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Integrated Engineering at University College London: Embedding Transferable Skills using PBL, Illustrated by the Biomedical Engineering Degree Programme

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The Integrated Engineering Programme (IEP) at University College London (UCL) was designed to make the development and assessment of transferable skills and competencies — such as teamwork and communication — an explicit and embedded part of the engineering curriculum. Recognising that these skills are best learned through experience, the IEP integrates them from the first term of the first year of undergraduate studies. This chapter describes the approach taken when embedding transferable skills into the engineering curriculum using problem-based learning (PBL). The latter sections illustrate how the department of Biomedical Engineering makes use of the IEP framework in early years of study and further builds upon the framework in later years of the degree programme. It should be noted that whilst Biomedical Engineering is discussed in this chapter, the application of the IEP framework applies to most of the undergraduate degree programmes at UCL Engineering and thus this chapter is written to be relatable to any engineering discipline looking to embed transferable competencies and skills into their curriculum.

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1 Introduction

There is a growing imperative to explicitly embed transferable skills within engineering curricula to meet evolving industry demands and global challenges. The AHEP4 framework and the World Economic Forum's *Future of Jobs Report* identify skills such as analytical thinking, adaptability, communication, teamwork, and ethical reasoning as critical for employability and innovation (World Economic Forum, 2025). These are increasingly valued alongside technical expertise. Addressing complex challenges like sustainability also requires competencies listed by UNESCO, including systems thinking, anticipatory reasoning, and integrated problem solving (UNESCO, n.d.). Such skills enable engineers to collaborate across disciplines, engage stakeholders, and design socially and environmentally responsible solutions. Embedding these competencies prepares graduates to navigate uncertainty, drive change, and contribute to sustainable development, reinforcing that engineering is both technical and societal.

Transferable skills development must be continuous and embedded throughout the degree, rather than treated as a one-off intervention. Skills such as communication, teamwork, ethical reasoning, and systems thinking require repeated practice in varied contexts to become meaningful and transferable. Embedding these opportunities across modules (including design projects, laboratories, interdisciplinary collaborations, and reflective assessments) supports deeper learning and application in real-world scenarios. This ensures such skills are integral to engineering identity and professional readiness.

Real-world problems, including climate change and global health, do not respect disciplinary boundaries. Embedding interdisciplinarity is therefore essential. Integrating perspectives from fields such as social sciences, business, design, and environmental studies fosters broader thinking and innovation. At UCL Engineering, interdisciplinarity is supported through problem-based learning (PBL), where students engage in identifying problems, designing solutions, and applying engineering principles collaboratively.

The Integrated Engineering Programme (IEP), introduced in 2014, catalysed curriculum transformation at UCL by embedding a shared educational vision centred on PBL, interdisciplinary learning, and transferable skills. Core modules and module components include 'Engineering Challenges', 'How to Change the World', and team-based 'scenarios', providing scaffolded opportunities for students to engage with global challenges and collaborate across disciplines. This structure promotes coherence, innovation, and graduate preparedness, while fostering pedagogical collaboration. The IEP has positioned UCL Engineering as a leader in curriculum reform (Graham, 2017).

Importantly, the IEP functions *not* as a traditional degree programme but as a pedagogic framework mapped across programmes. This enables consistency in skills-based teaching while supporting interdisciplinarity. It is coordinated by a central core IEP team to ensure alignment across departments.

This chapter examines how the IEP enables the embedding of transferable (professional) competencies and skills at curriculum level. It outlines the rationale for explicit skills development and presents a case study of the UCL Biomedical Engineering programme, developed alongside the IEP, demonstrating integrated delivery of technical and transferable competencies.

2 Institutional context and need

University College London (UCL) is a world-class, research-intensive university, founded in 1826, with a significant global presence. As of 2025, UCL hosts over 51,000 students from 150 different countries and employs more than 17,000 staff of which over 4000 are academic and teaching staff. The institution comprises of 11 faculties, including the Faculty of Engineering Sciences which includes 10 academic departments: Biochemical Engineering, Chemical Engineering, Civil, Environmental & Geomatic Engineering, Computer Science, Electronic & Electrical Engineering, Mechanical Engineering, Medical Physics and Biomedical Engineering, Science, Technology, Engineering and Public Policy (STEaPP), Security and Crime Science and the School of Management.

Most departments have at least two variations of their undergraduate programme: a 3-year programme (usually denoted as either a BEng — Bachelor of Engineering or BSc — Bachelor of Science) and a 4-year integrated master programme (MEng — Master of Engineering), all EQF level 7, where the first 3 years are the same as the aforementioned BEng or BSc. Each academic year comprises of three terms (or semesters), each 10 weeks long, sandwiched between Christmas and Easter breaks. Terms 1 and 2 contain the bulk of teaching and term 3 is traditionally used for exams. In the first year of a typical BEng/MEng programme, terms 1 and 2 consist of four 15-ECTS modules each.

