The Comfort Curriculum: How Engineering Education Systematically Buffers Students from Professional Reality

Jennifer R. Ayres

Independent Engineering Consultant, Adelaide, South Australia.

ORCID ID 0000-0002-4538-6512.

Abstract

Engineering education is widely criticised for inadequately preparing graduates for professional practice, yet this critique typically frames the problem as a collection of discrete gaps. This paper proposes the Comfort Curriculum as a unifying theoretical framework that explains how well-intentioned pedagogical structures systematically buffer students from the epistemic, emotional, organisational, and socio-technical tensions that characterise real engineering work. Drawing on epistemic culture theory, work-as-imagined versus work-as-done distinctions, situated learning, and recent research on emotional labour in engineering, the paper identifies four interconnected mechanisms through which comfort is produced: epistemic simplification, procedural assurance, emotional buffering, and organisational sanitisation. These mechanisms operate not as failures of individual curricula but as structurally embedded features of engineering education that prioritise stability, clarity, and control. The framework explains why graduates consistently experience practice shock, fragile professional identities, underdeveloped judgement under uncertainty, and surprise at the emotional demands of engineering work. It further illuminates how these consequences fall disproportionately on women, first-generation students, and engineers from underrepresented groups. Preliminary empirical evidence from a cross-national survey of practising engineers is used to illustrate key claims. The paper concludes by outlining how the Comfort Curriculum framework can inform targeted pedagogical reform without dismantling the legitimate protective functions of structured education.

Keywords: Engineering education, comfort curriculum, practice shock, epistemic cultures, hidden curriculum, professional identity, emotional labour, work-as-imagined, situated learning

1. Introduction

Engineering programmes continue to face sustained criticism for their limited ability to prepare students for the complexity, ambiguity, and socio-technical negotiation that characterise real engineering work (Heywood, 2005; Malmi et al., 2018). Recent studies show that early-career engineers experience significant dissonance between what they learned in university and what they must do in practice, particularly in managing uncertainty, coordinating with stakeholders, and making judgements under pressure (Trevelyan, 2019). These challenges are frequently interpreted as individual shortcomings or inevitable features of transition. However, emerging research suggests they reflect deeper structural misalignments in how engineering education represents professional work (Johri and Olds, 2011; Matusovich et al., 2010).

This paper argues that engineering education does not simply under-prepare students for practice—it constructs a systematically simplified version of engineering. Through pedagogical choices, accreditation pressures, and assessment structures, the curriculum presents engineering as linear, predictable, depoliticised, and primarily technical (Bucciarelli, 1994). Recent scholarship has shown that curricula systematically marginalise contextual, emotional, ethical, and socio-technical dimensions of engineering work (Leydens and Lucena, 2018; O'Connor, 2014). As a result, students develop epistemic expectations that diverge sharply from the distributed, uncertain, and negotiated nature of engineering practice.

To explain this divergence, I introduce the concept of the *Comfort Curriculum*: the set of curricular and pedagogical mechanisms that buffer students from the cognitive, emotional, organisational, and socio-technical tensions inherent in engineering work. The Comfort Curriculum is not a critique of educators but a theoretical lens for understanding how well-intentioned structures produce incomplete professional preparation.

This perspective integrates research on epistemic cultures (Knorr-Cetina, 2000), hidden curricula (Cech, 2022; Margolis and Fisher, 2003), workplace learning (Johri and Olds, 2011) and emotional dimensions of engineering identity (Lönngren et al., 2023; Walther et al., 2020). Insights from commissioning engineering—an environment where design assumptions encounter real system behaviour—further illuminate what the curriculum omits and why these omissions matter. Preliminary findings from a cross-national survey of 335 engineers across 22 countries and six continents (Ayres et al., 2026) provide illustrative empirical grounding for several of the framework's claims.

The paper offers three contributions. First, it synthesises disparate findings into a coherent framework naming how comfort is produced in engineering education. Second, it explains how these mechanisms contribute to practice shock, identity disruption, and early-career vulnerability. Third, it outlines how expanding students' engagement with uncertainty, socio-technical context, and emotional labour could strengthen professional readiness.

2. Theoretical Framework

Understanding the Comfort Curriculum requires analysing how engineering knowledge, identity, and practice are constructed through education. This section draws on four theoretical traditions: epistemic cultures, work-as-imagined versus work-as-done, situated learning, and focus on uncertainty and emotional labour in engineering.

2.1 Epistemic Cultures in Engineering

Epistemic cultures shape what a discipline values as knowledge and how it legitimises truth claims (Knorr-Cetina, 2000). Engineering's epistemic culture has long privileged reductionism, formal analysis, and calculability (Vincenti, 1990). Recent curriculum-analysis studies confirm that this preference continues to dominate assessment structures, with calculable, explicit, and bounded knowledge receiving disproportionate emphasis (Heywood, 2005; Malmi et al., 2018)

Such preferences shape learning environments where ambiguity, tacit knowledge, and socio-material reasoning are structurally minimised (Bucciarelli, 1994; Stevens et al., 2008). Students learn to expect stability, closure, and correctness where real engineering demands judgement, negotiation, and interpretive flexibility (Matusovich et al., 2010; Trevelyan, 2019). This contributes directly to the Comfort Curriculum by establishing epistemic norms that diverge from the knowledge practices engineers use.

