4.7

Multi-Level Integration: Transferable Skill Development at the University of Birmingham

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The University of Birmingham School of Engineering (United Kingdom) employs a multi-level approach to foster students' transferable competencies and skills. This integrated strategy, underpinned by conceptualisations of professional identity and engineering student belonging, operates across institutional, faculty, and curriculum levels. At the institutional level, the Birmingham Graduate Attributes cultivate skills through the qualities of intellectual curiosity, future focused, and practical wisdom. Concurrently, the co-curricular Birmingham Engineer Professional Identity Framework develops skills through professional identity via engineering perspectives such as professional registration and engineering habits. Finally, in the curriculum, Integrated Design Projects develop skills through interdisciplinary challenge-based learning in group settings. This holistic framework ensures that, during their studies, learners develop robust transferable competencies and skills for their future careers, enabling them to make broader societal contributions in line with the university's civic commitment to be at the centre of its region's renaissance.

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1 Introduction

1.1 Context and rationale

The University of Birmingham is a research intensive, internationally reputable public university located in the West Midlands in central England, considered the heart of industrial Britain. It has been consistently placed in the top 100 world universities (University of Birmingham, 2025). Its engineering education programmes exist within the context of a large multidisciplinary Engineering faculty of ca. 2500 students and ca. 150 academic staff.

At the start of the twenty-first century the landscape of UK higher education shifted significantly, with increasing marketisation creating an imperative to prioritise student satisfaction and employability. In this context, where students are perceived as customers, a robust and flexible transferable skills development framework was needed to deliver improved student experience. Furthermore, this had to be flexible enough to support a diverse student cohort from several engineering disciplines, who are equally split between home and international students. The merger of Civil, Electrical, Electronic & Systems, and Mechanical Engineering schools in 2015 served as the catalyst for this change, presenting a unique challenge to unify transferable skill development.

1.2 The University of Birmingham's multi-level skill framework

Our multi-level skill framework is designed to be synergistic to ensure that skills are developed, contextualised, and recognised across the entirety of the student experience, in and outside of the curriculum. The framework operates at three distinct levels, each conceptualising skills through a distinct lens so that abstract graduate qualities are grounded in engineering:

- *Institutional level.* The Birmingham Award and My Attributes Platform. This university-wide initiative establishes the core principles for skill development and reflection through the lens of qualities: the Birmingham Graduate Attributes (see Sections 2.2 and 4.1).
- *Faculty level.* The Birmingham Engineer, a professional identity framework that acts as a crucial bridge by contextualising the Birmingham Graduate Attributes through the lens of professional identity, thus supporting the development of a sense of belonging (see sections 2.3 and 4.2).
- *Curriculum level.* Integrated Design Projects (IDPs) put theory into practice, conceptualising skills through the lens of competencies, so that students can demonstrate they can apply those skills in a professional context. The IDPs are a series of challenge-based, multidisciplinary level 6 modules — in accordance with the European Qualifications Framework (EQF) — run across multiple engineering programme. They serve as the primary setting where students learn a range of transferable skills in a scaffolded, team-based environment (see sections 2.3 and 4.3).

1.3 Chapter overview

This chapter presents a holistic, multi-level framework for transferable skill development, offered as an evidence-based case study and actionable guide for institutions seeking to implement a similar approach. We move beyond single interventions by connecting institutional graduate attributes to faculty professional identity formation and challenge-based learning. Section 2 describes our underlying philosophy and models. Section 3 describes the change management required. Section 4 presents case studies of each level in practice and the student journey. Section 5 concludes with a summary, outlook, and advice for practitioners.

2 Conceptual foundations: understanding transferable competency and skill development at Birmingham

Table 4.7.1 provides a high-level overview of our framework, listing the key aspects and activities at each level, and the lens through which skills are conceptualised and presented to students.

Table 4.7.1: The University of Birmingham's multi-level skills framework.

Birmingham initiative	*Level*	*Lens*	*Key aspects/activities*
The Birmingham Attributes and Award	Institution	Qualities	Intellectual curiosity, future-focused, practical wisdom
The Birmingham Engineer Professional Identity Framework	Faculty	Identity	Professional registration, engineering habits of mind
Integrated Design Projects	Curriculum	Competencies	Multidisciplinary, challenge-based teamwork

2.1 Theoretical underpinnings and application framing

The approach to transferable skills development at Birmingham draws on educational psychology and pedagogical theory, particularly Vygotsky's (1978) concept of zone of proximal or potential development (ZPD) — the gap between what the learner can do independently and what they can achieve with guidance of educators and/or more knowledgeable peers. The related idea of scaffolding (Wood et al., 1976) describes the temporary structures that enable learners to function within their ZPD and then move beyond it. Both theories emphasise the social nature of learning, highlighting the importance of interaction, language, and cultural context in developing analytical and practical skills, including in STEM education (Rahman, 2024).

Bloom's revised taxonomy (Anderson & Krathwohl, 2001) adds a cognitive structure to this social framing, supporting the use of formative feedback, peer mentoring, and problem- and design-based learning as methods to promote progression. These strategies guide learners through iterative challenges that shape their personal and professional identity. Integrated Design Projects (Section 4.3) make direct use of ZPD and scaffolding principles. While educators often apply ZPD intuitively, explicit application has stronger and longer-lasting effects, benefiting students and the professional community.

