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Introduction: Why We Need Transferable Competencies and Skills in Engineering Education

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Engineering education today is increasingly challenged to provide students not only with technical expertise but also with transferable competencies and skills. In the introduction chapter to Part 1 of this SEFI Handbook on Teaching Transferable Competencies and Skills in Engineering, we trace current developments in the field and outline the rationale for our handbook, situating transferable competencies and skills as part of an inseparable triad of technical, transferable and transdisciplinary skills that should underpin any engineering degree. This chapter details the intended relevance for practitioners and our commitment to academic rigour, combined with practice through our evidence-informed approach. It further presents the overall structure of the handbook, highlights how the different parts of the handbook interrelate, and then zooms in on the chapters of Part 1, emphasising the practical value they provide for engineering education practitioners.

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1 Setting the scene: why are transferable competencies and skills needed in engineering education?

Today, we live in a world facing complex challenges with global dimensions and major impacts on society. At the same time, these challenges are embedded in diverse and fast-moving transformation processes. These transformations include both new and potentially disruptive technologies on one side, and social changes on the other, such as how people interact, how we work, and how we learn. Think for instance of the development of the smartphone, which has significantly changed the way we work, learn, communicate, and interact with each other. This is often described as a sociotechnical transformation, where technical and social changes are inherently connected and involve many different stakeholders, new infrastructures, industries, and products as well as changing professional cultures and skills (Schot & Steinmueller, 2018).

Because these challenges are dynamic, complex, and not easily solved, they are often called 'wicked problems' (Buchanan, 1992; Mazzucato, 2018). We would also argue that we are facing a 'wicked situation', shaped by what is often described as a VUCA world — volatile, uncertain, complex, and ambiguous — combined with an emerging Fifth Industrial Revolution, or Industry 5.0 (Gürdür Broo et al., 2022; SEFI, 2025). Think, for instance, of the need to manufacture protective clothing and face masks locally during the COVID-19 pandemic, when the existing supply chains collapsed and an acute shortage occurred; the spreading of misinformation which is being accelerated through developments in Artificial Intelligence; or the accelerated use of cybertechnology in the commitment of increasingly global crimes and as a weapon in the increasing number of armed conflicts and the accompanying intelligence war.

From these new global challenges follows a demand for engineering education: we, as educators and practitioners, must prepare future engineers to face these challenges and to engage in collaborative, complex activities, both in their professional lives and as responsible citizens. To be able to act and shape their environment in the long term, our engineering students need the conditions that help them develop knowledge, attitudes, values, and abilities. In other words, they need transferable competencies and skills that allow them "*to become agile, adaptive learners and citizens equipped to navigate personal, academic, social, and economic challenges*" (UNICEF, 2019, p. 1).

Transferable competencies and skills are defined as "*competencies and skills that are needed to adapt to various life contexts and that people can potentially transfer to different social, cultural or work settings*" (UNICEF, 2022, p. 3). As such, transferable competencies and skills must be a part of engineering curricula if we are to prepare our students for the uncertain future that lies ahead of us.

2 Why a SEFI handbook? Our rationale and perspective

The idea of the importance of transferable competencies and skills must be part of any engineering curriculum laid the foundation for the decision to create this handbook. The handbook aims to facilitate, enable, and support engineering

educators and educational practitioners, such as yourself, in developing these transferable competencies and skills in students or, more generally, in all learners in engineering education.

In addition, because engineering activities reach into almost every part of modern societies, we strongly believe that a future-oriented engineering education must be practice-oriented and action-based. This is also reflected in various accreditation standards or programme outcomes for engineering degrees, such as the UK-SPEC (Engineering Council, 2020). To achieve this goal, embedding transferable competencies and skills, defined as "*competencies and skills ranging 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*" (SEFI, 2025, p. 2), in engineering curricula is not optional; it is essential. These competencies can make a significant contribution to solving societal challenges.

