5.2

How to Evaluate the Relevance of Skills and Competencies

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This chapter discusses the rationale and means to evaluate the relevance of transferable competencies and skills for engineering degrees. It presents three processes that have been used in different contexts to identify which transferable skills and competencies are needed in engineering work. The cases also illustrate how the viewpoints of different stakeholders can be brought to the table. Although the evaluation of the relevance of skills may be more pertinent to programme heads and other educational leaders responsible for the construction of entire degrees, knowing about these processes and their outcomes can also benefit lecturers of a single module by showing where some of the requirements set for the teachers originate from and how they are justified. The chapter finishes with recommendations for those who wish to conduct an evaluation of relevance in their own context.

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1 Introduction

This handbook rests upon a belief that transferable competencies and skills are essential in engineering and should be taught and assessed as part of engineering education. Therefore, in this chapter we aim not so much to convince the readers that evaluation of relevance of transferable competencies is needed, but to shed some light on how this might be done. Unlike the assessment of competencies (see Part 3 for assessment methods), which is often conducted by individual teachers and targets individual students, the external evaluation of relevance of competencies is more appropriately conducted at the level of modules or degrees and by groups of different stakeholders in order to get a more comprehensive understanding of the situation. Consequently, the contents of this chapter may be of more interest to programme heads and other educational leaders than to lecturers. Nevertheless, lecturers can also benefit from knowing about the evaluation processes and their outcomes, as this illustrates where the requirements for teachers originate and how they are justified.

Engineering innovation can be fast-moving, whereas adjustments to curriculum can be a slow process. Yet educators must continually be in touch with what is happening in industry in order to know how educational content should be adjusted to support new technologies, development trends, or industry practices. Educational leaders and administrators must also ensure that monitoring processes accurately reflect the need to embed these innovations in curricula. At the same time, transferable competencies and skills (e.g., communication, collaboration, critical thinking, leadership) and habits of mind remain essential yet often still underemphasised or only addressed in the 'hidden curriculum,' which refers to the often-implicit assumptions, norms, and values inherent to engineering education that are not made visible in the formal curriculum (Paul et al., 2022).

The research literature on employability in engineering education shows a wide consensus on newly graduated engineers' need for transferable competencies and skills, as well as on their relevance to the engineering curriculum. Less agreement, however, exists with respect to the emphasis that the teaching of transferable competencies and skills should receive in education, especially in relation to how transferable skills can or should be taught alongside technical skills and competencies (Winberg et al., 2020).

The significance of transferable competencies and skills to employability and the relevance for engineering curricula seem to be predominantly discussed from the viewpoint of industry. Student perceptions have also been studied to some extent (Murthy & Machel, 2021). Less is known about the views of the academics. However, some research suggests that their perceptions of the importance of various skills and competencies in engineering differs somewhat from the views of both graduates and industry professionals (Pyrhönen et al., 2019). This situation may make it difficult for educators to determine which competencies and skills are relevant to teach.

Like the earlier chapters of this handbook have revealed, there is no universally accepted definition, framework, or list of transferable competencies and skills in engineering (see Chapter 1.3 for the myriads of alternative existing competency frameworks). This is also demonstrated in research on their relevance. Sometimes the transferable skills and competencies are studied as a whole, referred to by terms such as professional skills, soft skills, transversal skills, etc. Sometimes they appear as a long list of specific non-technical skills, either separately or alongside a list of technical or engineering-specific skills. Often, the research focus is only on one transferable skill or competency or on a specific group of them, such as the cluster of communication skills that includes written, verbal, and aural communication. This makes research findings difficult to generalise or apply within particular programmes or to concrete challenges of curriculum development. Still, joining up what is needed by industry, what is taught by educators, and what is perceived to be important by students remains a challenge.

Essential to overcoming this challenge is knowing which skills and competencies are relevant to be taught in engineering education. As different stakeholders may view the relevance differently, it is also of great importance to recognise the differences and reconcile varying views. This creates a need for good methods and practices to collect information and facilitate discussion between the different stakeholders. This chapter introduces three examples of processes that aim to capture and monitor the relevance of transferable competencies and skills in engineering education in a way that enables timely and effective development of curricula and pedagogy of engineering programmes.

In the rest of this chapter, we begin by setting the context and discussing why a continuous evaluation of the relevance of various skills and competencies (including transferable skills) is needed in engineering education. We then present three different ways in which this evaluation bringing in relevant stakeholders has been conducted in various contexts. The cases come from different geographical locations (Finland, the UK, and Australia), emphasise various stakeholder perceptions (graduates, industry, and professionals) and consider education from a variety of angles (engineering in general, timber in construction, and nuclear engineering). Next, we analyse the cases to identify implications and recommendations for practice and conclude with recommendations for further reading and resources.

2 Context

The question "*which skills are relevant in engineering?*" is probably as old as any form of training to be an engineer. However, the perceptions of the need for transferable competencies, and of the kind of transferable skills needed, is likely to vary greatly depending on the context of engineering education.

Martin et al. (2023) distinguish between five different orientations within the history of engineering education: scientific, market, social, political, and ecological orientation. Scientific orientation sees engineering as applied science, or the quest to solve technical problems with the help of scientific theories. Market orientation opposes the scientific orientation by emphasising the needs of industry over the imparting of scientific knowledge. It is characterised by discourses of employability and entrepreneurialism. Social orientation is a more recent approach which stresses the social role of engineers and strives to develop engineering graduates' identity as citizens and community members. Political orientation shares the objectives on societal engagement and contribution to public good with social orientation, but with emphasis on top-to-bottom measures like policy and regulation and political decision making, instead of the bottom-up approach common in social orientation. Finally, the most recent orientation, the ecological orientation, focuses on advancing sustainable development especially from the viewpoint of environmental sustainability.

