E4E – Engineers for Europe: a study about the future of Engineering profession

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ABSTRACT

The paper discusses a project focused on the future of the engineering profession and the emerging requirements for developing appropriate professional competencies. The aim of the project is to bridge the gap between society's needs for engineering performance and the provision of suitable education and training. It is structured into four chapters. The first chapter outlines the inception of the initiative, the formation of

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the consortium, and the operational methods during the funding period. The second chapter addresses the assessment phase, evaluating both current and future training needs for graduating and practicing engineers by offering relevant online courses. The third chapter details the design and preparation of the training courses for testing and validation. Finally, the fourth chapter explores potential scenarios and advancements for the engineering profession, considering adaptations to evolving societal needs for development and progress. Conclusions to define the strategy for the future of engineers and diagnostics of engineering training needed will be produced at the end of the project E4E.

1. INTRODUCTION

1.1. E4E Introduction and Description

The aim of the E4E project is to enhance understanding and insight into the engineering profession in Europe. The subsequent actions are geared towards enhancing the quality of engineering education and continuous training, fostering innovative capacity, and improving the effectiveness of the engineering workforce. Proposed methods include the establishment of an online training platform, the creation of strategic and benchmarking reports, conducting dedicated stakeholder surveys, and launching extensive dissemination campaigns to share produced outputs. The project also aims to develop digital bridging tools to facilitate seamless connections between training and practical application for active engineering professionals and between academia and engineering companies.

One of the key challenges to address within the E4E project is the information gap concerning the collection and accessibility of relevant data for stakeholders. Certain consortium partners, such as national professional engineering associations, can systematically contribute by conducting surveys among their members and maintaining ongoing dialogues with engineering companies and government agencies. These associations can offer comprehensive insights into member engineers' backgrounds, education, ongoing professional development, career paths, training needs, and labor conditions. Such data is crucial for informing effective policy-making and implementing reliable actions to support the education, training, and personal development of engineers and their respective businesses.

Another significant challenge tackled by the E4E project is the human resources aspect of the engineering landscape. There is a widespread shortage of engineers across most economies worldwide, and in Europe, this shortage underscores the need to promote and nurture the engineering profession to inspire current professionals and prospective students alike. Shifting demographics and changing perceptions of the engineering field have further exacerbated the scarcity of engineering talent. This situation raises pertinent questions about training programs, recruitment strategies, working conditions, salary structures, mobility opportunities, career advancement, and potential career setbacks.

1.2. Partners of E4E

The project brings together partners representing various sectors, including professional engineering organizations, academia, vocational education and training (VET) institutions, and companies. On the academic side, partners include universities of applied sciences, research universities, and European associations. In the business sector, partners consist of national engineering associations, supplemented by

organizations such as engineering student associations, young engineers' groups, the council of engineering chambers and the association of the HVAC industry and professionals. Academic and vocational training partners play a crucial role in providing stakeholders involved in initial education and lifelong learning opportunities for engineers. Additionally, the consortium includes a quality accreditation agency for higher education programs like engineering.

Partnership comprises thirteen organizations from eight European Union countries, the project spans a duration of thirty-six months and receives a public grant of approximately EUR 1.5 million from the European Union Commission's Erasmus+ program. Coordination of the project is done by an European professional engineering organization with members that are national professional engineering organizations from 33 different countries (Engineers Europe, 1951). The project aims to establish a European Engineering Professional Skills Council, identify and define new trends in engineering education, and develop innovative training programs for the engineering profession. It's worth noting that the E4E project aligns with the objectives of current European policies in education and training, particularly in addressing future skills mismatches and promoting excellence in competence development for engineers. The project seeks to facilitate proactive dialogue between the engineering industry and the education and training sector, focusing on continuing professional development.

Among the project's outputs are the establishment of a permanent observatory of the engineering profession, the definition of entrepreneurial competencies for engineers, the creation of four online training courses tailored to emerging needs in the engineering field, and the proposal of an Engineering Skills Passport aligned with current European Union frameworks. Additionally, the project aims to develop an Engineers Europe Skills Compass to update the competencies required for the engineering profession. Task management within the consortium is divided among vertical and horizontal working groups dedicated to the six working packages. All Engineering stakeholders can participate in the project activities at any time since the significance of the work done will be more valuable with increased participation and diversified contribution.

