Credibility-Regulated Learning: A Conceptual Framework for Engineering Commissioning.

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Abstract

Commissioning—the transition from construction to live operation—forces engineers to make rapid interpretations amid uncertainty. Beneath these technical demands lies a largely unexamined social mechanism: credibility negotiation. This conceptual paper argues that commissioning operates as a credibility-regulated learning environment in which access to tasks, information, and developmental opportunities is shaped not only by capability but by perceived legitimacy and alignment with team norms. Drawing on workplace learning theory, situated learning, and research on identity, voice, and underrepresentation in engineering, the paper develops a theoretical framework that explains how credibility shapes participation, exposure to tacit knowledge, and professional identity formation. The framework shows that credibility gaps produce uneven learning trajectories, distort risk detection, and disproportionately disadvantage early-career engineers, women, and culturally diverse professionals. Organisational interventions—including structured rotation, reflective practice, and explicit credibility socialisation—are proposed to reduce inequity and strengthen collective competence in commissioning teams.

Keywords: commissioning; credibility; workplace learning; situated learning; tacit knowledge; engineering identity; gender.

1. Introduction

Commissioning is where engineering finally stops being hypothetical. It is the moment when weeks, months, or years of design assumptions are exposed to the uncompromising behaviour of a live system. It is also the moment when uncertainty, time pressure and organisational complexity collide. The technical demands are obvious. The social ones are far less so.

In these settings, engineers learn rapidly: how systems behave under stress, how systems behave, how risks emerge, and how decisions cascade. But who gets to participate in those learning moments is rarely governed by capability alone. In practice, commissioning functions as a *credibility-regulated learning environment*: an arena where trust, authority and voice determine not only who gets heard, but who gets to learn (Tynjälä, 2008).

At the same time, commissioning is saturated with tacit knowledge—diagnostic cues, embodied judgement, undocumented heuristics, and the "feel" of system behaviour. Tacit knowledge flows through trusted relationships. When credibility determines access, tacit knowledge becomes unevenly distributed(Collins, 2013), (Schön, 2017).

Voice under uncertainty is equally credibility-loaded(Edmondson, 1999), (Morrison, 2011),(Nembhard and Edmondson, 2006). In high-risk environments, speaking up depends on psychological safety and perceived legitimacy. The engineer who notices an anomaly may not be the one whose interpretation is taken seriously (Ayres et al., 2025).

Taken together, these dynamics create a structural blind spot in engineering practice. Commissioning is widely described as a meritocratic, high-learning environment; in reality, it is an arena where credibility, not competence, governs participation. This paper explains how credibility regulates learning, shapes access to tacit knowledge, and impacts system safety.

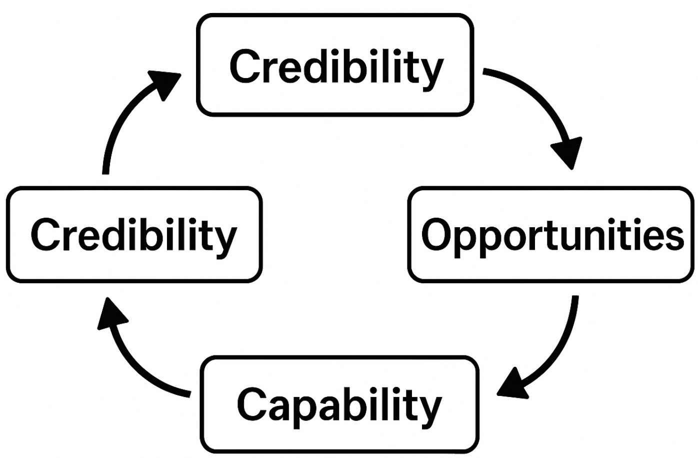

Figure 1. Credibility cycle in commissioning

This diagram illustrates the cyclical relationship between credibility, opportunities, and capability. Engineers who are perceived as credible gain access to energisations, fault diagnosis, and tacit knowledge flows — which in turn enhance their ability and reinforce their credibility. The exclusion path (shown in parallel) highlights how low-credibility engineers are denied access, limiting their development and perpetuating inequity.

2. Why Commissioning Demands a New Lens

Commissioning has long been framed as a technical milestone: verify the installation, energise the system, troubleshoot defects, close out punch lists and stabilise operations. But this framing obscures what commissioning is: a socially dense, judgment-heavy, epistemic bottleneck**.**

2.1 Commissioning as high-stakes workplace learning

Workplace learning research consistently shows that the richest learning occurs in authentic, uncertain environments where professionals exercise judgement and interpret complex cues (Gambheer and Acharya, 2024), (Rangraz and Pareto, 2021). Commissioning fits this description perfectly. Engineers must diagnose ambiguous behaviours, rapidly test hypotheses, negotiate intervention strategies and coordinate across boundaries. Yet opportunities to participate in these tasks are unequally offered. Some engineers are continually placed at the centre of the action; others remain observers, regardless of capability. Such exclusion slows skill acquisition and undermines professional identity. Commissioning, therefore, exemplifies how workplace learning is socially filtered, producing divergent trajectories even among equally qualified engineers

