/setting goals) that could be acquired through research- based learning and innovation -oriented learning.

Moreover, engineering applications and new technologies, sustainable developments goals and decreasing resources raise complex social and ethical challenges. This requires an increased awareness in ethics. So, Professional leadership comes with ethics diversity and interculturalism.

For this reason, Mastrangelo et al, 2004 state that *empathy is required*, integrating both concern for production and concern for people. Engineers should have a *better leadership in” both professional behaviours (e.g. setting a mission, creating a process for achieving goals, aligning processes and procedures) and personal behaviours (e.g. building trust, caring for people, acting morally “*. This relates to a more human-cantered society with less priority left to profit mode. Similar points were raised in Great Britain where creativity, innovation, and leadership were the keywords and in China which stressed the importance of experiential learning, project/problem-based learning, and study and leadership skills for future engineers increasingly competitive global economy that relies on the advancement of technology.

6. THE EUROPEAN ENGINEER PROFILE FOR EELISA

Based on the different elements mentioned in the earlier sections, we propose a definition of the European engineer profile, that will underpin the work of the EELISA alliance.

6.1. A favourable environment for promoting engineering education

While the European Union aims to be at the forefront of the technological and scientific challenges in a context of an increasing competition globally to innovate, it provides engineering students with a rich and diverse learning environment, teeming with creativity. However, to take advantage of that environment to its fullest, students need programs that stimulate mobility during their studies, and sustained interconnectedness after their studies, for a rich life-long learning experience. This is especially true in the field of engineering, where employability is high, but where complex problems require creative teamwork with multiple expertise in a quickly changing environment. Europe and the world need more engineers, and the more we can work to prepare strong and inclusive learning programs, the better.

As noted in the document, "European strategy for universities", from the European Commission (2022), Europe is home to close to 5000 universities, each deeply rooted in its respective local communities and cultures, but with shared ethical values regarding openness, democratic freedom, fairness and sustainability. Now, more than ever, engineering students require training in fundamental skills in their respective fields, while actively working on these shared values and visions. This was one of the main aims of the highly successful and unique Erasmus program, now 35 years old.

Moving above and beyond the Erasmus program, member states are now beginning to promote mobility and interconnectedness in specific fields with tighter networks, such as in the field of engineering. One aim is to find new ways of strengthening the European Education Area (EEA), the European Research Area (ERA) and the European Higher Education Area (EHEA) via the European Universities initiative, to favour deeper institutional cooperation in the context of alliances. These new joint programs will not only facilitate mobility, but provide a common study plan and a shared long-term vision of future student profiles. As with European citizens themselves, future European engineers will be embedded in their different communities but share common traits related to acquired skills that can help them to assess and tackle common challenges in multi-national, multicultural, and multilingual techno-economic networks.

6.2. Defining the contribution of engineering education

Engineers use science to solve problems. They are the interface between science and techniques at the service of society. Although there are many types of engineers, scientific knowledge and the application of the scientific method is common to all, underlying much of the historical progress in different fields. Engineering, in that sense, could be defined as the process of transforming an idea into a concrete artefact through the use of a collection of techniques.

Within the overall framework of an engineering degree program, which includes both a Bachelor and Master's degree in Engineering, a knowledge of basic engineering and scientific skills is essential. These acquired technical and knowledge-based skills involve understanding the importance of measurement (including data acquisition, literacy, analysis and management), in real or simulated contexts, and an analysis of how different equipment has evolved over the years, thanks to applied research. As confirmed in the general outline of the Learning Outcomes developed by ENAEE, engineers must have, first and foremost, "a thorough knowledge and understanding of mathematics and other basic sciences inherent to their engineering specialty". Acquiring these core skills is essential to support flexibility, adaptability to changing technologies and long-life learning.

However, given the current ecological context, the applications and developments of new techniques needs be compatible with planet boundaries and ecological limits (Rockström et al., 2009). They should also be compatible with democratically established societal goals.

Because these challenges (to which we can add the digital revolution) involve complex situations, uncertainties and multiple stakeholders, future engineers also need to acquire a series of skills that tend to revolve around the concepts of cooperation, innovation and entrepreneurship in an inclusive environment. Again, referring to the Learning Outcomes developed by the ENAEE, engineers must be able to "make judgements, communicate and work in teams". They should be able to use different methods to communicate their conclusions, clearly and unambiguously, and the knowledge and logical foundations that support them, to specialized and non-specialized specialized audiences, in national and international contexts.

Upon graduation, students may not be fully prepared to juggle the intricacies of how to deal with complex social, environmental, technological and economic problems, but they can be trained to analyse problems, communicate them and propose new strategies. This part of the training may be acquired on the job and through internships. According to the Conference of Deans of French Schools of Engineering (CDEFI), future engineers should be active team-members and contributors to innovation, with competences in management skills, economics and finance, working in multiple disciplines and with a spirit of interculturality to propose innovative solutions.

6.3. A European engineer profile

The EELISA Alliance aims to develop a European engineer profile (EEP) that includes a set of skills that encompasses scientific, technical and more relational outcomes, within the European context of diversity and mobility. The EELISA-EEP can help to provide a scaffolding for the Learning Outcomes for a future joint degree, as well as ideas for the EELISA Supplement and Credentials. The EELISAEELISA-EEP should be based on pre-existing frameworks such as the EUR-ACE® Framework Standards and Guidelines (November 2021) and the Washington Accord Graduate Attribute Profile (Nov 2021), but with some additions to emphasize the importance of mobility and the European dimension it provides. In that light, most international standards for engineer profiles underline the importance of key concepts such as understanding, practice, design, research, knowledge, methods and complexity, although not always in that order. Most frameworks can also be divided into hard skills and softer ones, with some emphasis on practical knowledge, but few point out the utility of mobility/diversity during the degree to help promote learning. We propose that the EELISA-EEP include four conceptual fields within its framework.

Scientific and theoretical knowledge

This part of the profile involves core skills or theory-based understanding of the basic sciences in each field of engineering, for example mathematics, computing, and their use to develop products, processes and systems. Students are exposed to theoretical problems and the formulation of possible solutions based on engineering fundamentals, in a design framework. Here access to research methodologies and relevant literature is key to help evaluate the data or processes using state of art methods. Excellent scientific knowledge is the backbone of the European engineer profile.

