1.4

Quality by Design: The Role of Accreditation in Transferable Competencies and Skills Development

Darren Carthy[a], *Richard Lillington*[b], *and José Carlos Quadrado*[c]

[a] Engineers Ireland, Ireland, ORCID: 0000-0002-9810-1189;
[b] New Model Institute for Technology and Engineering, United Kingdom, ORCID: 0009-0008-9558-4884;
[c] ENAEE, Belgium, ORCID: 0000-0002-5560-347X.

Keywords: *accreditation, graduate attributes, professional practice, transferable competencies and skills, quality assurance*

Over the past two decades, engineering accreditation has increasingly adopted an outcomes-based model centred on the development and demonstration of graduate competencies and skills. This chapter examines how local accreditation systems and international frameworks support the formation of competent engineers by focusing on what graduates should be able to do rather than prescribing detailed curricular inputs. The chapter explores the structure and function of contemporary accreditation frameworks, including the relationship between global principles and local professional standards. Particular attention is given to how programme teams translate accreditation requirements into curriculum design, learning outcomes, and assessment strategies that provide credible evidence of competence attainment. Approaches to curriculum mapping and assessment design that support successful accreditation are discussed, alongside examples of how engineering education research has informed the evolution of accreditation standards. A case study illustrates a practical approach to curriculum design that aligns programme learning outcomes, assessment practices, and accreditation expectations. The chapter concludes with recommendations for practitioners involved in programme leadership, accreditation preparation, and curriculum development. Collectively, these perspectives highlight how accreditation can function not merely as a quality assurance mechanism, but as a constructive framework supporting the development of capable, adaptable, and professionally prepared engineers.

DOI: 10.59490/mt.266.54.

1 Introduction

Engineering education has long relied on external accreditation, that is, "*the process by which a (non-)governmental or private body evaluates the quality of a higher education institution as a whole or of a specific educational programme to formally recognise it as having met certain pre-determined minimal criteria or standards. The result of this process is usually the awarding of a status of recognition, and sometimes of a license to operate within a time-limited period"* (Vlăsceanu, 2007, p. 25). Accreditation provides an independent, internationally recognisable assurance that an engineering programme truly prepares graduates for professional practice — not only in technical fundamentals, but also in professional judgement, ethics, and responsibility for real-world impacts — thus strengthening employer and public trust, improving graduate recognition and mobility, and differentiating graduates in contexts where the title 'engineer' may be used loosely. At the same time, accreditation acts as a structured driver of continuous improvement by bringing external peer and professional scrutiny, encouraging closer engagement with industry and society's needs, and ensuring that programmes communicate clearly and transparently about what students achieve and how quality is sustained over time.

In the nineteenth century, national engineering institutions emerged, gaining responsibility for the accreditation of engineering programmes and eventually forged contemporary multilateral accords such as the Washington Accord (WA) and the EUR-ACE Framework Standards and Guidelines (EAFSG), often referred simply referred to as EUR-ACE standards or framework. These frameworks and accords, which ensure globally aligned accreditation standards, have progressively converged on a shared understanding of what it means to be prepared for engineering practice. Over time, a system has developed that allows educational providers to benchmark their programmes against expected norms, these being informed by the underpinning science, relevant technologies, and societal concerns. Today, outcome-based descriptors of knowledge, skills and behaviours supply a common vocabulary for educators and regulators worldwide, enabling the mutual recognition of degrees and the mobility of graduates.

Accreditation, which is an objective evaluation and approval of third-level engineering programmes to ensure they meet professional standards, is more than a compliance exercise; it is fundamentally a curriculum design challenge. Programme teams must demonstrate that learning activities, resources and assessments are constructively aligned with the targeted outcomes, and that students attain them. This demands evidence-informed approaches to module sequencing, integrative projects, and authentic assessment, coupled with robust quality assurance loops that capture feedback from students, industry partners and (in some regions) external examiners[i], union representatives, or similar stakeholders who provide externality and sharing of good practice to maintain and develop standards. Institutional leaders, for their part, position accreditation as a strategic enhancer of educational quality, embedding it within broader improvement cycles rather than treating it as a periodic audit (Guerra et al., 2017). Though it is understood that it is a considerable undertaking, there are arguments for professionalizing the approach to the teaching of engineering, and institutional accreditation of degrees coupled to individual professional registration (as is required in some countries).

The landscape is being reshaped by powerful forces: digital transformation, interdisciplinary practice, sustainability imperatives, the widening participation agenda, and the pedagogical implications of generative and other forms of artificial intelligence. These trends are recalibrating the competencies expected of engineering graduates and the evidence accreditors look for, compelling universities to rethink not only programme content but also how learning is facilitated and verified.

Against this dynamic backdrop, the chapter that follows provides you, the practicing academic, with a guide to aligning programme design with contemporary accreditation needs. After quickly tracing the historical evolution of systems, the chapter dissects the logic of major international frameworks and translates these into high-level criteria. A case study illustrates how institutions have integrated these accreditation requirements into the education and assessment of their students, while a forward-looking analysis identifies persistent challenges before proposing coordinated, competency-focused solutions. Together, these insights aim to transform the perception of accreditation from a bureaucratic obligation into what it is meant to be: an evidence-based continuous improvement activity, and a driver of educational excellence to be embraced by all engineering educators.

2 Accreditation systems

2.1 History of accreditation framework

The first engineering institutions, professional bodies, and trade unions were established in the nineteenth century to advocate for the advancement of the profession and the development of its members, with the earliest examples appearing in the UK (1818), Ireland (1835), and the USA (1852). These are here referred to as Professional Engineering Institutions (PEIs). Some examples include the Institution of Engineers of Ireland (Engineers Ireland), Institution of Mechanical Engineers (IMechE) in the UK, and the Institute of Electrical and Electronic Engineers (IEEE) in the USA. Throughout the twentieth century, these professional bodies expanded their functions to include the regulation of the profession, through registration and professional licensure, and accreditation systems to ensure the quality of engineering programmes, with the first - ABET - being founded in the United States in 1932 (IEA, 2015).

