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COMPLEMENTING THE CONVENTIONAL: ENGINEERING COMPETENCIES AND SKILLS FOR AN UNCERTAIN FUTURE

The SEFI Position

The importance of skills-based engineering education

The European Society for Engineering Education (SEFI) recognises the importance of a multi-faceted, adaptable, skills-based engineering education to prepare future engineers for what will come. Since its first position paper on skills in 2016, there has been a growing demand for education to foster responsible engineers whose practice helps to address global challenges such as the United Nations Sustainable Development Goals. This updated position paper is necessary to reflect beyond these developments and to serve as a call to action for the engineering education community.

A VUCA world

Our volatile, uncertain, complex, and ambiguous (VUCA) world demands a diverse and adaptable engineering skill-set to develop boldly beyond traditional technical knowledge. Engineers must flourish in rapidly changing environments, collaborating effectively in interdisciplinary teams and communicating their ideas clearly and persuasively. Moreover, engineering practice is increasingly mediated by disruptive emerging digital technologies. Thus, engineering education must not only offer opportunities to develop technical, transferable, and transdisciplinary skills, but also maintain a high degree of adaptability to respond radically to future needs.

Engineering is collaborative and complex

Engineering is a collaborative and complex activity that requires engineers to nurture socio-technical, societal, environmental, economic, humanist, and systems perspectives. They work in teams to create products, processes, and systems that respond to challenges and opportunities. Their work is visible in almost every aspect of society and industry, from the buildings we live in, to the transportation systems we use, to the medical devices that save our lives.

The emerging fifth industrial revolution

Engineering education has evolved from medieval foundations in geometry and mechanics through the establishment of technical schools during the first industrial revolution. Subsequent revolutions introduced discipline-specific specialisations and, more recently, automation and cyber-physical systems in the fourth industrial revolution. Vitally, an emerging fifth industrial revolution, characterised by human-AI interaction, sustainability, resilience, personalisation, and ethics requires a further shift in the skills required of engineers.

ENGINEERING COMPETENCIES AND SKILLS FOR AN UNCERTAIN FUTURE

Early this century, discipline-specific engineering education has evolved to encompass a broader spectrum of skills rooted in the liberal arts and social sciences with a deliberate focus on the ethical and societal implications of advanced technologies. Our response for the new era must go beyond agreeing new skill definitions and developing practice opportunities, towards the facilitation and personalisation of learning processes.

Upholding SEFI's European values

Technical skills are essential for applying science. However, transferable and transdisciplinary skills, including communications and ethics respectively, are vital for success. The optimal balance between these three skill types is subject to ongoing debate: a tension arising from the finite resources available for teaching, the capability and capacity of engineering academics, and the need to ensure engineers make a distinct and valuable contribution to society. This balance should align with SEFI's values - **creative, innovative** and **professional**, engaged and **responsible** in European engineering education, supporting and respecting **diversity, equality** and different cultures, **inclusive** of all engineering stakeholders, **open and transparent** across disciplines, environmentally and socially **sustainable**, and **free from bias** and unilateral impulses.

From skills to competencies

The term "skill" is used for simplicity; however, when enacted, skills always integrate with knowledge and attitudes in unique settings to constitute context-specific competencies. The concept of "competencies to become competent" is key, as it mirrors the "learning to learn" approach to knowledge acquisition. Universities should foster these competencies to include attitudes such as self-awareness, self-reflection, and curiosity in students and educators, with a long-term perspective of continuous improvement, learning, and adaptability.

The 3Ts: technical, transferable, and transdisciplinary

There are multiple lists of skills produced by accrediting bodies, industry, and government bodies. These lists will naturally evolve over time as needs and problems change. While some skills may be widely applicable, their forms, associated suitable teaching and learning approaches and the expected levels of achievement may vary according to context. Hence it is important to not only actively research engineering skills, but anticipate and adapt to rapid changes in their real-world context. To address this, the focus should be on the interplay between technical, transferable and transdisciplinary skills and competencies:

- **Technical:** Range from the foundation and application of science to the applied mathematical and computational skills necessary to develop technical solutions in the sense of innovation and current demands.

- **Transferable:** The cognitive, social and emotional skills needed to thrive in various life contexts which people can potentially transfer from one social, cultural, or work setting to another. They include the ability to work creatively, effectively, and transversely with AI; planning, organising, and executing projects successfully; as well as motivating and inspiring team members to achieve common goals, active listening, persuasive writing, and the ability to work collaboratively in diverse teams. Working on self-development and continuously improving oneself as a lifelong learner is also part of this category.

- **Transdisciplinary:** Afford an outward facing, broader appreciation and active engagement with traditional and non-traditional sources of knowledge from both academic and non-academic domains. These encompass skills related to ethical decision-making, sustainability and social responsibility. These might include the full spectrum of engineering and science, humanities and social science, crafts and other practices from earlier civilisations as well as the business context of engineering solutions, beyond the project-level.

Championing a holistic approach

Engineering educators have the crucial responsibility to cultivate the next generation of globally-oriented professional engineers. We should champion a holistic approach to education by focussing not only on technical expertise and problem-solving, but also on the broader roles that engineers play in society. To achieve this, we must prioritise the development of transdisciplinary elements in our curricula alongside technical and transferable skills, provide challenge-based learning opportunities, and facilitate perspectives that recognise diverse and global viewpoints.

Error literacy through evidence-based practice

Embedding new skills and competencies into traditional resource-constrained curricula can be challenging, meaning that specific initiatives and activities may need to be dedicated to their development. Education innovation through trying new pedagogies inevitably involves risks and the possibility of failure, but we need to be open to this, developing "error literacy" to accept short-term setbacks for longer-term success. In supporting these movements, SEFI's annual conference facilitates the exchange of ideas and learning from each other. In addition, there is a growing scope of evidence-based literature and an active engineering education research field facilitated by journals such as the SEFI European Journal for Engineering Education (EJEE) and the SEFI Journal of Engineering Education Advancement (SEFI JEEA).

The SEFI Handbook on Teaching Transferable Competencies and Skills in Engineering

By producing a series of handbooks to help practitioners to teach skills, including the upcoming *"Handbook on Teaching Transferable Competencies and Skills in Engineering"*, SEFI members are responding to those ongoing demands and challenges, providing guidance on how to cultivate these skills in engineering students and highlighting the importance of lifelong learning to ensure alignment between teaching, assessment, and practice, and continuous professional development.

Beyond graduation

It is important to recognise that multifaceted skill and competency and skill development is an ongoing process that continues beyond academia throughout an engineer's education and career. Engineering educators should prioritise structuring opportunities for skills acquisition in practical settings, supporting students as they transition to professional roles and continue developing their skills throughout their careers. Gaining professional experience in industry, but also governmental and non-governmental sectors is crucial to foster the engineering mindset that supports personal growth and capacity to adapt in response to evolving social norms.

Pledge to renew

Because the engineer's skill-set and the language we use to understand and frame our practice are constantly evolving in response to new technologies and societal challenges, SEFI will continuously engage with all stakeholders of engineering education to both anticipate and react to changes. This includes working with the European Network for Accreditation of Engineering Education (ENAEE) and other stakeholders such as the Board of European Students of Technology (BEST) to ensure that new skills are integrated and anchored in curricula once matured. In light of this, we commit to renewing our position on skills at least every decade. This position paper, as with anything in engineering education, needs to remain a live document responsive to the changing world we are part of. We appeal to those working on engineering skills several years from now to reassess and transform our position in accordance with the futures that are yet unknown to us.

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