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Autonomous Motivation, Learning Beliefs and Learner Identity

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This chapter synthesises three interconnected competencies: autonomous motivation, learning beliefs, and learner identity that are often examined separately in engineering education. We review key learning theories related to these competencies, identify the factors that influence their development, and summarise empirical evidence on how they are assessed and why they are significant for engineering education. We then introduce four active learning approaches to support competency development: problem-based learning (PBL), project-based learning (PjBL), case-based learning (CBL), and design-based learning (DBL), illustrated with two examples from Aalborg University, Denmark, and Swansea University, UK. Drawing on both theory and practice, we advocate for a holistic approach to understanding these competencies, fostering inclusive learning communities for students, encouraging student ownership, engaging with real-world problems, promoting deep reflection, and emphasising social awareness and responsibility.

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1 Definition

This chapter discusses how three key competencies: autonomous motivation, learning beliefs, and learner identity can be embedded in engineering education through targeted, evidence-based approaches. Modern engineering requires graduates who are not just technically skilled but possess the abovementioned competencies to persist in the engineering field, adapt to rapid change, prepare for future professions, and engage in lifelong learning. However, the interconnected nature of student learning and persistence has not always been fully addressed in engineering education. This chapter thus adopts a synthesized, holistic approach to understanding autonomous motivation, learning beliefs, and learner identity.

We begin by reviewing relevant theories, defining and synthesizing the three competencies in an interconnected manner. We then identify key factors influencing their development and summarise empirical evidence on their assessment and significance in engineering education. Finally, we illustrate their application through four active learning approaches, two cases from Aalborg University, Denmark, and Swansea University, UK, and recommendations for implementation and learning for educators and practitioners.

1.1 Concepts

To begin this synthesis, we adopt the definitions most commonly used in educational research, as follows.

- *Autonomous motivation.* Intrinsic motivation, doing something because it is inherently interesting or enjoyable or motivating oneself by focusing on positive external factors (Ryan & Deci, 2000).
- *Learning beliefs.* A person's subjective judgements about the relation between learning and his or her values or attributes (Fishbein & Ajzen, 1975).
- *Learner identity.* "*The way in which individuals see themselves as learners, seek and engage in life experiences with a learning attitude, and believe in their ability to learn*" (Kolb & Kolb, 2009, p. 5).

The three concepts are viewed as deeply intertwined; they dynamically evolve through reciprocal interactions over time (Sade, 2009). Learning beliefs are closely linked with autonomous motivation: students with positive beliefs are more motivated, adopt diverse strategies, and engage more willingly (Kramer et al., 2024). When learning is meaningful and self-determined, students demonstrate greater persistence, creativity, and responsibility (Ryan & Deci, 2000). Through sustained engagement in learning activities, learners develop their societal and professional identity that organises their beliefs, motivation, and approaches to sustainability and collaboration (Sade, 2009).

1.2 Literature review of relevant theories

The synthesis of the three concepts shapes how learners engage with, persist through, and derive meaning from their educational experiences. Several existing theories help explain the connections among them, which can be grouped into three perspectives: motivation-centred theories, identity development theories, and integrative theories.

Motivation-centred theories, including Self-Determination Theory (SDT) (Ryan & Deci, 2000), Expectancy-value Theory (EVT) (Wigfield & Eccles, 2000), and Achievement Goal Theory (AGT) (Anderman & Anderman, 1999), explain how learners' beliefs and values shape motivation, engagement and goal orientations. SDT explains how autonomy, competency (including beliefs about one's ability), and relatedness support autonomous motivation. EVT illustrates how beliefs and values mediate between identity and motivation, translating identity-based self-understanding into motivational energy. AGT explains how beliefs about mastery and performance shape goal orientation and motivation.

Identity development theories, such as Erikson's psychosocial development and Marcia's identity status paradigm (Cô & Levine, 1988), alongside moral development theories (Kohlberg & Hersh, 1977), emphasize how identity formation processes, including exploration, commitment, and ethical reasoning shape learners' beliefs, values and motivation. These perspectives position identity as an overarching construct through which learners interpret experiences, form beliefs, and develop motivation.

Integrative theories, including Social Cognitive Theory (Bandura, 2001) and Transformative Learning Theory (Daramola, 2018), highlight the dynamic and reciprocal relationships among beliefs, behaviours, identity, and motivation within social and experiential learning contexts. They emphasise how interaction, reflection, and disorienting dilemmas reshape learners' perspectives across cognitive, emotional, and social dimensions.