By 1989, six professional bodies had found sufficient common ground in their accreditation systems to found the WA, a multilateral agreement between Australia, Canada, Ireland, New Zealand, the United Kingdom, and the United States, that recognised the substantial equivalence of engineering qualifications attained in each signatory's jurisdiction. The WA as of 2025 has 25 full signatories and six provisional signatories, making it the largest mutual recognition agreement currently in operation in the world (IEA, 2015).

In 2006, the European Network for the Accreditation of Engineering Education (ENAEE) was established by 14 associations concerned with engineering education, with the main goal of building confidence in accreditation systems for engineering degree programmes in Europe. ENAEE stemmed from the European Standing Observatory for the Engineering Profession and Education (ESOEPE), which was founded in 2000 by five professional bodies from Germany, Italy, France, the United Kingdom, and Portugal (ENAEE, 2022a). The first ENAEE general assembly took place in March 2006, with the implementation of the EUR-ACE system of accreditation following shortly afterward in 2007. The EUR-ACE label is a European Quality Label authorised by ENAEE to PEIs who accredit engineering programmes. Initially developed to provide mutual recognition of engineering qualifications and first-degree cycle (FCD), often bachelor degree, and second-degree cycle (SCD), often master degree in Europe, the number of professional bodies and agencies authorised to award the label has grown substantially since 2007 to 23, reaching jurisdictions across three continents (ENAEE, 2022b).

In 2007, in response to several accords and agreements being created globally for the recognition of engineering qualifications from technicians, technologists and professional engineers, the International Engineering Alliance (IEA) was formed and a secretariat established to manage them (IEA, 2015).

The growth of these organisations did not come without challenges, as the IEA and ENAEE remain to this day separate entities with different philosophies. However, many strides toward cooperation have been made, with the publication of the ENAEE IEA Best Practices in Accreditation of engineering programmes in April 2015.

2.2 Learning outcomes, programme outcomes, and graduate attributes

Now that the history of accreditation frameworks has been sketched, some clarity can be added to the picture by defining learning outcomes, which link university programmes, national accreditation standards and international accreditation frameworks. While the definitions of competencies and skills have been predefined for the purposes of this handbook, it becomes important to talk in terms of outcomes when discussing what PEIs expect graduates to be able to do at the end of their studies. Broadly speaking, these outcome frameworks, which have been developed based on the same outcomes-based education (OBE) theory (Spady, 1994), may be achieved in various ways, which overlap somewhat, and which are used in different ways in different countries.

Learning outcomes form the basis on which national qualifications frameworks are built and are increasingly influential in defining and writing of qualifications and curricula as well as the orientation of teaching and assessment (Winterton et al., 2006). Learning outcomes are statements of what a learner knows, understands, and is able to do on completion of a learning process. The achievement of learning outcomes must be assessed through procedures based on clear and transparent criteria. Learning outcomes are attributed to individual educational components and to programmes as a whole. They are also used in European and national qualifications frameworks to describe the level of the individual qualification (European Commission, 2015).

Programme outcomes (POs), which can be categorised in a similar manner to competencies and skills (both technical and transferable) are the discrete, observable outcomes expected of graduates upon completion of an engineering programme. They are written at a higher level than learning outcomes and refer to principles or goals for an engineering programme. For example, "*students will be able to demonstrate the ability to solve complex engineering problems relevant to their particular branch of engineering".* Programme and learning outcomes should be aligned in order to achieve accreditation.

Graduate attributes, in the context of accreditation requirements, can be taken as synonymous with programme outcomes but may reflect more specific requirements. In some cases, for example in accreditation frameworks, they have more specific meaning, e.g., both the IEA and ENAEE have a set of definitions for graduate attributes which are intended to guide PEIs in developing POs within their respective accreditation requirements.

A critical point to note here is that individual PEIs have some latitude to interpret the graduate attributes within accreditation frameworks to formulate POs. This is often an action taken which reflects a more general, abstracted nature of (national or international) guidelines which apply to all engineers, regardless of the branch of engineering being practiced.

Locally, each signatory to the IEA accords or EUR-ACE is at liberty to define and emphasise the POs that are most relevant to their jurisdictional context, provided they can demonstrate alignment with the graduate attributes defined by these international frameworks. These local requirements will simply be termed accreditation requirements here, as they encompass a small number of input-resource requirements (quality assurance mechanisms, entry standards) as well as output requirements (POs). In recent years, several jurisdictions have taken a research-informed approach to the revision of accreditation requirements. In recent revisions to its outcomes, ABET has incorporated several refinements that align closely with empirical insights from Passow and Passow's (2017) systematic literature review of engineering competencies. Notably, ABET's expanded articulation of teamwork demonstrates a substantive shift from the earlier, passive formulation of '*functioning on multidisciplinary teams*' toward a richer conception of collaborative practice. The revised outcome emphasizes leadership, goal formation, task planning, and the cultivation of inclusive environments. Similarly, ABET's updated ethics outcome foregrounds informed judgement and explicit consideration of societal, environmental, and global impacts, partially addressing the critique by Passow and Passow (2017) that ethical responsibility in practice entails proactive stewardship rather than simple awareness. The integration of contextual constraints into both design and ethical reasoning further reflects their call to embed impact analysis within core engineering processes. While ABET's criteria stop short of fully incorporating competencies such as initiative, creativity, and self-management — identified by Passow and Passow as central to professional effectiveness — the revisions nonetheless represent a meaningful recalibration toward a more evidence-based understanding of engineering practice.

Over the past decade, the wider societal aspects of competencies and skills and their implementation in accreditation requirements have also garnered much attention. Examples include ethics, and sustainable practice. Martin (2020) and Homan (2020) both highlight the influential role PEIs play in shaping the engineering ethics curriculum and professional development of engineers. Homan also highlights how accreditation systems, as well as driving innovation in the curriculum, may also serve as a barrier to change, as many PEI accreditation processes lack one key stakeholder: the public; the end user of many engineering innovations.

