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A Systems Approach to Transferable Skills in PBL-Based Engineering Education: The Aalborg University Case

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Keywords: *problem-based learning, problem design, project work, teamwork, interdisciplinarity, professional identity, professional agency*

This chapter advances a systems approach to transferable skills in engineering education, using Aalborg University's project-organised problem-based learning (PBL) model as a central case. It highlights key competencies — complex problem solving, project management, leadership, collaboration, co-creation, interdisciplinarity, and professional identity, and professional agency — as essential for addressing contemporary challenges. Drawing on three decades of research, the chapter shows how these skills can be cultivated through authentic problems, project work, and teamwork. Each competency is defined, grounded in theory and empirical evidence, and illustrated with examples from practice, along with typical challenges and practical guidance for educators. Together, the chapter argues that PBL supports progressive, authentic, and reflective competency development. It concludes with research-informed recommendations for embedding transferable skills in engineering programmes, emphasising constructive alignment, scaffolding, interdisciplinarity, psychological safety, and real-world engagement to prepare adaptable, collaborative, and agentic engineers.

DOI: 10.59490/mt.266.83.

1 A systems approach to transferable competencies and skills in PBL-based engineering education

1.1 Why transferable skills matter

Engineering graduates nowadays need more than disciplinary expertise to thrive in professional practice and to address urgent societal challenges such as climate change, digitalisation, and sustainability transitions. Alongside strong STEM foundations, engineers must also develop transferable competencies and skills such as problem solving, project management, collaboration, interdisciplinarity, and the ability to negotiate their professional identity, and exercise professional agency (European Commission, 2019). The question for educators is how to support the development of these skills systematically, not as isolated add-ons but as an integrated and continuous part of the curriculum. This chapter draws directly on three decades of research conducted at Aalborg University (AAU), where systemic PBL has been continuously developed, studied, and refined. Our approach to transferable competencies and skills is research-based and integrates insights from multiple perspectives, including students' learning processes, educators' practices, and institutional leadership strategies.

1.2 PBL as a systemic foundation

Problem-based learning (PBL) offers a system-oriented foundation for developing transferable skills. Since its foundation in 1974, AAU has implemented a university-wide problem-based, project-organized learning (hereafter PBL) model, making transferable skills a defining feature of its engineering programmes. Every semester, students work in small groups, learning by solving real and authentic problems through project work. In the 1970s, PBL emerged from the need for graduates to possess practical, ready-to-use skills (know-how) when transitioning into the labour market. PBL evolved informed by research and to accommodate changes reflecting national and European higher education policies (e.g., the shift from individual to group-based exams and the implementation of the ECTS system through the Bologna Process), as well as societal and professional trends (e.g., digitalisation, the COVID-19 pandemic, interdisciplinary learning). Even though these trends have shaped AAU's PBL curriculum and practice, three interrelated dimensions remain present: problem, project, and teamwork (Aalborg University, 2015).

Together, these dimensions, as described in Table 4.2.1, create a curriculum-wide system in which transferable skills are developed through authentic practice, iterative cycles of learning, and reflection. Within this model, educators take on multiple roles: not only as researchers in their engineering fields, but also as lecturers who provide disciplinary input, and as facilitators who support project teams and assess student learning outcomes of project work (Aalborg University, 2015). A system approach to transferable skills means that competency development is integrated across the curriculum, not confined to individual modules; interdependent, recognising connections between skills such as teamwork, reflection, and project management; progressive, offering students repeated opportunities to build skills from basic to advanced levels; and contextualized, aligning learning with authentic problems and professional challenges.

Table 4.2.1: Interrelated dimensions of Aalborg's PBL Curriculum

Problem	Students engage with real-world, contextual challenges that may be disciplinary, multidisciplinary, or fully interdisciplinary. Addressing these problems often involves interacting with stakeholders beyond the university, linking academic learning to societal needs.
Project	Students work in semester-long, project-organised formats where they apply and integrate knowledge to design, analyse, and propose solutions. Projects act as the main vehicle for combining disciplinary expertise with transferable skills such as project management, collaboration, and communication.
Teamwork	Students collaborate in teams throughout the semester, supported by facilitators and structured reflection and feedback. Teams typically range from two to six members, with larger groups common at bachelor level and smaller teams at master level.