2.2 Tacit knowledge as both asset and gatekeeper

Tacit knowledge drives commissioning. Engineers rely on sensory interpretation, embodied experience and undocumented heuristics to understand what a system is "trying to tell them" (Hutchins, 2006), (Orr, 2016). This type of knowledge cannot be accessed through manuals; it requires repeated exposure, trust, and participation in real events, where credibility shapes who gets invited into those moments and tacit knowledge becomes a selective currency. High-credibility engineers accumulate interpretive power; others are left without the experiential foundation required to develop commissioning judgement. Research shows that tacit knowledge is often transmitted through informal mentoring and storytelling, but these pathways depend heavily on trust and legitimacy (Collins, 2013). Exclusion from these flows creates lasting capability gaps, reinforcing inequities in commissioning expertise.

2.3 Credibility as a filter for participation

Across engineering workplaces, credibility is not granted equally. Studies show that women, culturally diverse engineers, and those who deviate from dominant communication norms often face higher thresholds for recognition as competent or authoritative. In commissioning, credibility acts as a sorting mechanism. Over time, these patterns harden into unequal learning trajectories. Recent organisational research highlights how credibility judgements are often rationalised as "fit" or "readiness," masking bias and reinforcing stereotypes (Gherardi, 2001), (Trede, 2009). Credibility functions as an epistemic filter, determining whose knowledge counts as legitimate (Fricker, 2007). In STEM fields specifically, women and minorities face systematic credibility deficits (Faulkner, 2009), (Dotson, 2011) where their technical knowledge is questioned more readily than that of majority group members. This filtering mechanism explains why commissioning remains a bottleneck for equity and capability development.

2.4 Voice, silence and risk detection

Commissioning risk is often first detected by those closest to the technical work. But in high-pressure operations, voice behaviour depends on psychological safety and perceived legitimacy (Edmondson, 1999), (Nembhard and Edmondson, 2006). Engineers who anticipate dismissal or backlash hesitate to speak up—even when they see clear warning signs. When people speak, their input may be ignored if the listener does not consider them credible (Hale et al., 2015). Commissioning failures frequently involve this pattern: technical signals were present, concerns were raised, but credibility dynamics determined the response. In high-risk industries, voice depends not only on individual willingness but on team cultures that actively solicit input (Morrison, 2011), (Nembhard and Edmondson, 2006), (Dekker, 2017). Selective listening, rather than silence, often precedes incidents (Weick and Sutcliffe, 2001). This highlights the need to broaden interpretive authority to strengthen organisational safety.

2.5 Why commissioning needs a credibility lens

Commissioning is not merely a learning-rich environment. It is a credibility-dependent learning system in which social judgements regulate access to technical knowledge. Without naming credibility as a mechanism, the profession cannot address unequal skill development, attrition, or systematic under-reporting of risk. A credibility lens reveals commissioning as a determinant of both professional capability and organisational reliability.

3. Credibility as a Social Regulator of Participation

Commissioning is often described as a meritocratic proving ground—an arena where engineers "show what they can do." Yet the patterning of participation suggests something different: credibility, not competence, regulates who is trusted to act, interpret, diagnose and decide.

Credibility here is not a static personal trait. It is a *socially distributed resource* shaped by identity, organisational history, communication norms and the existing status order of a team. Credibility tends to cluster around those who align with dominant cultural prototypes (Faulkner, 2009), (Hatmaker, 2013). Engineers who diverge from these patterns are frequently required to "prove" their competence repeatedly (Cech and Blair-Loy, 2019), (Fouad et al., 2017), whereas others are granted trust by default.

In commissioning, credibility allocation is magnified by the stakes. Under these conditions, teams lean heavily on *assumptions* about whose judgement is reliable. High-credibility engineers are entrusted with energisations, fault-finding, vendor negotiations and interactions with control room staff. Their interpretations anchor the narrative of what the system is doing and what should be done next.

Low-credibility engineers observe from the margins, checking drawings and logging events without access to interpretive work. These patterns reproduce themselves. Highly credible engineers accumulate greater experience, strengthening both real and perceived expertise. Others accumulate far less, despite equal or greater technical ability.

Credibility deficits also shape how errors are attributed. When high-status individuals misinterpret system behaviour, the failure is often externalised and blamed on equipment, unforeseen interactions or incomplete information. When lower-status engineers make the same call, the error is personalised, reinforcing the impression that they cannot be relied upon. Over time, this creates a self-reinforcing cycle of credibility bottlenecking: high-credibility engineers become indispensable, and low-credibility engineers are denied access to precisely the experiences that would allow them to demonstrate capability.