Taken together, these three perspectives clarify the interconnectedness of the three concepts: motivation-centred theories emphasize how beliefs shape motivation, indirectly contributing to identity development over time (longitudinally). Identity development theories highlight how identity influences both motivation and beliefs (hierarchically), while integrative theories address the dynamic relationships among all three (reciprocally).

1.3 Etymology

The conceptual integration of motivation, belief, and identity has evolved over time from compartmentalised views of learning toward a more holistic, systematic understanding. Early behaviourist perspectives emphasised external reinforcement while largely neglecting internal beliefs, treating motivation, beliefs, and identity as separate domains (Skinner, 1957).

With the cognitive shift in the 1970s and 1980s, beliefs were recognised as important mediators of learning, while motivation was explained through expectancy-value and attribution theories (Wigfield & Eccles, 2000). This shift highlighted their fundamental interdependence, showing that learning requires alignment between what learners find motivating, what they believe about learning and themselves, and how they see themselves as learners (Wigfield & Eccles, 2000). These frameworks have changed from addressing linear, fixed, and homogeneous problems to adopting a complex and dynamic approach, where learners' psychology is seen as adaptive, and positive development emerges when the three concepts are aligned and mutually supportive.

Later, constructivist and socio-cultural perspectives highlighted how epistemological beliefs shape learning (Hofer & Pintrich, 1997), and how self-determination theory emphasises autonomy, competency, and relatedness as key to autonomous motivation (Ryan & Deci, 2000). These frameworks bridge individual psychological processes with social and cultural contexts, aligning with 21st-century competency models that emphasise learner agency, adaptability, and lifelong learning. They have taken a more holistic and domain-specific approach, showing that beliefs, motivation, and identity are reciprocally interrelated and shaped by disciplinary practices and societal expectations.

1.4 Systematic approach

While previous research has largely framed these concepts as psychological constructs, they can also be understood as developable competencies that engineering educators and practitioners can support students through pedagogy and instructional strategies. Identifying factors that influence the development of autonomous motivation, learning beliefs, and learner identity is therefore a necessary step.

In classroom settings, engineering students' motivation is strongly influenced by their perceived difficulty of and interest in the subject, learning goals, sense of ownership over learning, and perceived connection to real-world scenarios. It is also affected by teachers' interactions with students, teaching style, subject expertise, and the quality of feedback (Wijnia et al., 2024).

The development of students' learning beliefs is shaped by students' prior experiences, their confidence in organising and executing learning tasks, their estimations that their actions will lead to desired outcomes, and their perceptions of their ability to achieve success through effort. Contextual instructional factors, including teaching methods, type of assessment, and teachers' support and recognition of students' efforts, also play a key role (Kramer et al., 2024; Wijnia et al., 2024).

Learner identity development is a dynamic and complex process shaped by both internal factors such as personal goals, beliefs, motivation, interests, prior knowledge and experience, and external factors such as teacher-student interactions, classroom environments, institutional norms (Jiang et al., 2024; Pierrakos, 2025; Pierrakos et al., 2009). As engineering students make sense of new learning experiences, they form a sense of themselves as learners, which in turn shapes their beliefs and motivation.

These factors call on educators and practitioners to adopt a holistic perspective that considers intrapersonal, relational, and contextual aspects of students' competency development. They are also encouraged to engage students as 'whole persons' by supporting subject knowledge (head), practical skills and actions (hands), and affective and emotional engagement (heart), rather than focusing solely on content delivery (Best, 2008; Pierrakos et al., 2024)

1.5 Contextual variations and cultural considerations

The three concepts manifest differently across cultural and educational contexts. In individualistic cultures, autonomous motivation may emphasise personal interest and choice, learner identity focuses on individual achievement and self-actualisation and learning beliefs emphasise personal control and individual capability (Kramer et al., 2024; Ryan & Deci, 2000). In collectivistic cultures, autonomous motivation may be more closely connected to community contribution and social responsibility, learning beliefs emphasise effort, persistence, and collective learning processes, and learner identity centres on membership in learning communities and the fulfilment of social roles (Kramer et al., 2024; Wigfield & Eccles, 2000). In higher education, student learning often focuses on the development of a broad learner identity, sophisticated beliefs, and autonomous motivation for personal knowledge. In contrast, professional learning contexts in engineering link identity to career development and social contributions, beliefs to continuous learning and adaptation, and motivation to stay up to date in rapidly changing fields (Godwin et al., 2016).