While undoubtedly a range of approaches to teaching ethics can be observed in practice, Martin's findings suggest that ethics education is viewed as an add-on subject and is treated superficially in most curricula examined. To resolve this, a conceptual framework integrating ethics as a set of skills alongside ethics as concepts, knowledge, values, and attitudes was developed by Gwynne-Evans et al. (2021). Having applied their framework to the Engineering Council of South Africa's accreditation requirements, a new set of POs emerged that repositions ethics at the heart of engineering graduate attributes. This research is yet to garner the attention of an accreditation framework, such as the EUR-ACE or the IEA graduate attributes. It does, however, demonstrate how the social dimensions of engineering activities can be effectively embedded in the curriculum.

2.3 Accreditation frameworks

As intimated in the earlier sections, there are two prevalent accreditation frameworks with which PEIs who conduct accreditation can align their accreditation requirements to ensure the global mobility of graduate engineers educated within their jurisdiction. Table 1.4.1. provides a comparison of the POs from the ENAEE, EAFSG and the IEA Graduate Attributes, which set out the competence requirements that PEIs must evaluate as part of their accreditation criteria to be recognised under these respective accords. For comparison, the Engineers Ireland accreditation criteria have been included to illustrate how each set of POs has influenced the formation of a local set of accreditation requirements, as Ireland is a signatory to both the IEA Accords and EUR-ACE. Similarly, the Accreditation of Higher Education Programmes, Fourth Edition (AHEP4) standard applied in the UK is shown, indicating how the taxonomy alters by region for similar activities.

Both frameworks, as well as the Engineers Ireland and UK AHEP4 criteria, are in perfect harmony regarding the technical outcomes; all emphasising the importance of foundational knowledge of the engineering sciences, problem solving, analysis, and investigation. Differences emerge relating to transferable competencies and skills, but in the relative emphasis each receives within individual frameworks. Taking lifelong learning as an example, Table 1.4.2 shows that in the IEA Graduate Attributes and EAFSG, lifelong learning is the unitary object of analysis. By contrast, Engineers

Ireland adapted their accreditation requirements for lifelong learning to include teamwork. By contrast, AHEP4 stipulates these outcomes separately, as two of the 18 learning outcomes required.

Table 1.4.1: A comparison of the IEA graduate attributes, EUR-ACE programme outcomes, Engineers Ireland programme outcomes, and UK AHEP4 learning outcome groupings

IEA graduate attributes (IEA, 2021)	*EUR-ACE framework standards and guidelines (ENAEE, 2022b)*	*Engineers Ireland programme outcomes (Engineers Ireland, 2021*	*AHEP4 learning outcomes (ECUK, 2020)*
Engineering knowledge	Knowledge & understanding	Knowledge & understanding	Science and mathematics (commonly referred to as knowledge & understanding)
Problem analysis	Engineering analysis	Problem analysis	Engineering analysis
Investigation	Investigations	Investigation	
Design/ development of solutions	Engineering design	Design	Design and innovation
Tool usage			
Engineer & the world	Making judgements	Professional & ethical responsibilities	Engineer & society
Ethics			
Lifelong learning	Lifelong learning	Teamwork & lifelong learning	Engineering practice
Individual & collaborative teamwork	Communication & teamworking		
Communication		Communication	
Project management & finance	Engineering practice	Engineering management	

Table 1.4.2: Comparison of definitions in competency statements on lifelong learning between IEA, EAFSG and signatory members Engineers Ireland and AHEP4 to both frameworks

IEA (IEA, 2021)	*ENAEE (ENAEE, 2022b)*	*Engineers Ireland (Engineers Ireland, 2021)*	*AHEP4 (ECUK, 2020)*
(1) Recognize the need for and have the preparation and ability for independent and lifelong learning,	(1) Ability to recognise the need for and to engage in independent lifelong learning.	(1) the ability to recognise and make use of the interactions between various engineering disciplines and other professions; the ability to work with a broad range of stakeholders in multidisciplinary settings;	(1) Function effectively as an individual and as a member or leader of a team.
(2) Recognize the need for and have the preparation and ability for adaptability to new and emerging technologies, and	(2) Ability to follow developments in science and technology.	(2) knowledge, understanding and active participation in diverse and inclusive teams;	(2) Evaluate effectiveness of own and team performance.
(3) Recognize the need for and have the preparation and ability for critical thinking in the broadest context of technological change.		(3) recognition of the need for, and the ability to plan and carry through, self-directed continuing professional development (CPD).	(3) Plan and record self-learning and development as the foundation for lifelong learning (CPD).

The tendency of individual PEIs to organise accreditation requirements in a way which aligns with social and cultural conventions is encouraged within accreditation frameworks, provided PEIs can demonstrate the substantial equivalence of their accreditation requirements to the relevant framework. It is noteworthy that strides have been made to better harmonize these frameworks and national accreditation requirements under a common set of competence statements. Van den Broeck et al. (2024) conducted a systematic literature review on lifelong learning competencies.

Through analysis of 65 papers, they identified and clustered 254 competencies relevant to lifelong learning to develop a six-competence lifelong learning framework for university students, unveiling fruitful ground for future revision of the definitions within accreditation frameworks and national accreditation requirements.

3 Strategies for curriculum design

Now that some sense of the interaction between accreditation frameworks and PEIs' jurisdictional accreditation requirements has been established, we explore the interaction between higher education institutions (HEIs) and the PEIs. To meet accreditation requirements, programmes taught at HEIs need to demonstrate that the POs defined by the PEIs are aligned with individual module learning outcomes. Here we see how developments to national and international standards impact local design and delivery of taught and assessed material. Accreditation acts as both driver for change in a curriculum and means to stabilize it: change driven by new, evolved stipulations from PEIs, and stabilization by the need to continuously demonstrate suitable adherence to a standard.