Unlike design offices or routine operations, commissioning teams are temporary, cross-organisational and often male-dominated. Women in engineering face persistent credibility challenges (Faulkner, 2009), with many leaving the profession despite strong qualifications (Fouad et al., 2017). There is little time for trust-building, and assumptions travel fast. Judgements about competence spread quickly, usually based on limited interactions. The result is a credibility regime that shapes who becomes central to the work and who remains peripheral—a regime that profoundly influences learning, voice, risk detection and identity formation.

4. Tacit Knowledge, Interpretation Power and Exclusion Mechanisms

If credibility determines who gets access to commissioning's core tasks, tacit knowledge determines who becomes fluent in its invisible craft. Commissioning is saturated with tacit knowledge: the hum of a pump that is "not quite right," the transient oscillation that signals an impending control loop fight, the subtle drift in a pressure signature that reveals a mis-installed instrument. These cues are rarely documented. They are learned through exposure, repetition, and dialogue with more experienced practitioners.

Crucially, tacit knowledge circulates through *relationships*, not formal processes. Engineers are drawn into troubleshooting huddles, invited to inspect a suspect valve, or included in an after-action discussion because someone trusts their judgement. Those who are not trusted—or not noticed—are excluded from these informal knowledge flows. Access is uneven, and the more tacit the knowledge, the more its distribution depends on credibility (Orr, 2016), (Collins and Evans, 2007).

Engineers who lack credibility miss the deepest learning moments and cannot access the interpretive reasoning behind decisions. Second, they are denied the chance to *practice* tacit knowledge. Tacit expertise develops through doing, not through watching someone else do it. Engineers relegated to observational roles cannot meaningfully develop the diagnostic sensibility required for commissioning.

Interpretation power also becomes stratified. The engineers with accumulated tacit knowledge—and the credibility to assert it—become the default interpreters of what the system is "saying." They build narrative authority: the power to define the meaning of observations. When disputes arise ("Is that oscillation significant?"). Those with interpretive authority typically win by default, even if others have more accurate insights.

Commissioning teams often operate under extreme time pressure, relying on those perceived as safest to involve. This accelerates expertise for the trusted few while leaving others chronically under-skilled—an effect not of capability, but of opportunity.

Engineers excluded from the interpretive centre doubt their judgement; those repeatedly deferred to internalise authority that may exceed their competence. These dynamics not only influence who becomes a commissioning specialist—they determine who *feels entitled* to take up space in commissioning conversations.

In short, tacit knowledge is the currency of commissioning. Credibility decides who gets paid in it. The result is a stratified learning system in which interpretive power accumulates among those who already enjoy legitimacy. In contrast, others remain at the periphery of the very experiences that define commissioning expertise.

5. Voice, Silence and Hazard Detection

Commissioning is a phase in which system anomalies appear early, unpredictably, and sometimes subtly. The engineers closest to the equipment are often the first to notice these anomalies — a faint oscillation, a sluggish valve response, a smell of overheating insulation, an unexpected pattern in alarms. Yet seeing a problem and *acting* on that noticing are two different things. In commissioning, the pathway between perception and response is heavily mediated by credibility, psychological safety and the dynamics of speaking and listening.

Voice behaviour is shaped by perceived legitimacy, fear of negative evaluation, and anticipated consequences. Engineers who carry credibility deficits — particularly early-career staff, women, culturally diverse engineers or those in contractor roles — learn quickly that speaking up is risky when their concerns are routinely dismissed or overruled.

In commissioning, where decisions unfold rapidly, credibility shapes *who is allowed to interrupt the flow of work*. High-credibility engineers who flag deviations show diligence; low-credibility engineers appear over-cautious.

Speaking is only half the equation. Recent work on "safety listening" shows that listening failures — not speaking failures — are the more common precursor to incidents. Teams under time pressure often default to the judgment of those with established authority, even when others are offering more accurate diagnostics. This creates a narrow detection bandwidth: only signals routed through credible messengers are processed, while signals from others remain unamplified. Commissioning teams often discover, in hindsight, that the system *had been communicating* its distress, but those closest to the cues were not considered authoritative interpreters.

Silence also shapes how uncertainty is managed. In environments where low-credibility engineers do not feel able to question assumptions, teams lose interpretive diversity precisely when they need it most. System drift becomes harder to detect, emergent failures escalate more quickly, and early-life instability becomes normalised. The cost is not only technical. Over time, engineers who remain unheard withdraw emotionally from commissioning, seeing it as a place where their expertise is unwanted or unsafe to express.

Thus, voice and silence in commissioning cannot be understood without examining how credibility regulates both speaking and listening. Hazard detection — and the organisational ability to respond to weak signals — is deeply social. When credibility narrows who is allowed to contribute to sensemaking, organisations become vulnerable to blind spots that manifest as commissioning debt, prolonged instability and preventable failures.