The Birmingham Graduate Attributes (Sections 2.2 and 4.1) and related initiatives that strengthen learners' academic and disciplinary belonging also connect to these frameworks, highlighting the value of guided interaction, structured support, and aspirational thinking in shaping learning outcomes within the Birmingham engineering community.

A sense of belonging (Section 2.3) fostered through psychological safety as explored by Edmondson et al. (2016), then acts as a catalyst for deeper engagement, sustained motivation, and self-efficacy (Lytle & Shin, 2020). When students feel recognised and valued, they are more likely to take intellectual risks, seek feedback, and collaborate meaningfully. This emotional and social anchoring complements the cognitive and pedagogical structures above, reinforcing the impact of scaffolding and ZPD-based approaches in shaping confident, capable graduates, and links these practices to the Birmingham Graduate Attributes that frame how skills, qualities, and values are cultivated across the university.

2.2 The Birmingham Graduate Attributes

These institution-wide attributes were first launched in 2015 and were intended to help drive and contextualise all faculty-level skills initiatives, including those in Engineering. Education leaders were tasked to ensure that all students experienced a range of carefully crafted activities to help them to develop attributes deemed to be essential qualities that will help learners to be successful in their study, work, and wider lives. Following a three-year process of research, consultation, and revision, the attributes were revised in 2023. In this current formulation, nine attributes sit under three overarching headings.

1. *Intellectually curious:* to be self-motivated researchers and learners, engaging in cutting-edge academic disciplines.
    a. *Subject specialists:* experts in discipline-specific knowledge and enquiry-informed practices.
    b. *Critical and creative thinkers:* analytical and independent reflective thinkers.
    c. *Interdisciplinary as people:* possessing a breadth of knowledge beyond specialist subject that is shared with others.
2. *Future-focused:* to be resilient and innovative in the activation of positive change with a commitment to lifelong learning and personal development.
    a. *Instinctively digital:* ability to use and evaluate new and emerging digital technologies.
    b. *Entrepreneurial spirit:* creative with the ability to generate ideas and lead change that benefits others.
    c. *Sustainability-focused:* committed to sustainable development in every aspect of life.

3. *Practical wisdom:* to act with humility, confidence, and good judgement to do the right thing at the right time.
    a. *Socially engaged:* actively helps others and the wider community to flourish.
    b. *Natural collaborators:* works collaboratively and can communicate with diverse audiences. Removes barriers for people who are different from themselves.
    c. *Courageous integrity:* takes on new challenges. Committed to truth and acts in alignment with moral principles.

While no list of attributes can be definitive, in developing this current list, it was important to ensure there was a balance between the skills, qualities, and values that will help students become successful in their life or career, as well as those that are necessary for them to contribute positively to their communities, in line with the university's broader civic mission. Through widely championing a list of nine attributes, the aim is for academic and professional services colleagues to adapt them into the context of their work, in ways which best support learners to develop the essential knowledge, skills, and character qualities required to flourish in the modern world.

The transferable competencies and skills as distinguished in this handbook can be associated to the nine attributes, with the caveat that any association may be up for debate. For example, both Birmingham Graduate Attributes 'subject specialists' and 'instinctively digital' fundamentally rely on the ability to 'seek, evaluate, use, and create information effectively', that is, information literacy. A suggested mapping comparing the nine attributes against the competencies and skills as formulated in this handbook is provided in Table 4.7.2. This will assist readers in formulating their own attributes or considering their existing institution's graduate attributes, where available, and relating them to transferable competencies and skills.

2.3 Operationalising skills and the role of student belonging

Student belonging, defined as "*a feeling or sensation of connectedness, and the experience of mattering or feeling cared about, accepted, respected, valued by, and important to the campus community or others on campus such as faculty, staff, and peers"* (Strayhorn, 2018, p. 4), is a relational and developmental quality of the student experience. It interacts with students' expressed and perceived identities as they move through their academic and professional journey.

Belonging is more than 'fitting in': it is a set of skills that enable individuals and groups to interact safely and meaningfully, build knowledge, and create meaning together. Belonging connects closely to personal qualities such as resilience, engagement, and courage.

It makes proactive engagement easier, while also acting as a buffer against adversity. Structural and societal barriers to belonging in engineering must therefore be recognised, especially for minoritised and marginalised groups, alongside situational challenges such as module or group dynamics. Addressing these barriers requires both supportive learning environments and broader institutional action. Offering alternative and culturally diverse perspectives on engineering problems accelerates authentic development, while curriculum decolonisation broadens the range of approaches available to students. This is not about substitution but expansion, enhancing adaptability, cultural awareness, and 'courageous integrity'.

Table 4.7.2 Mapping of Birmingham Graduate Attributes to this handbook

	I - Responsibility, project management, and leadership	*II - Communication and interpersonal skills*	*III - Professional commitment/ lifelong learning competencies*
1.a Subject specialists	Project management (on process level)	Written reporting skills	Information literacy skills
1.b Critical and creative thinkers	Risk analysis and risk management skills	Listening skills	Self-reflection
1.c Interdisciplinary	Project management (on process level)	Teamwork; multi-, inter-, and transdisciplinary teamwork	Learning strategies
2.a Instinctively digital	Operational awareness	Visualisation skills	Information literacy skills
2.b Entrepreneurial spirit	Leadership skills	Pitching skills	Initiative
2.c Sustainability focused	Risk analysis and risk management skills	Adaptive communication style	Adaptability for change
3.a Socially engaged	Leadership skills	Interconnection/ interrelation ability	Autonomous motivation
3.b Natural collaborators	Meeting skills	Teamwork; collaborative goal setting	Self-regulation
3.c Courageous integrity	Leadership skills	Giving feedback	Resilience

A recently developed engineering student belonging model (Cooke et al., 2023) combines psychologically safe, culturally diverse teamwork, professional identity, curriculum decolonisation, and race equality promotion as complementary elements (Fig. 4.7.1).