The motivations for radical curriculum change within UCL Engineering, leading to the Integrated Engineering Programme (IEP), stemmed largely from a perceived skills gap (Mitchell & Tilley, 2024). It sought to address the lack of interdisciplinarity in the curriculum at the time, meaning that each engineering programme was taught mostly in isolation. The aim was to develop a new generation of engineering graduates who were technically skilled, and ready to effectively transition into employment and become the progressive engineering leaders of the future, which required the acquisition of transferable competencies. This focus on a broader skillset aligns with ongoing discussions and policy projects, such as the Royal Academy of Engineering's 'Engineer 2030' initiative, which explores the future skills needs of engineers (Royal Academy of Engineering, 2025).

The implementation of the IEP involved a major revision of teaching and learning practices undertaken over three years before its launch in 2014. It was a cross-Faculty process, built on input from academics across various disciplines and while the concept was driven top-down, the implementation was largely from a bottom-up approach. In its implementation, a team of experienced teaching academics was assembled, supported by a small number of external hires who brought complementary skills and insight to the development. This process fostered a cultural change across the faculty, shifting the focus from teaching purely technical content to integrating project activities and skills development. and as of 2026, the IEP has formally integrated into the curriculum of 8 departments across the faculty (see Fig. 4.6.1).

3 Curriculum design

3.1 Introduction of a new engineering educational approach: the IEP

The IEP, as delivered at undergraduate programme level, consists of three core modules in year 1, two departmentally-led modules in year 2, a design challenge at the end of year 2 (that counts towards the year 3 capstone project) and a curated choice of elective modules taken in years 2 and 3, known as IEP minors. The IEP framework primarily sits within the first two years of the UCL Engineering degree programmes as this is where the majority of the commonalities across disciplines are. However, the educational philosophy behind the IEP has been adapted and adopted on engineering programmes beyond the first two years, as seen in this chapter within the Biomedical Engineering programme. The structure of the IEP framework and how it sits across the multiple Engineering programmes at UCL can be seen in Fig. 4.6.1. Each of these components is described below.

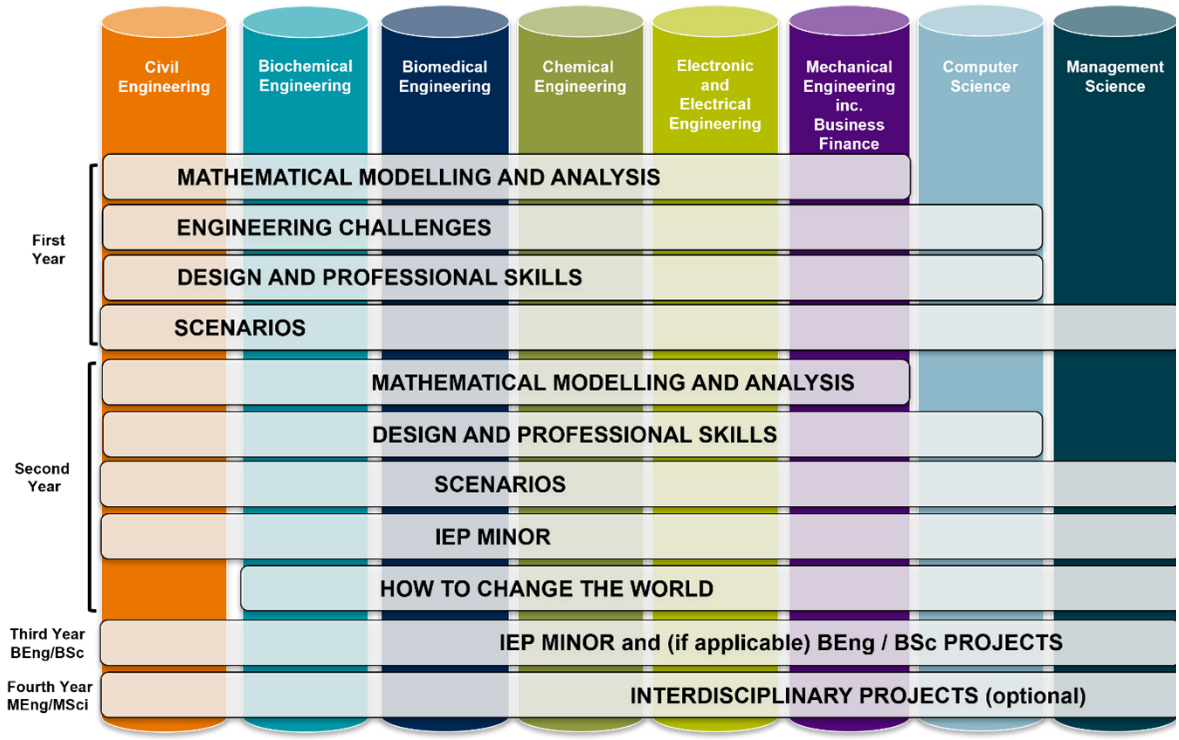

Figure 4.6.1: IEP structure (simplified) (University College London, n.d.) Used with permission no further reuse allowed.