2.2 Work-as-Imagined and Work-as-Done

Hollnagel's distinction between work-as-imagined (WAI) and work-as-done (WAD) provides a powerful lens for understanding educational misrepresentation (Dekker, 2011; Hollnagel, 2017). WAI reflects idealised workflows—ordered, controlled, and compliant with procedure—while WAD reflects how engineers adapt to uncertainty and emergent system behaviour.

Recent socio-technical studies reaffirm that engineering work is negotiated, relational, and highly contingent (Stevens et al., 2008). However, educational structures continue to deliver WAI, seldom providing opportunities for adaptive reasoning or boundary-spanning problem-solving (Johri and Olds, 2011). The Comfort Curriculum can thus be understood as the educational institutionalisation of WAI—the structural commitment to presenting work as imagined rather than as done.

2.3 Situated Learning and Legitimate Peripheral Participation

From a situated learning perspective, professional competence emerges through participation in authentic practices (Lave and Wenger, 1991). Contemporary research shows that students often lack exposure to the informal, tacit, and relational aspects of engineering practice that shape professional identity and confidence (Matusovich et al., 2010).

The concept of legitimate peripheral participation is especially relevant here. Lave and Wenger (1991) argue that newcomers develop competence not through abstract instruction but through gradually increasing engagement with the full complexity of a practice. In engineering education, however, students are rarely positioned as peripheral participants in authentic engineering communities. Instead, they occupy a parallel educational world where the tasks, constraints, and social dynamics of real engineering are replaced by pedagogically managed approximations. Laboratory exercises, for example, are designed to demonstrate known principles rather than to confront students with the diagnostic ambiguity that characterises real system behaviour. Design projects, while increasingly common, typically operate within artificially bounded constraints that remove the organisational, commercial, and interpersonal negotiations that shape real design outcomes. The consequence is that students develop confidence within the educational frame but lack the situated repertoire—

the informal knowledge, relational skills, and adaptive judgement—that would prepare them for peripheral participation in actual engineering practice.

Critically, Trevelyan (2010) demonstrates that students frequently misinterpret classroom approximations as accurate representations of work, rather than curated simplifications. This reinforces epistemic and affective expectations that diverge from workplace realities. The Comfort Curriculum restricts legitimate participation in authentic engineering, limiting the development of judgement, situational awareness, and identity resilience.

2.4 Uncertainty, Judgement, and Emotional Labour

Recent work shows that emotional labour and uncertainty navigation are central to engineering professionalism (Walther et al., 2020). However, Cech (2022) demonstrates that engineering culture tends to depoliticise and de-emotionalise work, reinforcing the idea that the "real engineer" is rational, objective, and unaffected.

Education reproduces this stance. Time pressure, interpersonal tension, ambiguity, and conflicting priorities—routine in early-career workplaces (Trevelyan, 2019)—are rarely represented in structured learning. The Comfort Curriculum, therefore, establishes emotional expectations that contradict the realities of engineering work.

2.5 Integrating the Lenses

Together, these theories show how the curriculum constructs a coherent but incomplete image of engineering. The Comfort Curriculum emerges at the intersection of epistemic preferences, pedagogical structures, cultural norms, and assessment regimes, producing a stable environment that misrepresents the socio-technical and affective demands of practice. No single theoretical tradition fully explains this phenomenon; the integration is what gives the Comfort Curriculum its explanatory power.

What this integration reveals is that the misalignment between education and practice is not a series of isolated oversights but a structurally coherent system. Epistemic culture theory explains why certain knowledge forms dominate; the WAI/WAD framework explains how idealised representations become institutionalised; situated learning theory explains why the absence of authentic participation limits professional development; and emotional labour research explains why the affective dimensions of practice remain invisible. Each tradition illuminates a different facet of the same underlying phenomenon. The Comfort Curriculum names that phenomenon and provides a framework for understanding how these facets interact to produce a consistent, predictable, and ultimately misleading educational experience. Importantly, this integration also suggests that addressing any single dimension in isolation—for example, adding socio-technical content without also addressing emotional buffering or procedural assurance—is unlikely to produce meaningful change, because the mechanisms compensate for one another.

3. The Comfort Curriculum: A Conceptual Model

Engineering curricula do not merely omit aspects of practice; they organise learning in ways that consistently buffer students from the epistemic, emotional, and organisational tensions that define engineering work. This section elaborates on four interconnected mechanisms:

epistemic simplification, procedural assurance, emotional buffering, and organisational sanitisation. These mechanisms shape students' expectations of engineering and contribute to the persistent mismatch between formal preparation and early-career experience.

3.1 Epistemic Simplification

Engineering curricula necessarily reduce complexity to provide tractable learning experiences. However, these reductions reflect long-standing epistemic traditions that privilege formal, explicit, mathematically tractable knowledge (Trevelyan, 2019; Vincenti, 1990). Recent large-scale curriculum studies show that engineering programmes remain overwhelmingly dominated by calculable, decontextualised, and bounded knowledge forms (Heywood, 2005; Malmi et al., 2018). This systematic privileging constructs an epistemic image of engineering work that is closed rather than open-ended, certain rather than interpretive, individual rather than distributed, technical rather than relational, and stable rather than emergent.