In regard to demonstrating the meeting of standards, multiple aspects are used, such as using a heatmap, cross-table, or other tool which highlights claims made about learning outcomes and their alignment to the accreditation requirements of the PEI in a particular jurisdiction. A sample heatmap is provided in Fig. 1.4.1. While we have seen many methodologies for the establishment of the scores attributed to each PO for a given module, an aggregated score based on the assessment of the learning outcomes for each module in terms of their contribution to a given PO is sufficient. The heatmap or cross-table serves as much as a reflective tool for you as the module lead as it does as an aid to the external assessors in directing their review of the evidence provided.

Module	**ECTS**	**PEI Programme Outcomes**			
		Teamwork	Communication	Ethics	Management
Module 1	3	4	3	5	2
Module 2	5	5	1	0	1
Module 3	10	0	0	5	4
Module 4	3	3	2	1	0
Module 5	5	5	5	5	1
Module 6	3	3	2	1	0

Figure 1.4.1: Sample heatmap for highlighting claims about the achievement of programme outcomes (Own Work by Carthy)

3.1 Mapping learning outcomes

Learning outcomes constitute the backbone of contemporary engineering curricula, articulating the knowledge, skills, and attitudes that graduates are expected to demonstrate (ENAEE, 2022b). For engineering programmes, well-formulated outcomes perform three interconnected functions: (1) they align learning with rapidly evolving industry requirements and global standards such as the EAFSG and the IEA graduate attributes; (2) they assure transparency for students, employers, and accreditation bodies; and (3) they enable international mobility by providing a common language for recognition of competences and skills. The adoption of a shared terminology has enabled the preparation of the exemplar *Best Practice in Accreditation of Engineering Programmes* (ENAEE & IEA, 2024). A holistic perspective demands that cognitive, social, and emotional dimensions be addressed in tandem. Technical proficiency in areas such as analytical modelling and problem solving must be complemented by teamwork, leadership, intercultural communication, and an ethical mindset, while emotional attributes — resilience, adaptability, and professional responsibility — support lifelong learning (Biggs & Tang, 2011). Recent revisions of the EUR-ACE and WA graduate attribute descriptors broaden the scope further by embedding sustainability, digitalisation and artificial intelligence literacy as cross-cutting themes, yet institutions still struggle to balance technical depth with wider professional capabilities, particularly in interdisciplinary or emergent fields where the target profile is itself fluid.

A major challenge faced by academic staff in the pursuit of mapping outcomes to accreditation requirements is in allocating responsibility for the mapping exercise. Here a *top-down* approach from the programme director (or programme director) can cause issues if the nuance of teaching in particular modules is not understood. Similarly, a *bottom-up* approach, where the responsible lecturers (or module leads) allocate learnings, can lead to unbalanced mapping, as the wider programme aims are not as visible. A *mixed-mode* approach works well, where the programme director asks responsible lecturers where modules are strong, then concerts the efforts of the lecturers to allocate mapping where the evidence of robust demonstration is strongest. The mapping exercise may invoke a decision to be made on whether to create modules based on the learning need or to retrofit learning to existing modules. A reflection by the authors on the practices in the UK and Ireland highlights that several additional challenges have emerged and persist:

- Module topics based more on historical precedent than functional need. An example is the practice of resource teaching mathematics - where lecturers from the mathematics department teach engineering students fundamental mathematical content, which can be broad in scope with limited contextualisation within the physical science curriculum requirements of an engineering programme.
- To improve teaching efficiency there are drivers towards greater commonality in early parts of some degrees, with engineers from many disciplines taking the

same modules. This adds constraint due to differing PEI needs but affords opportunity to define activities that are truly core learning for all engineers.
- The professional experience of teaching staff, where staff teach on accredited programmes who themselves hold no professional registration, i.e., are not members of a PEI in a given jurisdiction, or who do not hold a pertinent teaching qualification, and so have not demonstrated understanding of the competencies required of an engineer. This is not to say that these educators are not competent, but that their competence has not been verified in an objective and systematic way in a manner consistent with the programme they are supporting.
- Striking the balance between the teaching of *up-to-date* skills, readily useful to service a narrow set of needs, with the development of confidence and competence in the application of underpinning principles to a wider set of problems; i.e., what Poser (1998) defines as "*the difference between know how and know why*".
- Confusion of module learning outcomes and programme outcomes as defined within PEI accreditation requirements.

Considering these factors, a hybrid approach to mapping appears typical, where long-standing outcomes (for example associated with aspects of engineering science) may be easily accommodated in existing modules, but emergent standards may necessitate a new module. Key to successful mapping is a wide view of the programme needs, coupled with a narrower view of where and how claims are best demonstrated.

Other points to consider here include threshold and coverage: learning outcomes need to be demonstrated at a threshold (usually a passing grade) level only; the meeting of learning outcomes is not usually stipulated in terms of association with a specific module credit. Assessment needs to show learning needs are being met for a student getting a passing mark, not a high mark, and (usually) there is some latitude in the extent to which a particular learning outcome is demonstrated. A complicating factor here though is that if an assessment tests multiple competencies, there is a potential for a passing student to not adequately demonstrate all of these. As such, the careful design of assessments, including segregation into *must pass* elements, is important to ensure a robust and balanced coverage and a clear mapping onto PEI programme outcomes.

3.2 Authentic assessment to support the achievement of accreditation requirements

A significant challenge for HEIs is mapping transferable competencies and skills embedded within learning outcomes to accreditation requirements. Transferable skills such as communication, networking, creativity, and problem solving are increasingly prized by employers who recruit engineers for multi-disciplinary, client-facing roles — skills which are not always present at satisfactory levels in graduate engineers (Carthy et al., 2022). The role of authentic assessment, specifically how HEIs can leverage assessment to better align curricula with accreditation requirements, merits further discussion. Authentic assessment requires students to demonstrate competencies and skills that realistically represent problems and situations likely to be encountered in their work life, or where students are required to complete tasks that have real-world applications. Practical examples include developing case studies, solving ill-structured problems, and participating in multidisciplinary projects. Authentic assessment remains one of the most reliable ways to measure transferable competencies and skills, because the approach mirrors the complexity of contemporary professional practice (Ajjawi et al., 2024).