To address these challenges in engineering curricula, recent developments in engineering education are showing a shift toward programmes that combine student-centred learning with curricula focused on major societal, environmental, and technological challenges (Graham, 2018), in which these competencies and skills are embedded alongside technical skills. These developments have even led to the argument that competencies and skills may become more important than formal degrees (Gürdür Broo et al., 2022). Whether or not you agree with this claim, a strong focus on student-centred learning and competency-based learning outcomes (Biggs & Tang, 2011) requires a continuous evolution of teaching and learning methods. These methods must keep up with changing demands and help learners develop the competencies and skills they need.

This evolution becomes visible in the growing number of engineering programmes that construct learning around real societal and technological challenges as a shift from "*first teach the fundamentals*" to "*first engage with the engineering problem*" (Hadgraft, 2017, p. 112). For instance, challenge-based or project-based curricula require students to integrate technical analysis with communication and teamwork.

These developments have been accompanied and supported by SEFI, the European Society for Engineering Education. SEFI's mission is to "*support the advancement of engineering education by promoting innovative, inclusive, responsible, and forward-looking practices that are open, ethical, transparent, and sustainable*" (SEFI, n.d.). Within SEFI, the Special Interest Group (SIG) on Engineering Skills focuses specifically on analysing the current landscape of engineering competencies and skills to explore emerging trends, aiming to inform and inspire the engineering education community and keep programmes up to date.

As part of this aim, an initial position paper was published by SEFI in 2016 (SEFI, 2016). In response to the aforementioned rapid developments, a new position paper has been created with great effort and released by SEFI in 2025 (SEFI, 2025). This new publication draws a distinction between technical, transferable, and transdisciplinary competencies and skills, defining transdisciplinary competencies and

skills as "*competencies and skills that 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*" (SEFI, 2025, p. 2). While developing technical competencies and skills tends to align closely with the core expertise and disciplinary identities of engineering educators — and as technical competencies and skills are generally less challenging to teach due to clear accreditation and professional guidelines — integrating transferable and transdisciplinary competencies and skills into teaching practices often presents greater difficulty. This difficulty motivated us, the editors of the handbook, as active members of the SEFI SIG on Engineering Skills, and many engineering educators who, like us, actively implement transferable competencies and skills in our teaching, to create the handbook that you are now reading, focused specifically on transferable competencies and skills. As this handbook emerged from the SEFI SIG, it reflects a strong European perspective. Although the contributions are Europe-centred, they are globally applicable. Throughout the entire process, we have aimed to ensure relevance and compatibility across various contexts and conditions and ensured an evidence-informed approach.

To the best of our knowledge, this handbook on teaching transferable competencies and skills in engineering is the first of its kind. We hope that this handbook will offer you useful insights, practical guidance, illustrative examples, and constructive inspiration for engineering education practitioners.

3 Who the handbook is for and what it offers

This handbook has been created for you, engineering education practitioners of all disciplines, regardless of your specific subject area. It has been written by your peers, sharing what they wished someone had told them when they started. All our than 155 authors and editors are or have been involved in developing educational resources, teaching and often also researching transferable competencies and skills in engineering education. Our goal is to provide you with support that is relevant and useful across the full spectrum of engineering education when it comes to teaching transferable competencies and skills. Thus, this handbook is for you, if you are looking for inspiration and practical guidance on how to teach transferable competencies and skills in your classes. Allow us to take you through a bird's eye view of each part of the book.

In Part 1, we start with setting the scene: introducing you to the concepts of transferable competencies and skills, how transferable competencies and skills development connects to wider frameworks and accreditation standards, and ending with an explanation of which transferable competencies and skills we have included in this handbook. If you are aiming to unlock hidden potential in your existing teaching and learning settings and would like to include these individual competencies and skills on a sound basis: We detail each of them in a dedicated chapter in Part 2. The handbook is also for you if you want to strengthen competency- and skills-oriented teaching, improve learning development, and revise existing or design new effective

assessments of these transferable competencies and skills (Part 3). If you want to go one step further and you are looking for inspiring examples or reference models at programme level: in Part 4 of this handbook, we provide global role-models from three continents that can support organisational development, programme planning, or curriculum design in your own institution. The closing part of this handbook, Part 5, explores how you can evaluate or research your learning outcomes when it comes to these transferable competencies and skills. Lastly, we have also added a glossary to the back of this handbook. As you read this handbook, you will come across many terms that you may be unfamiliar with within the context of this handbook. The glossary will allow you to look up any terms you may be unfamiliar with and how they are used within this handbook.