2 Why teach autonomous motivation, learning beliefs, and learner identity competencies

This section begins with an examination of how the three concepts have been explored and developed in prior studies, and their significance for learners, educators and practitioners. Although existing theories have highlighted the convergence of the three concepts within a holistic perspective, the present analysis focuses specifically on autonomous motivation and beliefs. Learner identity is acknowledged as an overarching concept that provides interpretive coherence to these dimensions, but it is not addressed in detail here. This delimitation allows us to establish a clear foundation for understanding the roles of motivation and beliefs, before considering their integration with identity in suggestions and recommendations.

2.1 Empirical evidence

This section describes previous empirical research on the timing of examining beliefs, motivation, and identity development, and findings of how these competencies change over time. Prior literature suggests that educators and practitioners measure these competencies at multiple stages, such as mid- and end-of-semester within a single term, across consecutive semesters, before and after instructional interventions, and through longitudinal comparisons of different cohorts of students over the years (Brown et al., 2015; Kramer et al., 2024; Morelock, 2017).

Previous studies also indicate that beliefs, motivation and identity may increase, decrease, or remain stable over time. For example, by following the same student cohorts over four years, Cech (2010, 2014) reported a decline in engineering students' beliefs in professional and ethical responsibilities, social awareness, and understanding the consequences of technology use during their studies. This shift was attributed to the limited emphasis on ethical engagement within their engineering programmes. Another study examining changes in student motivation within a semester-long engineering module found that students' motivation declined when they were exposed to monotonous teaching styles, theory-heavy teaching, lecture-based formats, and limited interactions with teachers (Hauzel et al., 2024). Students' motivations evolve and curricular experiences shape students' beliefs as learners and as engineering students (Pierrakos et al., 2016; 2024).

In contrast, experiential interventions such as a ten-day field trip enhanced students' beliefs about the role of science and technology in society by immersing them in authentic contexts. It offered students hands-on fieldwork experience, during which they lived closely with the situated environment, which strengthened their belief system (Nesbit & Mayer, 2010). Similarly, industrial engineering students demonstrated higher autonomous motivation when engaged in semester-long projects involving real cases (Pernia-Espinoza et al., 2025). Learner identity can also be developed through meaningful engineering-related experiences, particularly in the first year of study (Pierrakos et al., 2009; 2024).

In summary, students lose motivation, experience declining beliefs, and become disengaged when they lack a sense of ownership over learning, perceive a disconnect between theoretical knowledge and real-world problems, or have limited opportunities for meaningful knowledge application. These conditions may, in turn, lead to lower academic performance, higher attrition rates, and decreased educational satisfaction (Hauzel et al., 2024). Educators and practitioners are therefore encouraged to adopt active learning approaches at an early stage of student learning, link module content to real-world contexts, and provide practical experience for students to apply theory.

2.2 Significance for engineering education

Understanding and developing beliefs, motivation, and identity is valuable, as they underpin both individual growth and broader engineering and social systems.

At the individual level, first, these competencies shape students' learning behaviours, including academic choices, persistence, and retention in engineering, decision-making processes, and behavioural intentions (Kramer et al., 2024; Al Kakoun, 2023).

Second, they enable engineering educators and practitioners to critically reflect on the roles they assume in supporting students' acquisition of engineering-related knowledge and consider what pedagogical practices most effectively foster active engagement in technical problem solving and self-directed learning (Jiang et al., 2024; Kramer et al., 2024; Pierrakos, 2025). Therefore, the competencies are important for educators and practitioners to create learning environments that strengthen persistence, agency, and long-term engagement in learning.

Third, these competencies shape how engineers see their roles within the engineering profession and demonstrate confidence that they perform effectively in engineering. Engineers with stronger autonomous motivation and positive beliefs in their performance are more likely to see themselves as capable and committed members of the engineering profession (Curtis et al., 2017; Godwin et al., 2016; Pierrakos et al., 2009; 2016; Stoup & Pierrakos, 2016).