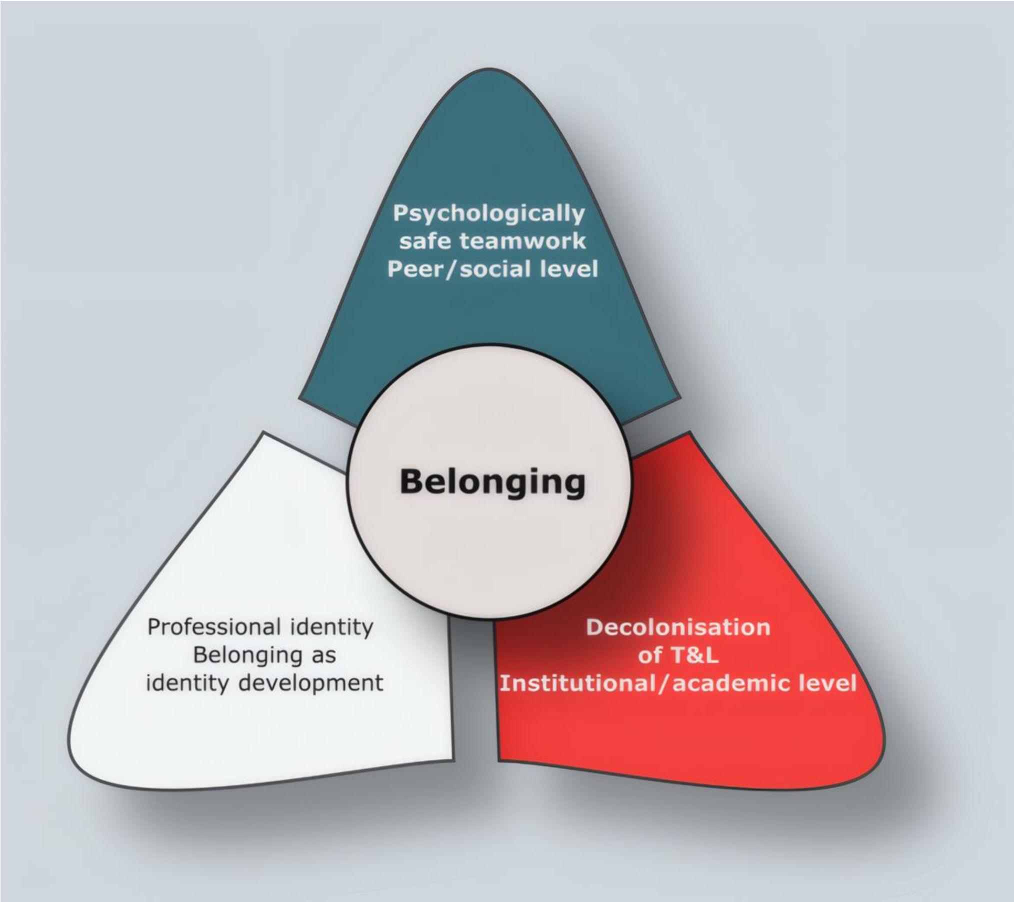

Figure 4.7.1: Engineering student belonging model, artwork by Favero (Own Work)

The principles of this model shape the practical design of transferable skills at Birmingham. For example, the Integrated Design Projects (Table 4.7.1, Section 2) are structured to promote psychologically safe and culturally diverse teamwork in scaffolded settings. Likewise, the Birmingham Engineer Framework (Table 4.7.1) supports the development of students' academic self-concept as emerging professionals.

In this way, belonging is embedded in the multi-level skills framework: institutionally through initiatives such as the Birmingham Award and My Attributes Platform, co-curricular through the Birmingham Engineer, and in the curriculum through IDPs. This alignment creates a synergy between personal identity, peer interaction and institutional culture, ensuring that belonging functions both as a developmental experience and as a transferable competence across all levels of the framework. These dimensions also connect with the three levels of the belonging model that follow: individual, peer, and institutional.

Individual level: belonging as identity development

On an individual level, student belonging is closely linked to identity development as learners and future engineers (Lytle & Shin, 2020). As demonstrated by investigations of belonging at the individual student level (Dost, 2024; Dost & Mazzoli Smith, 2023), initiatives that address both identity and belonging together promote growth while reducing isolation and alienation. The development of belonging in the students as a process at Birmingham is supported through skills-focused programmes such as the Birmingham Engineer, which frames identity as social, personal, and domain-specific.