Addressing sustainability

European engineers will need to understand how the techniques they develop are compatible with the depletion of natural resources and not generate irreversible situations. Especially they will need to take into account the entire life cycle of products and services they design and produce. This implies a critical and thorough analysis of the socio-environmental risks that pertain to the development of new technologies.

Interculturalism: an engineer embracing the European project

Just as practical learning may help to understand engineering fundamentals, adding mobility in a degree program can help facilitate understanding and incorporating soft skills on a personal level. By being exposed to different professors, university environments and cultures, students will

become more aware of different societal issues, ethical problems and cultural dispositions. Mobility also provides a means to being exposed to a working environment in a different country via internships. The ambition with mobility in EELISA is to go beyond an exposure to different cultures and different ways of thinking. The core of this project is to nurture an atmosphere of cooperation and common values around cohorts of students that will embrace the European engineer vision of EELISA and develop across geographies and over time a shared vision of Europe and its values.

Business and communication skills: Practical and applied knowledge

Engineers should be able to work with materials, equipment and tools outside the classroom in order to apply problem solving techniques. This will also expose them to economic, organisational and managerial issues, and enhance a critical sense and judgment about the application of different solutions. They need to adopt a user-centric approach that enables to gather societal expectations with technological ambitions. There are many ways to ensure that students engage in work to ensure they acquire the expected expertise of engineering analysis, design and practice, including problem-based learning.

Given the uncertainty and complexity of real world situations, while applying the theoretical and practical knowledge they obtained, engineers will need to take into consideration social objectives, and ethical responsibilities in addition to sustainability issues mentioned above. Because they are at the interface between science, techniques and society, they will also require training related to communication skills, decision-making and independent learning (learning on the job) to better integrate the views of multiple stakeholders into their decision and creative processes. These skills are best learnt in real contexts, in which students, having acquired its basic principles, put them into practice in actual multi-lingual, multi-cultural and inter-disciplinary contexts. The complexity of decisions they will need to tackle involves a reflexive thinking posture on their own practice. This analytical thinking can feed back into their professional actions and further improve common knowledge. Given the fast evolving technological and societal environment, the European engineer needs to adopt a position of continuous learning that will maintain its ability to address societal challenges over time and to manage younger collaborators within its firms.

6.4. In conclusion

The EELISA-EEP can be created by a combination of different life experiences, acquired knowledge, exposure to the real and changing world problems, constraints and social context, mindful of the ethical consequences of the engineering solutions and trained to understand and communicate with other professionals, in diverse cultures and environments. It’s sound education

and training makes the EELISA-EEP more flexible to adapt to a quickly changing context and enables students to learn by themselves.

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ANNEXES

Annex 1. Web-based survey

Annex 2. Interviews (International Consultancy)

Annex 3. Workshop on the European engineer

Annex 1: Web-based survey

Defining the European Engineer of the future – an EELISA collaborative consultation

One of the main missions of the EELISA Alliance is to propose a convincing, implementable and shared vision of the profile of the future European Engineer. This vision needs to inspire the necessary transformations in the training processes that will foster the new generation of engineers in Europe and strengthen the competitiveness of the continent. With this purpose, EELISA is launching a consultation process open to experts, professionals, researchers, teachers, students and all members of the EELISA network and beyond.

We therefore thank you for completing this survey and we will welcome any informed opinions, data, documents or reflections towards this potential definition of the future European Engineer. The submitted opinions and views will be processed confidentially without disclosing the identity of the purveyor. Completing this questionnaire will take you around 15 minutes.

Who are you?

- Academic or researcher
- Student
- Administrative
- External stakeholder

Are you part of one of the EELISA partner institutions?

- Yes
- No

In which sector do you work or study?

- Resource extraction, mining
- Agriculture, agronomy, food sciences
- Manufacturing
- Construction, civil engineering
- Utilities – Energy
- Transportation
- Business, finance
- IT, information and communication
- Community, social and personal services
- Public administration and defense
- Human health and social work
- Arts, entertainment and recreation

Physical education and sports

Other:

Reflection on the profile of a European engineer. What are the needs of such a degree in the following areas?

What specific skills should they bring?

Please rate (between 1 and 10, 1 : low interest, 10 : high interest) the interest of a European engineering degree in addition to a national engineering degree

Please rate the interest of a European engineering degree instead of a national engineering degree

What should be the minimum scientific and technical learning outcomes common to all engineering disciplines? Please rate between 1 and 10 the following propositions, and/or add other propositions

c.1. To analyze and synthesize complex problems by mastering scientific fields

c.2. To design, implement and validate innovative methods, products and solutions

c.3. To carry out research activities and to set up experimental devices

c.4. To be adaptable to current and future real-life challenges

c.5. Other (please specify)

c.6. Other (please specify)

c.7. Other (please specify)

What are the required learning outcomes related to social and environmental issues of an engineering degree? Please rate between 1 and 10 the following propositions, and/or add other propositions

d.1. Developing human-centred view of solutions

d.2. Knowledge of ethical responsibilities

d.3. Knowledge of health, safety and diversity issues

d.4. Consideration of the societal and environmental consequences of developed solutions (products/devices/processes, etc)

d.5. Other (please specify):

d.6. Other (please specify):

d.7. Other (please specify):

What are the required learning outcomes related to management and leadership skills of an engineering degree? Please rate between 1 and 10 the following propositions, and/or add other propositions

e.1. Project management
e.2. Innovation and creativity
e.3. Ability to find compromises
e.4. Recognizing the value of other (foreign) systems and approaches
e.5. Curiosity and pragmatism (not self-centred)
e.6. Team management, practice collaborative and remote work
e.7. To be able to communicate with specialists and non-specialists
e.8. Other (please specify):
e.8. Other (please specify):
e.10. Other (please specify):

What are important intercultural skills that can be taught to strengthen the European dimension of the of engineering education? Please rate between 1 and 10 the following propositions, and/or add other propositions

f.1. Knowledge of histories and cultures of other countries
f.2. Accept different abilities to work in relation to different nationalities, societies and ways of life
f.3. Mastery of one or several foreign languages
f.4. Knowledge of systems of thought of the societies
f.5. Knowledge of social, political and economics frameworks of the societies
f.6. Other (specify)
f.7. Other (specify)
f.8. Other (specify)

What are the aspirations of students in terms of professional endeavours in your point of view? (max 5 keywords, separated by commas)

Are there other areas or learning outcomes you would like to mention? (max 750 characters)

Here is a list of EUR-ACE © learning outcomes which are recommended to train an engineer. Could you provide a specific innovative teaching method you think of, or a best practice you have in mind to obtain these learning outcomes?