From a social perspective, beliefs, motivation, and identity reflect the culture and norms of engineering education. They capture how values such as ethics, efficiency, or social responsibility are emphasised (or marginalised) within engineering programmes. As Berger et al. (2017) suggest, understanding these competencies of both students and educators helps reveal what kind of knowledge and practice are legitimised and valued in a department or society. This means that beliefs, motivation, and identity are not merely individual traits; they are shaped by institutional contexts and broader societal influences (Kramer et al., 2024). Consequently, they contribute to sustaining or transforming the dominant narratives of engineering, such as whether it is seen primarily as a technical discipline or as a profession that also carries ethical and societal responsibilities.

3 Forms of implementation

Students' learning beliefs, autonomous motivation, and learner identity have been extensively studied across educational stages, from secondary and vocational education to higher education, and in diverse learning contexts (Brown et al., 2015; Kramer et al., 2024; Morelock, 2017; Wijnia et al., 2024). Educators and practitioners can use intentional teaching methods, structured module design, and targeted support resources to support student development (Wijnia et al., 2024). Accordingly, this chapter highlights some specific active learning approaches, followed by practical examples of module design and supportive resources. It also discusses the challenges engineering educators and practitioners may encounter in cultivating students' motivation, beliefs, and identity.

3.1 Teaching methods

As stated previously, student learning gets strengthened through problem-solving, practice-oriented, interactive, and student-centred active learning methods. This section thus outlines instructional strategies, such as problem-based learning (PBL), project-based learning (PjBL), case-based learning (CBL), and design-based learning (DBL) approaches, that can be implemented in the classroom settings. This section starts with providing brief definitions of each approach and highlights key practices to support educators and practitioners.

Problem-based learning (PBL) involves students working in small groups to define and solve ill-structured, real-world problems (Kolmos et al., 2008). PBL enhances autonomous motivation and beliefs and fosters identity development when students have genuine choice over problem framing, and when teachers provide directive yet non-controlling support and normalise uncertainty in complex problem-solving practices (Kolmos et al., 2008).

Project-based learning (PjBL) involves projects through which students individually or collectively learn the core concepts and principles of a field (Kolmos et al., 2008). In PjBL, student motivation is supported when essential project elements, such as standards (scope, goals, and purpose), time (deadlines, milestones) and resources (persons, equipment, material, budget), are clearly justified by educators and practitioners. Within teams, students should be given the autonomy to decide problem-solving routes, distribute tasks, and assume different team roles to complete projects. Students are more likely to develop a growth mindset when they engage in projects connected to real-world scenarios and apply knowledge in practice (Jiang et al., 2023), and when teachers simultaneously provide structured coaching through regular progress meetings and ongoing formative feedback (Pierrakos et al., 2024).

Case-based learning (CBL) uses cases to contextualise discipline- or practice-specific knowledge (Wijnia et al., 2024). However, students tend to report lower autonomous motivation and weaker beliefs when cases are used only as examples to complement lectures, with all information provided by teachers, all students working on the same case, and discussions led entirely by teachers. In contrast, co-creation approaches involving students, teachers, and relevant external stakeholders in authentic cases are found to promote student learning beliefs and ownership over learning (Lavi & Marti, 2023).

Design-based learning (DBL) focuses on the design process itself, and the designers' engagement with that process (Al Kakoun, 2023), by encouraging iterative prototyping, testing, and refinement, rather than solely focusing on the final product (Azizan & Abu Shamsi, 2022; Pierrakos et al., 2024). Students' autonomous motivation and beliefs are strengthened if students can empathise with users' needs, clearly identify problems based on those needs, and generate, test, and prototype tangible solutions.

In summary, these active teaching methods can be applied to individual module designs or systematically integrated across programmes or institutional strategies to support students' beliefs, motivation, and identity development (Chen et al., 2024; Pierrakos, 2025; Wijnia et al., 2024). Educators and practitioners can nonetheless draw on or combine key practices from these approaches, such as real-world problems, small-scale projects, authentic cases, collaboration with community partners and external stakeholders, or a structured design process to meaningfully inform and enrich their own teaching practices. Although the following section presents only the four approaches mentioned above as practical examples, other active learning strategies, such as the flipped classroom, collaborative learning, and experiential learning, may also effectively support student learning.