Peer/social level: teamwork and interaction

Peer interactions play a central role in shaping how students engage with others, navigate team dynamics, and develop a sense of belonging within the wider engineering learning community. Teamwork offers opportunities but also challenges, especially in culturally diverse context where norms may be unfamiliar. Ongoing research at Birmingham shows that learners from diverse social or cultural backgrounds, including international students, can feel unsettled by dominant cultural norms. In response, educators have introduced smaller group sizes, structured heterogeneity, role definitions, and communication training (e.g., leading meetings, productively engaging with peers, and managing conflict). These interventions build confidence and belonging while developing skills aligned with both the Birmingham Graduate Attributes and the Birmingham Engineer.

The emphasis on psychologically safe teamwork is reinforced by principles of non-violent communication (Pinto et al., 2023) and by recognising cultural and personality differences. Rather than assuming prior knowledge, educators actively support students in developing respectful, inclusive collaboration skills. This reduces reliance on staff to manage conflict and encourages autonomous, constructive teamwork, ultimately enhancing students' sense of belonging and their ability to co-create knowledge.

Institutional level: inclusive culture

At the institutional level, belonging depends on policies, practices, and cultural frameworks that shape the learning experience. Students must not only access disciplinary knowledge but also feel empowered to influence institutional culture. This requires developing contextual competencies: understanding and navigating academic and professional norms while contributing to them.

At Birmingham, inclusion is a strategic priority, reflected, among others, in race equality initiatives, curriculum decolonisation, and inclusive pedagogy. These broaden perspectives and problem-solving approaches students are exposed to and enhance adaptability, cultural awareness, and what Birmingham terms 'courageous integrity' as defined in the Birmingham Graduate Attributes (Section 2.2). Curriculum decolonisation is framed as constructive — broadening rather than replacing — and is tied to students' academic self-concept and professional identity as individuals and as part of a community of knowledge.

Institutional belonging also means tackling systemic barriers faced by minoritised and marginalised groups, not just individual or situational challenges. Practices that create inclusive environments help students feel recognised, supported, and able to thrive. In turn, this reinforces belonging as relational and developmental, deeply embedded in the social and institutional fabric of engineering education.

3 Catalyst: The School of Engineering merger

Our multi-level skills framework was an organic response to the top-down 2015 merger of engineering schools to create a new School of Engineering. This section details key aspects of the change process: its catalyst, the challenges it presented, and how they relate to the skills framework that was developed in response, driven by faculty engagement and buy-in to the change.

3.1 The catalyst: a school-wide merger

The School of Engineering is a combination of three departments: Civil Engineering, Electronic, Electrical & Systems Engineering and Mechanical Engineering. It was formed in 2015 due to market, economic, and organisational imperatives, as well as the complexity and demands of a modern engineer. Such an amalgamation required strong leadership, coordination, and detailed planning to ensure a smooth transition. The complex nature of the merger led to a number of challenges, including change in the environment, estate, relocation, and emotional attachment to previous schools and their cultures. In breaking down disciplinary silos, it provided a unique opportunity to unify transferable skill teaching across engineering disciplines.

3.2 Addressing the merger's key challenges

Integrating diverse student cohorts

We implemented a revised structure for the delivery of the undergraduate curriculum, including a shared common first year for all disciplines. As part of the process to support the integration of this diverse student cohort, the skills framework was instigated. The Birmingham Engineer (Section 4.2) was rolled out across all programmes, supported by personal academic tutors. In tandem we developed the Integrated Design Projects (Section 4.3), a flagship suite of modules running from the first to third years of the three- and four-year bachelor degree programmes. Furthermore, visiting professors from industry were appointed to support the development of an industry-ready curriculum. Careful consideration was given to all school aspects, including education support and administration, student well-being, integration, and culture.

Scaling the student experience

To meet the challenge to maintain a personalised, inclusive student experience in response to increased student numbers, we responded with strategies to improve perceptions of belonging (Section 2.3) including professional identity through the Birmingham Engineer. The demand to enrol on Engineering degrees in the UK has risen over the past decade (Fowler et al., 2023). Indeed, cohort sizes at Birmingham increased significantly since 2020, with undergraduate and postgraduate total populations growing approximately 25% to 2500 in 2025. This dramatic rise in student numbers risked a depersonalised and diluted student experience; therefore, a scalable support strategy within institutional constraints was fundamental. As is often the case, the increase in cohort size did not lead to an immediate in-step increase in resources of the same proportion. Notably, maintaining practical skills within the curriculum, such as laboratory and workshop practical skills, was the key challenge, compounded by the greater emphasis on teaching transferable skills. This challenge was met by encouraging co-curricular activities, including a state-of-art makerspace for students to pursue personal interest projects as part of the Birmingham Engineer.

Navigating accreditation demands and entry patterns

The majority of our degree programmes are accredited by the relevant professional engineering institution (PEI) through the UK Engineering Council framework (Accreditation of Higher Education Programmes (AHEP) (Engineering Council, 2021). We learned several lessons. Notably, the interpretation of AHEP for each PEI varied, guided by subject-specific learning outcomes. Consequently, requirements on their assessment had to be satisfied in programme designs in such a way that no discipline fell short of its accreditation requirements. Early identification of issues was fundamental to this process. Moreover, updated versions of AHEP, notably AHEP4, required reconsideration. Notably with reference to Bloom's taxonomy (Anderson, 2021), the cognitive level for many of the learning outcome areas was raised, changing requirements from understanding and applying to creating and evaluating. Moreover, not all students arrive at the beginning the first year (IET, 2021). Other entry patterns include foundation year and direct entry into Years 2 and 3 from regional colleges and international partner universities, as well as Degree Apprentices from industry partners, which include mature students. The coherent structure of our multilevel skills framework to cater to all engineering disciplines in a unified presentation fulfilled these needs to deal with multiple accreditation bodies and student entry patterns.