The relevance of transferable competencies and skills looks quite different from the perspectives of the five orientations. Scientific orientation appears not to put much weight on transferable skills. A systematic literature review by Winberg et al. (2020) noticed that although employability literature arguing in favour of a strong technical knowledge base did not deem employability unimportant, it emphasised the relevance of the disciplinary core in enhancing employability. In contrast, in market orientation certain transferable competencies play an important role, which is illustrated in frameworks such as EntreComp and the CDIO syllabus (see Chapter 1.3 for more information about these and other competency frameworks). Like market orientation, social, political, and ecological orientations all seem to stress various transferable skills and competencies but with different levels of emphasis. Hence, the suitability of a particular competency framework or other kind of definition of required skills and competencies is heavily dependent on the educational orientation prevailing in the country, discipline, institution, or programme.

Other factors that change engineering work and the requisites for engineering education regardless of the orientation need to be taken into consideration when determining the relevance of transferable skills. One of these is technological development, which especially in the field of ICT has had a great effect on engineering in all disciplines. The current era, often referred to as the fourth industrial revolution, the digital revolution, or the digital era, started in the 1970s and 1980s. It has been characterised by the widespread use and development of digital technologies, particularly the internet and computers, both in free time and in working life. The latest advancement in this realm is generative artificial intelligence (GenAI). Engineers Australia (Bell, 2025, p. 2) anticipates GenAI to elicit many kinds of changes to engineering work and therefore set new challenges for education: "*The growth of AI in engineering allows some of the traditionally labour- and cognition-intensive tasks to be delegated to these new technologies effectively. At the same time, it elevates engineers' responsibility to do so with wisdom, and to apply engineering skills to higher-order tasks. ... To harness AI effectively, we need the right education settings, ensuring the next generation of engineers are trained in the ethical and responsible use of these systems*".

Digitalisation in general and the growth of GenAI in particular thus come with requirements for yet another set of both technical and transferable competencies needed in engineering.

3 Approaches to evaluate the relevance of skills & competencies

Deciding upon which transferable skills and competencies to focus on in any engineering programme is not the only challenge related to the evaluation of their relevance. Other questions to consider include aspects like who should be involved in the evaluation, how to ensure the timeliness of the data, which fields and disciplines to look at, and how to ensure that the evaluation results are actually used in educational processes. In this section we introduce three different examples of how the evaluation of relevance of skills and competencies is carried out in different contexts (engineering in general, theme-specific, and field-specific), yet all resulting in an effective process with genuine impact on the delivery of engineering education

Table 5.2.1: The primary processes for data collection and analysis and taking action used in the three cases of the evaluation of relevance

Case	*Focus*	*Methods for collecting data*	*Methods for analysing data*	*Processes for taking action*
TEK	Skills and competencies in university level engineering degrees in Finland	National annual survey administered to all engineering MSc graduates	Descriptive statistics of distinct skills and competencies, and of groups of competencies; group comparisons enabled through interactive visualisation	Yearly seminar for discussing the results; Workshops in all participating universities; faculty/degree programme-specific procedures (e.g., workshops)
NMITE	Skills and competencies for timber construction professionals at many educational levels	Stakeholder workshops and roundtables culminating in an industry-agreed framework	Evaluation of learner achievement of framework competencies across a series of short courses	Feedback from Employer Advisory Group; faculty workshops; programme accreditation procedures
UNSW	Knowledge, skills, attributes and competencies for nuclear engineers in Australia	Define Your Discipline (DYD) workshops for professionals	Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), a multi-criteria decision making (MCDM) analysis method	Integrating results in the curriculum design processes at UNSW

All cases use different processes for collecting and analysing information, as well as turning it into educational development actions, while ensuring the industry involvement. These processes are summarised in Table 5.2.1. More details on how to scientifically approach the process of data collection and analysis can be found in Chapter 5.1 of this handbook and more information on accreditation and associated processes can be found in Chapter 1.4.

3.1 Case 1: national evaluation and monitoring of the relevance of skills in all MSc-level engineering skills (TEK & Finnish universities)

The first case study illustrates national cooperation in the continuous evaluation and monitoring of the relevance of the skills and competencies taught in Finnish engineering degrees. This process is based on the annual collection of data from recent graduates. This data is analysed and published centrally, and it is discussed within and across all universities providing engineering education to identify areas for improvement.

The TEK Graduate Survey (TGS) is an annual nationwide study conducted by Academic Engineers and Architects in Finland (TEK) in collaboration with Finnish universities. TEK is responsible for carrying out the survey, while the universities are responsible for reaching their new graduates. The feedback and results are utilised in developing university education and influencing educational policymaking. The cooperation started in 2011, and has thus accumulated a significant amount of data, which allows for many analyses from different perspectives.

The survey is one of the most extensive graduate feedback mechanisms in Finland, offering valuable data for universities, policymakers, employers, and students alike. It plays a crucial role in evaluating the relevance of higher education, identifying skill gaps, and supporting the development of engineering education to meet the evolving needs of society and the labour market. The main themes are study experience, thesis work, employment status, salary, job satisfaction, and future plans. The target group in the TGS are graduates with an MSc in Engineering or Technology or an Architecture degree from Finnish universities. The survey is open continuously and is administered to the respondent at a specific moment in their graduation process: when they have completed their studies and apply for graduation. Therefore, the survey results primarily offer a student perspective. Every year, thousands of graduates respond, with rates often exceeding 60%. The survey is available in three languages: Finnish, English, and Swedish.