2. METHOD FOR OVERVIEW OF COMPETENCES NEEDED

2.1. Description of Survey

The "Engineers for Europe" (E4E) project seeks to narrow the gaps between education, training, and industry while operationalizing EU competence frameworks. At the core of the E4E project lies the challenge of how educational innovations and curricula can align systematically and proactively with the evolving needs of industry and the increasingly dynamic and diverse roles that engineers play. As underlined in literature (Aljohani et al, 2022), there is a need to strike a balance between providing education that encourages the skills, values, and attitudes required by society at large and meeting the expectations of the market. The industries of the future require engineers who, as representatives of their technological domains, can leverage innovation and leadership to integrate specialized expertise with the ability to navigate creatively across boundaries in complex environments (Taylor, 2019). Project is coordinated by an European

Within the E4E project's second work package (WP2), there is a focus on skills monitoring and anticipation tools. WP2 aims to develop a sustainable and effective framework and systemic approach for identifying the skills and competences needed to address societal challenges. This framework entails assessing the current situation

regarding the demand and supply of skills and competences for the engineering profession, with particular emphasis on non-technical aspects such as digital skills, green skills, and resilience through transversal, professional, and entrepreneurial skills. Additionally, it involves anticipating future needs, while the third work package considers strategic considerations regarding the evolution of skills demand and supply for the engineering profession.

The framework/methodology underscores an operational approach to analyzing the engineering profession, combining primary and secondary research methods to gather relevant data and identify opportunities and challenges. Primary research involves utilizing focus groups, interviews, and questionnaire-based surveys with representatives across the entire education, training, and industry spectrum. Secondary research relies on desktop analysis to capture specific trends in the engineering profession. The methodology aims to offer actionable insights to stakeholders in the profession on addressing skills shortages and mismatches and promoting the acquisition of digital, green, resilience, and entrepreneurial skills among engineers.

Over a period of two months, from May 15 to July 15, 2023, the project partners issued a survey to various stakeholders, comprising 33 closed questions. A total of 3045 fully completed responses were received. Responses from the seven countries' engineering professional organizations represented in the E4E consortium (Belgium, Germany, Greece, Spain, Ireland, Portugal and Slovakia) were isolated, resulting in 802 applicable responses. The survey covered topics such as sustainability, engineering education, stakeholder policies, and entrepreneurship. The majority (about 88%) of respondents were professionally active, with about 65% having more than 10 years of professional experience in either industry or the educational sector. The survey findings offer insights into the issues that the E4E project should prioritize to support European policy development through independent study and engagement as an impartial advisor. Concerning validation of the first survey, this phase is not addressed in the project during the first year of the project. The second survey is ongoing in the second year of the project and will be analysed in the next phase of the project.

2.2. Main Outcomes of Enquiry

The survey results provided fourteen insights relevant to the development of a Skills Strategy (E4E, 2023), which can be categorized into four overarching themes:

1. Role of Education Providers:

Engineers benefit most from competency-based learning, with critical thinking, collaboration, and communication skills identified as crucial professional requirements. Specific policy measures are needed to foster diversity and inclusion by encouraging experimental and problem-based learning opportunities that cultivate ethical decision-making skills. Additionally, attracting a more diverse talent pool to the engineering profession necessitates mentorship programs and diversity/inclusion training for professionals and organizations. Finally, universities/technical schools should collaborate with industry to develop formal or informal curricula aligned with job market needs.

2. Emphasizing Sustainability:

Increasing emphasis on sustainability and environmental concerns, alongside greater utilization of automation and AI in engineering processes, emerged as priorities for the engineering profession in the next five years (2023-2027). This requires innovation

and technological advancement in renewable energy and green infrastructure, emphasizing sustainability principles in formal engineering education and training. Engineers play a crucial role in promoting green energy and efficiency by implementing new technologies and providing technical expertise and guidance to businesses, particularly SMEs, to encourage sustainable practices.

