2.18

Initiative and Perseverance in Engineering Education

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Keywords: *motivation, self-regulated learning, pedagogy*

This chapter examines initiative and perseverance as essential but often underdeveloped competencies in engineering education. Initiative refers to self-starting and proactive behaviour, while perseverance is the ability to sustain effort in the face of setbacks, uncertainty, and failure. Using self-regulated learning as a framework, we describe how these qualities develop through cycles of planning, action, monitoring, and reflection. We also draw on studies of perfectionism to demonstrate how personal motivations and traits influence students' ability to act and persist in their academic pursuits. Engineering education culture, characterised by heavy workloads, rigid grading, time pressures, and perfectionist expectations, creates conditions that can both encourage and hinder these qualities. Case studies demonstrate how active and experiential pedagogies, combined with reflective practice, offer students opportunities to develop initiative and perseverance. We recommend that educators create feedback-rich, autonomy-supportive environments, while ensuring that their modules and interventions align with students' personal motivators and mitigate perfectionist tendencies. By combining cultural, personal, and pedagogical perspectives, engineering education can better prepare students to become adaptable and resilient engineers who are able to meet uncertainty with creativity and persistence.

DOI: 10.59490/mt.266.74.

1 Definition

In this chapter, initiative and perseverance refer to engineering students' ability to independently make rational decisions and solve problems in their academic programmes and personal lives. Nowadays, it is increasingly critical for engineering students to skilfully handle unpredictable and disruptive events that are often out of their control; devise new strategies to address complex, interdisciplinary engineering problems; and achieve their goals in a constantly evolving academic and career landscape (Jonassen et al., 2006; National Academies of Science, Engineering, and Medicine, 2017). Over time, students can develop initiative and perseverance in response to the conditions and disruptions imposed by their personal and academic environment (Gesun et al., 2021). We also connect initiative and perseverance to self-regulated learning and perfectionism to discuss some of the complex mechanisms that reinforce or undermine these competencies.

1.1 Defining initiative

According to Frese and Fay (2001), the concept of 'personal initiative' manifests in the workplace through three key behaviours: being self-starting, proactive, and persistent. Self-starting involves taking control of situations without external prompting, proactive behaviour requires anticipating and adequately preparing for potential future events, while persistence ensures that goals and plans are successfully executed. Effective initiative arguably requires openness to change, new ideas, experiences, and growth (Birkinshaw, 1999) and a willingness to take risks (Highhouse et al., 2022). In contrast, individuals lacking initiative display passive and reactive behaviours, waiting for instructions, information, and assistance rather than seeking them independently.

1.2 Defining perseverance

Table 2.18.1: Definitions of grit, growth mindset, and resilience

Term	*Definition*
Grit	The ability to work strenuously toward challenges, maintaining effort and interest over years despite failure, adversity, and plateaus in progress. It consists of passion and perseverance for long-term goals (Duckworth et al., 2007).
Growth mindset	The belief that intelligence and ability are malleable (Dweck & Legget, 1998; Dweck & Yeager, 2019).
Academic resilience	The ability to effectively deal with setbacks, challenges, adversity, and pressure in academic settings (Martin & Marsh, 2006).

Perseverance, a synonym for persistence, complements initiative. It refers to students' unwavering resolve in the face of challenges and setbacks during their academic journey, including learning complex concepts, performing poorly on an assessment, or failing an engineering module (American Psychological Association, 2023; Cambridge University Press, n.d.). Perseverance is closely related to grit, a growth mindset, and resilience — concepts that have been extensively studied in engineering education (Table 2.18.1). Together, these concepts suggest that the key to skilfully navigating disappointments and unfavourable circumstances is a positive, long-term outlook.