As part of the study experience theme, TGS explores over 30 skill areas. The data shows: 1) how important graduates perceive each skill to be in their careers, and 2) how well their education prepared them in those areas. Other questions, such as areas for improvement and the benefits of education, also provide insights into the importance of skills or their acquisition during studies. The skill areas can be examined individually or by dividing them into six groups (with three to nine areas of expertise per group): 1) working life skills; 2) analytical skills; 3) social skills; 4) communication and information processing; 5) expertise and substance knowledge; and 6) business and management. With the exception of expertise and substance knowledge, all the skill areas can be regarded as transferable competencies and skills.

Results are published yearly as an interactive visualisation, which enables anyone to filter the data by university, field of engineering, age (under or above 35), gender, and nationality (Finnish or non-Finnish), and view the importance and development of specific skills or skills groups either separately or in relation to each other. Universities receive all the data regarding their respondents as well as a basic analysis of the data. All data is available for research purposes upon request. Another interactive visualisation with the same filtering possibilities is available for the past five years of data.

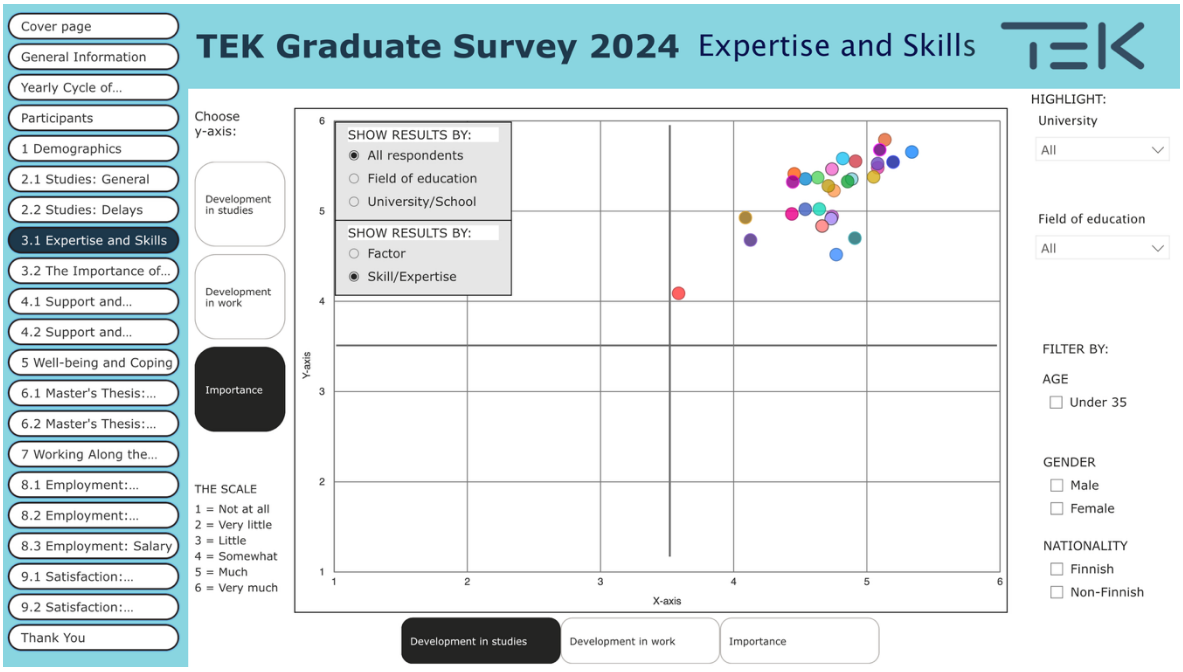

Figure 5.2.1: Screen capture from the interactive visualisation of the TGS data. From TEK graduate survey 2024. Interactive visualisation by TEK (2025). Copyright TEK, used with permission, no further use allowed.

A snapshot of the TGS results from the year 2024 (see Fig. 5.2.1) reveal that for all engineering MSc graduates in Finland, the skill area deemed least important was entrepreneurial capacities, while problem solving was the most important. The skill area where the development need was the greatest (the score for importance of a skill is higher than the score for development) was looking after their own well-being and the least (development greater than importance) were mathematical and natural science, and knowledge of the history and development of their own field.

The long tradition of surveying, nationwide data collection, continuous process, and high response rates have yielded comprehensive data which allows for detailed monitoring of the graduates' perceptions of the importance of different skills as well as their acquisition during their degree.

The survey reveals that in the year 2024, approximately a quarter of respondents already had over two years' work experience in their field, and over a third had one to two years' experience (TEK, 2025), suggesting that the results also provide insight into the views of early-career engineers (Naukkarinen & Bairoh, 2022). One fifth of the respondents entered the MSc programme with a BSc degree from a university of applied sciences (TEK, 2025). These graduates often work as engineers in between their first (BSc) and second cycle degree (MSc). It is also customary, especially for the Finnish students, to work part-time during the last years of their studies, contributing to quite extensive work experience at the moment of graduation. Both these factors suggest that the results reflect not only insights gained from education but also some first-hand experiences from the industry.

The results are discussed among the whole engineering education community in Finland in a yearly seminar as well as in university-specific events, where the focus is naturally on the university's own results, but the expertise from TEK brings in insights from general trends and interesting benchmarks. In addition to university-specific events, the results are built into the quality assurance processes of universities in various ways. For example, in Lappeenranta-Lahti University of Technology (LUT) the degree-specific survey results are further analysed and discussed in yearly feedback workshops, where they are brought together with feedback data from other sources to indicate improvement needs and actions for the coming year.