3. Employment Opportunities:

There is widespread agreement that the majority of new job opportunities will arise in completely new occupations or existing ones undergoing significant transformations in content and skill requirements. Concerns are raised about shortages of engineers in fields such as electrical/electronic, ICT, and agronomic/environmental engineering to support these growth areas. Additionally, respondents view skills gaps in the local labor market as a greater obstacle to business transformation (60%) than a shortage of investment capital (37%) across various industries.

4. Partnership:

Collaboration between industry and educational institutions, alongside investments and increased funding in research and development (R&D) for emerging technologies, are deemed the most effective tools for addressing skill shortages in digital, green, resilience, and entrepreneurship within the engineering profession. Entrepreneurship is recognized as a key competence for enhancing European competitiveness, with R&D efforts focusing on developing a social and green economy. Professional engineering organizations have a role in fostering an entrepreneurial mindset among engineers and promoting interdisciplinary collaboration among their members.

It is underlined that the project is ongoing until September 2025 and the results presented correspond to the first half of the project. These observations are preliminary in terms of the analysis of the engineering needs and will be complemented by the ensuing questionnaire that is more focused and concise.

3. ONLINE TRAINING COURSES

3.1. Tailoring and Design

The E4E courses are carefully crafted to empower engineers, equipping them with advanced competencies (knowledge, attitudes, and skills) to augment their professional prowess. As such, the intended beneficiaries encompass engineers at qualification levels 5, 6 (technician and first-cycle degree – bachelor level), and 7 (second-cycle degree – master level). Drawing from the findings of research conducted to monitor trends in the engineering profession, project established clear objectives for developing courses aimed at fostering competencies deemed essential for all engineers, irrespective of their area of specialization. These competencies, defined according to the European Commission frameworks (EQF), are pivotal for the engineering profession.

Transversal skills pertinent to the engineering profession encompass green skills (sustainability), digital skills, entrepreneurship skills, and life skills, sometimes defined as soft skills. These four groups of skills (may also be designated as competencies) derive from the existing European Frameworks: GreenComp, DigComp, Entrecomp and Lifecomp (European Education Area, 2023) . The significance of green skills, including political agency, is increasingly pronounced (Atkisson et al., 2018), with engineers expected to address sustainability challenges set forth by the European Union, such as the transition to a circular economy and decarbonization.

Digital skills, such as information and data literacy, hold crucial importance in the contemporary engineering landscape (Van Den Bossche et al., 2019). Proficiency in digital tools and platforms enables engineers to streamline processes, boost productivity, and deliver innovative solutions with greater efficiency, thereby positioning them as catalysts for progress and agents of sustainable development across various sectors.

Entrepreneurship skills, such as opportunity recognition, empower engineers to innovate and commercialize solutions, thereby augmenting their technical prowess with invaluable competencies essential across diverse functions and roles within the profession (Fayolle et al., 2015). Engineers equipped with entrepreneurship skills not only spearhead technological advancements but also foster economic growth, job creation, and societal advancement by translating ideas into impactful solutions and ventures.

Soft skills, such as communication and teamwork, are indispensable for fostering effective collaboration and project management in engineering endeavors (Murthy et al, 2021). These skills are fundamentally linked to adaptability, change management, and societal engagement, encompassing principles of resilience. Professionals endowed with these transferable competencies enable companies and industries to address complex challenges, drive innovation, and make meaningful contributions to sustainable development.

These competencies, also called transversal and transferable skills, are essential for the engineering profession, as these are learned and proven abilities which are commonly seen as necessary or valuable for effective action in virtually any kind of work, learning or life activity. These competencies are ‘transversal’ because these are not exclusively related to any particular context (job, occupation, academic discipline, civic or community engagement, occupational sector, group of occupational sectors, etc.). (Cedefop, 2021).

3.2. Courses Composition

Each of these skill groups has been structured into individual courses. The intended learning outcomes/competencies for the E4E courses were selected from four frameworks: DigiComp (Vuorikari et al., 2022), GreenComp (Bianchi, 2022), EntreComp (Bacigalupo, 2016), and LifeComp (Sala, 2020). This resulted in a 'constructive alignment' (Biggs, 1996), (Biggs et al, 2011), (Loughlin et al, 2020) of the competencies/learning outcomes, with the learning objectives derived from these frameworks. The methodology employed for creating the E4E courses adopted a modular approach, ensuring that each of the four courses comprised at least three modules (EQF levels ranging from 4 to 7), each focusing on the development of competencies within the respective skill groups outlined in the mentioned frameworks. All modules will be made available online without access restrictions, utilizing Open Educational Resources (OERs) such as micro-videos, papers, other documents, practical activities, tests, etc. The necessity for courses grounded in academia-industry collaboration was emphasized by the primary research survey results. A teaching manual will be provided for the local piloting of these courses.