Example 1. Design and professional skills module in year 1 term 1 (D&PS1)

This is a module co-ordinated by the IEP core team who sit at faculty level and delivered by departmental teaching teams. The module framework is split into 3 elements: Technical communications (worth 40% where written and verbal communication skills are developed), discipline specific (worth 20%) and 2 scenarios (worth 20% each), spanning across 6 departments. The goal of the module is to embed transferable competencies and skills early in the undergraduate experience, and ensuring students develop a holistic understanding of engineering as a socially aware and creative discipline. The module introduces students to core design methodologies (Fig. 4.6.2) that are tailored to discipline-specific needs such as, the use of AutoCAD for piping and instrumentation diagrams for Biochemical Engineers or programming Arduino for Electronic and Electrical Engineers. The module also integrates professional skills such as project management, reflective practice, and ethical reasoning while explicitly teaching professional skills like communication, teamwork and ethics across all the UCL Engineering disciplines.

Figure 4.6.2 Own work: The Design Cycle
(Mitchell et al., 2021 p.7)

Example 2. The Engineering Challenges (EC) module in Year 1, term 1

This module is an introduction for students to projects and teamworking and is led by the IEP central team with classroom teaching delivered by departments. It is an experiential, PBL module taken by 7 departments across the faculty from the first week of year 1 studies throughout the first term. It consists of two separate disciplinary and interdisciplinary challenges, the first of which takes place in the first 3 weeks of term, whilst the interdisciplinary challenge takes place in the subsequent

7 weeks of term. During the interdisciplinary challenge, student teams design solutions to a real-world problem, making use of all elements of the design cycle (Fig. 4.6.2).

The D&PS1 and EC modules are highly linked in a just-in-time approach. The two modules run alongside each other, so students are taught about certain competencies that they need to put in place in practical projects, then they experience them, and then they are guided through reflection. The aim of the integration between these modules is to avoid dropping students into a situation and hoping that they will learn the skills they need but rather support and guide them. Sessions are carefully linked, with a skill discussed in class in DPS1 one week and then used within EC the next week; this just-in-time approach means that students have a basic grounding in a skill before they attempt to use it within a project but they are not learning so far ahead that they forget the grounding before they are able to use it in context.

Example 3. Scenarios across Years 1 and 2

Scenarios are week-long intensive group projects embedded within D&PS1 and D&PS2 but delivered by individual departments. Students complete two scenarios in Year 1 (Term 2) and four scenarios in Year 2. These activities follow a repeating five-week cycle: four weeks of conventional teaching are followed by a one-week intensive project. This structure is intentionally designed to connect theoretical learning with practical application, enabling students to engage deeply with authentic engineering challenges in a concentrated timeframe.

While all scenario weeks are centred on the design process, the projects become progressively more complex across the programme and increasingly require the creation of tangible outputs. The production of physical artefacts enhances the realism of the learning experience and provides a valuable form of authentic assessment.

Scenario styles vary, but the majority align with established models of problem-based learning that emphasise critical thinking, evaluative judgement, and analytical reasoning. Drawing on frameworks by Kolmos et al. (2009) — building on the work of Savin-Baden (2000) —these projects go beyond straightforward application of taught material. Instead, students engage with open-ended that demand thoughtful evaluation and synthesis of ideas.

The introduction of scenarios is a key innovation in the IEP framework, promoting the benefits of scenario-based learning, where students tackle open-ended problems contextualised within societal or industrial settings. This approach fosters creativity, resilience, and adaptability-skills essential for future engineers.

Design and Professional Skills (D&PS2): This is an extension of D&PS1, run in year 2 by departments. The module continues the thread of applied and practical implementation of skills learning but now tailoring it to specific skills that are most relevant to the individual engineering discipline.

How to Change the World (HtCtW): This is a two-week intensive, interdisciplinary team-based design challenge centred around the UN's Sustainable Development goals. It often involves industry and government clients, aimed at tackling socially-based global problems and exposing the students to different stakeholders. This activity takes place in term 3 of year 2 (after exams) and feeds into departmentally-led 3rd year capstone projects.