Naturally, there are also limitations to the TGS process and the data it produces. The TGS data stored in the system and accessed through visual illustrations is quantitative. Therefore, it can only answer questions regarding which skills and competencies are important to engineering graduates, but it does not explain why. Although the survey includes some open-ended questions, respondents are not prompted to comment upon the relevance of skills and qualitative data regarding the issue remains scarce. TGS data contains the perceptions of newly graduated engineers, but while many of them already have some experience of engineering work, the responses do not represent the viewpoint of industry, which can only be gathered from experienced engineering professionals and managers. The nature and formulation of the TGS is quite general, which comes with the risk of the respondents answering according to their espoused theories rather than more context specific theories-in-use, meaning that their answers may reflect what they think they should say rather than what they actually think or would advocate in practice (for more information about espoused theories vs. theories-in-use see e.g. Argyris & Schön 1974). Finally, to keep the results comparable in time, the evaluated skills areas are seldom modified or changed, which can make the process slightly rigid in terms of addressing rapidly evolving needs.

Monitoring and responding to evolving skill demand in engineering education remains an ongoing challenge. Annual surveys like TGS can offer a structured and data-rich approach to understanding graduates' perceptions of skill relevance and preparedness. With broad scope, consistent methodology, and high participation rates, surveys such as TGS serve as cornerstones for evaluating the alignment between academic training and labour market needs. The insights gained from the survey support curriculum development, institutional quality assurance, and national education policy. To further enhance their impact, future efforts should integrate qualitative methods to better capture the real-world applicability of skills and inform the strategic development of engineering education.

For more details on the process as well as the results obtained in recent years, we recommend reading the research part of the website of the Academic Engineers and Architects (TEK, 2026).

3.2 Case 2: industry-defined skills framework to advance the use of timber technology, engineering, design, and construction for a sustainable built environment (NMITE, UK)

The second case study describes the development of an expanding portfolio of short courses aimed at industry professionals and a new BSc focused on the sustainable built environment. The skills framework was created in cooperation between two higher education institutions, industry, and trade organisations to align educational offerings with sector-specific skills in timber technology, engineering, design, and construction. The process of defining relevant skills and creating courses in response formed the core of the development process.

Industry reports a pressing need for both transferable and specialist skills to achieve a sustainable future. It is unclear how many university courses currently integrate knowledge and skills specifically related to innovative timber products, designing with timber, and timber construction methods into relevant programmes (e.g., civil and structural engineering, construction management, architectural technology, etc.). However, as recently as 2021, a Canadian survey called for more specialised mass timber courses and at the very least the integration of these topics into existing courses to augment the content on steel, concrete, and masonry (Daneshvar et al., 2021). The Green Skills Survey by the UK Institution of Engineering and Technology (IET) indicates that "*a lack of skills is the biggest barrier to meeting net zero*" (IET, 2023, p. 9). Out of the ten countries surveyed, a lack of appropriate skills at both the management and workforce level is consistently cited as a top three priority, and these are often identified as transferable skills. For example, UK respondents reported that while 18% of people entering the workforce are missing technical or engineering skills, 36% are missing the skill 'whole systems thinking'.

In creating a sustainable built environment, retrofitting existing buildings and delivering future housing and infrastructure demands a productive, regenerative, and collaborative approach that requires a shift to the use of sustainable materials, new forms of manufactured construction systems, and innovative digital technologies. The UK Government's presumption in favour of these modern methods of construction (MMC) was underpinned by the launch of a Timber in Construction Roadmap (UK Government, 2025), which cites the need for new education and training models for reskilling and upskilling existing and entrant-level labour. These workers will need an understanding of the materials and a unique approach to scheduling, skills, and management which are different from other traditional forms of construction.

Given the historic educational emphasis on carbon-intensive materials, and the arrival of new technologies like building information modelling (BIM) and VR/AR, current built environment professionals will need continuing education to enact the required changes in practice. They also need a more holistic understanding of building performance to ensure healthy, durable assets, as well as a suite of transferable skills in communication, sustainability, and ethics. In the UK, no further or higher education courses currently offer timber construction training focusing on MMC with clear pathways towards membership in professional bodies. Since timber construction is seen as so essential to future sustainable, efficient building practices and vital to meeting building targets (as evidenced by the UK government roadmap described above), this link to professional recognition is essential. In addition, training must be provided to those from other industry sectors to help close the skills gap.

To enable this much needed educational and construction delivery transition, the New Model Institute for Technology and Engineering (NMITE), a newly founded (2018) university based in Hereford, England with a focus on engineering and technology, developed courses in response to a sector-defined skills competency framework, the Timber in Construction Skills Action Plan (Timber Development UK, 2023). This framework defines the required technical knowledge and transferable skills that should be embedded in the education of work-ready and multi-disciplinary professionals who can embrace net-zero construction approaches and integrate principles of circularity (Hitt et al., 2023).