1.3 Self-regulated learning

Self-regulated learning (SRL) theory (Bandura, 1986; Pintrich 2000) connects desired observable behaviours (e.g., initiative and perseverance) to internal learning mechanisms. At the individual level, SRL operationalizes learning as a continuous process with three phases: (1) forethought, (2) performance; and (3) self-reflection. In the forethought phase, students set goals and make strategic plans based on their motivational beliefs. The next phase, performance, is characterized by task execution. For example, students can control and observe their behaviour towards academic tasks in real-time by focusing their attention, employing time management strategies, and seeking help. In the final phase, self-reflection, students evaluate their performance, revise their goals as required, and prepare for future tasks. In collaborative settings, SRL can occur simultaneously at the individual and group levels, as shown in Fig. 2.18.1 (Hadwin et al., 2018; Panadero, 2017).

SRL presents learning as an active, student-driven exercise. A key assumption of SRL theory is that students will act to achieve their goals (Pintrich, 2000). However, not all goals are necessarily focused on learning. Students may be motivated to develop competence (i.e., mastery goal orientation), or they may desire to appear competent relative to their peers (i.e., performance goal orientation) (Pintrich, 2000). These orientations determine whether students approach or avoid academic tasks (Table 2.18.2).

Table 2.18.2: Mastery and performance goal orientations (adapted from Pintrich, 2000)

	Mastery goal orientation	*Performance goal orientation*
Approach	Seeks to promote deep understanding and skill acquisition	Seeks to feel superior and appear competent
Avoidance	Seeks to avoid a loss of knowledge and skills	Seeks to avoid feeling inferior and appear incompetent