Education-focussed career pathways for academics

Finally, we recognised that the challenge of developing a skill framework within a multidisciplinary engineering context amidst the pressures of a research-intensive institution could not be solely met by an academic body primarily motivated and incentivised through maximising grant capture and scientific publication. An education-focussed path was offered to academics to ensure faculty capacity could expand to meet this challenge of developing the new education offer and student experience. This freeing up of academics' time from research to focus on education value-creation included developing the skills framework. Over time this has had the result of facilitating the development of engineering education research and scholarship within the academic body. Valid concerns about career stagnation by academics in education-focussed routes were met by the school's leadership moving on to create a comprehensive and transparent promotion system across the whole university in December 2021 – The Birmingham Academic Career Framework (Sterling et al., 2023). This provided 3 core promotion pathways for staff to follow: Research and Education, Education, and Enterprise, Engagement and Impact. This has subsequently created several professors in engineering education.

Adaptation and resilience: aligning with institutional strategy

In 2021, the university launched its Birmingham 2030 strategic plan. It set out a visionary framework for the institution, focusing on sustainability, innovation, and inclusivity. It introduced a fresh institutional language emphasising collaborative growth, interdisciplinary research, and community engagement (University of Birmingham, 2021). Because our skills framework preceded the plan, we had to retrofit it to align with this new context. This alignment process was significant: the graduate attributes (Section 2.1) were updated from their 2015 version, the Birmingham Engineer was revised with more action-oriented language to encourage more students to participate in skill-development activities, and the IDPs incorporated a stronger focus on transferable skill reflection. Our successful adaption validated our approach, proving it to be robust to university-level strategic shifts while maintaining integrity and relevance to engineering in meeting the needs of students, accrediting bodies, and industry.

4 The multi-level initiatives in practice

Having established the theoretical foundations in Section 2 — the 'what' — and the context for change in Section 3 — the 'where', 'why', and 'when' — this section details the practical application of the framework — the 'how'. We describe each of the three levels separately, finishing with an example of a student journey to illustrate the interplay between levels to create a single, cohesive experience.

4.1 Institutional-level initiative: the Birmingham Graduate Attributes, Birmingham Award and My Attributes platform

While the Birmingham Attributes described in Section 2.2 are 'caught' through the ethos, values, and culture of the organisation, they are also more explicitly 'taught'. Students are offered planned opportunities to develop the attributes. Examples of opportunities afforded to all students include 'My Attributes', a digital portfolio developed by the University Careers Service, and the opportunity to receive the 'Birmingham Award'.

My Attributes platform

The My Attributes platform is optionally available to all students to review, and aims to reward them for developing knowledge, skills, and attributes necessary for study, work, and life. We developed this in consultation with students. On the platform, students can access the assessment section to self-audit their skills and attributes and gain a personal overview of the strengths and competences they might seek to develop further. Students also have access to learning pathways for each of the graduate attributes. The primarily online learning modules enable students to develop their knowledge and understanding about the graduate attributes through the completion of self-directed learning activities. Learning activities are available for them to work through at their own pace.

The Birmingham Award

The Birmingham Award is an optional programme that undergraduate students take alongside their degree to develop, recognise, and articulate the attributes they have developed from engagement in student life at Birmingham. Students can choose from a portfolio of circa 250 activities that are part of student life, each mapped to the graduate attributes. If students complete four attribute reflections on extracurricular activities which they feel have helped them to develop one or more of the graduate attributes, they will be rewarded by gaining the Birmingham Award on their graduation transcript. Students who complete it are offered the opportunity to gain the more advanced Birmingham Award with Distinction. The Distinction level is a quality-assured structured education programme that allows a learner to explore and develop a deeper understanding of their attributes through online and classroom-based teaching sessions, co-produced with graduate recruiters. Every year c. 2000 students enrol onto the award, from a range of undergraduate year groups and disciplines. The most recent post-evaluation self-assessment indicates that of the students who completed this optional programme in 2022-23, 87% were motivated to undertake further action to enhance their employability as a direct result of undertaking the award. Individual student reflections also show that the Award has helped them to develop their attributes gained and to articulate them, particularly within an employability context.

4.2 Faculty-level initiative: the Birmingham Engineer Professional Identity Framework

Bridging the gap between institution and profession

While the attributes set a general transferable skill development, the faculty needed to relate it to engineering. As a vocational subject, skill requirement is specified through PEIs for accreditation and employer needs. To bridge this gap in institutional expectations of graduate attributes to that of PEIs, we developed the Birmingham Engineer Professional Identity Framework.

Engineering identity

Defining engineering identity and its progression has gained interest over the last decade. Many identity studies in STEM education define it according to the conceptual model by Carlone and Johnson (2007), which comprises three overlapping aspects of identity: social, personal, and domain (engineering). The Birmingham Engineer builds on this model (Fig. 4.7.2). The Engineer aspect of student identity (left plane, more detailed in the middle plane) is developed by cultivating the student's subject interest, recognition, ability and performance. The embedding framework (right plane) comprises of four dimensions:

1. *Accreditation.* the learning outcomes of an accredited degree as defined by AHEP4 (Engineering Council, 2021).
2. *Institutional.* general skills and competences desired by the university for all students as defined by the Birmingham graduate attributes.
3. *Habits of mind.* thinking patterns associated with engineering professionals as defined by the Royal Academy of Engineering (Lucas et al., 2016).