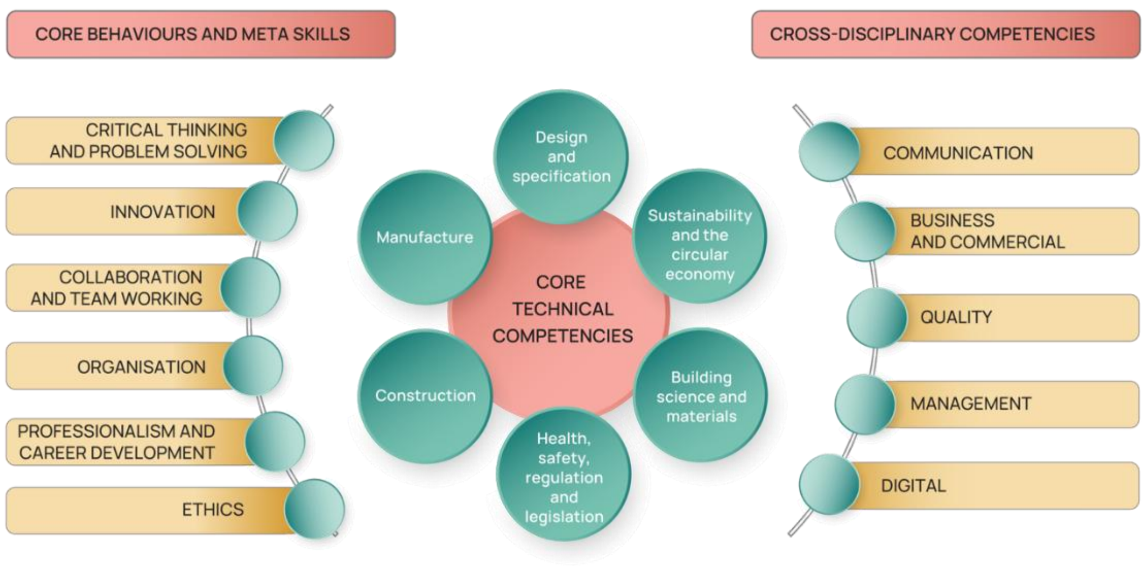

Figure 5.2.2: Skills and competencies outlined in the Timber in Construction Skills Action Plan. Visualisation by L. Kovacova, 2023. Copyright Timber Development UK, adapted with permission, no further use allowed.

The skills framework was the impetus for the development of Timber Technology Engineering and Design (TED), an award-winning series of courses that form the foundation of NMITE's Centre for Advanced Timber Technology's (CATT) educational offerings. The TED courses are an example of widespread collaborative creation across industry and academia to co-develop the course syllabus. The original course structure comprised three distinct topic areas over a 12-week hybrid model delivered by CATT's academic team, hired for their experience in industry as well as in further and higher education. With feedback from students and industry partners, the course was later revised into three separate modules, two delivered online and the third module delivered partially online, with practical skills experience in the CATT workshop. This approach exemplifies educational design that continually redevelops content to meet the changing landscape of construction and adjusting delivery mechanisms for easy uptake by industrial partners.

The online content uses the Canvas Learning Management System, allowing for skills development tracking. Outcomes are outlined according to the Skills Action Plan, and each online learning activity is linked to relevant learning outcomes. Individual quiz questions, for example, can be aligned to specific skills, e.g. in communication, ethics, health and safety, or sustainability, and learner development of those skills is tracked throughout their engagement with the module activities. Skills mastery is then defined through a proficiency rating (4 – exceeds mastery, 3 – mastery, 2 – near mastery, 1 – below mastery, 0 – no evidence), which results from learners achieving certain scores on module learning activities. This can be tracked through a gradebook that the learners can also access, meaning that they can demonstrate their learning in different skill areas to their current or potential employers.

Whereas TED was designed to specifically address timber skills, NMITE's recently started (2025) BSc Construction Management will take a broader view of the construction industry's skills needs. Still, the transferable skills identified in the Timber Skills Framework remain consistent and will be brought into the BSc, using the same mastery tracking method.

Industry partners like those represented in the BSc's Employer Advisory Group (EAG) have been vital to NMITE's educational approach since its inception (Rogers et al., 2021). Its first cycle degree BSc modules also provide an incubation centre for the industry to explore new techniques and methods in a controlled environment. Testing new methods can be costly and potentially damaging to reputations if the resulting process or method creates unintended consequences. By creating collaborative educational approaches with industry-led challenges, students learn to solve problems that also inform future innovations. This highly engaged approach to partnering with industry gives CATT the ability to continually evaluate the relevance of the skills emphasised in its educational offerings.

The development of short courses at NMITE's CATT demonstrates how lessons from industry can be fed into educational offerings and suggests ways in which courses can be steered to meet the building industry's ever-changing landscape through industry engagement. Moving forward, exploring the impact of these programmes on both individuals and businesses will help derive additional insight about emerging needs. Further research connected with industrial partners to accurately measure current skill levels and identify needed skills is yet another possible approach to prepare workers for the future construction economy. For more information about this case study, we refer to the Centre for Advanced Timber Technology, CATT (NMITE, 2026).

3.3 Case 3: identifying and validating core competencies, essential knowledge, and skills and attributes in nuclear engineering (UNSW)

The third case study presents a systematic, collaborative approach to identifying and prioritising the skills and competencies required for nuclear engineering practice in Australia. The process is based on engagement with industry professionals through workshops, supported by position description analyses and standards-based competency modelling. The findings were translated directly into curriculum design decisions, ensuring alignment between workplace expectations and university education.

The Define Your Discipline (DYD) process was used to develop Australian competency frameworks in environmental engineering, geoscience, and mining engineering (Dowling & Hadgraft, 2011, 2013). These frameworks have been adopted by professional bodies such as Engineers Australia as Stage 1 competencies in these disciplines. Prompted by National Defence priorities and emerging energy security questions, nuclear engineering in Australia is entering a period of growth, and several universities are considering new education programmes. There is also a recognised need to upskill the existing industrial workforce to work in this emerging sector. Thus, there is a clear need for a national competency framework for Australian nuclear engineers.