It is a common quality assurance requirement that assessment demonstrates how individual students, not cohorts, have met learning outcomes. This should inform the design of any group assessment such that individuals are given the opportunity to demonstrate learning. Assessments including teamwork or communication often hinge on subjective judgement, so that reliability across assessors is hard to guarantee, and heavy workloads encourage summative tests at the expense of formative feedback. This can constrain the type of skill assessed in groupwork, but recent initiatives to mitigate these risks include institution-wide rubric design workshops, systematic peer and self-review cycles, and the deployment of AI-enhanced analytics capable of detecting rating anomalies in real time (Li et al., 2025).

It is important to remember that mapping itself is simply a tool to enable careful formation of the educational underpinning of future careers in engineering; the actual demonstration comes via assessment. Much of the challenge in mapping transferable competencies and skills to accreditation requirements stems from the need for authentic assessment strategies for the evaluation of transferable competencies and skills, which by contrast to traditional forms of assessment utilised in the evaluation of technical competencies, can be perceived as illusory. To support you in developing authentic assessment strategies for transferable competencies and skills, Part 3 of this handbook has been dedicated to assessment.

While PEIs will state that the most appropriate pedagogical method is the one that best achieves their accreditation requirements, in our experience student-centred approaches that embrace these alternative forms of assessment map much more precisely to the accreditation requirements relating to transferable competencies and skills than traditional forms of instruction and assessment.

3.3 Advances in mapping methods

A significant challenge for practitioners who are engaging in an accreditation process is understanding how to identify and structure relevant evidence of students' attainment. Contemporary engineering programmes draw on a rich array of complementary evidence streams, supporting the demonstration of accreditation requirements. Rubrics now provide the backbone for consistent judgements across modules and instructors, ensuring that similar standards are applied irrespective of who marks the work. Alongside these matrices, curated student portfolios chart longitudinal growth in design capability and encourage systematic reflection on learning trajectories. Peer evaluation systems further enhance the evidence base by sharpening students' collaborative awareness and offering additional perspectives on individual contribution (Cole, 2023; Power & Tanner, 2023). Project-based learning assessments, grounded in real-world constraints supplied or developed with the industry in mind, furnish authentic artefacts that mirror professional practice (Farrell & Carr, 2019; MacLeod & van der Veen, 2020). Finally, detailed work placement reports, triangulated against feedback from workplace supervisors, supply robust confirmation of graduates' readiness for professional responsibilities. PEIs have responded by foregrounding programme-level mapping of direct (e.g., design outputs) and indirect (e.g., graduate surveys) indicators. Nevertheless, it should be acknowledged that there is a significant administrative burden imposed on HEIs in mapping learning outcomes to accreditation requirements.

Advancement in the mapping of learning outcomes to programme outcomes has been made using Natural Language Processing (NLP). Pauzi and Capiluppi (2023) developed a web-based tool for educators and university administrators that maps Learning Outcomes to PEI accreditation requirements. Advancements have also been made in streamlining the accreditation audit process. Hussain et al. (2020), in response to the challenges to accreditation auditing during the COVID-19 pandemic, developed an OBE framework and system capable of collecting, evaluating, and reporting continuous quality improvement data to ABET, allowing remote accreditation audits to take place.

3.4 Case study on the effective Integration of accreditation requirements into the curriculum

The principles outlined above are illustrated in the following case study, which demonstrates the effective integration of accreditation requirements into curriculum design and delivery. In 2015, Northern Border University's (Saudi Arabia) Industrial Engineering programme undertook a comprehensive curriculum redesign to align with the ABET accreditation requirements (Aoudia & Abu-Alqahsi, 2015). The initiative aimed to ensure that the programme met ABET standards for educational quality, continuous improvement, and competence requirements. The redesign process followed a structured, multi-level approach that connected ABET programme outcomes, programme objectives, module outcomes, and student learning outcomes into a coherent assessment and improvement system.

We would like to emphasize that the redesign began with a clear articulation of why change was necessary. Three levels of analysis guided this step:

- *high-level analysis.* review of programme objectives to ensure alignment with stakeholder expectations, including employers, alumni, faculty, and students.
- *mid-level analysis.* evaluation of the broad student learning outcomes, particularly those aligned with ABET's criteria, which emphasize abilities such as problem-solving, teamwork, ethics, and communication.
- *low-level analysis.* assessment of module learning outcomes to determine whether individual modules effectively contributed to the broader student learning outcomes.

This hierarchical approach ensured that the redesign was not superficial but deeply rooted in ABET's continuous improvement philosophy and ensured that ABET outcomes were not treated as add-ons but were embedded throughout the educational experience.

The programme team aligned assessments with ABET criteria. Exams, quizzes, lab reports, and design projects were used to measure student mastery of module learning outcomes. Rubrics were standardized across modules to ensure reliable evaluation of ABET programme outcomes such as design ability, experimentation, and communication. Indirect assessment of student attainment was established using surveys of students, alumni, and employers, which provided qualitative insights into perceived strengths and weaknesses.

The programme ensured that students received a strong foundation in mathematics, science, and engineering fundamentals, as well as core industrial engineering knowledge in areas such as operations research, manufacturing systems, ergonomics, and quality engineering, culminating in a capstone design experience integrating multiple ABET outcomes, including teamwork, design under constraints, and professional responsibility. The redesign also emphasized modern engineering tools and technologies, aligning with ABET's expectations for contemporary practice.

ABET stresses the importance of engaging a broad range of stakeholders in defining and evaluating programme objectives. The programme team incorporated employer feedback to ensure graduates possessed industry-relevant skills. Alumni input was used to validate long-term effectiveness of the curriculum. Faculty workshops aimed to align teaching strategies with ABET expectations. This participatory approach strengthened the program's relevance and credibility.