Students internalise this epistemic orientation long before entering practice. Margolis and Fisher (2003) describe this as part of the hidden curriculum, in which epistemic preferences are implicitly encoded through assessment and task design. More recent socio-technical work emphasises that engineering knowledge in practice is negotiated, emergent, and co-produced across actors and artefacts (Stevens et al., 2008). Yet these dimensions appear rarely—if at all—in the formal curriculum.

Commissioning provides a particularly clear counterpoint: systems seldom behave as design models predict, assumptions fail under load, and engineers must combine formal reasoning with contextual judgement and tacit system sense. Preliminary survey data reinforce this observation: in a cross-national sample of 335 engineers, 93.8% of the commissioning subsample ($n = 81$) reported working routinely with incomplete documentation (Ayres et al., 2026), a figure that reflects the distance between the tidy knowledge environments of the classroom and the interpretive demands of real systems. Under the Comfort Curriculum, these forms of knowing remain largely invisible, leaving graduates unprepared for knowledge practices central to real engineering.

3.2 Procedural Assurance

A second mechanism arises from heavy reliance on structured, prescriptive, stepwise approaches to laboratory work, problem-solving, and design. These procedures support student learning by reducing cognitive load—but they also communicate implicit expectations that engineering tasks unfold in stable sequences, have correct methods, reward compliance with defined steps, and produce predictable outcomes.

Recent research shows that students routinely overgeneralise classroom procedures as authentic representations of engineering work (Jonassen et al., 2006; Stevens et al., 2008). This effect is amplified by what Rozenblit and Keil (2002) describe as the illusion of explanatory depth: structured tasks can create a sense of mastery that collapses when learners encounter real complexity.

Workplace studies reveal that engineers deviate from procedures frequently as they negotiate emergent conditions, conflicting priorities, uncertain data, and stakeholder constraints (Trevelyan, 2010). Adaptive expertise—the ability to shift between procedural fluency and innovative problem-solving—is central to engineering competence (Martin et al., 2006) yet curricula predominantly assess procedural execution. Survey data from practising engineers illustrate this tension: 54.3% of the commissioning subsample reported experiencing pressure to proceed with testing before systems were ready situations in which rigid procedural adherence would not merely be inadequate but potentially dangerous (Ayres et al., 2026).

Commissioning again illustrates this gap sharply: engineers often must override, adapt, or sequence procedures differently as systems become "alive." The Comfort Curriculum, by contrast, conveys that procedures are stable, sufficient, and reflective of real work.

3.3 Emotional Buffering

A core characteristic of the Comfort Curriculum is shielding students from the emotional and interpersonal tensions embedded in engineering work. Educational environments regulate or eliminate time pressure, conflicting priorities, stakeholder disagreement, responsibility under uncertainty, interpersonal negotiation, and consequences of error.

Yet a growing body of research shows that engineering practice requires substantial emotional labour and affective competence (Walther et al., 2020). These experiences shape both professional identity and engineers' ability to act in the face of ambiguity.

However, engineering culture traditionally privileges objectivity, emotional detachment, and rationality (Cech, 2022). This cultural stance flows directly into educational norms, which downplay affective dimensions and frame emotional labour as irrelevant to "real engineering." The result is a pipeline where students master technical concepts but rarely develop tolerance for uncertainty, comfort with ambiguity, emotional resilience, confidence in navigating tension, or boundary-spanning communication.

Early-career engineers routinely report that the emotional and interpersonal demands of practice—not the technical ones—are the biggest shock (Trevelyan, 2019). The Comfort Curriculum, by minimising these dimensions, inadvertently increases early-career vulnerability.

3.4 Organisational Sanitisation

Engineering education often strips away organisational realities to focus on technical fundamentals. This sanitisation removes essential features of engineering practice: stakeholder politics, commercial pressures, contractual ambiguity, safety and operational risk, distributed authority, contested interpretations of data, and organisational learning and drift.

Socio-technical scholars argue that engineering work is inherently situated within organisational, political, and institutional structures (Bucciarelli, 1994; Stevens et al., 2008). Recent research shows that curricula rarely include these dimensions, reinforcing an image of engineering as purely technical and politically neutral (Cech, 2022; Leydens and Lucena, 2018).

Students, therefore, enter the workforce with expectations misaligned with contexts where engineering decisions involve negotiation, justification, compromise, risk acceptance, and trade-offs. Commissioning environments expose these dynamics acutely: decisions often reflect tensions between design intent, operational constraints, safety risk, schedule pressure, commercial incentive, and incomplete information. By excluding organisational complexity, the Comfort Curriculum constructs a false stability—preparing students for a world where engineering is isolated from power, politics, and constraint.

3.5 Interaction of Components

These four mechanisms are mutually reinforcing. Epistemic simplification narrows what is known, represented, and valued. Procedural assurance stabilises tasks into predictable, low-risk sequences. Emotional buffering removes discomfort, uncertainty, and responsibility. Organisational sanitisation removes politics, risk, and social complexity. Together, they produce an educational environment that is coherent, predictable, stable, and emotionally safe—the opposite of many early-career engineering contexts.