Given that most practitioners in Australia learn nuclear engineering informally or on the job, it is important to identify the common topics and concepts covered in learning nuclear engineering in the workplace. This research employed the DYD process to lay the foundation for a competency framework for the discipline of nuclear engineering. The overall approach was guided by standard IEEE (Institute for Electrical and Electronics Engineers, a professional engineering institution) Recommended Practice for Defining Competencies (2022).

Data was collected from DYD workshops (Dowling & Hadgraft, 2011, 2013) which had the aim to validate the core competencies required for specific groups of engineers and scientists practicing nuclear engineering in the workplace. Each workshop included a tailored DYD worksheet, developed based on relevant position descriptions (PDs) and customised to reflect the responsibilities of each role. The worksheet contained a comprehensive list of tasks, knowledge areas, skills, and attributes (collectively referred to as KSAs), derived from the PDs. An example of a DYD worksheet is presented in Fig. 5.2.3.

DYD Worksheet	**Position Number: 0668**	**Position Name: Reactor Engineer**
Instructions: 1. Read and highligh the Knowledge, Tasks, and Skills that are listed as part of your role. 2. Write and Knowledge, Tasks, and Skills that are missing from the list. 3. Rank the Knowledge, Tasks, and Skills that you highlighted in order of importance. 4. Using your rank number, match the Task to the Knowledge and Skill it requires.		
Knowledge	**Task**	**Skill**
Nuclear Industry & Governance Nuclear Operations & Technology Nuclear Reactor Physics & Engineering Nuclear Safety Quality Assurance & Plant Operations Regulated Environments		Analytical Communication (Written) Communicate (Verbal) Diagnostic Organisation and prioritisation Problem solving Teamwork

Figure 5.2.3: Example of DYD worksheet utilised to review, validate, and prioritise listed tasks and KSAs (Own Work)

Participants employed at the Australian Nuclear Science and Technology Organisation (ANSTO) were asked to review, validate, and prioritise the listed tasks and KSAs pertinent to their roles, as well as to identify and add any missing elements. Following this, participants were asked to map each task to the corresponding knowledge and skill it required. A gap analysis was conducted between the competencies identified by the staff of eleven roles in the DYD workshop and those baseline competencies derived from the PDs, using the IEEE 1484.20.20-2022 standard model.

A widely used multi-criteria decision making (MCDM) technique named TOPSIS (Hwang & Yoon 1981) was utilised to calculate the relative importance of the tasks and KSAs obtained from the DYD workshops. Following this, hierarchical clustering was performed utilising Ward's method (Ward, 1963), as this method minimises variance within clusters. A hierarchical tree (dendrogram) was constructed as seen in Fig. 5.2.4 and 5.2.5.

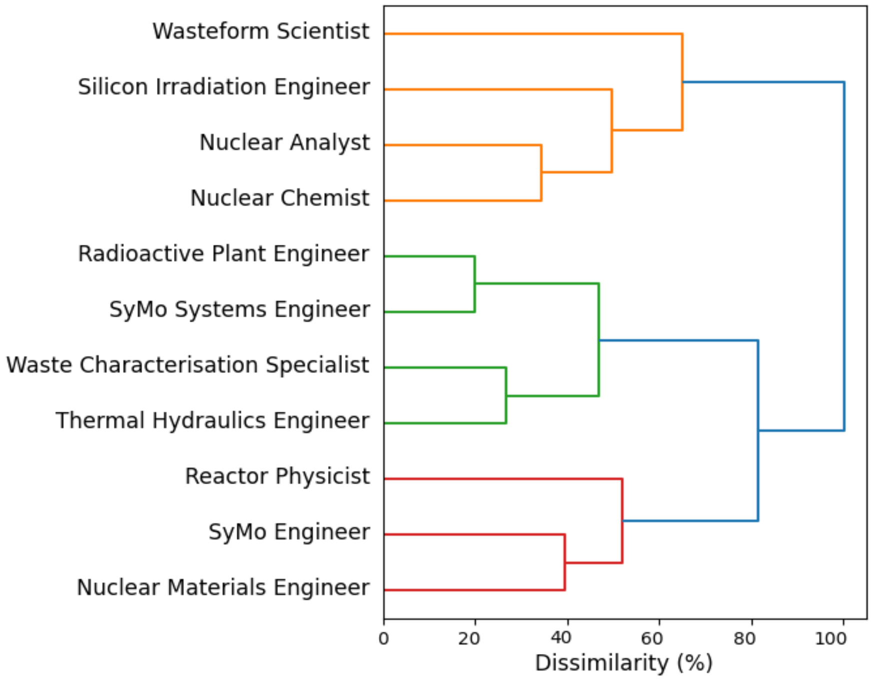

Figure 5.2.4: Roles compared based on technical skills requirement (Own Work)