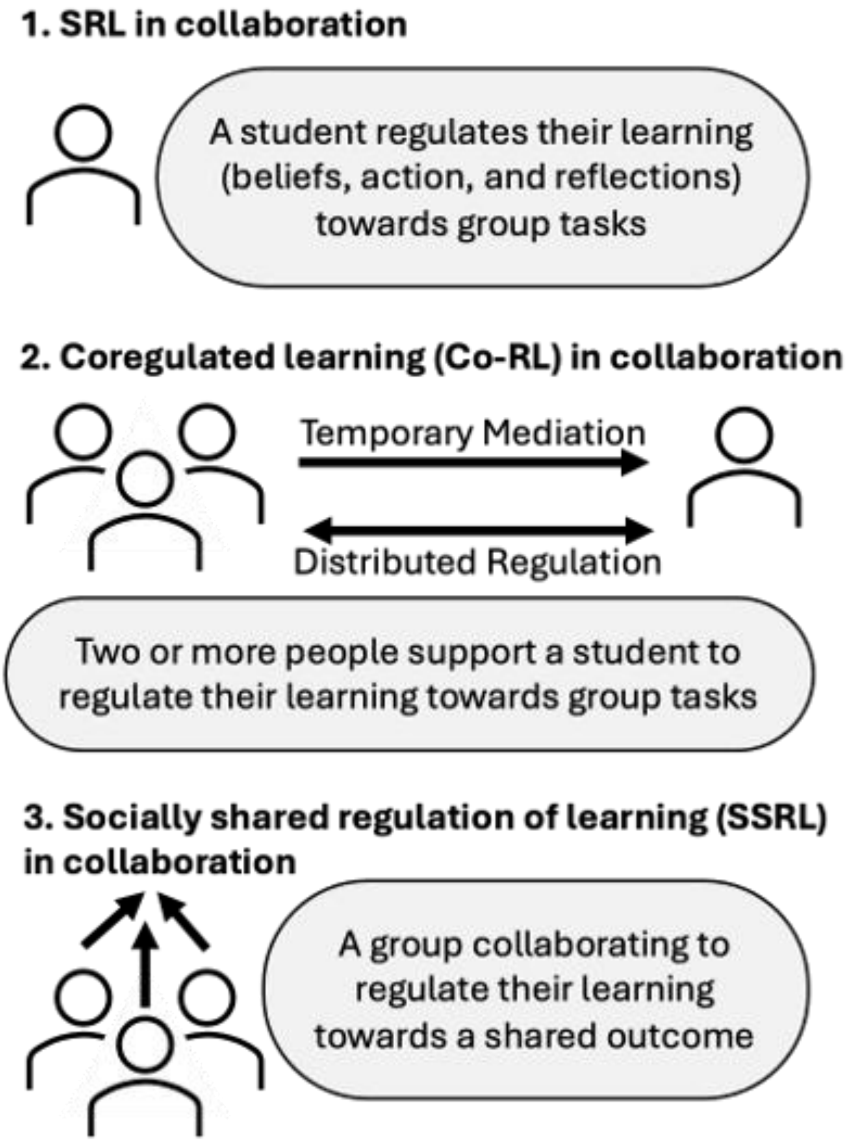

Figure 2.18.1: SRL in collaborative settings
(Own Work by authors)

We are not the first authors to connect initiative, perseverance, and SRL (Frese & Fay, 2001). In Table 2.18.3 the 'action sequences' of personal initiative echo the phases of SRL. Thus, we posit that the relationship between SRL, initiative, and perseverance is reciprocal. Students require initiative and perseverance to make decisions and take ownership of their academic development (i.e., plan, execute, and evaluate their performance). Similarly, by continuously engaging in the SRL process, they will deepen their capacity to actively and proactively take initiative and persevere over time.

Table 2.18.3: Facets of personal initiative (adapted from Frese & Fay, 2001)

Action sequence	*Self-starting*	*Proactive*	*Overcoming barriers*
Goal development	Set and redefine goals	Anticipate problems and opportunities	Protect goals from interference (e.g., frustration)
Information collection and prognosis	Actively search and find information	Consider potential problems, opportunities, and alternatives	Maintain search despite complex, negative emotions
Plan development and execution	Actively plan	Have back-up plans and action plans for unplanned opportunities	Overcome barriers; return to plan quickly when disturbed
Monitoring and feedback control	Self-developed checks and feedback	Develop alerts for potential problems and opportunities	Protect feedback from interference (e.g., unclear assignment rubrics, miscommunication)

1.4 Perfectionism

Perfectionism, a psychological trait characterized by setting high goals, expectations, and standards for oneself and/or others (Hewitt et al, 1991; Slaney et al., 2001), also affects student motivation. When high expectations are accompanied by harsh and overly critical self-evaluations and self-doubt, this can be considered unhealthy or 'maladaptive' perfectionism (Hewitt et al., 1991; Slaney et al., 2001). Maladaptive perfectionism is highly associated with how students choose to engage with engineering academic tasks, especially those that are explorative, non-computational, or ambiguous in nature (Al Kakoun, 2023; 2024). In such tasks, students' fears and/or anxiety of not being able to achieve said high standards are triggered, which would then lead to task avoidance (Weiner & Carton, 2012). Such a trait is thought to impact students' motivation, initiative, and/or perseverance in engaging with highly complex, ambiguous, explorative engineering education or practice. From an educator's perspective, it could provide a way to rationalize students' subconscious choices, behaviours, and reactions.

Furthermore, perfectionism appears to significantly influence initiative-taking behaviours, though its impact varies by type. Maladaptive perfectionism manifests as avoidant behaviour and risk aversion (Jia et al., 2025), and demonstrates strong inverse relationships with openness, divergent thinking (Al Kakoun et al., 2024; Goulet-Pelletier et al., 2025), and cognitive flexibility (Akkuş Çutuk, 2020), while correlating positively with cognitive rigidity (Ferrari & Mautz, 1997). In contrast, positive perfectionism enhances innovation by promoting mastery-oriented learning and experimentation (Jia et al., 2025). In addition, Leung et al. (2019) found that tolerance of ambiguity is positively associated with adaptive perfectionism but negatively associated with maladaptive perfectionism. Thus, maladaptive perfectionism undermines SRL.

In summary, we introduced initiative and perseverance as essential skills for academic and career success and used SRL to understand how motivation and perfectionism may promote (or hinder) their development in students. The following section presents findings investigating initiative, perseverance, and related concepts in engineering students and practitioners. In particular, we discuss the effect of the perfectionist mindset, engineering culture, and pedagogical decisions on students' ability to persist and take initiative.