Regarding assessment, the consortium will develop a Self-Assessment Tool (E4E SAT) for users to evaluate their level of readiness, understanding, and competence in transversal skills. As for certification, each course will be equivalent to 0.5 to 1.5 ECTS credit points in terms of workload, with a total duration of 12.5 to 45 hours, inclusive of

synchronous hours, in-person training, and autonomous work conducted by the trainees. Certificates of participation will be issued by the partners delivering the courses. Additionally, participants will receive micro-credentials, operationalizing the "European Approach to Micro-Credentials" (European Commission, 2022).

4. CONCLUSIONS AND RECOMMENDATIONS

Surveys provide valuable insights into the literature concerning future engineering requirements, including professional demands and the competences graduates need for their future careers. These careers often lack clear identification at the outset of their educational journeys. However, as discussed by Fleming et al. (2024) in their analysis of the technical and professional skills essential in the engineering profession, it is also crucial to focus on the preferences of employers. This study, unlike prior studies that relied on disparate methods to aggregate multiple previous studies, analyzed a single sample of 26,103 job advertisements for engineering positions. This approach enabled them to identify a broader range of more specific professional and technical skills than previous studies conducted on a national scale, capturing the pulse of the engineering profession and offering a more refined understanding for the future.

Future surveys conducted by E4E might also consider evaluating engineering programs and the perceived alignment or misalignment between education and the competences required in the engineering sector. By adopting frameworks like the Systems Approach for Better Education Results in Workforce Development (World Bank, 2013) framework and utilized by Fleming et al. (2024), the project can gain insights into the gaps between educational offerings and the profession's requirements. Additionally, utilizing databases related to the engineering profession can provide further understanding of prevailing input/output synergies and factors facilitating them.

The contemporary engineering landscape necessitates a multifaceted skill set beyond technical expertise, encompassing green skills, digital proficiency, entrepreneurship, and soft skills. The E4E project aims to equip engineers with new competencies covering transversal knowledge, attitudes, and skills, with a focus on innovative entrepreneurship, digital, green, and life skills as part of Continuing Professional Development (CPD). CPD plays a pivotal role in enhancing transversal skills for engineers, preparing them to excel not only as technical specialists but also as versatile professionals capable of driving impactful change in a rapidly evolving world. By investing in CPD, engineers can cultivate skills vital for collaborating across disciplines, fostering innovation, and embracing emerging technologies confidently.

As for future actions, defining stakeholders with justification for their status and communication outreach is essential. These stakeholders may have national, regional, European, or global areas of influence, and relevant contacts should be collected and stored in the project Observatory. Engineers Europe should manage these active stakeholders during and after the project conclusion. Passive future activities should focus on providing information to all stakeholders, including data about the engineering profession, its academic, professional, social, or regulatory aspects. This information could be centralized in a platform like an observatory, addressing issues such as CPD provision for engineers, engineer salaries, qualification frameworks, current engineering trends, international agreements, relevant events, mobility schemes/tools, and potential future scenarios for the engineering profession.

Looking ahead, the observatory could assist in defining priorities for actions, such as the sustainability response of engineers as outlined in the UNESCO II Engineering

report (Engineering for Sustainable Development). It could also compile examples of potential training opportunities for engineers, including additional competences that may become mandatory for active engineers. Moreover, the observatory could collect concrete data and training opportunities for engineers to promote sustainability in their actions and assess the influence of Artificial Intelligence (or Machine Learning) in the engineering profession.

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REFERENCES

Aljohani, N. R., Aslam, A., Khadidos, A. O., & Hassan, S.-U., Bridging the skill gap between the acquired university curriculum and the requirements of the job market: A data-driven analysis of scientific literature, Journal of Innovation & Knowledge, 7(3), 100190. 2022, https://doi.org/10.1016/j.jik.2022.100190.