For educators, this means designing environments where transferable skills are embedded in problems, projects, and teamwork, not left to chance or treated as optional extras of student learning.

1.3 Aalborg University PBL competency framework as an example

In this chapter, we refer to transferable competencies and skills as PBL competencies. The terminology is rooted in the Danish Qualification Framework for Higher Education (NQF-HE) and aligned with the European Qualifications Framework (EQF). Both define competencies as the capability to work responsibly and independently, and to apply knowledge and skills in study or work contexts (Danish Ministry of Higher Education and Science, 2008). Thus, *competency* combines knowledge in a field with the ability to act on that knowledge, making it actionable and context dependent. Research carried out at AAU identifies four overarching pillars of PBL competencies (Holgaard & Kolmos, 2019):

1. *Problem-oriented competencies.* Engaging with authentic problems across disciplines (e.g., problem identification, problem types, criteria for problem solving, ethics, sustainability).
2. *Interpersonal competencies.* Collaborating with peers, supervisors, and stakeholders (e.g., team building, team culture, team roles, communication strategies, decision making, conflict management, constructive dialogue).
3. *Structural competencies.* Organising and managing projects, roles, and methods (e.g., project management, delegation of work, time and activity management).

4. *Metacognitive competencies.* Reflecting on one's learning and adapting based on experience (e.g., reflection, values clarification, personal learning goals, anticipation for future).

The four overarching PBL competencies pillars, or areas, are each broken down into 12 specific competencies (Habbal et al., 2024, p. 216). Together, these four pillars outline 48 competencies. Not every student develops all competencies equally, but the framework shows how PBL provides diverse opportunities for competency development, depending on how curricula and projects are designed (Habbal et al., 2024).

Practitioner takeaway

The AAU case shows that transferable skills are best developed when embedded in authentic problems, project work, and teamwork, rather than taught separately. Educators play a key role, balancing research expertise with their roles as lecturers and facilitators.

2 Implementation of the systems approach to transferable skills in PBL-based engineering education

Building on a systems perspective, the AAU model shows how PBL dimensions emphasise different aspects of transferable skills. Table 4.2.2 shows how problems, projects, and teamwork provide distinct yet interconnected pathways for developing transferable skills.

Table 4.2.2: How problems, projects, and teamwork foster transferable skills

Dimension	*Key transferable skill*	*How they are fostered*
Problem	Problem solving, critical thinking, contextual awareness, interdisciplinarity, innovation	Students engage in authentic real-world problems, often requiring cross- or interdisciplinary perspectives and interaction with external stakeholders.
Project	Project management, planning and organisation, decision making, communication (written and oral), integration of knowledge	Semester-long projects require managing time, tasks, and deliverables, applying disciplinary knowledge, and presenting results to diverse audiences.
Teamwork	Collaboration, co-creation, leadership, negotiation, conflict resolution, professional identity, professional agency	Teamwork demands coordination, shared responsibility, reflective practice, and developing the ability to take initiative and act within professional roles.

2.1 Complex problem solving

Why does it matter?

In a world increasingly shaped by sustainability challenges and rapid socio-technological transitions, complex problem solving is a core competency in engineering, complementing specialized technical knowledge. The OECD (2024) highlights the labour-market value of communication, interpersonal skills, and problem-solving skills, while the World Economic Forum (2025) emphasises problem solving and resilience as critical for success. Our understanding of problems, problem-solving skills, and their importance can be summarized by answering the following questions:

- *What counts as a problem?* A problem is an unknown situation requiring resolution, ranging from simple tasks to complex societal challenges, and is meaningful or valuable to solve (Jonassen, 2011).
- *What are problem-solving skills?* They are part of broader cognitive and transferable skills — such as reasoning, critical thinking, and systems thinking — that enable tackling complex, real-world, and interdisciplinary challenges (Holgaard et al., 2017; Jonassen, 2011; OECD, 2024).
- *Why are they important?* They help individuals adapt, innovate, and address societal challenges while remaining agile in a changing professional landscape

How PBL supports complex problem-solving skills

In PBL, problem framing is central: it serves as the driver of student learning. Well-designed problems contextualise knowledge, challenge students to connect disciplines, and open reflection on societal and ethical dimensions of technology (Guerra & Holgaard, 2019; Svihla et al., 2021). We refer to this process as problem design, beginning with real and authentic situations that may be disciplinary, cross-disciplinary, or interdisciplinary in nature.