2 Why teach initiative and perseverance competencies

Whether facing academic challenges, professional setbacks, or technical obstacles, successful engineers must proactively identify opportunities, initiate action without external prompting, and persist through failures and uncertainties. Yet, despite the industry's clear valuation of these competencies, they remain largely absent from formal engineering curricula, being neither explicitly taught nor systematically assessed (Jonassen et al., 2006). This pedagogical gap leaves students unprepared for the realities of engineering practice.

2.1 Engineering careers require initiative

While initiative has received extensive attention in psychology and entrepreneurship research, engineering education has only begun to explore this critical competency. Industry consistently signals the importance of initiative for engineering practice. Engineers face ill-defined, complex problems requiring evidence-based, pragmatic solutions — work that necessitates technical knowledge, resourcefulness, adaptability, and determination (Godfrey & Parker, 2010; Passow & Passow, 2017; Winberg et al., 2018). As a result, companies desire entry-level engineers who possess initiative-related competencies and demonstrate forward-thinking and proactive behaviours such as 'stepping up' and 'going that extra step', as well as self-confidence and leadership (Hartmann & Jahren, 2015; Passow & Passow, 2017, Syal et al., 2020).

Taking initiative requires people to be open to change. Concerningly, however, engineering students' ability to do so appears to be declining over time (Al Kakoun, 2021, 2023), potentially undermining their capacity for initiative. These interconnected competencies — initiative and openness — are essential for contemporary engineering practice.

2.2 Engineering careers require perseverance

Engineering students need perseverance to complete an engineering degree. Graduation rates, one well-documented method of observing engineering student persistence, refers to students' ability to graduate from their engineering programme without changing majors or dropping out of university (Seymour & Hunter, 2019; Susan et al., 2019). A significant proportion of engineering education research is devoted to improving the graduation and attrition rates of engineering students, especially those who belong to historically marginalized groups within engineering. Students are more likely to persist and overcome challenges when they have strong interests in their engineering discipline, positive self-efficacy beliefs, are willing to ask for help and open to feedback, and have a strong support system (Hunsu et al., 2021; Seymour & Hunter, 2019; Washington & Momdisa, 2021). As an illustration, Hunsu et al. (2021) examined the resilience of three categories of students who failed the first exam in a foundational engineering module. The students who improved academically consistently demonstrated higher resilience than those who did not improve and those who dropped the class after the first exam. Therefore, students' ability to persevere in engineering programmes is influenced by personal, programmatic, and institutional factors.

Grit, often described as a combination of passion (interest) and perseverance (effort), is another method of observing engineering students' ability to persevere. It is a relatively new area of research in engineering education, so its impact on engineering students' academic outcomes (e.g., persistence in the discipline) remains unclear (Direito et al., 2019; Duckworth et al., 2007). In engineering education, it has been assessed using Duckworth's Grit scale, interviews, open-ended survey questions, students' journal entries, and observations (Direito et al., 2019). Current results show that engineering students tend to think about grit in terms of 'working hard', being 'resilient', and having 'short-term motivation'; younger students have more grit compared to older students; and women are 'grittier' than men (Direito et al., 2019). These results suggest that engineering students have a limited view of grit that prioritizes effort or hard work over 'passion'. In addition, the ability to persevere is not fixed but varies across different student groups and likely changes over time.

2.3 Perfectionism and engineering culture

The prevailing attitudes toward academic achievement in engineering education profoundly influence how students approach creativity, risk-taking, and failure. Engineering modules are notorious for low grades, norm-referenced grading practices, demanding coursework, high assignment volumes, and often misaligned teaching methods (Deteres et. al, 2024; Jensen et al., 2023; Seymour & Hunter, 2019). While students may bond over challenging circumstances (Godfrey & Parker, 2010), these experiences can undermine the persistence of students who do not find a community within their engineering contexts. In the United States educational system, women and historically minoritized students face additional experiences of negative stereotypes and isolation in engineering education (Jenson & Cross, 2021; Seymour & Hunter, 2019). The importance of peer networks in supporting the persistence of engineering students is well-documented (Jensen et al., 2023; Seymour & Hunter, 2019). Furthermore, the high stress and poor health outcomes endemic to engineering education further compromise students' ability to persist (Jensen and Cross, 2021; Seymour & Hunter, 2019).