The Comfort Curriculum does not fail to represent practice by accident. It is the accumulated effect of epistemic preferences, accreditation pressures, assessment constraints, cultural norms of "real engineering," and pedagogical logics designed to manage risk and fairness. This coherence makes the Comfort Curriculum highly effective at supporting student success—but equally effective at misrepresenting the socio-technical, emotional, and organisational realities of engineering work.

Figure 1 illustrates how these four mechanisms interact to construct a coherent educational environment that diverges from the demands of professional practice. The left panel represents the curriculum as students experience it: a stable, predictable, and emotionally safe space shaped by the four mechanisms. The right panel represents what professional engineering demands. The gap between these two worlds is not a minor adjustment that graduates absorb over time; it is a structural discontinuity that the Comfort Curriculum both produces and conceals. The consequences of this gap—practice shock, identity disruption, fragile professional identity, and early-career vulnerability—are examined in the following section.

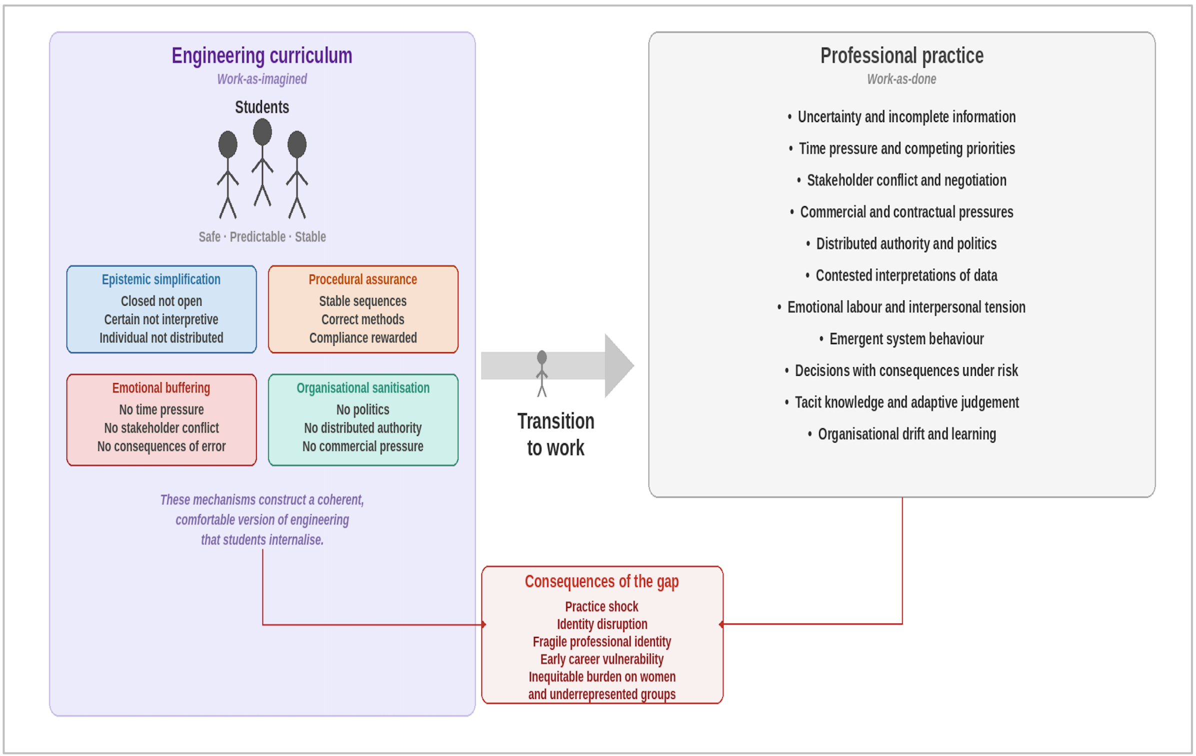

Figure 1. The Comfort Curriculum: four mechanisms construct a simplified version of engineering (left) that diverges from the demands of professional practice (right), producing predictable consequences at transition to work.

4. Consequences of the Comfort Curriculum

The Comfort Curriculum does more than shape what students learn; it shapes who they become, how they interpret engineering work, and how they navigate the earliest stages of their professional lives. Its effects extend across three interconnected domains: professional identity formation, transition-to-work readiness, and equity and inclusion.

4.1 Professional Identity Formation

Professional identity is shaped not only by what students know but by how they learn to locate themselves in relation to engineering work, expertise, responsibility, and legitimacy. Studies show that identity formation is a dialogic process involving perceived expectations of the profession, students' internal models of "real engineers," social feedback during education, and early workplace interactions (Matusovich et al., 2010; Trevelyan, 2010).