Knowledge and understanding (max 750 characters)

Engineering analysis (max 750 characters)

Engineering Design (max 750 characters)

Investigations (max 750 characters)

Engineering Practice (max 750 characters)

Making Judgements (max 750 characters)

Communication and Team-working (max 750 characters)

Lifelong Learning (max 750 characters)

If you are interested you can leave your contact for more discussion on it (face to face)? (Not mandatory of course)

Here are key features that have been proposed for engineering education 5.0 to more effectively and efficiently transform engineering education with the ambition to successfully address current global challenges (see for example A. Díaz-Lantada, International Journal of Engineering Education Vol. 36, No. 6, pp.1814–1832, 2020). Please pick the 7 more important features of such a new engineering program and rank them from 1 to 7.

Dynamic and continuously evolving

Modular and flexible

Personalized for joint personal and professional development

Sustainability and solidarity focused

Combining knowledge-based and outcome-based approaches

Holistic

Humanistic

Guided by ethics

Collaborative and open source

Involving international experiences

Including external academic internships

Supported by project-based learning activities hybridized with service learning

Technology-supported and artificial intelligence- aided

Oriented to lifelong learning

Enjoyable for enhanced results

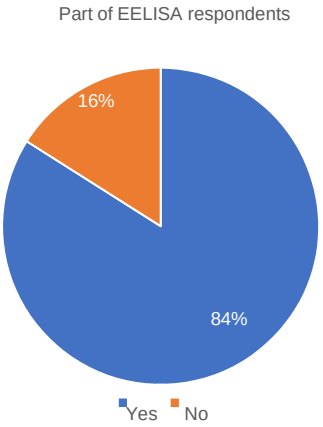
Equitable, aimed at ‘‘engineering education for all”

Add any comments or list of keywords that you consider important

Overall results of web survey

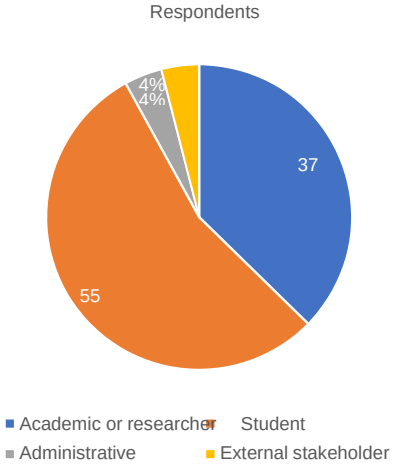
Part of EELISA within the respondents

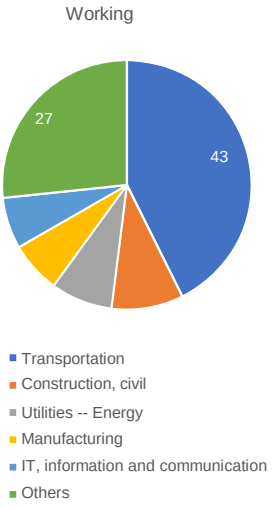
Total number of respondents: 75



Most part of the respondents from EELISA Alliance

Profile of the respondents



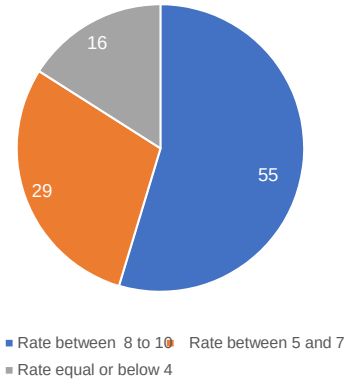


Most part of the respondents = Students & Academic

Interest for European engineering degree

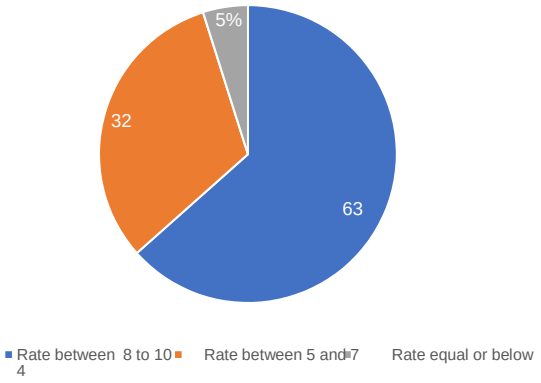
ALL RESPONDENTS

Interest for European engineering degree in addition to a national engineering



STUDENT ANSWERS

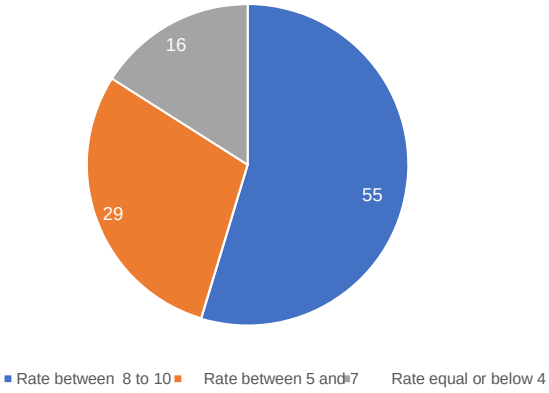
Interest for European engineering degree in addition to a national engineering degree