2.4 Perfectionism as a fixed mindset

Within this culture of difficulty, maladaptive perfectionism emerges as a particularly problematic mindset. Students may view mistakes and failures as measures of ability instead of learning opportunities (Deck & Yeager, 2019). Additionally, they may be more concerned with defending their intelligence rather than developing their competencies and skills over time, which hinders their ability to take initiative. Perfectionism can be assessed using instruments such as the Revised Almost Perfect Scale (Slaney et al., 2001) and the Multidimensional Perfectionism Scale (Hewitt et al., 1991).

Highly prevalent among engineering students, perfectionism creates specific vulnerabilities for high achievers (Al Kakoun, 2023; Al Kakoun et al., 2024). 'Effortless perfectionism', i.e., the belief that true ability means earning good grades with minimal effort or assistance, transforms academic struggle into an identity crisis. Students who tie their self-worth to effortless achievement interpret lower grades despite hard work as evidence that they do not belong in engineering (Dringenberg et al., 2022). Students embracing this performance-avoidance orientation struggle with challenging tasks and avoid risks, whereas mastery-oriented students of similar ability adaptively seek challenges and transform setbacks into learning opportunities. Stevens et al. (2007) documented how these meritocratic attitudes create persistent insecurity about abilities. Thus, a perfectionist mindset undermines the persistence of otherwise capable students.

2.5 Pedagogical considerations

In the classroom, teaching practices, assessment methods, and pedagogical choices translate faculty's beliefs into educational experiences (Godfrey & Parker, 2010). These practices directly shape students' opportunities to develop initiative and perseverance. In particular, the interaction between students' mindsets, engineering culture, and pedagogical choices creates barriers to developing initiative and perseverance. Educators who view initiative and perseverance as inherent traits (Seymour & Hunter, 2019) or cultivating them in students as outside the scope of technical engineering content (Godfrey & Parker, 2010) are less likely to design learning opportunities targeting their development in students. Typically, students encounter these professional skills peripherally, in isolated professional development modules or end-of-semester capstone projects, which limits their meaningful application to ongoing academic and personal development.

In addition, the preference of content delivery through lecture-based instruction over student-centred pedagogy (Seymour & Hunter, 2019) denies students opportunities to take ownership of their learning through creation, reflection, decision making, and iterative practice (Sukackė et al., 2022). The focus of engineering education on quantifiable outcomes, such as exam grades and grade point averages (GPAs), inadvertently excludes difficult-to-measure but crucial competencies, like perseverance and initiative, despite their importance for holistic development (Gesun et al., 2021; Godfrey & Parker, 2010).

Moreover, decontextualized teaching of engineering principles (i.e., prioritizing formulas and derivations while omitting sustainability, societal impact, and historical context) misses crucial motivational opportunities for learning (Godfrey & Parker, 2010). By stripping away the people, processes, and circumstances behind engineering knowledge, educators miss opportunities to demonstrate how previous generations of engineers persevered through challenges, learned from mistakes, and took initiative toward innovation.

Finally, students' experiences inside and outside the classroom also impact their ability to persevere. Many scholars have documented how the meritocracy of difficulty within engineering education normalizes struggle while attributing success solely to individual factors, obscuring the impact of social inequalities and access to resources (Cech, 2013; Deters et al., 2024; Godfrey & Parker, 2010; Stevens et al., 2007). Similarly, one of the main criticisms of grit is that it perpetuates systematic inequalities by overlooking the effect of the environment on individual success (Direito et al., 2019). In a recent study, Deters et al. (2024) observed a misalignment between some instructors' expectations and the realities of online learning during the COVID-19 pandemic, demonstrating how different levels of access to a distraction-free home environment and reliable technologies (e.g., internet connectivity) resulted in unequitable learning experiences. These findings illustrate how contextual factors outside of engineering modules impact individual students' ability to persist and ultimately succeed.