The Comfort Curriculum influences this process in several ways. First, engineering is framed as rational, controlled, and precise, shaping an identity ideal centred on technical mastery, procedural correctness, emotional neutrality, and objectivity (Cech, 2022). Students internalise these norms long before entering the workplace. Second, when procedural assurance is dominant, competence becomes equated with applying formulas, following steps, and producing correct outputs—yet professional practice often rewards judgement, prioritisation, and sensemaking over procedural execution. Third, graduates who expect engineering to be stable, linear, and predictable may experience dissonance when encountering ambiguity, conflict, or incomplete information. This creates identity instability that early-career engineers frequently report as "not feeling like a real engineer" (Stevens et al., 2008; Trevelyan, 2019).

The Comfort Curriculum, therefore, cultivates an identity template that aligns with a fictionalised view of engineering, leaving graduates underprepared for the adaptive and socio-technical dimensions of real practice.

4.2 Transition to Work

Transitioning into engineering work is widely recognised as one of the most precarious periods in an engineer's career. Several recent studies highlight that early-career engineers struggle not with technical tasks but with uncertainty, competing priorities, organisational complexity, interpersonal negotiation, and distributed authority (Trevelyan, 2019). The Comfort Curriculum intensifies this gap in four ways.

First, practice shock becomes more severe when graduates who have experienced years of clear boundaries and complete datasets must suddenly navigate missing information, unclear objectives, evolving constraints, and divergent stakeholder expectations. Second, judgement under uncertainty feels foreign because curricula rarely provide opportunities for students to make decisions with partial information, weigh conflicting risks, or justify decisions to non-technical audiences. Third, graduates lack a repertoire of practice-based heuristics—tacit system knowledge, pattern recognition, distributed sensemaking, and informal coordination—that emerge through situated participation (Johri and Olds, 2011), not classroom problem sets. Fourth, emotional demands become a second shock: research shows that early-career engineers are often surprised by interpersonal conflict, emotional labour, risk-related tension, and the need to "perform" competence when unsure (Lönngren et al., 2023; Walther et al., 2020). Because these experiences are largely absent from the curriculum, graduates interpret them as personal failings rather than structural features of engineering work.

What makes this transition particularly disorienting is that the Comfort Curriculum does not simply leave gaps in students' knowledge—it actively constructs expectations that contradict professional reality. Graduates do not enter practice with a blank slate; they enter with a fully formed but inaccurate model of what engineering work involves. A graduate who has spent four or five years in an environment where problems have correct answers, where procedures are followed sequentially, where emotional neutrality is the norm, and where organisational politics are absent has not merely missed information about these dimensions of practice. They have internalised their absence as a feature of engineering itself. When they encounter ambiguity, conflict, or organisational constraint, these experiences register not as normal professional demands but as evidence that something has gone wrong—either with the workplace or with themselves. This misattribution is a direct product of the Comfort Curriculum's coherence: because the educational environment is internally consistent, students have no reason to suspect that it is unrepresentative. The stronger and more coherent the comfort, the more destabilising the eventual encounter with reality.

Transition-to-work difficulties are therefore not simply gaps in technical competence—they are predictable consequences of a structurally comfortable educational environment.

4.3 Equity, Inclusion, and Retention

The Comfort Curriculum does not affect all students equally. Its omissions disproportionately disadvantage students who lack prior exposure to real engineering practice, are from underrepresented groups, have limited access to informal technical networks, experience stereotype threat or marginalisation, or rely on educational signals to infer what engineering "is."

Hidden curricula reproduce epistemic norms that favour dominant groups. Epistemic cultures that reward certainty, objectivity, and detachment align more closely with the norms associated with majority-group engineers (Cech, 2022; Leydens and Lucena, 2018). Students whose strengths lie in communication, coordination, contextual reasoning, or relational work may find these undervalued—despite being essential to real engineering. Emotional buffering hides the disproportionate labour carried by women and minoritised engineers, who often shoulder more emotional labour, coordination work, and boundary-spanning communication in practice (Stevens et al., 2008). When education fails to acknowledge these dimensions, these engineers enter the workforce less prepared for the very forms of work they will disproportionately perform.

Studies show that identity tension, epistemic injustice, and lack of access to tacit knowledge disproportionately drive attrition for underrepresented groups (Collins and Evans, 2007; Lönngren et al., 2023; Trevelyan, 2019). If "real engineering" is framed as technical, solitary, and procedure-driven, students who excel in socio-technical reasoning or integrative judgement may feel undervalued or illegitimate.

The equity implications are compounded by the fact that the Comfort Curriculum operates invisibly. Because its mechanisms are embedded in the structure of education rather than in explicit policies or individual behaviours, they are difficult to identify and resist. Students who struggle with the transition to practice are more likely to attribute their difficulties to personal inadequacy than to recognise them as predictable consequences of an educational structure that prepared everyone inadequately—but that prepared some groups more inadequately than others. First-generation engineers, students without family connections in engineering, and those from cultural backgrounds that do not align with engineering's dominant epistemic norms face a double disadvantage: they lack the informal networks that might partially compensate for the curriculum's omissions, and they are more likely to interpret early-career difficulties as confirmation that they do not belong. The Comfort Curriculum thus functions as a hidden sorting mechanism that appears neutral but systematically advantages students whose pre-existing cultural capital aligns with its implicit assumptions about what engineering is and who engineers should be. In sum, the Comfort Curriculum reinforces existing inequities by privileging certain identities, knowledge forms, and affective dispositions over others.