These situations often involve contact with external stakeholders, further anchoring learning in societal contexts. Several frameworks can support students in developing complex problem-solving skills. At AAU, problem design is widely applied, but other complementary approaches such as design thinking and the Cynefin Framework (Snowden & Boone, 2007) have also proven valuable (Table 4.2.3).

All three frameworks in the context of engineering education provide a conceptual scaffold for cultivating students' ability to engage with real-world, ill-defined problems. They draw on constructivist learning, systems thinking, iterative learning, and epistemological pluralism, recognizing that complex problems require diverse ways of knowing and transdisciplinary integration. These principles align closely with PBL principles, where students work in teams to solve open-ended, authentic problems. Educators can use these frameworks to help students to recognise the nature of a problem; select appropriate strategies (e.g., stakeholder engagement, interdisciplinary collaboration); reflect on decision making and adapt approaches; and develop resilience and adaptability (Guerra et al., 2025; Habbal et al., 2024; Snowden & Boone, 2007; Svihla et al., 2021).

Table 4.2.3: Example of frameworks to foster complex problem solving

Frameworks	*Description*
Problem design	Structured in three stages: problem identification, analysis, and formulation. Uses inquiry-based approaches (e.g., 5W1H: what, why, who, when, where, how). Students conduct literature reviews, stakeholder interviews, and fieldwork to define solvable problems within real-world constraints (Holgaard et al., 2017).
Design thinking	Follows five stages: empathise, define, ideate, prototype, and test. Encourages empathy, user orientation, and consideration of ethical, societal, and environmental dimensions. Promotes creativity and iteration in engineering design (Habbal et al., 2024).
Cynefin framework	Categorises problems into five domains: simple, complicated, complex, chaotic, and confused (Snowden & Boone, 2007). According to Snowden and Boone, "*Cynefin, pronounced kunev-in, is a Welsh word that signifies the multiple factors in our environment and our experience that influence us in ways we can never understand*" (Snowden & Boone, 2007, p. 2). Supports decision making by recognising cause-effect relationships and selecting strategies: best practices, expert analysis, experimentation, stabilisation, or sense-making (Habbal et al., 2024).

Integrating frameworks such as problem design, design thinking, or the Cynefin framework can greatly enrich students' capacity to address ill-defined, real-world problems. At the same time, successful use of these frameworks depends on how educators design, scaffold, and assess the learning process (Table 4.2.4).

Table 4.2.4 Educator guide: Fostering complex problem-solving skills

What students gain through PBL	*What educators need to consider*
Recognise the type and nature of a problem	Align learning outcomes with complex problem-solving competencies
Select strategies to understand the context of the problem in depth and inform decision-making processes.	Scaffold student in designing authentic problems and allocate sufficient time for exploration and framing
Reflect on decision making and adapt approaches during the process	Balance disciplinary teaching with facilitation and coaching roles
Build resilience in navigating uncertainty and complexity	Ensure assessment captures both disciplinary knowledge and transferable skills

Practitioner takeaway

For educators, fostering complex problem solving goes beyond assigning exercises. It involves designing authentic, real-world problems that prompt students to integrate knowledge, engage stakeholders, and reflect on their approaches. Frameworks like problem design, design thinking, or the Cynefin framework offer useful scaffolds when aligned with outcomes, activities, and assessment. Through repeated engagement with ill-defined problems, students build analytical and creative abilities, alongside resilience and adaptability essential for their professional futures.

2.2 Project management and leadership

Why do they matter?

Engineering graduates are expected to manage complex projects and lead collaborative teams addressing societal challenges. In engineering education, project management and leadership are often mentioned together, but they are not identical (Routhe et al., 2024). Management is about planning, structuring, and monitoring processes, while leadership is about setting direction, motivating others, and enabling change (Kotter, 1990). In practice, the two overlap: leaders must sometimes manage, and managers must sometimes lead (Bass, 1990). Our Conceptualisation of project management, and leadership and why they are important in engineering education context, can be captured in three questions:

- *What is project management?* Project management means to apply processes, methods, skills, knowledge, and experience to achieve specific project objectives according to the project acceptance criteria within agreed parameters (Association for Project Management, 2024).
- *What is leadership?* Leadership means creating the environmental conditions conducive to good performance: support of shared understanding, innovation, problem solving, resilience, and learning (Technical Leadership in Systems Engineering - SEBoK, 2024).
- *Why are they important in engineering?* Project management provides the tools and structures needed to plan and deliver outcomes, while leadership ensures direction, alignment, and innovation in complex and interdisciplinary contexts. Together, they enable engineers to collaborate effectively and respond to societal and technological change.