2.6 Implications for engineering education

Addressing these challenges requires fundamental shifts: viewing competencies as malleable rather than fixed, creating scaffolded opportunities throughout the curriculum, implementing assessment methods that value process alongside product, and providing time and space for meaningful engagement with complex problems. For example, open-ended problem-solving pedagogies, including project-based learning, problem-based learning, and inquiry-based learning, naturally cultivate initiative and perseverance by emphasizing the process over the product. These methods align with engineering practice, where outcomes depend on creative and technical decision making (Smith et al., 2013; Sukackė et al., 2022). Only through deliberate interventions can engineering education cultivate the initiative and perseverance that professional practice demands. In the next section, we present and discuss different case studies that illustrate these methods.

3 Forms of implementation

In the previous sections, we argued that initiative and perseverance competencies can change over time. Therefore, creating multiple, scaffolded opportunities for students to practice, receive feedback, and refine these skills throughout their education may prove beneficial. While research in this area continues to evolve, we suggest that engineering educators may develop students' initiative and perseverance through two complementary approaches: implementing authentic learning experiences that reflect the complex nature of engineering problem solving (Sukackė et al., 2022), and (re)designing authentic learning environments. By creating opportunities for students to continuously practice proactive and reflexive academic behaviours, guided by peer and instructor feedback, these two approaches reinforce self-regulated learning mechanisms required to develop initiative and perseverance. In the following section, we present a few case studies that range from simple, ungraded assignments to more complex projects and module redesign efforts. With careful consideration for the local context, these examples can be implemented either in spirit or in letter in different contexts. We also hope that they inspire new and creative possibilities.

3.1 Learning experiences that promote initiative and perseverance

Authentic learning experiences, such as capstone design, laboratory modules, undergraduate research, and project-based learning, can foster motivation, thus enabling persistence and initiative-taking. For example, participating in a community service project increased the perseverance of STEM students at a Hong Kong secondary school in solving problems and completing tasks (Nalipay et al., 2024). Another example that targets student motivation is an ungraded cover letter assessment (Example 1) that develops persuasive communication skills students need to navigate professional opportunities (Allen & Pierce-Cottler, 2008). In writing the letters, students reflected on their current abilities, interests, and future career goals. Furthermore, the interactive weekly discussions encouraged students to take ownership of their project as they delivered updates, sought help, and received feedback. To support student persistence, instructors anticipated potential problems in advance and provided students with weekly advice to proactively address them. In addition, by requesting students to provide frequent updates and act on feedback, this practice also addresses unhelpful perfectionist tendencies.

Example 1. Promoting student responsibility and professional development in a capstone module (Allen & Pierce-Cottler, 2008)

This mandatory, undergraduate capstone design module was conducted over two semesters in the final year of the program.

Matching process

First, students received a list of potential capstone projects that summarized the project's needs and expectations. Then, the engineering department hosted a project fair to connect clients and students. Students could also submit their own project if it aligned with the module's learning objectives. Afterwards, students *applied to a few projects, describing how each project aligned with their qualifications and future career goals. Then, instructors matched the students and clients based on mutual preferences.*

Learning process

- *Each week, a few teams presented progress updates and received feedback from peers and instructors.*
- *Students received weekly emails summarizing important professional tips (e.g., "How to ask questions when one is trying to learn about a project?").*
- *Guest lectures and workshops covered a range of professional topics.*
- *In addition to oral and written reports, students were evaluated on their ability to regularly communicate with the client and demonstrate resourcefulness (i.e., being proactive).*

Example 2 is an engineering module designed to help students 'learn from failure' (Winkens et al., 2024). This approach increased students' personal and social-technical resilience competencies. In the reflective journals, students frequently reflected on their academic struggles (e.g., conducting literature reviews), conceptual changes (e.g., defining resilience vs. risk analysis), and how to incorporate resilience (e.g., flexibility, adaptability, and preparedness) into their future careers. Therefore, the reflection activities helped students develop personal resilience and also deepened their conceptual understanding of resilience for sociotechnical systems. This example illustrates how initiative and perseverance can be presented alongside technical content in engineering courses to deepen students' conceptual understanding.