Atkisson, A., & McDonnell, S. Green engineering: Environmentally conscious design of chemical processes. John Wiley & Sons, 2018.

Bacigalupo M. Kampylis P, Punie Y. and Van Den Brande L., “EntreComp: The Entrepreneurship Competence Framework”, EUR 27939 E, Luxembourg (Luxembourg): Publications Office of the European Union, 2016..

Bianchi, G., Pisiotis, U. and Cabrera Giraldez, M., GreenComp The European sustainability competence framework, Punie, Y. and Bacigalupo, M. editor(s), EUR 30955 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-46485-3, doi:10.2760/13286.

Biggs, J., “Enhancing teaching through constructive alignment”, Higher Education 32, 347–364, 1996, https://doi.org/10.1007/BF00138871.

Biggs, J., Tang, C., “Teaching for quality learning at university: what the student does”, Maidenhead: McGraw-Hill, 2011, ISBN 9780335242757.

Cedefop, The future of vocational education and training in Europe: volume 3: the influence of assessments on vocational learning, Luxembourg: Publications Office. Cedefop research paper, No 90, 2022 http://data.europa.eu/doi/10.2801/067378

E4E, D2.3, “Results of primary and secondary research: inputs to E4E Skill Strategy”, 2023, www.engineers4europe.eu.

Engineers Europe, https://www.engineerseurope.com/.

European Education Area, Strategic Framework, European Commission, 2023, https://education.ec.europa.eu/.

European Qualification Framework (EQF), “Description of the eight EQF levels”, 2017, https://europa.eu/europass/en/description-eight-eqf-levels.

European Commission, “Flexible, inclusive learning opportunities”, 2022, https://education.ec.europa.eu/education-levels/higher-education/micro-credentials.

Fayolle, A., Gailly, B., & Lassas-Clerc, N., “Assessing the impact of entrepreneurship education programmes: A new methodology”, Journal of European Industrial Training, 39(4), 309-331, 2015.

Fleming, G. C., Klopfer, M., Katz, A., & Knight, D., “What engineering employers want: An analysis of technical and professional skills in engineering job advertisements”, Journal of Engineering Education, 2024, https://doi.org/10.1002/jee.20581.

Loughlin, C., Lygo-Baker, S., & Lindberg-Sand, Å., “Reclaiming constructive alignment”, European Journal of Higher Education, 2020, *11*(2), 119–136, https://doi.org/10.1080/21568235.2020.1816197.

Murthy, K. Machet, T., “Systematic Literature Review of Students’ Perception of Employability Skills”, Proceedings of REES AAEE, The University of Western Australia, Perth, Australia, 2021.

Passow, H. J., & Passow, C. H., “What competencies should undergraduate engineering programs emphasize? A systematic review”, Journal of Engineering Education, 106(3), 475–526, 2017, https://doi.org/10.1002/jee.20171.

Sala, A., Punie, Y., Garkov, V. and Cabrera Giraldez, M., “LifeComp: The European Framework for Personal, Social and Learning to Learn Key Competence”, EUR 30246 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-19417-0, doi:10.2760/922681, JRC120911.

World Bank, “What matters for workforce development: a framework and tool for analysis”, Systems Approach for Better Education Results (SABER) working paper series, no. 6, Washington, D.C.: World Bank Group, 2013, http://documents.worldbank.org/curated/en/608191468326178977/What-matters-for-workforce-development-a-framework-and-tool-for-analysis.

Taylor, A., “Engineering education systems that are fit for the future”, 2019, https://raeng.org.uk/media/3c0l1oyl/engineering-education-systems-that-are-fit-for-the-future-conference-report.pdf.

Bossche, V., Gijselaers, P., Segers, W., Kirschner, P., “Transfer of learning: Participants' perspectives on the transfer of learning in collaborative learning environments”, D. H. Jonassen (Ed.), Handbook of research on educational communications and technology (pp. 91-101). Springer, 2019.

Vuorikari, R., Kluzer, S. and Punie, Y., “DigComp 2.2: The Digital Competence Framework for Citizens - With new examples of knowledge, skills and attitudes”, EUR 31006 EN, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/490274.