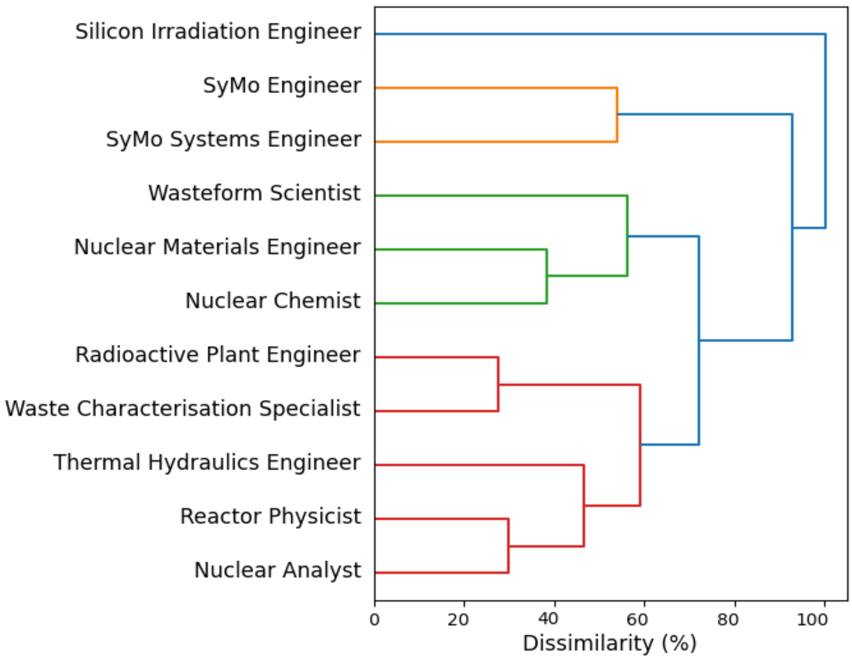

Figure 5.2.5: Roles compared based on non-technical (soft) skills requirement (Own Work)

The dendrogram provides a visual representation of the clustering process, showing the roles that are most similar to each other in terms of technical and non-technical skills. The branches of the dendrogram indicate the roles that were most similar to each other based on the relative importance obtained from the MCDM TOPSIS analysis. The highest-ranked tasks and associated KSAs for all the respondents were identified. Since task importance varied across roles, the top five tasks, knowledge, and skills for each role were prioritised to inform course design in nuclear engineering.

Biclustered heatmaps were generated to visualise the distribution and intensity of skill importance across roles. By clustering both roles and skill domains, the heatmaps reveal groups of roles that require similar competencies and highlight shared skill domains. From a curriculum perspective, these clusters indicate opportunities to design shared core units for roles with overlapping skills and competency requirements, while distinguishing specialised streams where knowledge patterns diverge. From an assessment perspective, the visualisation helps identify which skills and competencies should be assessed collectively within integrated tasks, and which require role-specific evaluation. Together, the dendrograms and heatmaps translate workforce competency data into structured guidance for curriculum architecture, unit sequencing, and targeted assessment design. All roles require up to 50% or more non-technical skills, as illustrated in Fig. 5.2.6. This highlights the importance of embedding non-technical skills in the engineering curriculum.

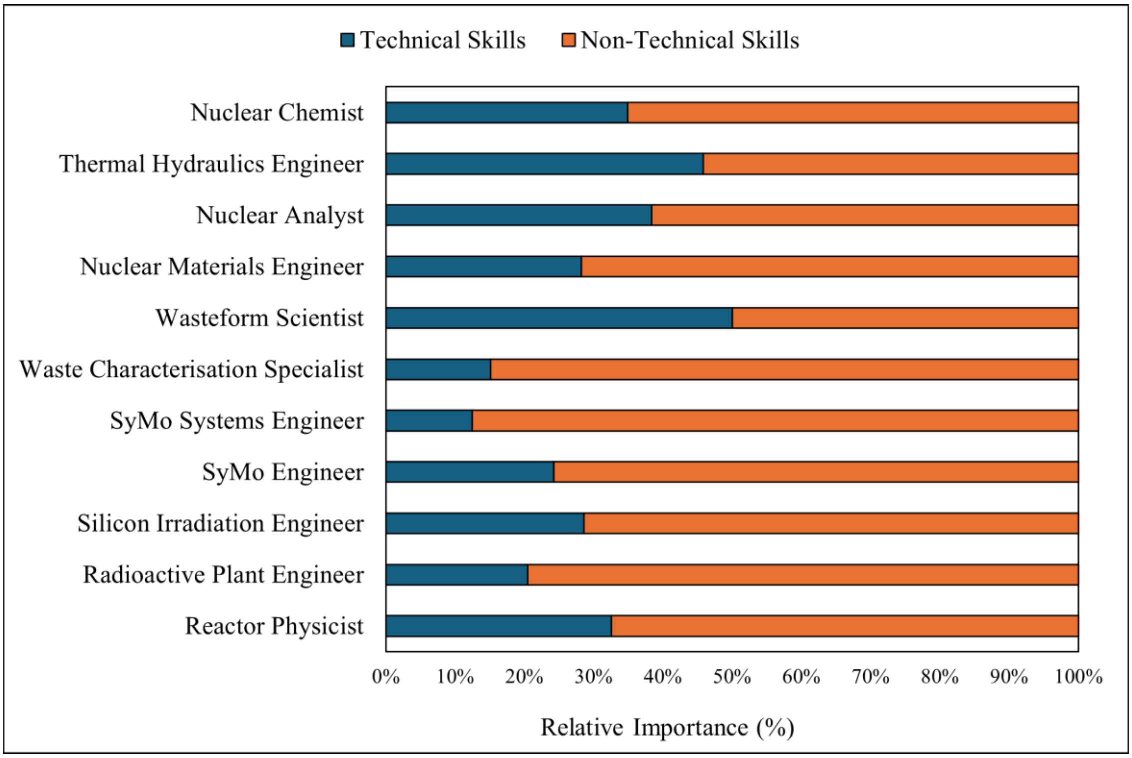

Figure 5.2.6: Technical versus non-technical skills bar chart for a range of roles at ANSTO (Own Work)

The method of evaluating skills and competencies for UNSW nuclear engineering through position description analysis and DYD workshops highlights the value of industry and academic collaboration. The transferable, non-technical skills identified across eleven nuclear science and engineering roles were translated into tangible outcomes in UNSW's course design and delivery, ensuring that it directly reflects workplace needs. This case shows how engineering education can be aligned with the real-world skills needed in a rapidly changing sector. Looking ahead, ongoing engagement with industry and professional bodies will be essential to maintain relevance, while further research will provide evidence needed for tracking skills and competencies alignment and feeding insights back into engineering education development.