So why rely on our handbook? As stated before, we believe that transferable competencies and skills are an essential and intrinsic part of engineering education. Although no practical handbooks exist, there is an abundance of scientific literature. Yet, we are also aware that the relevant literature detailing research and practice of including transferable competencies and skills in engineering education is often difficult to identify and navigate. In addition, the body of research on transferable competencies and skills comes from a wide range of perspectives, with fundamentally different theoretical backgrounds (Kiesler, 2024). This field is broad, context-dependent, and not very accessible. We are also very aware of national and institutional contexts in which specific frameworks and requirements may limit the direct transferability of approaches reported in literature. This is why in this handbook we have provided you with contributions that are grounded in evidence and elaborated within their context but also demonstrate broader applicability across different settings. To do so, we have committed to an evidence-informed approach in which all contributions are rooted in empirical research, theoretically and methodologically rigorous, combined with practice, and with clear, direct, practical value for your work. All chapters have undergone two rounds of peer review to ensure robustness. You will find insights into relevant competencies and skills, assessment methods, and evaluation strategies, always presented in a way that supports their integration at module and programme level.

Therefore, if you are looking for a focused, practice-oriented, evidence-informed introduction to specific topics in the field of transferable competencies and skills, we dare to say this handbook is for you.

4 What to expect in Part 1 and how to use it

Part 1 of this handbook aims to provide context for the following parts. At the beginning of this chapter, we discussed why transferable competencies and skills matter in engineering education, who this book is for, and the contents of the five different parts of this handbook. However, this does not yet address the specific nature of competencies and skills as such.

These terms are often debated, as they resist a single, unified definition, making them difficult to handle clearly and consistently. This ambiguity poses a challenge for

competency- and skills-oriented engineering education. In Chapter 1.2, Sofie Craps, Helena Kovacs, Roger Hadgraft, Roger Penlington, and Anette Kolmos explore the concept of competencies and skills in detail. To this end, they address potential semantic pitfalls, trace the genealogy of the term, and place it within political and industrial discourses from an engineering education perspective. Following up on the latest SEFI Position Paper (2025), they explain how technical skills differ from transferable competencies and skills, and how these are linked to sector-specific interests, such as the demand for qualified professionals in industry. Importantly, they show that these discussions often leave little room for broader goals like personal development, even though such goals are deeply relevant. The situation becomes even more complex when regional and cultural factors enter the discussion. Here, the authors offer guidance to help you make sense of this complexity. They also outline key implications for engineering education research, arguing that terminology should be seen as a tool for theoretical reflection in both research and practice. For engineering education practitioners, this chapter is especially valuable. It supports a deeper theoretical understanding of teaching practices and provides a foundation for integrating competencies meaningfully into competence-based learning and teaching formats.

In Chapter 1.3, Grant Penny, Ann-Kristin Winkens, Neil Cooke, and Esther Perea Borobio explore existing skills and competency frameworks. To this end, they introduce the concept and explore what composes a framework. The authors then highlight that there is an abundance of frameworks, many of which are highly specific, while others overlap significantly. For engineering education practice, these frameworks are often insufficient as they tend to remain too general and offer little in the way of practical guidance or concrete references. Instead, due to their sometimes-abstract nature they often serve as a frame of reference to give orientation for strategic processes. To address this challenge, the authors propose a distinction between frameworks and taxonomies. They provide clear, practical advice for engineering education practitioners on how to engage with frameworks and which questions to ask to utilise them effectively in supporting learners' competency and skill development, as well as inform the complementing assessment. Moreover, if frameworks are linked to appropriate criteria and performance indicators, they can also be very useful for curriculum development. To help you navigate the field, the authors then present an overview of relevant frameworks in engineering education and, building on that, reflect on their practical value. They emphasise that the relevance of any framework must be determined in relation to the sociotechnical context, and that its usefulness may shift as conditions and goals change. In this regard, higher education institutions carry a particular responsibility, as they must prepare students for professional life, but without reducing education to market needs. Externally, frameworks can serve as a tool in organisational development while also providing guidance internally for staff in their roles as educators, curriculum developers, or in other capacities. Addressing the latter, the authors offer practical suggestions for how to make use of frameworks in a constructive way. They show