The curriculum redesign described in this case study represents a comprehensive, systematic integration of professional accreditation requirements into an engineering programme. By aligning programme objectives and learning outcomes with ABET criteria, implementing robust assessment mechanisms and engaging stakeholders, the programme team established a sustainable framework for continuous improvement of the programme.

This case study demonstrates how ABET accreditation can serve as a catalyst for elevating educational quality and ensuring that engineering graduates are well-prepared for professional practice.

4 Challenges and future directions

4.1 Societal awareness

The underpinning fundamentals of engineering science and mathematics are well-understood, and, importantly, unlikely to change significantly in the lifetime of our students. This is empowering, as the development of understanding of as yet unknown technologies is based on the same principles as our understanding of the current state of the art, and others which may grow from the current state of the art. However, certain new topics have grown in prominence in recent years, and amongst these notable examples include studies on the importance of diversity and inclusivity (Murphy et al., 2025) and sustainability in accreditation requirements (Carthy et al., 2023). These topics were previously not included in engineering curricula, as their deeper importance was not yet appreciated, but a recent willingness by those who govern accreditation frameworks to adopt a research-informed approach creates opportunities for this research to inform quality standards of the future. Now, it is generally accepted that engineers will be the people making decisions required to transform outcomes for people, and so a solid appreciation of what is *good*, *fair*, and *sustainable* practice is required. Notably, these topics seem to find traction with students, possibly because they are already more culturally adapted to the need for change than older generations. Regarding the teaching and assessment of transferrable skills in these areas there are several tensions to note:

- Topics relating to ethics and diversity and inclusion, are amongst the most challenging material to teach, and that students might face, both emotionally and cognitively. The development of effective teaching strategies is an imperative (Lawlor, 2021), so that the subjects are well integrated into curricula (Gwynne-Evans et al., 2021) and not treated as add-ons (Martin, 2020). The *International handbook of engineering ethics education* (Chance et al., 2025) goes some way to provide solutions to teaching such material, which the authors of this chapter endorse.
- The inclusion of these subjects in the programme is difficult, as they are quite different to other material. It can also be easy to trivialize them, compared to 'more technical' content, but this would be a serious error in curriculum design, given the equal weight given to technical and non-technical accreditation requirements by PEIs. This aspect is compounded by the zero-sum nature of teaching time in the curriculum.
- External factors exist beyond engineering which may erroneously see engineering only as an application of mathematics and science.

We feel that it is important to highlight that a broadly encompassing view of the role of the engineer in society has long been part of engineering education, it being incumbent upon academics, practicing engineers and PEIs to uphold and promote this view. The pressures endured by some *new* topics in the curriculum were not so long ago targeted at content such as sustainable practice, which few of us would argue the case for exclusion nowadays in any modern curriculum. It is essential that engineering graduates are effectively prepared to address evolving societal, and global challenges.

4.2 Digital trends

Engineering education has historically been at the forefront of adopting digital technologies to support learning, design, and professional practice. The rapid emergence of AI represents the latest stage in this evolution. For engineering programmes subject to accreditation, the integration of such technologies must be considered not only as a pedagogical innovation but also in relation to the attainment of required graduate attributes and competencies defined by PEIs.

Both the WA and EAFSG emphasize attributes such as problem solving, critical thinking, ethical responsibility, and the ability to use modern engineering tools appropriately. AI systems may support these attributes when used as cognitive tools that assist exploration, modelling, and reflection. However, they also present a risk that students may rely on automated outputs rather than demonstrating their own competence. As a result, engineering educators must design learning activities and assessments that ensure students can still demonstrate authentic attainment of PEI accreditation requirements, even where AI tools are available.

A related challenge concerns academic and quality assurance, both of which fall within the scope of the accreditation requirements of many PEIs. The widespread availability of AI has created tensions between traditional assessment models and new forms of technologically mediated authorship. Attempts to detect AI-generated work through automated detection tools have proven inconsistent and, in some instances, unreliable (Cheng et al., 2025) reinforcing the need for all of us to rethink assessment design rather than relying solely on detection technologies.

At the same time, AI presents opportunities for personalised and adaptive learning support, potentially allowing students to engage with complex engineering concepts at their own pace. International policy guidance increasingly emphasises that the educational use of AI should prioritise transparency, accountability, and the development of critical digital literacy among learners (UNESCO, 2023). For engineering education in particular, this means ensuring graduates are not only capable users of advanced digital tools, but also reflective professionals who understand their limitations, ethical implications, and appropriate application within engineering practice, pursuant to the programme outcome requirements by PEIs.

4.3 Closing the loop on continuous quality improvement

A relevant problem regarding the way in which academia engages with the problem of usefully developing competencies and skills in undergraduates is that the effectiveness of teaching in preparation for practice is difficult to evaluate. Using the analogy of a system to control a process, a measurement is typically fed back to a controller, such that corrective action may be taken to account for deviation from a target output value, in many cases in near real time. However, in the academic context, little direct feedback is available on how teaching enables engineers at any stage of their career, let alone in real-time. At best feedback is partial, selective, and infrequent. As such control of the process tends to become *open loop*.

To 'close the loop' on this problem multiple options are available. For example, close analysis of graduate data (Phillips & Quilligan, 2024) and first-hand engagement with recent graduates operating in a range of professional roles can help inform programme leads on the effectiveness of provision (Aoudia & Abu-Alqahsi, 2015). Notably, close engagement with professional engineering institutions (for instance via accreditation activities) can act to drive wider industrial engagement, which will itself enable more opportunities to receive useful feedback. With PEIs stating that the most appropriate pedagogical method is the one that best delivers their accreditation requirements, a view on how well these requirements are met at every stage of an engineer's development would serve as compelling evidence of attainment.