How PBL supports project management and leadership

In a PBL context, project management and leadership are developed through the project and teamwork dimensions. Students plan and deliver semester-long projects, negotiate roles, and share responsibility for outcomes. Leadership here is typically informal, with practices such as shared leadership (distributed responsibilities across the team) (Carson et al., 2007), emergent leadership (individuals stepping up when needed) (Davis & Eisenhardt, 2011), and rotating leadership (leadership positions changing over time) (Hanna et al., 2021).

As problems and organizational contexts become more complex — e.g., interdisciplinary collaboration or multi-team systems — the demand for explicit project management increases, while leadership is needed to provide direction, alignment, and motivation (Kolmos et al., 2024; Lindvig et al., 2017). Developing project management and leadership competencies in PBL does not happen automatically; it requires explicit opportunities for practice, reflection, and feedback. The guide below summarises what students can gain through project work and what educators should consider when supporting the development of these competencies (Table 4.2.5).

Table 4.2.5: Educator guide: fostering project management and leadership in PBL

What students gain through PBL	*What educators need to ensure*
Understand differences and dependencies between project management and leadership	Make learning outcomes, activities, and assessments explicitly target both competencies (constructive alignment)
Practice planning, monitoring, and delivering projects in disciplinary and interdisciplinary teams	Provide space and tools for students to experiment with project structures and roles
Experience informal leadership through shared, emergent, and rotating roles	Support student-centred learning and create opportunities for leadership to emerge naturally
Learn to navigate multi-team and interdisciplinary contexts	Scaffold collaboration across disciplines and teams; help students reflect on leadership practices

Practitioner takeaway

For engineering educators, the key is not to treat project management and leadership as tacit or implicit outcomes. Instead, they should be explicitly embedded in curricula, supported by constructive alignment, practical opportunities for role-taking, and space for reflection. This helps students carry forward both competencies into their professional lives.

2.3 Collaboration and co-creation

Why do they matter?

At PBL-based institutions like AAU, where projects are team-based, collaboration and co-creation are essential transferable competencies. They enable students to share and build ideas, supporting problem solving and innovation, but depend on psychological safety. Their meaning and importance in engineering education can be summarized as follows.

- *What is collaboration?* Collaboration can be defined as a joint effort by multiple people towards a group goal (Briggs et al., 2006). It requires abilities like working productively with others toward shared goals, communication, coordination, and conflict resolution (Marks et al., 2001).

- *What is co-creation?* Co-creation goes beyond collaboration by generating new knowledge or solutions together, requiring creativity, shared ownership, and openness to diverse perspectives.
- *Why important in engineering?* Collaboration and co-creation are essential for addressing complex, interdisciplinary challenges, while fostering creativity, innovation, and mutual learning — skills highly valued across engineering sectors.

Psychological safety and well-being as foundations for collaboration and co-creation

Psychological safety refers to a climate where individuals feel safe to take interpersonal risks when voicing ideas, asking questions, or admitting mistakes, without fear of judgement (Edmondson, 1999; Kahn, 1990). Research shows that psychological safety enhances open communication, trust, and creativity in teams (Edmondson & Mogelof, 2005; Han et al., 2019). In PBL, psychological safety closely links to academic well-being, which includes both emotional aspects (enjoyment, low stress) and cognitive-behavioural aspects (engagement, a sense of accomplishment). Well-being is shaped by students' self-efficacy and autonomy as well as by how supportive the learning environment is (Chen et al., 2023a; Clausen et al., 2025). Educators therefore play a central role in cultivating environments where collaboration and creativity can flourish, through practices like establish shared norms early in a project (e.g., '*no question is stupid*', and mistakes as learning opportunities; set learning goals for their collaboration skills and reflect on their progress; and create spaces for creative collaboration, open communication, and trust-building (Hansen et al., 2025; Hansen & Christensen, 2025). Such practices encourage academic agency — students' belief that their efforts can influence learning outcomes — which is associated with greater well-being (Chen et al., 2024).