4. *Career.* consideration of future identity and career.

Each dimension has an inventory of relevant skills and career aspirations associated with it, which is updated yearly in line with new approaches and policies. The overview in Fig. 4.7.2 is an example of a complete inventory.

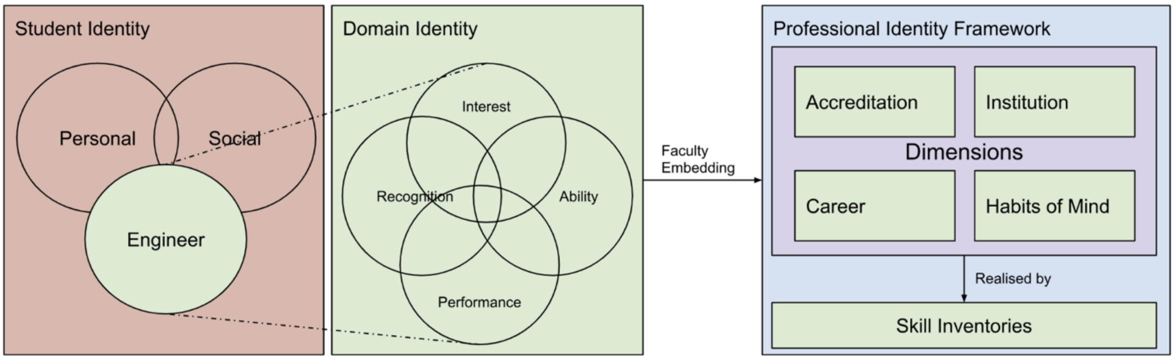

Figure 4.7.2: Professional identity embedding framework for engineering identity (Own Work by Cooke)

Process of activation and reflection

Students reflect on skill development through curricula and co-curricular experiences during their academic reviews. These are meetings held three times a year with their tutors — an academic assigned to them throughout their study to monitor their progress, provide academic support, and assist in referral for pastoral issues when necessary. To prepare for these meetings, against each skill specified in the skill inventories for the Birmingham Engineer, students rate themselves on a five-point Likert scale and upload one piece of work they have done as evidence.

Crucially, this process is not only reflective but also activates students' development of skills. For example, to acquire engineering habits in dimension C, students are encouraged to begin a passion project outside of the curriculum such as designing or building something in the school's makerspace — a state-of-art facility supporting both additive (3D printing) and subtractive (machining) manufacturing processes, visualisation tools (virtual reality), and electronics-printed circuit design. Likewise, attending industry-run events is seen to progress dimension D.

Useful analytics

Insightful analytics are available from the reflections students provide for their tutor meetings. We have used text analysis tools to examine word frequencies in students' written reflections of their skills to help reformulate our choice of words when describing the Birmingham Engineer's dimensions (Cooke, 2020). In the academic year 2024/25, students showed a small yet significant increase in identifying as an engineer — the average score increased from 3.9 in Year 1 to 4.2 in Year 3 (n=1178). Beyond tracking identity over time, the data allows for a deeper analysis of how students perceive the relationship between different skills and career motivations. To explore this, we analysed the skill ratings from our 2020/21 cohort using a statistical technique called agglomerative clustering. This method groups skills into a hierarchy based on how closely each student's ratings correlate, in essence creating a dendrogram (family tree) of related skills and career preferences (Fig. 4.7.3). This analysis reveals a logical and insightful structure to the students' developing professional identity from students in Year 2 upwards. We observed two primary clusters:

1. a 'core engineering' cluster, comprising of skills like engineering design, analysis, creativity, and systems thinking.
2. a 'transferable skills' cluster, which included skills such as learner strategies, leadership, and communication skills.