IEP Minors: The IEP framework also aims to give students the opportunity to learn about an engineering field or topic outside their discipline, or deep dive into a particular area of their speciality. Students do this by taking an IEP minor, consisting of a stream of three connected modules, allowing students to customize their degree.

Mathematical Modelling and Analysis 1 and 2 (MMA1 and MMA2): These modules focus on the development of mathematical skills, both theoretical and applied. A key IEP pedagogical design is that these modules are taught via an applied flipped learning approach with the aim of teaching not just theory but also how to use mathematics within in an engineering context, using examples from across disciplines. The module also features the use of real data and the training of students on how to visualise and analyse that data, which we see as an important component of technical communication. The module taught lectures are led by the faculty and taken by students in many of the UCL Engineering disciplines, while workshops are run at departmental level. Whilst the approach to teaching mathematics forms a key part of the IEP pedagogical design, it is not the focus of this chapter.

It can be seen how the IEP framework strongly emphasises P(j)BL. The flagship real-world, project- based activities start with the Engineering Challenges (two multi-week global engineering projects, one of which is interdisciplinary), continue with the scenarios (six one-week projects done within the discipline) across years 1 and 2 in D&PS 1 and 2, and leads onto the HtCtW (2-weeks interdisciplinary project) at the end of year 2. This thread of project-based activities is the central spine of the integrated curriculum model developed which connects technical instructions and transferable skills development through disciplinary and interdisciplinary projects.

3.2 Implementing the IEP framework in Biomedical Engineering

As mentioned in the Introduction, the Biomedical Engineering programme was selected as it was developed at the same time as the IEP framework, hence incorporating this new philosophy of education from its conception. However, the principles, journey and reflections can be applied to any engineering discipline.

The Biomedical Engineering programmes (Biomed Eng) were developed at the UCL Medical Physics and Biomedical Engineering department, comprising a three-year BEng and a four-year MEng. Their development was a significant change for the department, which was until then almost purely research-focused and only had a few undergraduate students on a shared programme predominantly taught by another department. In acknowledgement of the scale and importance of this change, two education-focused staff members were recruited to support the design and delivery of the new Biomed Eng programmes. These individuals subsequently became key contributors to the development of the IEP framework and its associated modules. The programme initially launched with a deliberately small intake (12 students) as a pilot. Since then, it has grown into a highly successful and popular offering, reaching an intake of 170 students in the 2025/26 academic year.

From inception, the Biomed Eng programme was structured around four main principles listed in Example 4.

Example 4. Principles of UCL Biomedical Engineering programme development

- Integration of the IEP framework. *Including its focus on PBL, competence learning, and design methodology*
- Progressive skill building. *Founded in the IEP framework but extending to discipline-specific modules across all years and culminating in higher stakes, research-informed projects.*
- Whole programme coherence. *Learning outcomes are intentionally mapped across modules to avoid fragmentation and promoting progressive lines of learning (topics) and skills with numerous references across modules.*
- Authentic assessment for learning. *A deliberate shift toward authentic, coursework rich and varied assessment, using multiple formats of assessment and asking students to address their work to different audiences hence developing different styles of communication.*

Integration of the IEP framework: As the IEP and the Biomed Eng programme were developed in parallel—by overlapping teams with strong pedagogic interests and a shared commitment to coherent, connected, and practically focused, employment-relevant education—the Biomedical Engineering curriculum was designed from the outset to fully embrace the IEP framework and fully integrate PBL, professional skills, and the design methodology. Furthermore, this educational philosophy was extended beyond the IEP-branded modules and permeates the entire programme. This includes many of the so-called technical modules across all years of study (from Year 1 to Year 4).

This progression in the development of skills has recently been more formally articulated through use of the AHEP4 graduated definitions of each learning objectives (e.g., "*Communicate effectively with technical and non-technical audiences*" at first-year level deepening to "*Communicate effectively on complex engineering matters with technical and non-technical audiences, evaluating the effectiveness of the methods used"* at master level).

We assessed our approach and investigated how critical thinking and communication skills were developing across the programme, specifically looking at the effect of three types of activities aimed at teaching these skills, namely (1) practical open-ended group activities; (2) discussion with experts or as experts; and (3) peer assessment.

These methods were assessed in terms of student and staff opinions, but also practicality, and we observed it was beneficial to integrate and balance these three types of activities as they complement each other (Garcia-Souto et al., 2017).

As a department we also led the way in assessing some additional skills within the context of a scenario, and not by additional assignments associated with the taught elements of the module (Yerworth et al., 2017). This practice has now been widely adopted through the IEP affiliated modules. An example of this is interpersonal communication skills — Adaptive Communication Styles. Students are required to write a user guide for the aid-to-independent-living they design in Scenario 6 using the Easy read format (Gov.uk, 2025), a format originally developed by and for people with learning disabilities.