Interest for European engineering degree instead of a national degree

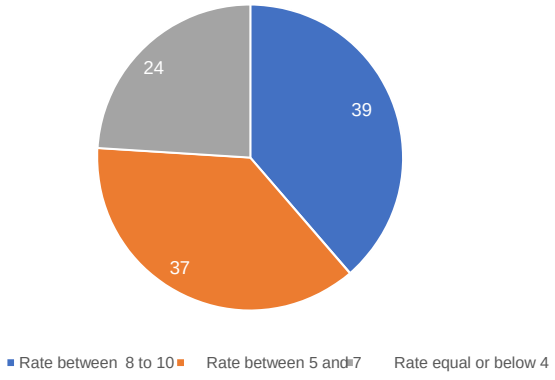
ALL RESPONDENTS

Interest for European engineering degree in addition to a national engineering degree



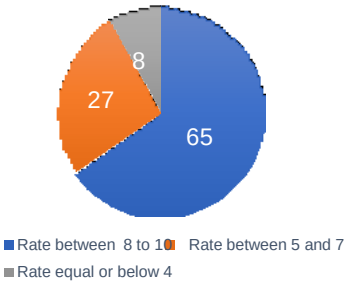
STUDENT ANSWERS

Interest of a European engineering degree instead of a national engineering degree:

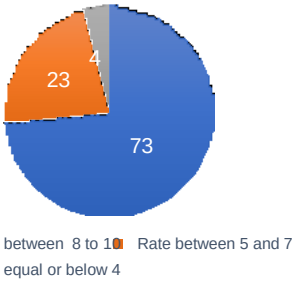


What are the required learning outcomes related to social and environmental issues of an engineering degree?

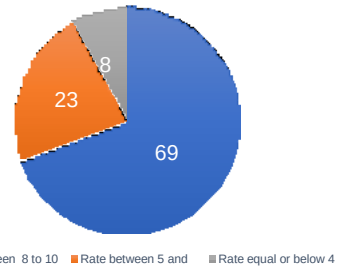
Developing human-centred



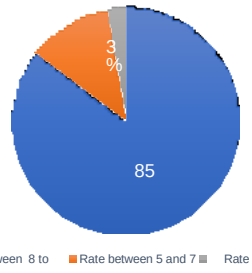
Knowledge of ethical



Knowledge of health, safety and



Consideration of the societal and environmental consequences of developed solutions (products/devices/processes, etc)



What should be the minimum scientific and technical learning outcomes common to all engineers?

To be adaptable to current and future real-life challenges	**Rate ≥ 8 for 85%**
To analyze and synthesize complex problems by mastering scientific fields	**Rate ≥ 8 for 72%**
To design, implement and validate innovative methods, products and solutions	**Rate ≥ 8 for 71%**
To carry out resaerch activities and to set up experimental devices	**Rate ≥ 8 for 44%**

What are the required learning outcomes related to social and environmental issues of an engineering degree?

Consideration of the societal and environmental consequences of developed solutions (products/devices/processes, etc)	**Rate ≥ 8 for 85%**
Knowledge of ethical responsibilities	**Rate ≥ 8 for 73%**
Knowledge of health, safety and diversity issues	**Rate ≥ 8 for 69%**
Developing human-centred view of solutions	**Rate ≥ 8 for 65%**

What are the required learning outcomes related to management and leadership skills of an engineering degree ?

Be able to communicate with specialists and Non specialists	**Rate ≥ 8 for 81%**
Team management, practice collaborative and remote work	**Rate ≥ 8 for 77%**
Curiosity and pragmatism (not self- centered)	**Rate ≥ 8 for 77%**
Recognizing the value of other (foreign) systems and approaches	**Rate ≥ 8 for 76 %**
Ability to find compromises	**Rate ≥ 8 for 71 %**
Project management	**Rate ≥ 8 for 69 %**
Innovation	**Rate ≥ 8 for 68 %**

What are important intercultural skills that can be taught to strengthen the European dimension of the of engineering education?

Accept different abilities to work in relation to different nationalities, societies and ways of life	Rate ≥ 8 for 59%
Mastery of one or several foreign languages	Rate ≥ 8 for 49%
Knowledge of systems of thought of the societies	Rate ≥ 8 for 49 %
Knowledge of social, political and economics frameworks of the societies	Rate ≥ 8 for 44 %
Knowledge of histories and cultures of other countries	Rate ≥ 8 for 32 %

Here is a list of Eurace learning outcomes which are recommended to form an engineer.
Could you provide a specific innovative teaching method you think of, or a best practice you have in mind to obtain these learning outcomes?

Knowledge and understanding

Here is a list of Eurace learning outcomes which are recommended to form an engineer.
Could you provide a specific innovative teaching method you think of, or a best practice you have in mind to obtain these learning outcomes?

Engineering design

Here is a list of Eurace learning outcomes which are recommended to form an engineer.
Could you provide a specific innovative teaching method you think of, or a best practice you have in mind to obtain these learning outcomes?

Investigations

Here is a list of Eurace learning outcomes which are recommended to form an engineer.
Could you provide a specific innovative teaching method you think of, or a best practice you have in mind to obtain these learning outcomes?

Engineering Practice

Here is a list of Eurace learning outcomes which are recommended to form an engineer.
Could you provide a specific innovative teaching method you think of, or a best practice you have in mind to obtain these learning outcomes ?

Making Judgements

Here is a list of Eurace learning outcomes which are recommended to form an engineer.
Could you provide a specific innovative teaching method you think of, or a best practice you have in mind to obtain these learning outcomes ?

Communication and Team-working

competitions language learning non-teachers presentation
project-based projects public teamwork

What are the aspirations of students in terms of professional endeavours in your point of view?

balance competiting design developing excellence freedom international job
knowledge life passion path position product professional respect responsible
salary success work

Are there other areas or learning outcomes you would like to mention?

Annex 2. Interviews

Qualitative Research conducted by Kantar (https://www.kantar.com/)

This document is a qualitative interview guide for moderators.

The qualitative nature of these interviews implies that the objective is not measurement but understanding the characteristics – from the point of view of the respondents – that the future European Engineer should have. In this sense, the dynamics of the interview will be very open and spontaneous, letting the respondent create his/her own discourse, so that we can analyse his/her own words to identify what is more relevant.

Therefore, the objective of this guide is to ensure the correct understanding of the nature of the information to be collected in the interview. It is not a questionnaire with closed questions and the moderators needn't ask the questions word for word. At the end of the research all areas of the study will be addressed comprehensively.