3.2 Practical examples for module design

This section presents two cases illustrating how these four active learning approaches can be integrated into module design to foster students' autonomous motivation, learning beliefs, and learner identity, as well as how educators and practitioners may assess these competencies. The cases are drawn from the authors' own teaching practices across different institutions and nations, including Aalborg University, Denmark, and Swansea University, UK.

Example 1. Problem-based learning (Aalborg University, Denmark)
Target group. *First-year engineering undergraduate students*
Active learning approaches used. *DBL, PBL, and PjBL*

Framework. *five stages of a design-based approach for teaching design*

Stages:

1. Empathise*. Students start with an ill-structured problem in their own field, develop contextual understanding, and consider the needs of key stakeholders.*
2. Define. *Students synthesise insights from the empathise phase to articulate a clear and actionable problem.*
3. Ideate. *Students apply divergent thinking and use appropriate tools or strategies to generate multiple solutions for the defined problems.*
4. Prototype*. Promising ideas are transformed into tangible prototypes, such as products, processes, or experiences, to test assumptions for further refinement*
5. Test. *Students gather feedback on their prototypes, evaluate results, and determine next steps.*

Module activities:

- Preparation. *Students access videos, slides, readings, and a toolbox on the university's Moodle platform to build foundational knowledge and understanding of problems (link to stages 1 and 2).*
- Workshops. *Students apply strategies and tools on problem design, project management, and team collaboration (link to stages 1 to 4).*
- Online consultation. *Students seek clarifications and guidance from teachers to select appropriate tools for project management, problem design, and team collaboration, if needed (link to stages 3 and 4).*
- Assignment. *Students submit group assignments (link to stage 4).*
- Portfolio. *Students document their learning process, reflect on the effectiveness of strategies used, and identify areas for improvement (link to stages 4 and 5).*
- Feedback. *Students receive rubric-based written feedback from teachers on both their assignment and portfolios (link to stages 4 and 5)*

Examples:

- Problem identification, analysis, and formulation. *Students use the 5W1H model (what, why, who, when, where, how) to identify problems. Students conduct literature reviews, stakeholder interviews and analysis, and fieldwork to analyse problems within real-world scenarios. Students also use the Pugh matrix, a criteria-based decision-making tool, to compare and evaluate multiple design options and identify the most suitable solution to the problems they have identified.*
- Project management*. students use a Work Breakdown Structure (WBS) to define clear project goals, milestones, and tasks. They apply critical path analysis to estimate project timelines and use tools such as Gantt charts and Scrum to maintain an overview of progress and support daily task management.*

The following tools are used for assessing students' motivation and beliefs development):

- *Qualitative content analysis of students' portfolios.*

Theoretically, this example reflects a motivation-centred theory lens, highlighting how students' beliefs and values about their learning shape their motivation and, over time, indirectly contribute to their identity development. In practice, students' motivation and learning beliefs in this module can be assessed at two points — mid-semester and at the end of the term — to track their development over time. Their beliefs and motivation are strengthened when they receive consistent rubric-based criteria and detailed written feedback, work with clear project goals, engage in hands-on workshops, collaboratively identify and solve problems grounded in stakeholder needs and fieldwork, and participate in structured reflections (Jiang et al., 2022, 2023). The staged design-based learning approach (empathise–define–ideate–prototype–test) further supports this development by combining structure with autonomy, enabling students to move from passive participation towards more active, collaborative, and self-directed learning.

More detailed information about practices at Aalborg University can be found in Chapter 4.2: Systems Approach to Transferable Skills in PBL-Based Engineering Education: The Aalborg University Case.

Example 2. Conceptual design: human-focussed design workshop, Swansea University, UK

Target group. *first-year and third-year civil engineering undergraduate students*

Active learning approaches used. *DBL and CBL*

Framework. *Communal Design lens within a human-centred designing assignment (DBL sequence)*

Stages

1. Surface learner dispositions (diagnostic phase). *Students complete disposition questionnaires before the design task that may influence their decision making and their ability to handle uncertainty.*
2. Orient to social impact and responsibility. *A guided class discussion frames how civil engineering designs shape quality of life and social responsibility, and invites students to reflect on privilege and real-life impacts to build empathy before designing.*
3. Contextualise and analyse the case (part A). *Students are shown a district in Beirut, Shatila, using plans, maps, structural information, occupation listings, and quality-of-life reports to identify how needs have been met or unmet, and how this appears in well-being indicators.*
4. Define unmet needs and propose a conceptual design (part B). *Students identify the physical and metaphysical needs of Shatila residents and propose a conceptual civil engineering design to improve their life quality. The task uses the Matrix of Human Needs and Satisfiers (Max-Neef et al., 1991), a framework that identifies how different practices meet fundamental human needs while reducing subjective bias of "satisfactory living" and avoiding hierarchical assumptions about human needs.*