that frameworks are essentially tools, not checklists. They are there to support your work, not to be followed rigidly.

Chapter 1.4 explores the role of competencies and skills in the accreditation processes of engineering education. Darren Carthy, Richard Lillington, and José Carlos Quadrado begin by explaining what accreditation systems are and what purposes they serve, before focusing specifically on how transferable competencies and skills are addressed within engineering programmes. The chapter takes a close look at learning outcomes at both programme level and module level and introduces three key international accreditation standards. The authors examine the criteria applied in these standards and highlight their practical implications as they are formulated in the general principles of the International Engineering Alliance (IEA) and the European Network for Accreditation of Engineering Education (ENAEE). They then discuss how these frameworks connect both technical and non-technical skills. Of particular value to practitioners is the section of this chapter that is dedicated to learning outcomes of educational programmes. The authors explain the concept and its relevance, outline the dimensions such outcomes may cover, compare different accreditation frameworks, and identify key challenges. This helps to clarify the role of learning outcomes for the accreditation process, with a focus on their use for engineering educational practice. Closely linked, the chapter addresses the importance of defining measurable criteria and explores the role of assessment within accreditation. The authors discuss different forms and methods of assessment, thereby emphasising the value of competence-based learning outcomes. These points are illustrated with real-world case studies from engineering programmes. In the final section, the authors discuss common pitfalls and challenges across accreditation systems and offer insights into emerging trends and future directions in the field. The chapter concludes with practical guidance and recommendations for engineering education practitioners by connecting future avenues of development to the realities of current practice by offering concrete, actionable insights.

Finally, in Chapter 1.5, we, the lead editors, together with Esther Perea Borobio, introduce the competency and skills framework used throughout this handbook. Building on the previous chapters, we zoom in from broader concepts to a concrete structure that underlies this publication and aligns with its aims. We begin by outlining the definition of transferable competencies and skills that underpins this handbook by drawing from the SEFI Position Paper (2025) and referencing the UNICEF definition on transferable competencies and skills (2019, 2022). This definition is then situated within the competency framework adopted here, with considerations of its historical references, disciplinary foundations, and professional relevance. We then describe how the framework was developed and explain the criteria used in selecting the competencies and skills featured in this handbook and its base, the UK-SPEC — The UK Standard for Professional Competence and Commitment (4th edition) — as published by the Engineering Council (2020). As a result of this process, three overarching themes are introduced:

I. Responsibility, project management and leadership

II. Communication and interpersonal skills

III. Professional commitment and lifelong learning competencies

Each theme includes a set of specific competencies and skills, and for each of these, the handbook offers a definition and interpretation derived from literature and based in evidence. Subsequently, we reflect on which competencies and skills, as well as frameworks, were deliberately excluded. While the list of excluded competencies and skills is not exhaustive, it serves to ensure transparency regarding how we have reached decisions. We end the chapter with practical guidance on how to engage with the framework and the handbook from the perspective of engineering education practice.

5 In closing

To conclude, we would like to emphasise that the development of transferable competencies and skills in learners (and the educational practices that support them) is never linear or one-size-fits-all. It is always shaped by context, local conditions, and the people involved. For this reason, we invite you to use this handbook not only as a useful resource for your teaching and curriculum development, but also as a source of inspiration for your personal practice as an educator.

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AI statement

During the preparation of this work the authors did not make use of any AI tools.

Contributor statement

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