In other words, we let the participant speak as freely as possible addressing the different topics, probing for elements that are not mentioned spontaneously.

Interview guide

Reminder of context and objectives

- EELISA brings together complementary strengths and profiles in Europe to add value to engineering, transform engineering higher education in Europe, building new bridges between the applied sciences and education in order to train a new generation of engineers who will be engaged citizens able to face the challenges of tomorrow.
- The universities of EELISA aim to give students the opportunity to earn a European degree in engineering and increase their competencies and employability so that they can work anywhere in Europe in either the world of academic research the private sector or public administration.
- A fundamental aim of EELISA is to take on board the engineering education needs of stakeholders, include joint research and transfer activities so that their outcomes serve society and humanity, and help build smart and sustainable solutions in Europe.
- In this sense, the ambition of the EELISA is to define and implement a common model of European engineer rooted in society, with an increased inclusiveness, cross-disciplinarity and commitment.

Within this context, the objectives of this project can be defined as follows:

- What characteristics should the engineer of the future have?
- What is the set of skills that he/she should develop to face a professional development for being a leader for future generations?

Universe

Eight in-depth interviews of professional men and women with a profound knowledge of the engineer and technology professions and the European business context in the 2030 horizon.

- Company (agroindustrial) France, Male, Conducted on the 30th of March
- Company (virtual reality/ software), Turkey, Female, Conducted on the 7th of April
- Organization (energy), Spain, Male, Conducted on the 1st of April
- Company (Industrial manufacturing), Germany, Female, Conducted on the 1st of April
- Organization (specialism: transport), Internacional, Female, Conducted on the 4th of April
- Company (Finance) Hungary, Female, 7th of April
- Company (consultancy), Spain, Male, 20th of April
- Company (energy management and automation), France, Male, 7th of April

On a contextual level, it comes to the foreground that companies and organizations are facing different challenges on the short (covid, inflation) and long term (need for adaptation to quick technological development in both products as well as production process).

Also, sustainability is an important topic for almost all companies/ organizations on different levels:

- Companies whose activities are directly related to this (eg energy, agroindustrial).
- Industries that need to fulfill sustainability requirements.
- Organizations that have to deal with the consequences of climate change.

All this translates into an increasing need for being able to access high talents in the realm of engineering. In that sense, the difficulty of “getting the right people for the right job” in some cases is mentioned spontaneously.

For a lot of companies and organizations the main “unfulfilled demand” is centred around topics that are not strictly related to engineering, but to the way that different activities are developed on the workfloor.

Entrepreneurship: One the hand it is felt that this skill is a lot of times “acquired on the job”, on the other, respondents feel that universities could add value by training engineers in the different elements related to this topic.

Financial skills: This does not only refer to the managing of the viability of budgets of the projects they are doing but also to the handling of financial concepts within the company on a longer term

“for example, it is important to understand that, if you do not spend your budget this year – you might not have it the next year” “sometimes they don´t even know what a balance sheet is or they do not know about strategic tools or methodology”.

Customer/ consumer orientation: Some companies talk about the lack of psychological insight for the development of products/ services that take into consideration the human- machine interaction. Some companies state that they already work on this topic by sending their engineers to projects on quick prototype development and design thinking techniques (were attention is paid to the experience of the consumer), but it is seen as an added value if this would be included as an element that is present in the education.

Soft skills. The most important element is the communication (eg. Giving feedback to people that come from other disciplines, overall communication within the company). It is felt that a lot of engineers communicate in their own way, sometimes without realizing that the other people in the company do not have the same knowledge or background “it is a matter of empathy, sometimes they assume that you know what they are talking about”

Other topics come up after probing: they are relevant and should be addressed, but do not come up as a major friction at this moment:

Sustainability: For most respondents it is crucial that engineers have the knowledge and the mentality that is needed to overcome the different sustainabilty challenges. Overall, it is felt that both the motivation, awareness as well as the educational knowledge in this aspect are in line with what is needed (complemented by learning processes at the work floor).

Gender issues (equality/ being able to hire female engineers). Overall, it is pointed out that the main friction lies in the fact that in most engineering careers significantly less women are present, making it difficult to fulfill quotas and in some cases leading to higher wages for women (in order to attract them).

With regards the future, the high speed at which technology develops and creates a situation where respondents find it hard to give precise demands regards requirements of the Future Engineer “nobody knows what happens in 10 years, things go so quick”. This translates into an overall demand of flexibility and interdisciplinarity. The aforementioned demand for education in quick prototyping/ design thinking is related to this – as it helps engineers to be in contact with other disciplines, be more creative and understand the user/consumer.

Specially when it comes to computer/ software engineering, it is felt that – instead of being educated and specialized in specific tools – engineers should acquire the skill to be able to learn new tools and ways of working in a quick manner.

A relevant way of working on all these different skills to create the Future European Engineer,

is the continuous collaboration between companies and universities, as it would give students the possibility to “get in touch with reality” and be trained in all the different aspects that they normally learn when they start working.

Kantar report

KANTAR

Future Engineer Profile

Preliminary results

Qualitative Research Report

266408923
Marzo 2022

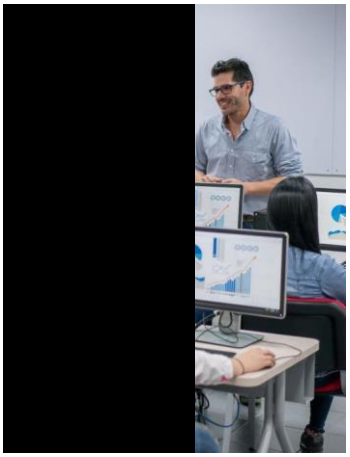
1
Context, objectives and methodology

Context

The EELISA Alliance was launched in November 2020 under the European Commission's support strategy for European Universities. Formed by 9 European universities from France, Italy, Germany, Turkey, Hungary, Romania and Spain, and coordinated by the Polytechnic University of Madrid, EELISA aims, among others, to create the European engineer of the future.
To this end, EELISA will design several joint degrees in engineering (Bachelor and Master's degrees) that will be taught at several universities in the alliance. A fundamental element when defining the joint degree is to obtain and form an idea of a Future European Engineer.