4.4 Summary of Consequences

The Comfort Curriculum shapes professional formation by producing identities based on fictionalised work expectations; transition to work by creating gaps in uncertainty navigation, judgement, emotional competence, and socio-technical reasoning; and equity and inclusion by ensuring that underrepresented groups experience sharper mismatches and higher early-career strain. These implications are structural, not incidental. Engineering education must therefore confront not only what it teaches, but the conditions under which learning occurs, the forms of knowledge it legitimises, and the practices it systematically renders invisible.

5. Discussion

The Comfort Curriculum offers a new lens through which to interpret persistent tensions in engineering education and early-career practice. While prior scholarship has identified specific gaps—such as limited socio-technical integration (Leydens and Lucena, 2018), weak attention to emotional dimensions of engineering formation (Walther et al., 2020), and inadequate preparation for uncertainty (Johri and Olds, 2011)—these analyses have tended to treat such issues as discrete shortcomings rather than symptoms of a systemic pattern. By contrast, the Comfort Curriculum positions these gaps as interdependent mechanisms that collectively stabilise a particular representation of engineering learning.

5.1 Connecting to Existing Engineering Education Debates

Several longstanding debates in engineering education intersect with the Comfort Curriculum. The *professional preparation debate* focuses on why graduates struggle with workplace readiness (Trevelyan, 2019), often emphasising skill gaps in communication, teamwork, leadership, and judgement. The Comfort Curriculum reframes these issues as predictable outcomes of the curriculum's structural features rather than as deficits in students themselves.

The *socio-technical integration debate* has long noted that, despite decades of advocacy, socio-technical thinking remains peripheral in many engineering programmes (Leydens and Lucena, 2018). The Comfort Curriculum clarifies why: socio-technical complexity disrupts the stability and predictability that the curriculum is designed to maintain. Its absence is not accidental; it is structurally necessary to preserving comfort.

The *hidden curriculum debate* highlights how messages about identity, legitimacy, and belonging shape engineering culture (Cech, 2022). The Comfort Curriculum extends this by identifying specific pedagogical mechanisms that transmit these messages through epistemic preferences, task structures, and assessment regimes—not just through informal norms.

The *emotional labour and identity debate*, while increasingly prominent (Lönngren et al., 2023; Walther et al., 2020), has often been positioned as complementary rather than central to engineering competence. The Comfort Curriculum makes emotional competence foundational by showing how its absence in education creates instability in early careers.

Finally, the *WAI/WAD misalignment debate* typically centres on safety and human factors (Dekker, 2011; Hollnagel, 2017). The Comfort Curriculum extends this dichotomy into engineer formation, arguing that education institutionalises WAI and systematically withholds WAD, producing predictable practice shock.

5.2 A New Explanatory Synthesis

The Comfort Curriculum synthesises these debates into a cohesive theoretical structure. Its explanatory value lies in three contributions. First, *mechanistic clarity*: rather than simply asserting that engineering education lacks realism, it identifies four mechanisms—epistemic simplification, procedural assurance, emotional buffering, and organisational sanitisation—that show how comfort is produced, not just that it exists.

Second, *system-level framing*: the model reveals how individual curriculum choices accumulate into a broader educational environment that systematically misrepresents professional practice. This helps explain why reform efforts often struggle, why realism is hard to integrate, and why change is slow despite strong evidence.

Third, *predictive power*: the Comfort Curriculum predicts several empirical patterns documented in the literature, including practice shock, fragile early-career identity, underdeveloped judgement, surprise at emotional labour, overreliance on procedure, socio-technical blind spots, and inequitable early-career burden on women and minorities. Instead of treating these as disconnected issues, the model positions them as logical consequences of a structurally comfortable educational system.

5.3 Why Engineering Education Has Difficulty Addressing These Gaps

The mechanisms of the Comfort Curriculum persist because they offer legitimate educational advantages: reduced cognitive load, fair and scalable assessment, predictable learning experiences, controlled classroom environments, alignment with accreditation and industry expectations, and minimisation of legal and safety risks in student laboratories. These benefits mean that discomfort cannot be reintroduced casually or quickly.

Reforms aimed at bringing more realism into engineering education encounter practical barriers. Authentic complexity is hard to teach at scale because real systems behave unpredictably while classrooms demand control. Emotional labour is difficult to assess within engineering's cultural history of resisting affect. Organisational realities are messy and politically sensitive, and universities prefer value-neutral depictions. Tacit knowledge is challenging to scaffold because codifying the informal often neutralises its essence. The Comfort Curriculum framework makes these tensions explicit, enabling more strategic reform conversations.

5.4 Implications for Pedagogical and Curricular Reform

Understanding the Comfort Curriculum opens new pathways for reform that do not require dismantling the entire educational structure. Instead of attempting to replicate real engineering in the classroom—an impossible task—educators can integrate targeted discomfort in controlled, ethical, and educationally sound ways.