5. Demonstrate communal design and reflect. *Interaction-oriented needs (Communal Design) are one evaluation criterion, referring to whether the design explicitly enables social interaction, identity, and togetherness beyond technical or basic physical needs. The design is qualitatively evaluated by two independent external referees, based on predefined criteria and cross-checking. Students' final outputs are then compared to their initial dispositions (of stage 1) to determine how personal dispositions relate to their design outcomes.*

Module activities:

- Preparation. *Students receive an information pack with Shatila maps and briefs, quality-of-life reports, and the Matrix for Human Needs and Satisfiers.*
- Workshop discussion. *Students engage in a facilitated discussion on social impact, social awareness, and responsibility in civil engineering.*
- Task delivery. *Students complete part A and B. No detailed design is required; the focus is on what needs and priorities students' foreground when designing for quality of life.*
- Empathy-building activity. *Students are shown pictures of Shatila residents carrying out daily tasks during their design assignment. The pictures are selected to support empathetic understanding of Shatila residents' regular living conditions and needs.*
- Post-task instruments. *After submitting solutions and designs, students complete a questionnaire pack capturing their social awareness and empathetic and prosocial indicators.*
- Evaluation. *Design outputs are coded as communal or non-communal designs based on criteria and activities in stage 5.*

Examples:

- Root-cause orientation and creative breadth. *Students are prompted to look for root problems rather than temporary fixes and to generate solutions that address multiple issues per concept, while repeatedly engaging in perspective taking (put yourself in the shoes of Shatila residents).*
- Communal design criteria (metaphysical and interaction needs). *Examples used as criteria include "living spaces/social environment/dwelling", "settings of participative interaction such as communities/neighbourhoods/family", and "privacy/intimacy/spaces of closeness".*

The following tools are used for assessing students' motivation, beliefs, and identity during the module (Al Kakoun, 2023; Al Kakoun, Boy, Groves, et al., 2021; Al Kakoun, Boy, & Xavier, 2021; Al Kakoun et al., 2024):

- Disposition questionnaire in stage 1. *Portrait Values Questionnaire-Revised (PVQ-RR) and Almost Perfect Scale-Revised (APS-R).*
- Empathy-building activity. *Interpersonal Reactivity Index (IRI).*
- Post-task instruments. *Self and Social Awareness Instrument, Prosocialness Scale for Adults; Prosocial Behavioural Intentions Scale.*

In this DBL- and CBL-oriented module, students' personal traits and underlying beliefs about social awareness, responsibility, and empathy influence how they exercise autonomous motivation and make decisions in uncertain, human-centred contexts. This example reflects a motivational-centred and integrative theories perspective, highlighting the dynamic interplay among the three competencies, showing how personal values and traits shape social awareness, empathy, and creativity in engineering problem solving and design. By engaging with the lived conditions of Shatila residents and developing empathy-informed, open-ended design processes, students are encouraged to move beyond purely technical or basic physical solutions. This process supports the development of a professional identity that integrates social responsiveness, ethical responsibility, and empathetic understanding into engineering practice. More detailed information about the Example 2 questionnaire results and module methodologies and practices can be found in (Al Kakoun, 2023; Al Kakoun, Boy, Groves, et al., 2021; Al Kakoun, Boy, & Xavier, 2021; Al Kakoun et al., 2024).

In summary, although these two examples show how active learning approaches could support students' beliefs, motivation, and identity development, educators and practitioners who adopt traditional lecture-based teaching can also draw valuable insights. By linking core concepts to real-world practices (e.g. stakeholder analysis, root-cause thinking, or contrasting community contexts), educators and practitioners can highlight the social impact of engineering and portray engineers as both technical experts and socially responsible professionals. In addition, integrating brief reflective prompts, clear rubrics, written feedback, or case-based illustrations can further strengthen students' beliefs and motivation without fundamentally altering the teaching format.