This concept is about the idea of a profile that allows people to develop a professional career and is configured around a set of skills, technical and transversal competences, experiential or work experiences, be a transformative leader, oriented and aware of global challenges, adapted to the technological, social, cultural and political reality of the future.

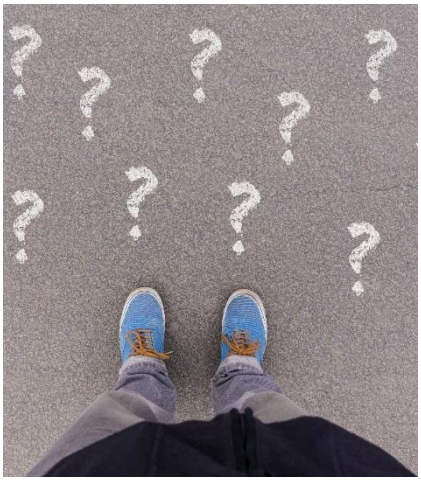
An essential aspect of building and developing the engineering profile of the future is to know the vision of European technology leaders and leading companies that hire and will hire young people who graduate from 2030-2032.
The purpose of this study is precisely to talk with the leaders and leading European companies and get their view on the Future European Engineer Profile.



Central questions

What characteristics and traits should the European engineer of the future have?

What are the set of skills that must be developed to face a professional development that allows you to be a leader adapted to future needs?



Objectives

Future Engineer Profile

Key issues:

Characteristics and features of the European engineer: Skills, competences, experiences, abilities that allow you to face a professional development. Gender issues and how to break down barriers to equality. Differences according to the interviewees (sectors, position in organization, etc.)

Decisions/actions to be taken according to the results of the research:

Creation and formation of the idea of the European Engineer of the future at an academic level.
Design of joint degrees in engineering.

Qualitative approach with Depth interviews

In-depth interviews

Online Depth interviews (Zoom/ Teams)

1 respondent per interview

45-60 minutes

Sample characteristics

- 9 leaders/ senior level management in leading companies and organizations (men and women)
- In different countries: France, Germany, Rumania, Hungary, Spain and respondents based outside Europe with international functions.
- English or local language

- Kantar has experience in using online platforms to conduct case online interviews or video calls.
- The interviews are recorded in video/audio for further analysis.

2
Findings: Context

There was a great variety in terms of the role of engineers in the companies and organisations that we interviewed

Different disciplines

- Civil engineering
- Chemical engineering
- Electrical engineering
- Software/ Computer engineering
- Mechanical engineering
- Industrial engineering
- Agricultural engineering
- Biomedical engineering
- Power/ Nuclear engineering

Different departments

- R&D
- Design
- Sales
- Service
- Project management
- Product development
- Maintenance
- Marketing

Different levels of leadership

- Leadership functions/ senior management
- Intermediate management
- Project leaders

Despite this, most demands overlap between different disciplines and departments. Although there is **not a "single engineer description", there are common elements** that can be used as a starting point for developing the future profile of the European engineer.

KANTAR | POLITÉCNICA

8

The main challenges of companies/ organisations set the context for the engineering profile that is needed

The main challenges mentioned by the respondents are centred around **competitiveness, development of technology and sustainability.**

- **Running a business in a competitive environment**, need "to stay ahead of the game"
- Need **for continuous transformation**, be flexible and adapt to the quickly changing technology/ digitalisation.
- Organisations: dealing with **complex environments** with multiple players and interests (governments, communities).
- **Dealing with sustainability issues** (with climate change as the most relevant topic)
  - Fulfilling requirements of society or state.
  - Dealing with the effects of climate change.
- The **Covid pandemic and inflation/shortage of supplies** are mentioned as recent events that **reinforce the strength of the challenges.**

3
Findings: Engineering profile

The spontaneous discourse focusses on elements that are associated with leadership

The specialized knowledge is not questioned…

- When it comes to **their discipline, overall it is not considered to be difficult to get personnel** that has the right skills and expertise.
- Note: one respondent talks about a lack of knowledge in "basic science" education (e.g. math, physics), making it more difficult for engineers to finish their career (energy sector).

…yet when it comes to"the reality of the job" there are (partially) unfulfilled demands

- The main areas that come to the foreground are related to the **way of working in companies and organizations as well as the human interaction** on a daily basis (e.g. business expertise, human interaction).
- They are also considered to be skills **necessary for leadership**.

"When it comes to their field of working everything is ok, there are no major problems"

"The engineers nowadays are very good but sometimes I feel that they do not have a global vision"

Business/ management skills as the key to success and/or leadership (1)

- Specially in companies, the main (partially unfulfilled) demand for Engineers is centered around **different skills that are related to "managing the business".**
- On a general level, mention is made of **the drive and working mentality to help the company grow**, in occasions verbalized as **entrepreneurship**. On a more specific level it is related to **specific knowledge and skills (as will be shown on the next pages).**
- It is felt that these skills **are "acquired on the job", while at the same time they also depend on personalities**.
- However, it is still considered a friction where **universities can add value** by training engineers in the different elements related to this topic.

"I mean, I am an entrepreneur and an engineer, but still I think it would still be usefull for schools and universities to teach more about how to run a business"

Business/ management skills as the key to success and/or leadership (2)

— One of the areas is about the ability **to work on/ consider the economic/ financial part** of the business or organization.

Understanding of decisions in a company: business knowledge in uncertain situations

— On a more general level, it not only refers to the importance of understanding **how to handle financial concepts**, but also to the way **decisions** are being taken in the company -> this includes **being able to deal with ambiguous situations.**

For example, it is important to understand that, if you do not spend your budget this year – you might not have it the next year"

"sometimes they don´t even know what a balance sheet is or they do not know about strategic tools or methodology"

"In huge corporations sometimes, you do not know why decisions are made. That is sometimes difficult for an engineer because it is not always fact based"

Handling of finance in projects

— On a very concrete level, it refers to the **managing of the budgets (and possible benefits)** of projects that are being carried out. In other words, consider the economic viability of the project from the start.