Potential strategies include designing for "productive discomfort" by incorporating uncertainty, partial data, conflicting priorities, or evolving constraints; embedding socio-technical reasoning through case studies, stakeholder simulations, and role-based engineering tasks; normalising emotional labour by teaching emotional resilience, conflict navigation, and reflective practice as standard engineering competencies; structuring early, guided legitimate participation through richer apprenticeships, shadowing, and authentic team-based project integration; and making tacit knowledge visible without trivialising it by inviting practitioners to narrate decision processes, uncertainty navigation, and system sensemaking.

Two of these strategies merit particular attention. First, designing for productive discomfort does not mean simply making tasks harder or adding ambiguity for its own sake. It means constructing learning experiences where the uncertainty is genuine, the constraints are realistic, and the resolution requires the kinds of judgement, negotiation, and prioritisation that characterise real engineering decisions. A project brief that changes partway through, a dataset with missing values and conflicting sources, or a design problem where stakeholder requirements are contradictory—these are not pedagogical failures but deliberate provocations that prepare students for the conditions they will encounter. The key is scaffolding: students need support to process discomfort productively rather than experiencing it as arbitrary or punitive. Second, making tacit knowledge visible requires more than inviting guest speakers. It requires structured opportunities for students to observe and reflect on how experienced engineers think—how they read a situation, weigh competing signals, make decisions with incomplete information, and navigate the interpersonal dynamics of engineering work. Commissioning engineering offers a particularly rich source of such examples, because the gap between documented procedures and actual practice is both wide and consequential.

These reforms do not eliminate the need for comfort—but they calibrate it so that comfort does not distort students' understanding of what engineering is.

5.5 Positioning the Contribution

The Comfort Curriculum contributes to engineering education research by offering a new conceptual vocabulary for describing misalignment, integrating multiple theoretical traditions into a coherent model, foregrounding the emotional, organisational, and socio-technical omissions in engineering education, explaining why certain inequities persist despite decades of reform, and providing a framework that future empirical work can test, extend, or operationalise. For readers of *Studies in Engineering Education*, the significance lies in reframing a familiar problem through a lens that reveals hidden structure and systemic coherence. This model provides not only critique but also a foundation for practical and theoretically informed approaches to reform.

6. Conclusion

Engineering education has long been criticised for failing to prepare graduates for the realities of professional practice, yet much of this critique has framed the issue as a series of independent gaps—insufficient socio-technical integration, insufficient attention to uncertainty, inadequate emotional preparation, or inadequate exposure to organisational complexity. The argument of this paper is that these gaps are not isolated defects. They are systemically produced by a coherent educational structure that prioritises stability, clarity, and control.

The Comfort Curriculum offers a conceptual explanation for why engineering education consistently generates familiar forms of misalignment. Through epistemic simplification, procedural assurance, emotional buffering, and organisational sanitisation, the curriculum constructs an environment that supports student success but simultaneously misrepresents engineering work as predictable, methodical, and technically bounded. This environment not only shapes students' expectations of practice but also conditions their professional identities, their readiness for early-career uncertainty, and their interpretation of the emotional and organisational challenges they encounter.

The implications extend beyond individual preparedness. Because the Comfort Curriculum systematically privileges certain knowledge forms, dispositions, and identity performances, it reinforces inequities affecting early-career engineers—particularly women, first-generation students, and those without prior access to engineering cultural capital. What appears to be a neutral curriculum thus functions as a gatekeeping mechanism that advantages those whose backgrounds or dispositions align with its implicit norms.

Recognising these mechanisms does not imply that comfort should be eliminated from education. Engineering curricula must remain safe, fair, and pedagogically manageable. Instead, this paper provides a language and structure for understanding how comfort is produced, why it persists, and where its consequences are most acute. This framework can help educators, programme designers, and researchers move beyond calls for "more realism" and instead identify specific opportunities to introduce targeted, ethical discomfort—structured encounters with uncertainty, socio-technical complexity, emotional labour, or organisational constraint.

Future work can build on this model in several directions. Empirical studies could examine how students internalise comfort-producing mechanisms across different institutional, cultural, and disciplinary contexts. Longitudinal research could explore how the Comfort Curriculum shapes early-career trajectories, including identity stability, risk negotiation, and retention. Intervention studies could test whether redesigned learning experiences—such as uncertainty-rich projects, stakeholder simulations, or reflective emotional practice—meaningfully shift students' readiness for engineering work. The cross-national survey data referenced in this paper (Ayres et al., 2026) offer one starting point for such empirical engagement, and further operationalisation of the four mechanisms into measurable constructs represents a priority for future research.

By conceptualising comfort as an active and structuring force within engineering education, the Comfort Curriculum reframes a persistent problem and invites a more sophisticated conversation about how engineers are formed. Preparing graduates for contemporary engineering work requires more than adjusting content—it requires rethinking the conditions under which learning occurs and the kinds of engineers those conditions quietly cultivate.

The Comfort Curriculum provides a conceptual vocabulary and analytical structure for understanding how engineering education shapes professional readiness, identity, and equity

Acknowledgements

The author wishes to acknowledge the use of Grammarly for grammar and manuscript editing. All work and opinions are the author's own.