Whole Programme Coherence: A programme-level approach was taken when developing the curriculum, with a high degree of intentional alignment between the modules and learning activities. One way of achieving that coherence was through the roles of subject leads — tasked with maintaining a knowledge of where, in every year and module, their subject manifests, and with influencing, motivating and helping the relevant module leads to nurture and develop the connections between those modules (Yerworth et al., 2018). This led to teaching staff regularly contextualising content by highlighting its upcoming application elsewhere in the programme. It was common for lecturers to explain to students: "*We are covering this material now because you will apply it in [named module] next week*." This explicit cross referencing strengthened students' sense of purpose, improved knowledge retention, and reinforced the coherence of the curriculum.

The structure of the Biomed Eng programme resembles a typical engineering degree, with three or four years of study (for BEng and MEng respectively) and typically eight 15-credit modules per year, four taught in October-December, and four others taught in January-March, with final exams in May-June (as outlined in sections 2). The structure of the programme is presented in Fig. 4.6.3 alongside a simplified mapping on where selected competences and skills are taught, developed, and assessed. Modules are colour coded to highlight IEP-branded modules with strong PBL and competence learning (in purple), modules where students develop general mathematical and science knowledge (in blue), technical modules (in green) and capstone project modules (beige). It can be seen how competencies are taught right from the start of the programme, firstly in the IEP-branded modules, but nicely complemented and expanded on within the discipline specific modules across all years, culminating in the Individual Research project in year 3 or the Group design project taken by year 4 MEng students as a capstone, with competences being explicitly or implicitly demonstrated at a more advanced level.

Authentic Assessment for Learning: Integrating a variety of assessment types within a programme enables students to build a broader set of competencies beyond subject-specific knowledge. The modular structure commonly used in UK higher education can often result in an over-reliance on a single assessment format, such as written reports. To address this, we adopted a programme-level perspective, designing and evaluating a more diverse mix of assessment approaches. These included traditional methods, authentic tasks reflecting workplace practices, research-informed activities, and assessments tailored to different audiences (Gibson et al., 2018).

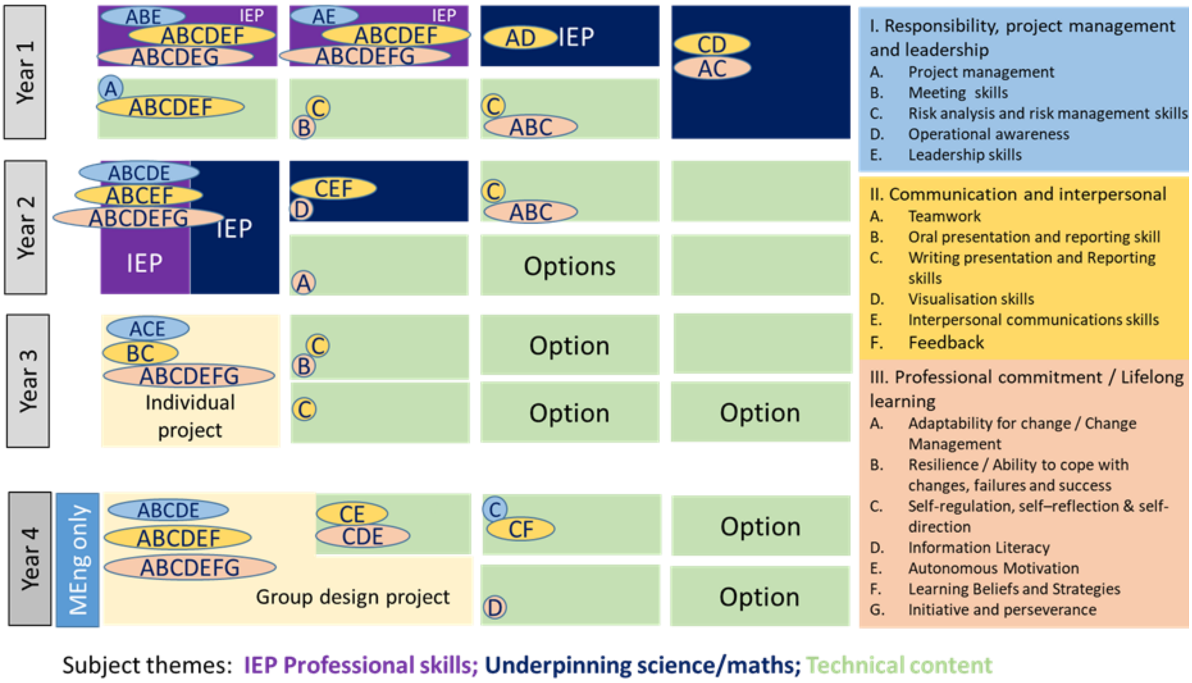

Figure 4.6.3: Biomedical Engineering programme structure with a simplified mapping on where selected competences and skills are taught, developed, and assessed (Own Work by the authors)