"It is basically a question of doing projects that are viable, that you don´t end up saying, this is very excitining but now we have to do the calculations and we can not carry it out or, it is not going to give us any money"

"you have some engineers who really arrive and only know about structural engineering or road engineering but no clue on how to calculate economic returns or financial returns"

Business/ management skills as the key to success and/or leadership (3)

— Another topic related to this area is the need to have people that go beyond **"giving logical solutions"** and take into account the other players involved.

General customer/ user orientation

— In a general sense, this is about "not only working on the objective of the project" but also **considering the end client that must use the solution.**

— This also applies to the project development in organizations, where multiple players are involved in the use of the solution (authorities, society).

"In our line of work, when you set up a project related to transport or agriculture, you must talk not only to authorities but to the whole community. If not, the whole project might be a failure"

Human-machine interaction

— Specially (but not only) when it comes to consumer-oriented companies (hardware, software) **the need for psychological insight** is also mentioned in order to **improve the human-machine interaction**.

– One of the respondent state that they already work on this topic by **sending their engineers to projects on quick prototype development and design thinking techniques**.

"You know, the problem is that a lot of engineers do not know that the consumer has a very different way of thinking, they have a totally different attitude when it comes to the use of technology"

Although related to personality, social skills could also be enhanced

— Taking into acount the previous topic about the need to take into account different players in a project, social skills come up as an element that deserves special attention: **different elements related to empathy** come to the foreground.

Taking into account the knowledge of other persons

— It is felt that a lot of engineers **communicate in their "own way"**, sometimes without realizing that the other people in the company do not have the same knowledge or background.

"it is a matter of empathy, sometimes they assume that you know what they are talking about"

They assume that we are experienced in using some software tools, but that is very complex for many people"

Tone of communication

— Empathy is also related to the tone in which feedback is given (or received): Some respondents mention that **engineers can communicate very directly,** without considering the feelings/ interests of the other party.

"Sometimes it is not only about objective facts, but about the way you talk to somebody. It can make a huge difference when it comes to the success of a project"

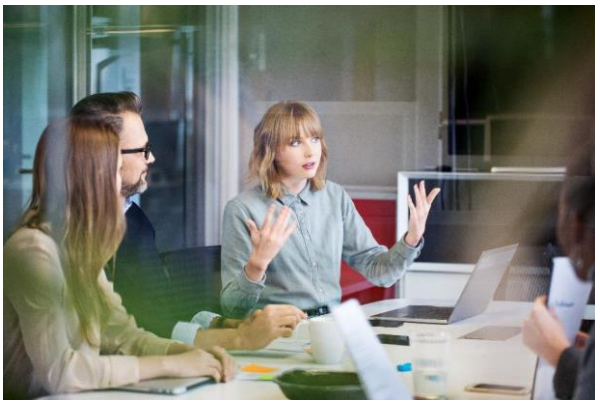
In some leadership positions specific communication skills are needed

— Some companies/ organizations mention the **need for being able to communicate with players from very different environments**: (high) authorities, companies & social communities.

— This does not only require social skills but also a wide knowledge on different areas (cultural, political, economical, etc).

"So, we need people who can go and speak to a minister , explain and understand all the perspectives of a development project"

"For example, in my case, yesterday I had a conversation with a minister"



Specialisation vs. multidisciplinarity & learning capacity

— Related to all the previous topics is the discussion regarding the specialized profile of engineers.

Specialisation vs. multidisciplinarity

— Although it differs between different industries, generally it is felt that the **current specialisation** of engineers should not be lost – rather it **should be enhanced/ complemented by more education in the previously mentioned skills** (business, management, social)

Learning capacity

— Specially (but not only) for computer/software related companies, the emphasis lies on **being able to adapt/ quickly learn about new technologies.**

"I mean who cares if you know C plus or Java, they have to be able to adapt themselves"

"The world is going so fast, so we have to teach to the young generation to adapt themselves and be ready to be alone all the time"

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The importance of being able to work in an international environment

— As all of the companies and organizations in our sample are operating on an international level, the ability to work with different cultures is key. The reason it did not come up as a key demand is related to the fact that **most respondents do not feel that there are currenty big frictions around this topic.**

Positive evaluation of European Engineers

— Overall, it is felt that **Europeans have a relatively high degree of mobility**: generally it is normal for them to work with different cultures.

— In that sense, they value positively that engineers spend time studying abroad.

"When I look at the CVs, everybody spends a year abroad"

Specific frictions/ demands

— Some respondents in Spain and France still see **room for improvement in English language skills** (already improving with younger generations).

— Some companies mention the challenge of **being able to work with non-European cultures**.

"For example, if a European works with somebody from India, if they say this is the plan, they don´t challenge it, you really have to ask how they are going to do it"

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Sustainability

— The fact that this topic is not mentioned spontaneously in the interviews is not because of a lack of importance. In fact, for most respondents, **it is crucial that engineers have the knowledge and the mentality that is needed to overcome the different sustainability challenges.**

Key relevance

— In general, the importance of climate action and general care for the environment (waste management) is highlighted.

— All respondents agree on the importance of the topic as **both authorities and society are demanding action.**

"Specially the topics of waste management and climate change are all over, we take it into account in everything that we do "

Motivation and education

— Respondents feel that the younger generations are well prepared:

— The **motivation regarding climate action is high**.

— Also, from the perspective of education, **respondents feel that the new engineers are well prepared**.

"I think it is a topic that is taken very seriously in European Universities. So again, everything related to sustainability, climate change…I see that the young generation is very well aware of those topics"

The issue of gender equality

Although not mentioned spontaneously as a topic, gender equality issues can be a challenge for companies.

— We found different attitudes regarding the relevance:

— Some only mention **the challenge of fulfilling the required quotas (**male/ female balance).

— Others highlight **the importance of this topic in society as** more females on the workfloor can create better working conditions (promoting work-life balance) and an overall change in mentality.

"More women leadership will give more opportunities for remote working or care for family needs"

"Women still have a very big role in the house…it is changing but to have more female engineers this has to grow a lot more"

The issue of gender equality (2)

- It is felt **that the shortage of female engineers is the main problem** (rather than inequality in conditions – some even suggest that the situation leads to higher wages for females).
- In order to create a better gender balance, some respondents point **to the need of stimulating female interest at a young age**.