Example 2. Teaching resilience (Winkens et al., 2024)

This elective module for master students in engineering uses case studies to develop resilience thinking and the ability to analyse and plan resilient sociotechnical engineering systems. Each group identified a real-world or existing system, defined its boundaries, and assessed its resilience against plausible future uncertainties and disruptions or crises, using scenario planning and resilience analysis. The module assessments included:

- *Regular reflective assignments in the form of journals documenting students' learning progress, written in response to provided prompts such as "How did you learn from what happened?"*
- *a midterm recorded presentation, after which the students received peer and instructor feedback;*
- *a final report that documented the collaboration, justified group decisions, and responded to peer feedback.*

These two examples illustrate how instructors can develop creativity and endurance in engineering students by creating opportunities for them to make decisions and take ownership of their educational experiences (e.g., goal-directed behaviour), requiring them to document their process to make their learning visible, and building in periodic check-in points to encourage reflection, help-seeking, and strategic planning towards their identified goals. Further, allowing them to make choices and well-designed authentic learning activities, such as cover letters and collaborative (peer) learning, increases student engagement. When implementing these types of assessments, the instructions and evaluation methods must be clear and transparent to minimize bias.

3.2 Interventions that promote perseverance

Bahnson et al. (2025) implemented a brief ecological belonging intervention — that is, performed with the whole class, within the classroom environment, at the same time — in a large first-year engineering module with historically persistent performance gaps across student demographics. In general, the intervention improved the students' module grades and continued enrolment in engineering. In particular, the intervention had a significant impact on the sense of belonging among women in the class and the module grades of students from historically minoritized populations, such as Black, Latinx, and Indigenous students. These results demonstrate the effect of a simple intervention on enhancing engineering students' sense of belonging and their ability to overcome academic challenges.

Example 3. A module-specific intervention to encourage persistence (Bahnson et al., 2025)

This brief (ca. 45 mins) intervention, implemented for first-year students in the first week of class, encouraged students to expect setbacks and obstacles as a normal part of the learning process and proactively shared strategies to address them. During class, students reflected on, shared, and heard from others about their experiences when overcoming challenges. During the intervention, the facilitator — i.e., module instructor or teaching assistant — led the class in the following activities:

- *The facilitator discussed common issues students face, such as feeling homesick as a first-year student;*
- *students individually reflected on a current challenging situation and considered how they resolved or will resolve it;*
- *the facilitator presented stories from students who recently completed the module, describing how they overcame the challenges they experienced in the module;*
- *students discussed these solutions first in small groups and then with a whole class.*

3.3 Learning environments that promote initiative and perseverance

Creating authentic learning environments extends beyond individual activities. It involves rethinking the underlying philosophy of a module and making pedagogical decisions that are well-aligned with it. To this end, Talbert and Clark (2023) proposed four pillars of alternative assessments: 'clearly defined standards', 'helpful feedback', 'marks that indicate progress', and 'reassessments without penalty'. Example 4 demonstrates how feedback and reassessments can be effectively integrated into engineering courses to foster initiative and persistence, thus enhancing academic performance (Morphew et al., 2019). Reassessments with feedback can direct students to take proactive steps towards improving their understanding. Instead of penalizing early mistakes and gaps, which are a normal part of the initial learning process, they reward students' persistence and effort towards achieving their academic goals.

Example 4. Building in feedback and reassessments into an engineering module (Morphew et al., 2019)

In the traditional schedule, students took two 'high stakes' midterm exams. Instead, the instructors of a large introductory engineering module implemented an alternative assessment schedule consisting of five open-ended lecture quizzes, seven computer-based exams, and a final exam. Students received feedback on the lecture quizzes after one week and the computer-based exams during and after each exam. During the exam, students could immediately retry incorrect solutions for reduced credit — time permitting — or they could choose to reattempt the (altered) exam in the following week.