6. The Credibility-Regulated Learning Framework

Commissioning is often portrayed as a neutral technical process: verify, energise, troubleshoot, stabilise. Yet the empirical patterns across engineering teams point to a more complex reality — credibility functions as a *regulatory mechanism* that determines who learns, who leads, who is heard, and how risk is interpreted. The Credibility-Regulated Learning Framework conceptualises commissioning as a system shaped by linked social, epistemic and technical processes.

The framework consists of five interacting layers, each shaped by credibility dynamics:

6.1 Credibility Allocation

Credibility in commissioning is not innate; organisational actors and informal gatekeepers allocate it. Senior engineers often determine whose judgment is trusted in pre-commissioning meetings, while operations managers decide who joins energisation teams. Project managers assign roles based on perceived "readiness," a term that appears objective but frequently reflects subjective assessments of fit (Powell et al., 2011). Informal gatekeepers—experienced technicians and lead engineers—reinforce these allocations by deciding who is invited into troubleshooting huddles or after-action reviews (Cech and Blair-Loy, 2019).

Allocation occurs at predictable junctures: team mobilisation (who is invited to the site), handover meetings (whose voice is heard), daily toolbox talks (whose input is sought), and energisation planning (who is "in the room"). At each stage, credibility serves as a filter that governs participation rights and the exposure of tacit knowledge (Collins, 2013).

Significantly, credibility operates invisibly. It is framed as "experience" but often reflects cultural fit; described as "confidence" but equated with being male, local, or familiar; justified as "readiness" but used to exclude younger engineers or international staff (Morrison, 2023). These judgements are naturalised as "team chemistry," masking bias and reinforcing stereotypes (Faulkner, 2009). Common phrases illustrate this dynamic: *"She's not quite ready for this energisation"* (gender), *"He needs more site time first"* (age), or *"They might not understand how we do things here"*(cultural background). Such statements reveal how credibility is socially allocated, shaping who learns, who leads, and whose interpretations anchor commissioning narratives.

6.2 Participation Rights

Participation in commissioning is not simply about being present; it is about being positioned at the interpretive centre of the work. Engineers with full participation rights are invited into the control room during energisation, given hands-on time with equipment, asked for input during troubleshooting, included in evening debrief sessions, and added to emergency call lists. These moments are not peripheral—they are the crucibles where tacit knowledge and trust are forged (Vailasseri et al., 2021).

The distribution of rights is subtle but decisive. It can take the form of invitation versus permission: *"You should join us"* signals inclusion, while *"You can watch if you want"* signals marginality. It can be explicit inclusion—*"We need your eyes on this"*—or passive exclusion, where meetings occur without notice. It can involve active mentoring—*"Let me show you this"*—or a sink-or-swim approach that leaves engineers unsupported (KPMG, 2023), (WGEA, 2024). Professional identity develops through repeated participation and recognition (Wenger, 1998), (Carlone and Johnson, 2007). When engineers are excluded or dismissed, identity formation is disrupted (Ibarra, 1999), (Tonso, 2006).

Exclusion has predictable consequences. Engineers miss critical learning moments that occur only once, fail to build relationships formed under shared stress, lack context for later work, and risk being developed as "helpers" rather than engineers. The mechanism is invisible: exclusion feels natural ("They're busy, I shouldn't interrupt"), while inclusion feels earned ("I proved myself worthy"). In reality, access is distributed by credibility rather than competence, reinforcing inequities in capability development and identity formation (WGEA, 2024).

6.3 Tacit Knowledge Flow

Tacit knowledge—the invisible craft of commissioning—transfers through proximity, observation, questioning, shared failure, and storytelling. Standing beside an expert during diagnosis, watching how they read instrument patterns, or asking *"Why did you check that first?"* builds interpretive fluency. Shared troubleshooting creates collective reference points, while storytelling embeds lessons from past failures and near-misses (Orr, 2016), (Collins and Evans, 2007).

Yet tacit knowledge is often gatekept**.** Diagnostic cues ("the pump sounds wrong"), embodied system feel ("this startup feels different"), timing instincts, undocumented workarounds, and war stories circulate only among those deemed credible (Eraut, 2000). Engineers excluded from control rooms, relegated to peripheral tasks, or left out of informal debriefs miss these high-value learning moments. Without mentors to translate tacit knowledge into explicit knowledge, they remain downstream of expertise.

This matters because tacit knowledge is commissioning expertise. It cannot be learned from manuals; it requires repeated exposure and pattern recognition. Exclusion, therefore, creates permanent capability gaps, stratifying who becomes commissioning specialists and who remains peripheral.

6.4 Interpretation and Identity Formation

Interpretation in commissioning is not simply a technical act; it is a socially consequential practice that shapes professional identity. Engineers who are trusted to interpret system behaviour develop confidence and legitimacy—*"I can read this plant"*—while those excluded remain uncertain about their role—*"I'm not sure I understand commissioning.* "Successful interpretation reinforces identity as a commissioning engineer, whereas repeated dismissal or lack of opportunity damages self-efficacy and prompts doubts such as *"Maybe this isn't for me"* (Trede, 2009).