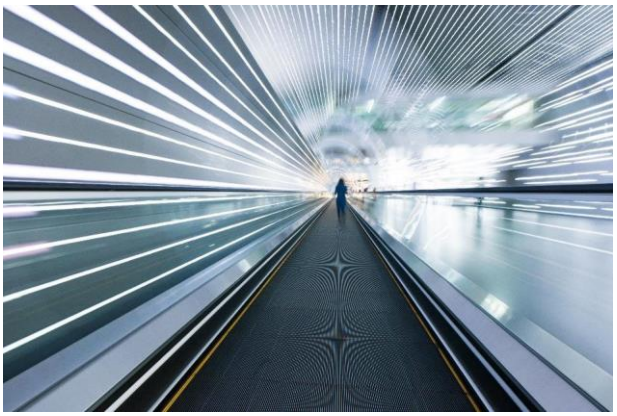
"The situation now is that some women choose engineering because of the career opportunities, but they are not necessarily motivated. It should be stimulated to work on this when they are still at school"

Note: with the exception of 1 respondent (energy sector; Rumania) that points out that the inequality starts when female engineers start working.

4
The Future of Engineering

The continuously changing environment demands flexibility and a quick learning capacity

- Interestingly, talking about the future was considered a difficult topic for respondents. The overall feeling is that ***"nobody knows what happens in 10 years, things go so quick"*** **.** This refers to the quick development of technology on different levels (eg; computer/ software/ AI, with an effect on different disciplines).
- It leads to an **increasing demand of engineers that are flexible in mentality and cognitive capacity** to be able to work with **other disciplines** and **continuously learn** about new developments.
- Although this is also a question of personality, schools and universities should train people on being able to acquire new knowledge.



"Maybe you are working on something and then – all of a sudden you need to be able to start from 0"

"Already during the university education, they could work on flexibility and the ability to transfer your knowledge from one field to the other"

However, no sacrifice should be made in the rigorous problem solving approach or specialist knowledge of engineers

- The learning capacity, flexibility and multi-disciplinarity should never be seen as something that is in contradiction with the **logic and scientific way of thinking that is seen as the basic skill of the engineer – the principal value he/she brings to society.**
  - In some specific cases respondents even express their worry that sometimes engineers have a less solid background in science/mathematics/ physics (minority view)
- Also, the need for higher vs. lower specialisation in their área depends on the disciplines, but in general respondents feel that **it is not a question of sacrificing specialisation yet enabling engineers to connect their specialisation(s) with other fields of knowledge**.

"So we need a problem solver with the technical approach but that can take into account the megatrends"

For most respondents, the key to this "flexible specialisation" might lie in the cooperation between universities and companies

- **The carrying out of joint projects** would allow students as well as teachers to be up-to-date regarding the demands that are required on a technological level in society (which, according to a part of the respondents, is not the case currently).
  - A positive example is **Skylab,** the innovation hub of the Technical University of Denmark, were students, researchers, designers, start-ups and other companies come together to work on prototyping and business acceleration.
- Practice in companies is also valued as **another way of "being in touch with reality"** before finishing their career.

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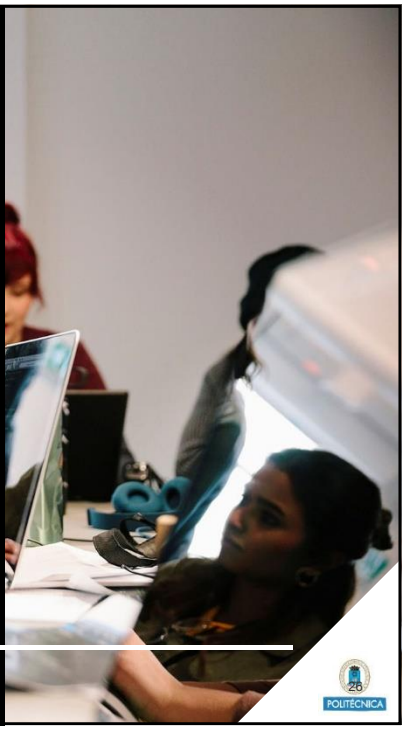

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Annex 3. Workshop

Brief summary of the workshop 'The profile of the European engineer' (held on March 15, 2022) – 20 participants

The workshop started with two presentations:

- Morris Villarroel UPM (*The European engineer mindset: employability and demand*) who developed a survey on the state of the art of engineering education followed by a presentation
- Andres Diaz-Lantada UPM (*Continuously Evolving Engineering Education*) who focused on the future of engineering education.

The four following sessions addressed the needs for a European engineer profile and the plus-value and originality of this profile. It was not intended to design recommendations on the methodology of pedagogy, although we know that the pedagogy and learning outcomes can be strongly interrelated.

1. What is the plus value for an engineer of being "European"?

The profile is built on the differences within the EU and not meant to be a harmonization of engineering through Europe. Still, across the diversity, the European engineer would share common values. The plus value of this diploma is the ability to embrace a career at European level (not at national level). It relies on increased networking opportunities and knowledge of European industries.

2. Interculturality in engineering

Working with diversity requires a curiosity and pragmatism that is not self-centered, recognizing the value of other systems and approaches. It is consistent with a more global and inclusive vision. It also shows an important retreat from a single frame of reference that guarantees a greater adaptability to changes of all kinds. Interculturality and diversity, as the opposite of consanguinity make the engineer prone to modernity, evolution ad continuous adaptation.

i) The balance between technical skills and managerial and leadership skills

This is an issue that has been debated for many years: is it a real one since many engineers become good managers and leaders? A student- centered pedagogy should allow any combination from the pure technical expert to the pure manager not in a standardized manner. This can be also corrected through life-long learning strategies. The importance is to develop problem-solving skills, the ability to address complex issues and the capacity to develop a system approach ("holistic" approach).

ii) Importance of the societal issues and SDGs for the learning experience

Sustainable Development Goals are a hot topic that will be included in the future accreditations of the Engineer diploma. The future engineers have to be trained to have a systemic approach, not only based on their technical knowledge and they must be concerned by their impact in the society at different levels. They should develop a human- centered view of solutions.