Role of facilitators and educators

Facilitators are central to shaping psychological safety and collaborative culture. Key strategies include early check-ins to monitor team dynamics and address conflicts, and structured scaffolding — particularly in the first year — through initiatives such as AAU's introductory PBL module on project management, teamwork, and conflict resolution (Du et al., 2020). Clear milestones help prevent last-minute crises, while constructive feedback and role modelling signal that students' progress is valued. These practices emphasise that collaboration and co-creation do not emerge automatically but require intentional support and scaffolding. The following guide summarises what students can gain through PBL teamwork and what educators should consider when creating the conditions for effective collaboration and co-creation (Table 4.2.6).

Table 4.2.6: Educator guide: supporting collaboration and co-creation in PBL

What students gain through PBL	*What educators need to ensure*
Learn to voice, share, and build ideas in teams	Create psychologically safe climates where all contributions are valued
Develop creativity and ownership through co-creation	Scaffold collaboration with clear structures and norms, especially in early semesters
Strengthen academic well-being and agency	Monitor team functioning with regular check-ins; provide timely feedback
Build long-term collaboration competencies (communication, trust, conflict resolution)	Align learning outcomes and assessments with collaborative skills, not only technical outputs

Practitioner takeaway

For educators, fostering collaboration and co-creation also involves supporting students' well-being. By developing teamwork norms, scaffolding early collaboration, role modelling, and constructive feedback, educators help students build confidence and creativity. Methods for creative teamwork can support this process. Without such support, collaboration may remain superficial; with it, students gain lasting professional competencies.

Complex problem solving, project management, collaboration, and co-creation form the core transferable skills in PBL. However, contemporary engineering also requires students to extend beyond these foundations — particularly through interdisciplinarity and the capacity to negotiate professional identity and exercise agency. The following sections show how these dimensions deepen and expand competency development within PBL.

2.4 Interdisciplinarity

Why does it matter?

Complex societal problems — such as sustainability transitions, digitalisation, and global health — are rarely confined to a single discipline. Addressing these challenges requires interdisciplinary collaboration, where knowledge, perspectives, and methods from different fields are integrated (Fortuin et al., 2023; Klein, 2018; van den Beemt et al., 2020). In engineering education, interdisciplinarity resonates closely with teamwork and collaboration but goes beyond them by explicitly requiring students to cross disciplinary boundaries and reflect on their own and others' contributions. Interdisciplinary and its importance in an engineering context can be summarized as follows.

- *What is interdisciplinarity?* Interdisciplinarity involves combining insights, methods, or approaches from two or more disciplines to address complex problems (Keestra & Menken, 2016; Klein, 2018). It ranges from narrow forms, involving closely related fields such as different branches of engineering, to broad forms that bridge more distant disciplines, such as engineering and the social sciences or humanities.
- *Why is it important in engineering?* It enables students to engage with ill-defined problems that require multiple perspectives. It supports the development of key competencies such as boundary crossing, coordination, reflexivity, and co-enactment, and prepares graduates to work effectively in multidisciplinary and cross-sectoral professional environments.

Challenges in interdisciplinary learning

Students often struggle with interdisciplinarity due to cognitive obstacles (e.g., conflicting disciplinary practices, different epistemic values) as well as institutional barriers (MacLeod, 2016). Research carried out at AAU shows that students working with broad interdisciplinarity frequently find it difficult to establish a common project focus, create interdependencies, or align disciplinary contributions (Routhe et al., 2021; Routhe et al., 2022). Without clear goals and facilitation, interdisciplinary learning risks remaining tacit and superficial.

How PBL supports interdisciplinarity

In a systemic PBL environment, problems are the point of departure, supporting both disciplinary and interdisciplinary competency development (Holgaard & Kolmos, 2019; Kolmos et al., 2024). Interdisciplinary competencies are fostered when students work with authentic, complex problems requiring input from multiple fields; reflect on how their disciplinary knowledge interacts with that of others; and engage in constellations where teams from different programmes collaborate on shared challenges.