4 Bringing it all together: competencies and skills development using PBL

In 2024, Mitchell & Tilley reported on how problem- and more specifically project-based learning is intentionally positioned as the central organising principle through which both disciplinary knowledge and professional competencies are developed. Rather than treating engineering science, design, and skills training as separate instructional streams, curricula built on PBL align these elements within a coherent sequence of authentic, progressively challenging projects. This structural choice enables students to encounter core theoretical concepts at the moment they are needed, creating an iterative interplay between conceptual understanding and practical application (Mitchell & Tilley, 2024).

What this means in our case is that PBL provides a useful pedagogic lens for distinguishing, and effectively relating, skills and competencies within an engineering curriculum. In conventional curricula, skills are often treated as discrete, teachable abilities: for example, report writing, CAD modelling, statistical analysis, or oral presentation. These are typically delivered in isolated modules or workshops and assessed independently of authentic engineering contexts. By contrast, competencies represent the integrated, context-dependent mobilisation of multiple skills, knowledge, attitudes, and professional judgement to address complex, real-world problems. Competence is therefore demonstrated not by performing a single task, but by demonstrating diverse capabilities (sometimes concurrently) in a coherent and purposeful and authentic manner (Gerstein & Friedman, 2016).

Two of the most studied and most iterated competencies and skills on the IEP are teamwork competencies and communication skills (Nweke, 2021; Nweke et al., 2023, 2025; Truscott et al., 2020; Truscott & Smith, 2025). Here we describe how PBL allows for their development whilst incorporating the technical aspects of the biomedical engineering degree programme on the scenarios.

Example 5. Teamwork development within the IEP framework

Teamwork development through PBL is closely aligned with the aims of Design & Professional Skills 1 (D&PS1), which provides students with an explicit foundation in how to work effectively in teams while they are simultaneously practising these skills in project work on The Engineering Challenges. In D&PS1, students are introduced to core concepts of professional teamwork such as effective communication, role allocation, project planning, inclusive collaboration, and professional conduct. These concepts are framed as practical tools that students are expected to apply directly within their PBL teams, and this is done by ensuring that the two modules run concurrently.

Students then enact and develop these teamwork skills through their PBL project work by actively structuring how their teams operate. They agree team norms and expectations at the start of projects, negotiate roles and responsibilities, and establish routines for meetings and shared decision making, drawing on the frameworks and guidance introduced in D&PS1. As projects progress, students practise professional communication by explaining technical ideas to peers from different disciplinary backgrounds, documenting group decisions, and presenting collective outcomes. When tensions or disagreements arise within teams, students are encouraged to draw on strategies discussed in D&PS1, such as constructive feedback, respectful challenge, and reflective dialogue, to manage conflict and maintain productive collaboration.

Leadership and responsibility are also developed through the interplay between D&PS1 and PBL practice. D&PS1 introduces ideas around shared leadership, ethical professional behaviour, and accountability within teams, which students then experience in practice by rotating coordination roles, taking responsibility for organising aspects of the project, and supporting peers' leadership when they are not leading themselves. This helps students understand leadership as a situational and collaborative process rather than a fixed personal trait, and reinforces professional behaviours such as reliability, responsiveness, and respect for others' contributions.

Reflection provides the link that helps students turn experience into learning. A commonly used tool for reflection (and peer assessment) on the IEP is IPAC (Individual

Peer-Assessment of Contribution to group work (Garcia-Souto et al., 2019, 2024) — see Chapter 3.2 for more details). Through the use of this tool for reflective activities and peer feedback aligned with D&PS1 learning outcomes, students analyse how their teams functioned, how effectively they communicated and collaborated, and how their own behaviour affected the group's performance. This reflection encourages students to connect theoretical models of teamwork introduced in D&PS1 with concrete experiences from their PBL projects, enabling them to identify specific areas for improvement and to apply these insights in subsequent team-based tasks. The students also receive peer feedback on how their contribution was perceived by their peers, so they can reflect on the effectiveness of their approach. Over time, this tight coupling between explicit skills teaching in D&PS1 and repeated practice in PBL supports the progressive development of teamwork competencies that are central to professional engineering practice.