The link between interpretation and belonging is direct. Being trusted to interpret signals membership in the commissioning community, while having interpretations ignored or dismissed, marks one as an outsider. Interpretive authority thus becomes a proxy for professional inclusion, shaping who is seen as "core" to the team and who remains peripheral (Colley et al., 2021). Engineers with high credibility quickly develop strong commissioning identities, while those with credibility deficits must either fight for recognition, adopt "helper" identities, or exit commissioning altogether (Billett, 2020).

The long-term consequences are profound. Engineers who experience interpretive inclusion come to see commissioning as "their work," pursue commissioning roles, and progress into senior positions. Those excluded avoid commissioning pathways, transition into less interpretive roles, or leave the field entirely. Organisations then lose diverse perspectives and talent, reinforcing homogeneity and narrowing interpretive bandwidth (Sahin-Dikmen et al., 2020). In this way, credibility-filtered interpretation not only shapes individual identity trajectories but also determines the collective resilience and inclusivity of commissioning teams.

6.5 Capability Development and Organisational Outcomes

The endpoint of the credibility-regulated learning framework is unequal capability development**.** Engineers on high-credibility trajectories experience rapid skill acquisition, build strong networks, and are positioned for future leadership. They become senior commissioning engineers and, later, commissioning managers because their identity as credible interpreters is reinforced at every stage (Trede et al., 2012). Conversely, engineers on low-credibility trajectories face stalled development, isolation, and eventual stagnation or departure from commissioning roles (Billett, 2020).

These divergent pathways have long-term career effects. Those who gain credibility early are promoted into leadership, while those denied interpretive authority either adopt peripheral "helper" identities or leave engineering altogether (Colley et al., 2021). The result is a stratified workforce where commissioning expertise is concentrated in a narrow group, limiting organisational diversity of thought and problem-solving approaches (Sahin-Dikmen et al., 2020)

Organisational consequences are significant. Expertise bottlenecking creates key person dependencies, making teams vulnerable when trusted individuals are absent. Risk detection narrows, as the same people make the same decisions, leading to repeat failures and reduced resilience (Eraut, 2007). Over time, the cycle reinforces itself: credible engineers gain opportunities, develop capability, and accumulate more credibility; those excluded remain underdeveloped. The capability gap begins to look like a competence gap, justifying the original allocation—*"See, they weren't ready"*—and creating a self-fulfilling prophecy (WGEA, 2024).

Breaking this cycle requires recognising that credibility does not equal competence. Organisations must deliberately distribute participation rights, make tacit knowledge explicit where possible, protect the voice of low-credibility engineers, and track who receives opportunities—not just who succeeds with them. These interventions are essential to broaden capability development, reduce attrition, and strengthen collective commissioning expertise.

6.6 How the Framework Works as a System

The framework is cyclical rather than linear:

Credibility allocation → controls participation rights → governs tacit knowledge flow → shapes identity and interpretation → produces uneven capability → feeds back into the next cycle of credibility allocation.

Commissioning teams rarely see this cycle because its components are normalised as personality, "fit," confidence, or seniority. The framework makes explicit what is typically invisible: the social dynamics that regulate technical learning in one of engineering's most consequential phases.

7. Implications for Capability, Identity and System Safety

The credibility-regulated learning environment produces patterned consequences — not random variation. These consequences shape workforce development, team dynamics and early-life system reliability. Three domains are particularly affected: capability development, identity and safety.

7.1 Uneven Capability Development

The credibility-regulated learning environment produces **divergent capability trajectories** even among engineers who begin with identical qualifications. Consider two early-career engineers: *Engineer A*, granted high credibility, is by year two leading energisations, trusted for complex troubleshooting, and embedded in the interpretive centre of commissioning. *Engineer B*, carrying low credibility, is by year two still completing documentation, rarely present in the control room, and excluded from high-value learning moments. Their qualifications are the same; their trajectories are entirely different.

The mechanisms of divergence are cumulative. Learning opportunities compound over time—each energisation or troubleshooting session builds interpretive fluency that accelerates future competence (Eraut, 2007). Network effects amplify this process:

engineers who are trusted gain access to broader professional relationships, reinforcing their credibility (Hatmaker, 2013). Meanwhile, the confidence gap widens: success breeds confidence and further inclusion, while exclusion fosters doubt and withdrawal (Cech and Blair-Loy, 2019).

Organisational impacts are significant. Expertise becomes concentrated in a few individuals, creating succession planning risks if those engineers leave. Commissioning capability cannot be scaled when knowledge is locked within narrow networks, and organisations lose the investment made in engineers who stagnate or depart (Cech and Blair-Loy, 2019). Over time, the capability gap is misinterpreted as a competence gap, justifying the original credibility allocation and reinforcing the cycle. Breaking this pattern requires deliberate redistribution of opportunities and recognition that credibility is not equivalent to competence.