At AAU, interdisciplinarity ranges from students borrowing perspectives from neighbouring disciplines to multi-team projects that span engineering, social sciences, and humanities. Examples include 'system projects' where teams from different engineering programmes collaborate on a shared theme such as sustainable mobility. Benefits include exposure to multiple perspectives on complex problems; opportunities for interdisciplinary project management and leadership; and reflection on the value and limitations of one's own disciplinary contributions.

These benefits, however, depend on intentional design and support. The following guide summarises what students gain through interdisciplinary PBL work and what educators need to ensure (Table 4.2.7).

Table 4.2.7: Educator guide: supporting interdisciplinarity in PBL

What students gain through PBL	*What educators need to ensure*
Collaborate across disciplines and perspectives	Set a clear vision and purpose for interdisciplinary learning
Manage interdisciplinary projects and leadership roles	Constructively align learning outcomes, activities, and assessments
Reflect on their own and others' disciplinary contributions	Co-construct boundary objects (e.g., societal challenge or shared artefact) to anchor collaboration
Develop boundary-crossing skills (coordination, reflexivity, co-enactment)	Scaffold team building across disciplines; provide facilitation focused on collaboration and leadership

Practitioner takeaway

For educators, interdisciplinarity should not be treated as an implicit outcome of teamwork. It needs to be explicitly embedded through aligned outcomes, interdisciplinary project design, and facilitation. Providing boundary objects, fostering common ground, and scaffolding cross-disciplinary collaboration helps students develop the competencies required for interdisciplinary professional contexts.

2.5 Professional identity and agency

Why do they matter?

Becoming an engineer involves more than acquiring technical knowledge. It also requires students to see themselves as future professionals and to act with confidence and purpose in shaping their learning journeys. Professional identity and learner agency are therefore intertwined transferable competencies that influence students' motivation, persistence, and capacity to adapt across academic and professional transitions. The meaning of professional identity and learner agency and their importance in an engineering context is summarized below.

- *What is professional identity?* Professional identity refers to how students see themselves as engineers-in-the-making, shaped by their motivations, beliefs, competencies, and recognition from communities of practice (Chen et al., 2022, 2023b). It is strengthened through engagement in authentic engineering tasks and validation from peers, educators, and external stakeholders.
- *What is learner agency?* Learner agency is the capacity and willingness to take purposeful action, such as setting goals, self-regulation, collaboration, and making decisions to shape one's learning. It emerges dynamically through students' interactions with curricular, social, and professional contexts (Du et al., 2022; Jiang et al., 2023).
- *Why is it important in engineering?* Professional identity motivates students to persist and find meaning in their learning, while agency enables them to act on this motivation, adapt to challenges, and contribute actively to collaborative

and professional contexts. Together, they prepare students not only to become engineers but to act as engineers.

How PBL fosters identity and agency

Research shows that PBL provides a powerful context for fostering both professional identity and learner agency. Identity develops through real-world, semester-long projects with stakeholder interaction, in which students internalise what it means to be an engineer, reinforced by recognition from others (Chen et al., 2022; 2023b). Agency develops by defining problems, setting goals, organising roles, and reflecting, through which students practise self-regulation and decision making (Du et al., 2022; Jiang et al., 2023). Mutual reinforcement occurs when identity strengthens motivation to act, while agency reinforces identity, especially through authentic project contexts (Guerra et al., 2022, 2025).

Despite these benefits, fostering identity and agency is not straightforward. Many students rely heavily on instructor guidance rather than engaging in self-directed learning, and while they may articulate their learning, they often struggle to translate it into professional action or sustained identity development. This development also varies across cultural, curricular, and disciplinary contexts, requiring context-sensitive approaches. Moreover, motivation may remain individual and passive if broader institutional or social factors are not addressed (Du et al., 2022; Chen et al., 2023a).

These insights highlight the need for intentional design and support. The following guide summarises what students gain through PBL experiences and what educators need to ensure to strengthen identity and agency (Table 4.2.8).

Table 4.2.8: Educator guide: supporting professional identity and agency in PBL

What students gain through PBL	*What educators need to ensure*
Develop a sense of 'becoming an engineer' through authentic practice	Design authentic, practice-oriented projects connected to real engineering challenges and external stakeholders
Learn to set goals, plan, monitor, and reflect on their learning	Balance scaffolding with autonomy; teach reflective practices for self-regulation
Experience progressive growth across the curriculum (from novice to advanced)	Embed progression: from first-year introductory projects to advanced capstones, with increasing independence
Connect their efforts to societal and professional contexts	Strengthening industry and community links through cooperative projects, internships, and showcase events

Practitioner takeaway

Supporting professional identity and learner agency requires more than granting students freedom. It involves authentic, progressive, and reflective PBL experiences where students are treated as engineers-in-the-making and equipped to act with agency. By balancing scaffolding and autonomy and linking projects to real-world contexts, educators help students actively develop into adaptable professionals.