Example 6. Communication development within the IEP framework

Communication on the IEP begins with the ability to articulate technical reasoning clearly to peers on the Challenges, through short peer-assessed videos that students create. An example of this in the Biomedical Engineering context would be "Describe a medical technology that most interests you and how you would apply this technology to UCL Grand Challenges". Students are then taken through how to define their research question, how to recognise reputable sources and how to cite correctly. Their communication develops as students explain concepts, assumptions, and calculations to teammates on the interdisciplinary portion of The Challenges in order to make collective design decisions. This builds precision in language, logical structuring of arguments, and the habit of making implicit reasoning explicit. Closely related to this is collaborative communication within teams, where students learn to ask productive questions, listen actively, negotiate meaning across disciplinary boundaries, and use shared artefacts such as sketches, models, and design documents to align understanding, so communication becomes a tool for coordination and joint problem solving rather than simple information transfer.

Another facet is audience-aware communication, which is cultivated because projects require students to present their work to different stakeholders, such as tutors, peers, and non-specialist audiences. D&PS1 lectures focus on ways to translate complex technical content into accessible explanations without losing essential meaning, to frame problems in terms of user needs and constraints, and to adapt tone, depth, timing and terminology to suit the audience (Bains, 2019). Students then use these principles to put together a 5-minute presentation on an emerging technology in their context which they then present to peers across the faculty.

Visual and multimodal communication is another important facet embedded in PBL on the programme. Students are taught how to represent data through various visualisation techniques and are taken through ways in which data representation can be manipulated to lead the reader on e.g., truncation of the y-axis and scale distortion.

Students are then tasked with creating a visual that communicates data accurately, with an appropriate figure legend as briefly describing what the data shows and ways in which it can be misinterpreted.

Authentic assessment is also embedded via PBL by aligning what students are assessed on with what engineers actually do: framing problems, developing and justifying designs, communicating with stakeholders and reflecting on professional practice. Rather than relying primarily on unseen exams, assessment is built around project artefacts and performances that emerge from real engineering activity, aligning with authentic assessment principles (Vlachopoulos & Makri, 2024).

On the Engineering Challenges, students are assessed on a team design project on vaccine production for the treatment of tuberculosis in Uganda. This open-ended brief has marks attached to the quality of the proposed solution, the evidence used to justify design decisions, and how well the team engages with user needs and constraints. This mirrors professional practice, where engineers must propose defensible solutions rather than reproduce known answers. Assessment includes design reports and presentations in which students explain their design process, documenting iterations and failures, and justifying trade-offs, developing the ability to evidence decision making in a professional manner. Scenario weeks use intensive, time-bounded design challenges assessed through interim reviews, prototypes, and final presentations, which simulate real project milestones such as design reviews and client briefings. In later years, IEP projects and capstone-style work require students to produce integrated portfolios combining technical analysis, design rationale, testing evidence, and stakeholder-facing communication, often assessed through demonstrations and viva-style discussions.

Across these assessments, authenticity is reinforced because students are judged on process as well as product, on how they respond to constraints and uncertainty, and on how effectively they communicate technical work to different audiences. This means assessment becomes part of the learning process itself, with feedback on real project outputs shaping how students develop professional engineering judgement over time.

Example 7. How these competencies are embedded in the Biomedical Engineering scenarios

Teamwork is embedded through how the scenarios are structured. Biomedical engineering problems are deliberately complex and clinically framed (e.g., designing a wearable ECG monitor, a rehabilitation device, or an imaging workflow). Each scenario requires multiple engineering perspectives — electronics for sensing, mechanics for device design, and biomedical science for physiological relevance — so no single student can solve the problem alone. Teams allocate roles (systems integration, experimental design, modelling, documentation), manage interdependencies, and coordinate iterative prototyping and testing. The open-ended nature of scenarios forces teams to negotiate assumptions, handle *uncertainty, and resolve technical disagreements, mirroring multidisciplinary collaboration in healthcare engineering.*

Communication is embedded through authentic biomedical engineering outputs. Students must communicate technical decisions: writing design reports that reference biomedical standards and safety constraints; presenting design reviews to academic "stakeholders" simulating clinicians or industry partners; and producing posters or pitches that translate engineering trade-offs into clinical value (e.g., patient comfort, data reliability, usability). Teams also document experimental validation (such as sensor calibration on physiological signals), requiring clear data visualisation and justification of methods.

Assessment and feedback reinforce both competencies. Group grades, peer assessment, and summative reflective components make teamwork behaviours visible and accountable. An example of questions used in the reflection is:

- *Describe something non-technical that you learned this week. How is it helpful to you as an Engineer?*
- *What have you learned about your strengths and your areas in need of improvement?*
- *How would you describe your role within the team? What tasks were you involved with?*
- *In terms of team dynamics, what would you say went well in this scenario? What didn't?*
- *What are you going to do differently in the next scenario and what are you going to do again?*

Regular formative feedback on presentations and reports helps students refine how they explain complex biomedical concepts to mixed technical–clinical audiences. Over successive IEP scenarios, expectations scale up, progressively strengthening collaborative practice and professional communication.