In short, to improve the efficiency of teaching, we urge you to consider the authenticity of the material taught in terms of usefulness to a graduating engineer, as well as the effectiveness with which assessment drives the student to develop a particular skill area. Hence, we would make the following recommendations. Firstly, limit the number of competencies addressed in a single module so that each intended learning outcome can be meaningfully taught and rigorously assessed. A smaller number of clearly defined outcomes will allow you to design deeper assessments that provide convincing evidence of the attainment of accreditation requirements. Secondly, engagement with your PEIs during consultations, accreditation visits, and peer interactions should be seen as an opportunity to identify good practice in curriculum design, assessment, and skills development from a helpful friend or peer. Thirdly, actively seek examples of effective approaches from other practitioners of accredited programmes and consider how these might inform the continuous improvement of your own offerings. Fourthly, when accreditation frameworks are revised, make your voice heard by contributing to consultations led by PEIs and related bodies. Your input ensures that accreditation requirements remain practical, evidence-based, and aligned with the realities of engineering education. Engagement in these consultations also helps communicate the importance of research-informed approaches to curriculum and competence development. Finally, engineers are expected to be prepared as lifelong learners during their education and initial professional development, so place an emphasis on developing the habits and skills associated with lifelong learning in your students early on in their education. Introducing your students to reflective practice, continuing professional development, and self-directed learning early in their undergraduate education helps prepare students for careers in which professional competence must continually evolve.

5 In closing

For the past two decades, engineering accreditation has increasingly adopted an outcomes-based approach that focuses on what graduates are able to do in terms of competencies and skills. Rather than prescribing detailed curricular inputs, related to the number of practice hours or the length of practice placements, accreditation frameworks articulate a set of programme outcomes that practitioners must evidence through their curriculum design, teaching practices, and assessment strategies. This principle-based model has become a defining feature of engineering education globally and has been widely disseminated through international agreements and accreditation frameworks.

In contrast to many other professions, where programme approval processes remain more strongly input-driven — specifying required contact hours, subject coverage, or curriculum structures — engineering accreditation places primary emphasis on the demonstrable attainment of competencies and skills relevant to professional practice. This shift has enabled greater flexibility for programme providers while ensuring that graduates meet internationally recognised standards of engineering competence.

For you as practitioners, this approach places responsibility on programme teams to design coherent curricula, align learning outcomes with accreditation requirements, and implement assessment strategies capable of evidencing graduate capability. When implemented effectively, outcomes-based accreditation provides a robust mechanism for supporting the development of competent engineers prepared for contemporary, rapidly evolving professional contexts.

References

Aoudia, M., & Abu-Alqahsi, D. A.-D. (2015). Curriculum redesign process for an industrial engineering program seeking ABET accreditation. International Journal of Engineering Pedagogy, 5(3), 45–52. https://doi.org/10.3991/ijep.v5i3.4670

Ajjawi, R., Tai, J., Dollinger, M., Dawson, P., Boud, D., & Bearman, M. (2024). From authentic assessment to authenticity in assessment: broadening perspectives. Assessment and Evaluation in Higher Education, 49(4), 499–510. https://doi.org/10.1080/02602938.2023.2271193

Biggs, J., & Tang, C. (2011). Teaching for quality learning at university. McGraw-Hill.

Boud, D. (2007). Reframing assessment as if learning were important. In Boud, D. (Ed.), Rethinking assessment in higher education: Learning for the longer term (pp. 14–26). Routledge. https://doi.org/10.4324/9780203964309-8

Cambridge Dictionary (2025). External examiner. https://dictionary.cambridge.org/dictionary/english/external-examiner

Carthy, D., Craps, S., Langie, G., Gaughan, K., & Bowe, B. (2022). A situational judgement test for engineers to evaluate their professional strengths & weaknesses. In Proceedings of the 50th Annual SEFI Conference. https://doi.org/10.5821/conference-9788412322262.1109

Carthy, D., Manton, R., & O'Gorman, L. (2023). Embedding sustainability in the engineering curriculum: Meeting the requirements of professional accreditation. In Proceedings of 51st SEFI Annual Conference (pp. 1782–1793). https://doi.org/10.21427/6K33-5W68

Chance, S., Børsen, T., Martin, D. A., Tormey, R., Lennerfors, T. T., & Bombaerts, G. (Eds.). (2025). The Routledge international handbook of engineering ethics education. Routledge. https://doi.org/10.4324/9781003464259

Cheng, A., Lin, Y., Reedy, G., Joseph, C., Wirkowski, S., Mallette, V., Nagesh, V., Krieser, D., & Calhoun, A. (2025). Ability of AI detection tools and humans to accurately identify different forms of AI-generated written content. Advances in Simulation, 10(1), Article 66. https://doi.org/10.1186/s41077-025-00396-6

Cole, R. (2023). The use of peer assessment and group peer moderation to develop "soft" skills in engineering students researching sustainable energy. In Proceedings of 51st SEFI Annual Conference (pp. 1849–1856). https://doi.org/10.21427/65GD-BR02

ENAEE. (2022a). About ENAEE. www.enaee.eu/about-enaee/

ENAEE. (2022b). EUR-ACE framework standards and guidelines (EAFSG). www.enaee.eu/wp-content/uploads/2023/11/EAFSG-approved-4-Nov-2021.pdf

ENAEE, & IEA. (2024). Best practice in accreditation of engineering programmes: An exemplar. https://www.enaee.eu/wp-content/uploads/2024/11/ENAEE-IEA-Best-Practice-in-Accreditation-of-Engineering-Programmes.pdf

Engineering Council UK (ECUK). (2020). The Accreditation of Higher Education Programmes (AHEP) fourth edition. https://www.engc.org.uk/media/isdl1tem/the-accreditation-of-higher-education-programmes-ahep-v44.pdf

Engineers Ireland. (2021). Accreditation criteria. https://www.engineersireland.ie/LinkClick.aspx?fileticket=Mz3SCCk_uRg%3d&portalid=0&resourceView=1

European Commission. Directorate General for Education and Culture. (2015). ECTS users' guide 2015. Publications Office. https://data.europa.eu/doi/10.2766/87192