References

Ayres, J.R., May, I., Bustami, R., Adam, J.H., Gamage, S., 2026. Pre-print - Global Workplace Pressures in Engineering: A Cross-Sectional Survey of Role-Based Pressures, Peer Influence, and Psychological Outcomes. https://doi.org/10.31224/6598
Bucciarelli, L.L., 1994. Designing engineers, Inside technology. MIT Press, Cambridge, Mass.
Cech, E.A., 2022. The intersectional privilege of white able-bodied heterosexual men in STEM. Sci. Adv. 8, eabo1558. https://doi.org/10.1126/sciadv.abo1558
Collins, H., Evans, R., 2007. Rethinking Expertise. University of Chicago Press. https://doi.org/10.7208/chicago/9780226113623.001.0001
Dekker, S., 2011. Drift into Failure: From Hunting Broken Components to Understanding Complex Systems. https://doi.org/10.1201/9781315257396
Heywood, J., 2005. Engineering Education: Research and Development in Curriculum and Instruction, 1st ed. Wiley. https://doi.org/10.1002/0471744697
Hollnagel, E., 2017. FRAM: The Functional Resonance Analysis Method: Modelling Complex Socio-technical Systems, 1st ed. CRC Press. https://doi.org/10.1201/9781315255071
Johri, A., Olds, B.M., 2011. Situated Engineering Learning: Bridging Engineering Education Research and the Learning Sciences. J. Eng. Educ. 100, 151–185. https://doi.org/10.1002/j.2168-9830.2011.tb00007.x
Jonassen, D., Strobel, J., Lee, C.B., 2006. Everyday Problem Solving in Engineering: Lessons for Engineering Educators. J. Eng. Educ. 95, 139–151. https://doi.org/10.1002/j.2168-9830.2006.tb00885.x
Knorr-Cetina, K., 2000. Epistemic Cultures. How sciences make knowledge. Redes Rev. Estud. Soc. Cienc. Tecnol. 7, 209–213. https://doi.org/10.48160/18517072re15.721
Lave, J., Wenger, E., 1991. Situated Learning: Legitimate Peripheral Participation, 1st ed. Cambridge University Press. https://doi.org/10.1017/CBO9780511815355
Leydens, J.A., Lucena, J.C., 2018. Engineering Justice: Transforming Engineering Education and Practice. Int. J. Serv. Learn. Eng. Humanit. Eng. Soc. Entrep. 13, 67–68. https://doi.org/10.24908/ijsle.v13i1.11855
Lönngren, J., Direito, I., Tormey, R., Huff, J.L., 2023. Emotions in Engineering Education, in: International Handbook of Engineering Education Research. Routledge, New York, pp. 156–182. https://doi.org/10.4324/9781003287483-10
Malmi, L., Adawi, T., Curmi, R., De Graaff, E., Duffy, G., Kautz, C., Kinnunen, P., Williams, B., 2018. How authors did it – a methodological analysis of recent engineering education research papers in the European Journal of Engineering Education. Eur. J. Eng. Educ. 43, 171–189. https://doi.org/10.1080/03043797.2016.1202905
Margolis, J., Fisher, A., 2003. Unlocking the clubhouse: women in computing, in: Proceedings of the 34th SIGCSE Technical Symposium on Computer Science Education. Presented at the SIGCSE03: SIGCSE 2003 Symposium, ACM, Reno Navada USA. https://doi.org/10.1145/611892.611896

Martin, T., Petrosino, A.J., Rivale, S., Diller, K.R., 2006. The development of adaptive expertise in biotransport. New Dir. Teach. Learn. 2006, 35–47. https://doi.org/10.1002/tl.254
Matusovich, H.M., Streveler, R.A., Miller, R.L., 2010. Why Do Students Choose Engineering? A Qualitative, Longitudinal Investigation of Students' Motivational Values. J. Eng. Educ. 99, 289–303. https://doi.org/10.1002/j.2168-9830.2010.tb01064.x
O'Connor, K., 2014. Professional Engineering Work.
Rozenblit, L., Keil, F., 2002. The misunderstood limits of folk science: an illusion of explanatory depth. Cogn. Sci. 26, 521–562. https://doi.org/10.1207/s15516709cog2605_1
Stevens, R., O'Connor, K., Garrison, L., Jocuns, A., Amos, D.M., 2008. Becoming an Engineer: Toward a Three Dimensional View of Engineering Learning. J. Eng. Educ. 97, 355–368. https://doi.org/10.1002/j.2168-9830.2008.tb00984.x
Trevelyan, J., 2019. Transitioning to engineering practice. Eur. J. Eng. Educ. 44, 821–837. https://doi.org/10.1080/03043797.2019.1681631
Trevelyan, J., 2010. Reconstructing engineering from practice. Eng. Stud. 2, 175–195. https://doi.org/10.1080/19378629.2010.520135
Vincenti, W.G., 1990. What engineers know and how they know it: analytical studies from aeronautical history, Johns Hopkins studies in the history of technology. Johns Hopkins University Press, Baltimore.
Walther, J., Brewer, M., Sochacka, N., Miller, S., 2020. Empathy and engineering formation. J. Eng. Educ. 109, 11–33. https://doi.org/10.1002/jee.20301