3.3 Challenges in developing beliefs, motivation, and identity

First-year undergraduate engineering students often begin higher education with beliefs shaped by their earlier schooling experiences, which may not align with student-centred pedagogies. For example, some may equate learning with memorising facts or view the teacher as the sole source of knowledge. These beliefs can limit their willingness to engage in active, student-centred approaches such as PBL, PjBL, DBL, or CBL, where students are expected to construct knowledge collaboratively and independently (Wijnia et al., 2024).

A further challenge is sustaining students' motivation and beliefs throughout extended learning processes. Such challenges often arise when students find a topic initially engaging but their motivation can quickly decline once the novelty wears off. In longer projects, motivation and learning beliefs may weaken further if students fail to see tangible progress, if tasks become repetitive and lack variety, or if the content feels less relevant (Cech, 2010). This issue is especially evident in engineering and project-based contexts, where the iterative nature of design and problem solving can sometimes lead to frustration (Jiang et al., 2022).

When students work in a group to deliver designs or projects, team dynamics can undermine students' motivation and beliefs as communication barriers, cultural misunderstandings, and unequal participation emerge. Such challenges often lead to frustration, reduced trust, and doubts about the value of collaboration. Conflicts and differing expectations within teams may lower students' self-efficacy and weaken their beliefs in the effectiveness of group work, while also diminishing intrinsic motivation to engage fully in the learning process (Jiang, Dahl, & Du, 2023).

4 Recommendations for implementation and learning

Drawing on earlier sections covering definitions, relevant theories, arguments, and forms of implementation, this chapter proposes several key recommendations for engineering educators and practitioners.

First, embrace a holistic view on autonomous motivation, learning beliefs, and learner identity. We summarize existing theories in three aspects: motivational-centred, identity development, and integrative theories to better understand their interconnectedness. Each lens can inform teaching design and guide the educators and practitioners to understand and measure these three competencies as developing over time (longitudinally), as structured in relation to one another (hierarchically), or as dynamically influencing each other (reciprocally).

Second, empower students to take responsibility for their learning. Autonomous motivation and learning beliefs grow when students can self-direct their learning by exploring real-world problems, choosing project topics, and identifying relevant learning content. High-impact practices like DBL, CBL, PBL, and PjBL support these processes while addressing both personal and societal needs. Meanwhile, teachers should serve as facilitators rather than learning controllers, supporting students to make meaningful choices, encouraging facilitation-based dialogues, set up learning goals, and understand mutual expectations.

Third, create authentic problems, challenges, and cases. Based on the learning principles of PBL, PjBL, CBL and DBL, it is essential that the problem or challenge aligns clearly with the module's learning objectives while being situated in a meaningful real-world context. Authentic problems should be connected to community partners, industry needs, or broader societal challenges. They should encourage student learning beyond the classroom through external collaboration with community, industry, or other organisations. Identifying and addressing real-world challenges also calls for educators and practitioners to structure modules in staged learning phases, enabling students to progressively develop motivation, beliefs, and identity.

Fourth, provide opportunities for self-reflection. Drawing on case 1, students should regularly reflect on their learning through tools such as learning portfolios, reflective journals, structured debriefing or in-class check-ins, enabling them to understand the three competencies as developing over time, structured in relation to one another, and dynamically interacting. A structured reflective loop, examining what, how, and why they learn, helps them connect current learning to future development and their careers (Gibbs, 1988). Constructive and structured feedback is essential for students to track their learning progression, refine strategies, and strengthen beliefs and motivations.

Fifth, build learning communities. Students learn best in an inclusive environment where they can exchange ideas, co-create meanings, and build their identities within supportive peer networks. Teamwork or group-based assignments could benefit students by creating space for co-learning and develop learning beliefs and motivation.

Sixth, highlight social awareness and responsibility. Inspired from both cases, educators and practitioners should integrate socially grounded examples and empathy-informed, community-connected challenges to strengthen engineering identity, positioning engineers not only as technical problem solvers, but as socially responsive professionals.

Lastly, if you want to deepen your knowledge, we want to recommend the following resources in addition to the literature cited in this chapter: Elliot et al. (2017) and Murray et al. (2011).

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AI statement

During the preparation of this work, the authors used ChatGPT in order to correct grammatical errors and improve sentence clarity and coherence. 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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