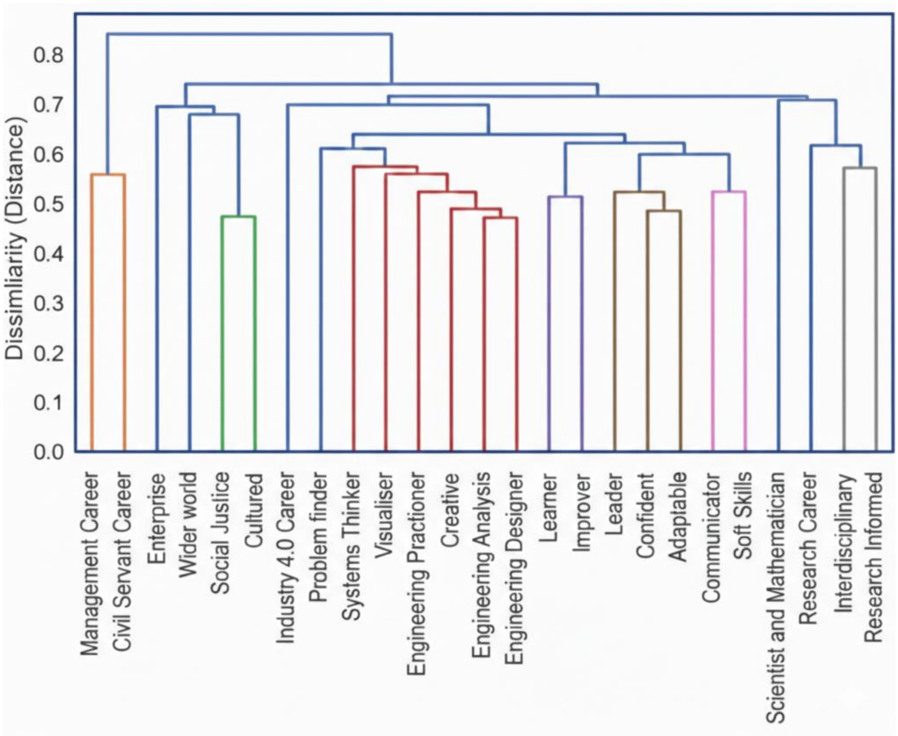

Figure 4.7.3: Dendrogram showing agglomerative clustering of self-ratings of skills by students in Year 2 upwards (n=263). The colours represent automatically identified clusters (Own Work by Cooke, 2021).

Crucially, these two clusters were strongly correlated with each other and with a stated motivation to pursue a career in industry. In contrast, a separate skill cluster including science and mathematics, interdisciplinary skills, and research-informed practice is correlated with a motivation to pursue a research career. This data-driven insight suggests that students appear to be forming coherent and distinct skill profiles that align with their career aspirations, providing evidence that the Birmingham Engineer is helping them to understand, develop, and articulate their unique identities. Notably, the same analysis of first-year students reveals no comparable structure, suggesting a valuable progression.

4.3 Curriculum-level initiative: Integrated Design Projects (IDPs)

The IDPs support the students' development of transferable skills and competencies in each year up to the third year of level 6 study. They employ challenge-based learning in multidisciplinary teams to find environmentally, socially and economically sustainable engineering solutions to real word problems. Each IDP module is 20 credits of 120 total credits awarded per year towards a degree, which is equivalent to 10 credits in ECTS. Each develops a key transferable competence area which can be broadly described as foundational, collaborative, and leadership for Years 1, 2 and 3 respectively.

Year 1: developing foundational competencies

IDP1 for first-year students is split into two parts. In the first, students develop individual professional engineering skills necessary to build a solid foundation as an engineer. These include research skills, report writing skills, presentation skills and design skills. The design process includes concept design sketches, product design specification, and computer-aided creative designs. In the second part, students build on the CAD skills developed in semester 1 by completing a more advanced design project and are introduced to teamwork to start building their collaborative competencies. They also complete an industry-standard project management spreadsheet to provide them with foundation-level project management skills that will be built on as they progress through their programmes.

Year 2: developing collaborative competencies

In IDP2, students in their second year develop collaborative competencies by completing two main assignments. For assignment 1, they complete an interdisciplinary team project which develops teamwork and project management skills. The real-world challenge project is typically motivated around the United Nations SDGs (Cooke, 2018), for example a concept design for an indoor vertical farm in a smart city. There are six students per group. To support teamwork, the assignment briefs provide detailed guidelines. The students follow sessions introducing them to project management principles including non-violent communication (Pinto, 2023), how to work effectively in a team, life cycle analysis, and building a business case. At the end of assignment 1 students are asked to reflect on the transferable skills needed for effective teamwork. In assignment 2 students are reallocated to discipline-specific teams with a shift in emphasis from transferable skill development and systems thinking towards discipline-specific designs. Because assignment 2 necessitates new groups, students have the opportunity to improve their transferable skills by putting into practice their reflections on teamwork required in the first assignment. Consequently, the teamwork experience is generally better.

Year 3: developing leadership competencies

For IDP3, third-year students take on a less structured and scaffolded real-life contemporary engineering design challenge which enables a focus on developing leadership competences. Whilst previous IDPs are taken exclusively by undergraduate students, the IDP3 cohort also includes postgraduate students from the MSc Advanced Mechanical Engineering programme, further diversifying the student cohort. IDP3 takes an innovative and intricate approach to teamwork. Like IDP2, students are divided into cross-disciplinary teams. However, the team size is bigger, typically up to 40 students. It is further divided into discipline-specific project groups to work on activities to feed into the team solution. To support accreditation requirements, distinction is also made in assessment criteria between students in bachelor (EQF level 6) and master (EQF level 7) engineering degrees.

A practical example of how a team challenge is distributed amongst the discipline-specific groups is shown in Table 4.7.3. To ensure students get a full experience of real-world engineering, there are several assessments. These include analysing the ethics of their design and identifying any risks, including health and safety and cybersecurity. In addition to leadership, students develop business and entrepreneurial competencies requiring financial plans, with MEng students required to provide a full business plan incorporating a financial forecast for the product as well as producing a prototype of it, allowing them to further develop practical engineering skills in addition to the transferable and design skills.

Table 4.7.3 Examples of team challenges and associated group design projects.