5 Considerations for large-scale implementation of interdisciplinary PBL education

Whilst implementing interdisciplinary PBL at scale to develop competencies and skills offers significant learning gains, it brings notable operational and pedagogical challenges. Here we outline key considerations, intended as guidance for practitioners, and describe how they were addressed in our context.

Space, facilities and timetabling present an immediate pressure point. Large cohorts require flexible, reconfigurable spaces that support teamwork, prototyping and, where appropriate, hybrid delivery. Traditional lecture theatres constrain interaction and limit staff access to teams. Although securing suitable spaces is challenging, we have mitigated this through strong, multi-level relationships with the central space-allocation team, involving administrative staff, teaching teams and senior leadership. Recognising that not all institutions have access to UCL's facilities, we recommend flexible and efficient approaches, such as structuring sessions to combine independent teamwork with targeted staff consultations, thereby reducing space demand while maintaining student support.

Assessing teamwork at scale is another challenge. Large cohorts, multiple assessors and interdisciplinary teams raise consistency concerns. Within the Engineering Challenges, a shared assessment rubric aligned to a common design cycle framework (Fig. 4.6.2) is used across departments. This has enabled consistent mapping of assessment outputs while accommodating disciplinary requirements. Prior work (Garcia-Souto et al., 2024; 2025) details challenges encountered and solutions implemented to preserve authentic interdisciplinary teamwork while ensuring discipline-specific learning outcomes for accreditation.

Uneven student contribution further complicates teamwork assessment. To address this, reflective components and the IPAC methodology were embedded, supporting accountability, team dynamics and assessment validity while reducing staff intervention (Garcia-Souto, 2024). The IPAC system is now integral to IEP modules and widely adopted across UCL Engineering and beyond (University College London, n.d.).

Finally, successful PBL implementation required a shift in staff skills and mindsets. Capacity building followed two strands: reinforcing IEP culture through senior leadership support and recognition and providing structured professional development. This included university-wide programmes for new lecturers, bespoke workshops on active learning and assessment, individualised support, and collaborative curriculum redesign focused on programmatic skills mapping (Perovic & Young, 2025). Dedicated training for Teaching Assistants ensured consistent delivery and feedback, while leadership opportunities supported TA professional development.

6 Concluding remarks

Engineering education is evolving in response to global challenges, technological change, and industry demands by embedding transferable skills such as communication, teamwork, ethical reasoning, and systems thinking alongside technical knowledge. Frameworks including AHEP4 and UNESCO’s sustainability competencies emphasise the importance of these abilities for employability and innovation. At UCL, the IEP exemplifies this shift through PBL, interdisciplinary projects, and authentic engineering challenges that embed skills development from the first term.

The Biomedical Engineering programme at UCL demonstrates how this framework can successfully balance technical content with professional competencies. Developed alongside the IEP, the programme was able to integrate skills directly into technical modules rather than treating them as separate elements. Similar reforms were also achieved across existing engineering programmes, although these often-required significant restructuring and difficult decisions regarding curriculum content. Central to the programme’s success has been a dedicated academic team maintaining a programme-level perspective, ensuring alignment across modules, coordinated assessment design, and progressive skills development. This has helped provide students with a more rounded educational experience while avoiding unnecessary repetition.

Students increasingly recognise the value of these approaches, reporting improved confidence, independence, and preparedness for employment, findings supported by previous research such as Nweke (2021). Positive feedback from industry and accrediting bodies, including two successful IET accreditations, further highlights the effectiveness of embedding competencies and skills within engineering curricula. The experience also demonstrates how a small but focused engineering education team can drive broader institutional change and encourage colleagues to engage with innovative teaching practices.

Looking ahead, engineering education must continue adapting to the rapid rise of generative artificial intelligence. AI is already influencing student writing and approaches to learning, often improving presentation while sometimes leading to superficial technical understanding. Although generative AI offers valuable opportunities to support learning and future professional practice, overreliance and misunderstanding of its limitations remain concerns. In response, the IEP aims to teach students how to use AI critically, ethically, and effectively, while future plans include integrating AI into assessments to evaluate both AI literacy and understanding of its limitations. Ultimately, engineering programmes must remain flexible and forward-looking to prepare graduates for the changing demands of the profession.

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AI statement

During the preparation of this work, the authors used Microsoft Copilot in order to check grammar and spelling, standardise the use of British English and tense-check. After using this tool, the authors reviewed, edited, and made the content their own as needed. They take full responsibility for the content of the publication.

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