Together, the eight competencies — complex problem solving, project management, leadership, collaboration, co-creation, interdisciplinarity, professional identity, and professional agency — demonstrate how transferable skills are systematically cultivated in PBL. While distinct, they are deeply interconnected and mutually reinforcing across problems, projects, and teamwork. This highlights the need for integrated, progressive learning designs in which such skills are made explicit, scaffolded, and constructively aligned.

3 Recommendations

Our recommendations draw on decades of research on systemic PBL at AAU while integrating students' insights. From a student perspective, engagement increases when projects have clear real-world relevance. Students value structured guidance in the first year, combined with greater autonomy in later stages. Many find it difficult to articulate their competencies unless reflection and assessment make them explicit. They also emphasise the importance of psychological safety, noting that feeling safe to contribute is essential for meaningful and effective collaboration. The aim of these recommendations is to provide clear, actionable guidance for embedding transferable competencies in engineering education.

3.1 Practical recommendations

Make transferable competencies explicit by clearly defining them in learning outcomes, teaching activities, and assessment criteria. In practice, this involves designing curricula where these competencies are not implicit but deliberately articulated and assessed. The rationale for this approach is that students often perceive transferable skills as 'hidden' unless they are explicitly taught and evaluated (Routhe et al., 2023).

Integrate competencies systemically by embedding skill development across the curriculum through repeated cycles of problem solving, project work, and teamwork. This ensures that students encounter and apply these competencies in multiple contexts over time. Evidence suggests that students are more likely to recognize and value competencies when they have multiple opportunities to practice them (Lindsay et al., 2024).

Balance scaffolding with autonomy by providing strong guidance in early semesters — such as through introductory modules and structured teamwork norms — and then gradually reducing support as students' progress. This staged approach helps students build confidence and foundational skills before taking on more independent and complex tasks. Research shows that early scaffolding enhances students' confidence and well-being, while more advanced, autonomous projects foster a sense of agency (Du et al., 2020; Chen et al., 2023).

Connect learning to real-world contexts by using authentic, interdisciplinary problems, ideally in collaboration with external stakeholders. This approach helps students see the relevance of their learning and apply their skills in meaningful ways. Recognition and feedback from professionals further strengthen students' sense of identity and motivation (Chen et al., 2022).

Foster psychological safety and well-being by creating learning environments where students feel comfortable taking risks, expressing ideas, and learning from mistakes. Such environments encourage deeper engagement and collaboration. Research indicates that psychological safety is strongly correlated with improved collaboration, creativity, and overall well-being (Clausen et al., 2025). For an overview of practical recommendations, see Table 4.2.9.

Table 4.2.9: Practical recommendations

Do's	*Don'ts*
Design authentic problems that connect to societal challenges	Assume competencies will 'just emerge' through team projects. Without explicit design, transferable skills remain underdeveloped
Use boundary objects (shared artefacts, project themes) to support interdisciplinarity	Overload students with unstructured PBL early on; this risks stress and disengagement
Provide structured opportunities for reflection on collaboration, leadership, and identity	Treat project management and leadership as implicit roles and make them invisible in the curriculum structures like expected learning outcomes.
Offer progressive exposure to interdisciplinary and multi-team settings	Neglect staff development — educators need training to act as facilitators, not only as disciplinary experts

3.2 Lessons learned, attention points, and adaptability

One important learning lesson is that identity and agency develop gradually over time, as students often require external recognition and exposure to role models before they begin to see themselves as engineers. Interdisciplinary learning, while valuable, presents challenges because it involves navigating different paradigms; this makes structured scaffolding and clearly defined goals essential. Shared leadership has proven to be effective, particularly when roles are rotated, as this fosters a sense of authentic responsibility among students. Additionally, reflection plays a critical role in learning, with activities such as journals and feedback helping to strengthen students' metacognitive skills.