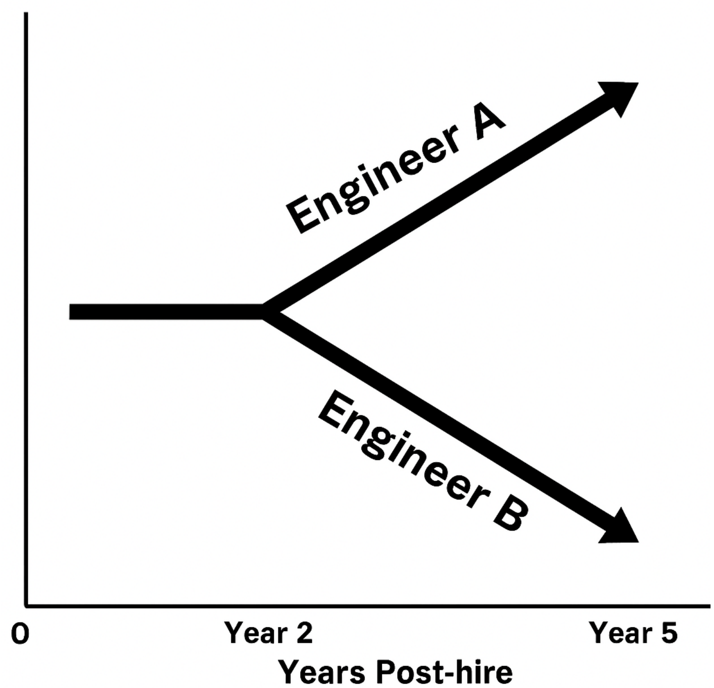

Figure 2. Divergent career trajectories shaped by credibility allocation

This figure compares two engineers over a five-year period. Engineer A receives early credibility, leads energisations, gains tacit knowledge, and is promoted to a senior role. Engineer B is assigned documentation tasks, excluded from energisation access, and exits commissioning.

7.2 Distorted Risk Detection

Safety in commissioning depends not only on the detection of anomalies but on whether those anomalies **are** believed and acted upon**.** Credibility barriers distort this process. Early warnings are often missed because low-credibility engineers stay silent, fearing dismissal or reputational damage. Anomalies may be noticed but not reported—*"No one will listen anyway"*—and risk information is filtered through a credibility lens, where trusted voices are amplified, and others are ignored (Edmondson, 1999).

Examples illustrate the pattern. A junior engineer hears an unusual vibration but does not speak up; the bearing fails days later. A female engineer questions a procedure, is dismissed, and a near-miss occurs. A contractor spots a problem but refrains from reporting it, believing it is "not their place"; the incident follows. These cases show that safety depends not just on detection but on believability (Weick and Sutcliffe, 2001) In high-reliability organisations, safety depends on diverse perspectives and open communication (Reason, 1990), (Dekker, 2017). When credibility filters voice, critical warnings may be missed (Perrow, 2011), (Hollnagel, 2018).

The consequence is a narrowing of organisational risk perception. Diverse perspectives are essential for a complete safety picture, yet credibility barriers create blind spots. When only certain voices are legitimised, organisations become less safe, not more capable (Hale et al., 2015). Research on "safety listening" emphasises that failures often arise not from silence but from selective hearing—warnings are voiced but discounted if the messenger lacks legitimacy (Weick and Sutcliffe, 2001).

Thus, credibility dynamics undermine hazard detection, producing preventable incidents and embedding systemic vulnerabilities. Addressing these barriers requires deliberate efforts to broaden interpretive authority, protect low-credibility voices, and institutionalise inclusive listening practices.

7.3 Identity Damage and Attrition

The credibility-regulated learning environment carries a significant emotional and psychological toll**.** Engineers who must constantly prove their competence experience exhaustion and hypervigilance, investing cognitive energy into avoiding mistakes rather than learning (Edmondson, 2021). Social exclusion compounds this burden: being left out of control room discussions or debrief sessions fosters isolation and self-doubt, even among highly qualified staff—*"Am I actually good at this?"(Ashforth and Humphrey, 1993)* Over time, these pressures erode confidence and fracture professional identity.

Attrition mechanisms follow predictable patterns. Some engineers leave commissioning for other technical roles, seeking environments where their expertise is recognised. Others exit engineering entirely, discouraged by repeated credibility barriers. A third group remains but disengages—"quitting in place"—withdrawing emotionally while continuing to perform minimal tasks (Tucker and Edmondson, 2002). In each case, organisations lose investment, diversity, and perspective, narrowing the talent pipeline.