For more information on the DYD tools and processes used in Case 3, we invite you to read *The DYD Stakeholder Consultation Process — A User Guide* by Dowling and Hadgraft (2013).

4 Implications for practice

Although the practices presented in the case descriptions above may seem quite different, we can still observe some commonalities. All processes include rather extensive networks of actors and certain level of industry involvement; they are based on a commonly agreed framework or listing of competencies; and they include elements by which the data gathered, and knowledge created in the process is formed into educational actions.

The NMITE and UNSW cases concentrated on specific fields (timber technology engineering and construction, and nuclear engineering), whereas the TEK case looked at the relevance of skills at a general engineering level. In the field-specific processes, the perspective of professionals was obtained by bringing in direct informants from the industry, whereas in the TEK process it was conveyed indirectly via the work experience of the graduates. However, the TEK case illustrates the benefits of a large national academic network, resulting in ample opportunities for benchmarking between different universities and engineering disciplines and degree programmes. As different actors view the purpose of engineering and engineering education differently, it is important that the evaluation of the relevance of transferable competencies and skills acknowledges these different viewpoints; evaluation should aim at a balanced compromise, so that the educational impact of the development work based on the evaluation serves all the stakeholders' needs.

In addition to having a sufficiently large network of actors, the comprehensiveness of the evaluation can be ensured by basing the evaluation on a carefully derived set or framework of skills and competencies. In the NMITE case, an existing Timber in Construction Skills Action Plan served as the framework for the definition of appropriate skills and competencies to be used in the educational programmes (see Fig. 5.2.2). In TEK case, the list of skills and competencies included in the graduate survey had been originally designed in cooperation with TEK and universities and had been monitored and updated yearly with the agreement of the whole network. In the

UNSW case, the competency framework was created following an established DYD process.

From the viewpoint of academic development, getting high-quality and appropriate evaluation of skills relevance is useless unless it is utilised for deriving actionable recommendations, which can then be executed. Although evaluation of relevance may often be an interesting pursuit of knowledge per se and even end up published in academic journals or conferences, the main objective should be the improvement of academic practice, and curriculum development processes should be designed accordingly. In the pursuit of practical gains, systematic procedures for disseminating and utilising the results, like the TEK seminars and workshops and NMITE's continuous course development, are essential. Even if academic publishing is a secondary objective compared to educational development, evaluations that are well designed, effectively implemented, and used to improve practices can also be valuable to those outside the immediate context. Disseminating them effectively is therefore advisable. Useful guidance on how to do this is found in Chapter 5.6. of this handbook.

Rapidly changing work demands and the enormous pace of technological development mean it is essential to ensure that the evaluation of the relevance of skills and competencies stays up to date. For instance, the TEK graduate survey is a continuous process which collects, analyses, disseminates, and utilises information yearly. To keep the process going, a formal structure with clearly defined roles, responsibilities, and resources is needed. In the case of NMITE, we have adopted an internal Programme Enhancement Plan designed to gather timely response to feedback from the Employer Advisory Group, to keep the relevancy current. Processes like these often require an official commitment from the leadership of the organisations involved. When the processes are not running continuously, repeating them when necessary is required. In this case, clear documentation of the procedures enhances effectiveness and saves time and resources.

5 Recommendation for practice

Whether starting a new initiative or building on existing data, practitioners should adopt a systematic approach that will help to ensure the ongoing relevance of transferable skills to their particular context and be willing to change course if feedback suggests it. The key steps we recommend taking include:

- Agree on contextual orientation and determine any relevant educational or industrial policy;
- Review literature for similarly oriented approaches;
- Find and engage industrial, academic, and civic partners;
- Make use of the existing skills and competencies frameworks (see Chapter 1.3 in this handbook);
- Make use of the existing and proven processes for creating skill profiles and/or evaluating their relevance, such as the cases introduced in this chapter;
- Design the processes for producing and using of the results to complement each other (see Table 5.2.1. for ideas about methods and their alignment);

- Produce clear documentation of the processes and keep it up to date;
- Embed continual evaluation and improvement into course design and delivery.

Communication and collaboration among all stakeholders are thus key to evaluating the relevance of transferable skills. Practitioners should be prepared to adopt a mindset that allows them to be prepared to question what and who is not represented in the available data, and how those gaps might be filled. They must also be flexible and adapt as new technologies and skills needs emerge and acknowledge their own need to upskill in order to better prepare tomorrow's workforce.

The three processes for evaluating the relevance of skills and competences which we described above were all based on competency frameworks developed by specific stakeholders for distinct contexts. This is often necessary due to the lack of a universally accepted or applicable framework. However, there is at least one attempt to systematise the research on student perception of transferable competencies and skills, namely the Generic Competence Perceptions Questionnaire (GSPQ) developed by Chan, Zhao and Luk (2017) which has been used to study students' perception of importance (Pinto et al. 2023) as well as students' perception of their competency levels (Chan & Fong 2018). This could serve as a useful starting point for example if you are a degree programme leader who wishes to gauge how your students currently perceive the relevance of transferable skills and competencies.

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AI statement

During the preparation of this work, some authors used Microsoft Copilot for help in formatting the references, and DeepL to check the grammar in the original draft. After using these tools, the authors reviewed, edited, and made the content their own as needed. They take full responsibility for the content of the publication.

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