Farrell, F., & Carr, M. (2019). The effect of using a project-based learning (PBL) approach to improve engineering students' understanding of statistics. Teaching Mathematics and Its Applications, 38(3), 135–145. https://doi.org/10.1093/teamat/hrz005

Guerra, A., Holgaard, J. E., & Jolly, A. M. (2017) Sustainability accreditation in engineering education. In SEFI 45th Annual Conference, Azores, Portugal (pp. 137–144). https://doi.org/10.5281/zenodo.14698011

Gwynne-Evans, A. J., Chetty, M., & Junaid, S. (2021). Repositioning ethics at the heart of engineering graduate attributes. Australasian Journal of Engineering Education, 26(1), 7–24. https://doi.org/10.1080/22054952.2021.1913882

Homan, E. (2020). The engineer in society: An exploration of the treatment of ethics in engineering education and practice. [Doctoral dissertation, NUI Maynooth]. https://mural.maynoothuniversity.ie/id/eprint/13534/

Hussain, W., Spady, W. G., Naqash, M. T., Khan, S. Z., Khawaja, B. A., & Conner, L. (2020). ABET accreditation during and after COVID19 - navigating the digital age. IEEE Access: Practical Innovations, Open Solutions, 8, 218997–219046. https://doi.org/10.1109/ACCESS.2020.3041736

IEA. (2015). A history of the International Engineering Alliance and its constituent agreements: Toward global engineering education and professional competence standards. www.internationalengineeringalliance.org/assets/Uploads/Documents/History/IEA-History-1.1-Final.pdf

IEA. (2021). International Engineering Alliance graduate attributes & professional competencies. https://www.internationalengineeringalliance.org/assets/Uploads/IEA-Graduate-Attributes-and-Professional-Competencies-2021.1-Sept-2021.pdf

Lawlor, R. (2021). Teaching engineering ethics: A dissenting voice. Australasian Journal of Engineering Education, 26(1), 38–46. https://doi.org/10.1080/22054952.2021.1925404

Li, H., Chu, Y., Yang, K., Copur-Gencturk, Y., & Tang, J. (2025). LLM-based automated grading with human-in-the-loop. https://arxiv.org/pdf/2504.05239

MacLeod, M., & van der Veen, J. T. (2020). Scaffolding interdisciplinary project-based learning: A case study. European Journal of Engineering Education, 45(3), 363–377. https://doi.org/10.1080/03043797.2019.1646210

Martin, D.A. (2020) Towards a sociotechnical reconfiguration of engineering and an education for ethics: A critical realist investigation into the patterns of education and accreditation of ethics in engineering programmes in Ireland. [Doctoral dissertation, Technological University Dublin]. https://doi.org/10.21427/7M6V-CC71

Murphy, E., Nolan, M., Carden, M., Keogh, C., & Goodman, L. (2025). Inclusive by design: Embedding EDI in engineering through design thinking hackathons. In R. Kangaslampi, G. Langie, H.-M. Järvinen, & B. Nagy, (Eds.), SEFI 53rd Annual Conference, Tampere, Finland. https://doi.org/10.5281/zenodo.17631664

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

Pauzi, Z., & Capiluppi, A. (2023). Applications of natural language processing in software traceability: A systematic mapping study. Journal of Systems and Software, 198, Article 111616. https://doi.org/10.1016/j.jss.2023.111616

Phillips, D., & Quilligan, M. (2024). Educating the whole engineer — educational experiences that have impact in a civil engineering problem based learning programme. Proceedings of the 52nd Annual Conference of SEFI, Lausanne, Switzerland. https://doi.org/10.5281/zenodo.14254848

Poser, H. (1998). On structural differences between science and engineering. Techné: Research in Philosophy and Technology, 4 (2), 128–135. https://doi.org/10.5840/techne1998426

Power, J. R., & Tanner, D. (2023). Peer assessment, self-assessment, and resultant feedback: an examination of feasibility and reliability. European Journal of Engineering Education, 48(4), 615–628. https://doi.org/10.1080/03043797.2023.2185769

Spady, W. G. (1994). Outcome-based education: critical issues and answers. American Association of School Administrators.

UNESCO. (2023). Guidance for generative AI in education and research. https://doi.org/10.54675/ewzm9535

Van den Broeck, L., De Laet, T., Dujardin, R., Tuyaerts, S., & Langie, G. (2024). Unveiling the competencies at the core of lifelong learning: A systematic literature review. Educational Research Review, 45, 100646. https://doi.org/10.1016/j.edurev.2024.100646

Vlăsceanu L., Grünberg & L. Pârlea D. (2007). Quality assurance and accreditation: A glossary of basic terms and definitions. UNESCO-CEPES. https://unesdoc.unesco.org/ark:/48223/pf0000134621

Winterton, J., Delamare-Le Deist, F., & Stringfellow, E. (2006). Typology of knowledge, competencies and skills. Office for Official Publications of the European Communities. www.cedefop.europa.eu/en/publications/3048

AI statement

During the preparation of this work, the authors used OpenAI, GPT 3.5 to structure the case study on the effective integration of accreditation requirements into the curriculum. Once a structure had been established, the authors wrote the substantive content of the case study. They take full responsibility for the content of the publication.

Contributor statement

Conceptualisation	Darren Carthy, Richard Lillingon, José Carlos Quadrado
Formal analysis	Darren Carthy, Richard Lillingon, José Carlos Quadrado
Investigation	Darren Carthy, Richard Lillingon, José Carlos Quadrado
Project administration	Darren Carthy, Richard Lillingon, José Carlos Quadrado
Writing - original draft	Darren Carthy, Richard Lillingon, José Carlos Quadrado
Writing - reviewing and editing	Darren Carthy, Richard Lillingon, José Carlos Quadrado

[i] *an external examiner is someone from outside a student's own school, college, or university who judges an exam. (Cambridge Dictionary, 2025).*