Who leaves versus who stays depends on identity resources. Engineers with strong external support networks or resilient self-concepts are more likely to persist, while those dependent on workplace validation are more vulnerable to departure (Morrison, 2023).

Attrition is disproportionately concentrated among women, minorities, and career-changers, groups already navigating heightened credibility thresholds (WGEA, 2024). The result is a workforce that becomes increasingly homogeneous, reinforcing existing biases and reducing interpretive diversity.

Thus, credibility barriers not only damage individual identity but also reshape the demographic and epistemic composition of commissioning teams, undermining both equity and organisational capability.

7.4 Concentration of Organisational Risk

Commissioning teams often become fragile when critical expertise is concentrated in only two or three individuals. These high-credibility engineers hold the tacit knowledge and interpretive authority required to stabilise systems. When they leave, retire, or are unavailable, organisations face significant vulnerability: projects stall, energisations are delayed, and commissioning capability cannot be scaled quickly (Eraut, 2007). The dependence on "the expert" creates bottlenecks that undermine resilience.

Organisations that concentrate knowledge in a few individuals become fragile (Orr, 2016). (Brown, 2000), vulnerable to expertise loss and repeat failures (Vaughan, 2016). Credibility barriers compromise succession planning. Junior engineers are denied high-value learning opportunities, preventing them from developing commissioning judgement. Without a pipeline of future experts, organisations remain dependent on retaining current specialists—an expensive and risky strategy. This lack of distributed capability means that knowledge transfer is slow, and organisational memory is fragile (Trede et al., 2022).

The consequences extend to repeated failures**.** When the same small group makes the same assumptions, groupthink emerges. Homogeneous teams lack interpretive diversity, reducing the ability to detect weak signals or challenge entrenched practices (Janis, 1982). Blind spots persist, and the same failure patterns recur across projects, embedding systemic vulnerabilities (Morrison, 2023).

Thus, concentrated expertise is not an organisational strength but a fragility. Breaking this cycle requires deliberate strategies: broadening participation rights, mentoring junior engineers, documenting tacit practices, and valuing diverse perspectives. Without these interventions, commissioning risk remains tied to the availability of a few individuals, leaving organisations exposed to preventable failures and succession crises.

7.5 Implications for Equity and Professional Futures

By year five, credibility-driven divergence produces starkly different career trajectories. Engineers on high-credibility pathways occupy senior commissioning roles, are trusted with leadership responsibilities, and begin to build industry reputations. Those on low-credibility trajectories often make lateral moves away from commissioning, disengage, or exit engineering altogether (Billett, 2020). The result is a bifurcated workforce in which advancement is less determined by competence than by early allocation of credibility.

Leadership pipelines reflect this imbalance. Commissioning managers typically emerge from high-credibility trajectories, reinforcing homogeneous leadership cultures that perpetuate the very credibility gaps that shaped their rise (Sahin-Dikmen et al., 2020). This cycle ensures that organisational norms remain unchallenged, and the culture of commissioning continues to privilege certain identities and communication styles (Trede, 2009).

The diversity pipeline is particularly affected. Women, minorities, and career-changers may be recruited into engineering but are disproportionately filtered out at the commissioning phase, where credibility barriers are most acute (WGEA, 2024). Without equitable access to commissioning experience, leadership cannot diversify. The profession loses precisely the talent it claims to value, narrowing perspectives and limiting innovation (Ashforth and Humphrey, 1993).

The wider impact is systemic. Engineering becomes less inclusive, innovation is constrained by homogeneous viewpoints, and organisational investment in diverse recruitment is wasted. Credibility dynamics thus reproduce inequality across career spans, embedding inequity into the very structures of professional advancement and weakening the resilience of the engineering workforce (Morrison, 2011).

Table 1. Mechanisms and Effects of Credibility-Regulated Learning Across Learning, Identity and Safety.

Mechanism	Effect on Learning	Effect on Identity	Effect on Safety
Restricted participation	Slowed capability development; uneven trajectories	Outsider identity; reduced belonging	Narrow detection bandwidth; degraded resilience
Tacit knowledge gatekeeping	Loss of high-value experiential learning	Lower confidence; reduced perceived legitimacy	Increased error escalation
Unequal voice	Limited interpretation diversity	Withdrawal from central tasks	Blind spots; over-reliance on central experts
Expertise bottlenecking	Concentrated capability	Reinforced hierarchy	Vulnerability when key individuals are absent

This table consolidates the five organisational consequences discussed in Section 7 — uneven capability development, distorted risk detection, identity damage and attrition, concentration of organisational risk, and equity implications. Each row maps the mechanism to its professional and organisational impact, providing a structured summary of how credibility dynamics shape commissioning outcomes

The implications of credibility filtering extend beyond individual engineers to organisational reliability and equity. Table 1 summarises these outcomes, consolidates the mechanisms described across Sections 7.1–7.5, and highlights their systemic significance.