Morphew et al. (2019) compared students' performance on the same final exam across two semesters, comparing the traditional schedule with the alternative schedule. Students with frequent exams performed better on the final exam (M = 83.6, SD = 13.0) compared to their peers in the traditional setup (M = 76.7, SD = 14.0). Relative to the traditional setup, fewer students failed and more students earned the highest grade in the alternative setup. To simplify the logistics of (re)assessment, the computer-based exams were administered outside of class through a testing centre, allowing students to take the exams at their convenience. Also, to make this system more manageable for students, the number of questions on the computer-based exams was significantly reduced relative to the traditional midterm exams. In general, assessment reattempts are more manageable in smaller classes, with 100 or fewer students (Talbert & Clark, 2023).

4 Recommendations for implementation and learning

We started this chapter introducing initiative and perseverance as essential skills engineering students need to navigate uncertainty and difficulty in their academics, careers, and life. As we discussed, because these skills are malleable and subject to change, engineering instructors can design academic activities and environments to help students develop them. In this section, we briefly share some practical recommendations based on the examples from the previous section. As you design learning activities and modules, we recommend:

Create opportunities for students to take ownership of their learning, which include:

- Offering options (e.g., students can select and apply to different capstone projects);

- Building flexibility into your module design (e.g., students can retake exams to improve their performance after receiving feedback);
- Setting up informal check-ins and progress reports with individual students or groups; for example, students can present a project update in which they explain their decision-making process and propose next steps.

Set healthy expectations for success, normalize failure especially early in the learning process, and encourage risk-taking behaviours. Working on open-ended engineering problems and community-engaged projects without clear-cut solutions is a great way for students to learn to grapple with uncertainty, manage timelines, work with others in a team, and manage different stakeholders' expectations. Students should be exposed to these types of problems throughout the curriculum, not only in capstone modules, so they can practice and build confidence in handling these types of unstructured problems.

Use reflection as a pedagogical tool for students to learn from previous mistakes and plan for the future. In Section 3, we shared how reflection activities were used to help students proactively think about their future goals, monitor their progress, and discuss their academic struggles. Reflection activities range from individual to group activities and graded to ungraded, informal activities. In addition to reflecting on their mistakes, students need an opportunity to demonstrate that they are making progress towards their goals.

Frequently give actionable and clear formative feedback to students, especially early on in their learning process. In addition, formally and informally evaluate students on their abilities to take initiative and persevere (e.g., resourcefulness, asking for help, incorporating feedback), in addition to technical engineering content. If you want to formally or informally evaluate student initiative and perseverance in your class, we recommend:

- Defining what resilience and perseverance look like in your context;
- Considering how you will observe, see, or measure resilience and/or perseverance;
- Consider how will you give students feedback;
- Consider how will you communicate your expectations with them;
- Anticipate the problems students are likely to encounter in advance and providing support systems and making resources available to students when they need it most.

In addition, we recommend increasing collaboration with various stakeholders to promote students' development of intrapersonal competencies, such as initiative and perseverance, through interdepartmental partnerships across modules, community and client partnerships, and by upper-level undergraduate and graduate students.

Finally, in addition to the literature cited in this chapter, we recommend the following literature to deepen your knowledge: Clark & Talbert (2023) and their guide to alternative grading practices and *Understanding by design* by Wiggens & McTighe (2025).

In summary, we recommend intentionally making space and time for students to develop initiative and perseverance in individual modules and throughout the curriculum, especially through activities that require strategic planning, reflection, and incorporating feedback. These types of strategies can give students a deeper appreciation for learning as an experimental process, full of risk and reward, that takes time and effort to eventually achieve desired results. Thus, they are prepared to productively engage with the ups, downs, and ambiguity that form a normal part of learning and life.

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AI statement

During the preparation of this work the authors did not make use of any AI tools.

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