Team challenge	*Civil*	*Electrical*	*Mechanical*
Develop smart infrastructure systems	Structural design, sustainable construction materials, novel applications for advanced materials	Smart grids, sensing and control hardware and software	Provision of sustainable energy and power for infrastructure, adaptive movable components
Improve energy efficiency of the UK housing stock	Zero net carbon houses, micro-wind turbines for houses	Smart meters and intelligent appliances	Heat and air management, insulation materials, phase change materials
Transportable and/or adaptable health care systems for conflict zones	Structure for deployment, training facility and sustainable construction materials	Communications or power support infrastructure and portable data processing	Diagnostic, trauma or treatment equipment that can be transported, deployed, and administered rapidly

4.4 The student journey: an integrated experience

In this section we present a composite student, Maria, a female electrical engineering student, showcasing how she experiences the framework to illustrate how the interplay between different levels produces a unified journey.

Institutional level: the My Attributes platform and Birmingham Award

Maria signed up to the My Attributes platform (Section 4.1) during her first year, becoming familiar with the nine graduate attributes and recognising that many activities are transferable skill development opportunities. As a keen rugby player with coaching responsibilities for the back line, which include conducting post-performance analyses using game video footage, she has identified 'socially engaged', 'natural collaboration' and 'instinctively digital' as strengths from her rugby experience. She logs this extracurricular activity as developing her future focus and practical wisdom. She adds to her my attributes reflection that in rugby, players have different strengths and play different positions, and that during the game continual communication ensures everyone has a shared awareness. In the second year studying IDP2, she quickly recognises her teammates' comparative inexperience in teamwork.

Faculty level: the Birmingham Engineer

Maria is developing her engineering identity through the Birmingham Engineer (Section 4.2). Her tutor encourages her to take actionable steps to progress her profession along the four dimensions, e.g., join the Institution of Engineering and Technology (IET) to gain professional registration, keep the My Attributes platform up to date, develop a personal interest project in the makerspace, for example around wearable devices to monitoring head concussion in rugby, and explore potential engineering careers through participation in events run by the School of Engineering Employability Network (SEEN) — a school-wide platform supporting career development through strong integration with industry partners, including placements, skills sessions, and careers events.

Curriculum level: the IDP

In class, Maria is taking the IDP2 module (Section 4.3). She is in a team of five other students who are collaborating to develop a concept design for an indoor vertical farm in a smart city. To encourage student belonging and psychologically safe teamwork, the group has been constituted so that at least half are female. While this does not guarantee belonging and safety, we consider it a positive contribution towards it. She has taken the module's short courses in multicultural teamwork and inclusive leadership. Furthermore, she is being taught non-violent communication skills to resolve group conflict and anxiety. She immediately recognises that her experiences in playing rugby are transferable to the IDP2 group setting, where communication establishes trust, and group profiling using team roles is analogous to playing in a position. Based on the quality of these and similar reflections spanning institutional, faculty, and curriculum level, Maria is on track to attain the Birmingham Award for her skill development upon graduation.

5 Review, outlook, and advice

The strengths of our multi-level integration of skill development are to simultaneously foster in students a strong professional identity as engineers, while also capitalising on the strong sense of belonging and esteem which arises from the University of Birmingham's reputation.

5.1 Reflection on the current situation

Considering skills development at multiple levels in an institution invariably results in different presentations and skill lists, which risk stakeholder fatigue and confusion. Engineering educators will naturally focus on the learning outcomes as required by PEIs to assure accreditation. In most universities, institution-wide graduate attributes are laudable, anodyne, and perhaps interchangeable. However, they risk being considered irrelevant, unless a coherent integration between attributes and skills learned in the program is enacted. We have found that the key to realising this coherence is to both explicitly define the lens through which skills are conceptualised at each level — qualities, identity, and competencies in our case — with appropriate activities and presentation to maintain a perception of relevance and usefulness. Furthermore, our framework's segmented architecture is adaptable to new or revised initiatives without unduly affecting other parts. Finally, our nine graduate attributes ought not to be considered mutually exclusive or complete; we encourage and support students to develop any skill, character quality, and attribute they deem necessary to meet their professional and personal aspirations.

5.2 Outlook

Our work to develop the framework is ongoing. At the time of publication, the institutional-level skills framework is optional to the student; only the faculty-level and curriculum-level skills frameworks are embedded. To make the institutional-level framework more universal, implanting of the institutional-level framework into the curriculum is currently underway through the Ad Alta Pathway. Furthermore, a new incentive at faculty level includes a Birmingham Engineer Award for launch in 2027 to recognise participation at faculty level to reward participation in co-curricular activities which develop engineering identity.

5.3 Advice to other engineering educators

For fellow educators seeking to implement a similar multi-level approach, we offer three key recommendations.

- At institutional level, you should focus on developing nuanced graduate attributes that represent the culture and ethos of your institution alluding to clusters of skills rather than a boilerplate, generic skills list.
- At faculty level, you should promote belonging by creating a dedicated framework for engineering identity formation, integrating it into personal tutoring, and using analytics to track its impact.
- At the curriculum level, you should design a clear progression model for collaborative skill building during challenge-based learning, making

psychologically safe teamwork an explicit learning outcome supported by targeted interventions.

Ultimately, the success of this approach lies not in any single initiative, but in the intentional synergy created between all three levels.

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AI statement

During the preparation of this work, the authors used Google Gemini and Microsoft Copilot to improve clarity and readability. Figure 4.7.3 was originally generated in Python, then enhanced using Google Gemini to improve its resolution and to add a vertical axis label. After using these tools, the authors reviewed, edited, and made the content their own. They take full responsibility for the content of the publication.

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