Institutional alignment is an important attention point, requiring that problem-based learning (PBL) competencies are embedded within broader educational frameworks such as the NQF or EQF. Equally important is ensuring progression, where competency development is staged across semesters with increasing levels of autonomy and complexity. Sensitivity to context is also necessary, as approaches must be adapted to reflect cultural and disciplinary differences. Finally, attention must be given to staff roles, ensuring clarity and appropriate support for educators who balance responsibilities as researchers, lecturers, and facilitators.

The effectiveness of these approaches depends on ability to adapt to local conditions and contextual factors such as class size, resources, and institutional culture. Smaller classes tend to support emergent leadership, whereas larger cohorts require more structured approaches and additional scaffolding. Even in settings with limited resources, transferable competencies can still be cultivated through well-designed problems and reflective activities. In institutions with less experience in PBL, it is advisable to begin with pilot projects and gradually scale up implementation as capacity and confidence grow.

3.3 Continuous improvement

To ensure students develop relevant and transferable competencies and skills, continuous improvement must be embedded in both curriculum design and teaching practice. Educators can:

- Use self-assessment tools to support students to track their skill development over time and create their own competencies profile;
- Gather feedback from students and external partners to evaluate how well projects support competency development;
- Share best practices and case examples among faculty through professional learning communities;
- Regularly revise curricula to align with emerging societal and industry needs.

These strategies are exemplified in several initiatives at AAU:

- *Introductory PBL module.* First-year students learn project management, collaboration norms, and conflict resolution in a scaffolded setting;
- *System projects.* Interdisciplinary, multi-team projects address sustainability challenges such as mobility and energy transition;
- *Project expos.* Students present their work to external stakeholders, strengthening identity and motivation through recognition;
- *Progression through tailor-made workshops.* After the first year, tailor-made workshops are introduced, addressing specific transferable skills to support students' progression in PBL competencies throughout the course of their studies;
- *Competency profiles.* Over 1,000 student profiles have been analysed to identify strengths and gaps, directly informing curriculum redesign.

Intentional support and continuous feedback loops help ensure that collaboration and co-creation are not superficial but become deeply embedded competencies which students carry into professional practice.

Practitioner takeaway

Embedding transferable skills in engineering education requires a systems approach, with explicit, progressive, authentic, and reflective learning opportunities across the curriculum. By aligning problems, projects, and teamwork with constructive outcomes, educators can ensure that students not only develop disciplinary expertise but also the transferable skills needed to thrive as engineers in complex and changing worlds.

4 Concluding reflections

This chapter has illustrated how a systems approach to PBL provides the conditions for developing transferable skills throughout engineering education. By focusing on key competency areas, such as complex problem solving, project management, leadership, collaboration, co-creation, interdisciplinarity, professional identity, and professional agency, we have shown how competencies are interdependent and reinforced through authentic problems, project work, and teamwork. For educators, the main message is that transferable competencies must be intentional, explicit, and progressively scaffolded, as they do not emerge automatically. For institutions and researchers, our decades of work at AAU demonstrate the importance of a long-term, research-based approach to understand competency development through PBL that continuously integrates the perspectives of students, educators, and leaders to sustain and evolve systemic PBL practices. A research-based approach extends beyond evidence-informed educational practice by recognizing the role of research in generating robust evidence and scientific knowledge to understand, inform, and advance engineering education. By integrating educational theories with rigorous research methodologies, it strengthens research and development efforts and supports the continuous improvement of practice in response to professional needs and societal challenges.

We hope that the following further reading and resources, which illustrate how AAU's PBL approach develops transferable skills, can be of inspiration for other practitioners in strengthening their pedagogical competence to integrate these skills explicitly into teaching and learning practices. For PBL competences and competence profile, see UCPBL. (n.d.-b, n.d.-c) and for problems in PBL, see UCPBL (n.d.-d). For all systems projects related background, see Aalborg University (n.d.-a, n.d.-b, n.d.-c) and for collaboration and co-creation Hansen and Christensen (2025). Finally for facilitation of learning, we recommend Du et al. (2025) and Kolmos et al. (2008) as well as UCPBL (n.d.-a).

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AI statement

During the preparation of this work, the authors used Microsoft Co-pilot in order to reduce the wordcount where appropriate and proofread the chapter. 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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