8. Conceptual Contributions

This paper makes four interlinked contributions to understanding commissioning as both a technical and social process.

8.1 Naming credibility as a regulatory mechanism in engineering work

Engineering scholarship has long focused on competence, expertise and the transfer of technical knowledge. What has been less visible is the role of credibility in governing access to the very conditions under which capability is developed. By identifying credibility as a regulatory mechanism, this paper reframes commissioning from a neutral technical phase to a socially mediated learning environment in which trust, legitimacy and identity shape the distribution of experience. This lens exposes a form of inequality that is rarely acknowledged but routinely reproduced in high-stakes engineering work.

Why it matters: Recognising credibility as regulatory reveals that capability gaps are socially produced, not simply technical. **Who will care:** Engineering educators, HR managers, and diversity advocates will care because credibility allocation directly affects retention and workforce equity. **What it enables:** Future research can measure credibility allocation empirically, while organisations can design interventions to decouple competence from stereotypes.

8.2 Integrating tacit knowledge, voice and identity into a single explanatory model

Commissioning is typically studied through reliability engineering, risk management or formal processes. This paper synthesises concepts from workplace learning, tacit knowledge research, psychological safety and engineering identity to explain why some engineers gain accelerated access to tacit knowledge while others remain epistemically peripheral. The framework demonstrates that participation, voice, tacit knowledge flow and identity formation are not standalone topics — they form an interdependent system regulated by credibility judgements. This integration offers a coherent explanation for persistent disparities in commissioning capability.

Why it matters: Fragmented approaches miss how credibility simultaneously regulates multiple dimensions of learning. Integration reveals systemic inequities. **Who will care:** Safety scientists, organisational psychologists, and commissioning managers will care because the model explains persistent disparities in capability. **What it enables:** Empirical studies can test how credibility shapes tacit knowledge flows, while practice can embed inclusive voice mechanisms in commissioning teams.

8.3 Revealing how credibility dynamics shape system interpretation and early-life reliability

Commissioning failures are often attributed to technical oversight, incomplete procedures or interface problems. This paper shows that social dynamics — especially credibility filtering — quietly structure how anomalies are interpreted, which warnings are acted on, and how system drift is detected. By linking credibility to early-life reliability problems, the paper positions credibility-regulated learning as a hidden driver of commissioning debt, operational instability, and long-tail system failures. This reframing invites new approaches to risk management that emphasise listening, interpretive diversity and the redistribution of tacit knowledge.

Why it matters: Linking credibility to reliability reframes commissioning failures as socially mediated, not purely technical. **Who will care:** Risk managers, reliability engineers, and regulators will care because credibility filtering creates blind spots in hazard detection. **What it enables:** Future research can track how credibility affects anomaly interpretation, while practice can implement inclusive listening protocols to reduce commissioning debt.

8.4 Providing a foundation for future empirical work on commissioning as an epistemic environment

The framework developed here offers clear constructs — credibility allocation, participation rights, tacit knowledge flow, interpretive authority and identity trajectories — that can be operationalised in empirical studies. These constructs enable qualitative and quantitative research on how engineers learn under uncertainty, how credibility shapes risk detection, and how commissioning cultures influence capability formation. In doing so, the paper establishes commissioning as an epistemic environment worthy of direct study, rather than a transitional stage attached to construction or operations.

Why it matters: Treating commissioning as epistemic highlights how knowledge is produced and legitimised under uncertainty. **Who will care:** Academic researchers, professional bodies, and industry leaders will care because it positions commissioning as a site of knowledge creation, not just technical transition. **What it enables:** Enables ethnographic studies of commissioning practice, surveys of credibility allocation, and interventions to broaden participation rights.

8.5 Practical Implications

The framework developed in this paper has clear practical implications for engineering organisations. By naming credibility as a regulatory mechanism, integrating tacit knowledge, voice and identity, and linking these dynamics to reliability and capability outcomes, the paper provides actionable insights for commissioning practice.

Why it matters: Without intervention, credibility barriers perpetuate inequity, concentrate expertise, and undermine organisational resilience. Recognising credibility as distinct from competence allows organisations to design fairer systems of participation.

Who will care: Industry leaders, commissioning managers, professional associations, and policymakers will care because credibility dynamics directly affect safety, workforce diversity, and long-term capability.

What it enables: Organisations can implement structured rotations, inclusive voice protocols, and mentoring schemes to redistribute tacit knowledge. Researchers can operationalise credibility constructs in empirical studies, while professional bodies can embed credibility awareness into training and accreditation. Together, these steps enable commissioning to evolve from a fragile, inequitable practice into a robust epistemic environment that supports both technical reliability and workforce equity. This framework generates research questions through problematization (Alvesson and Sandberg, 2011), challenging assumptions about meritocratic learning in engineering. Future empirical work can test these propositions using ethnographic (Orr, 2016), comparative (Argyris, 1990), or experimental methods.

9. Research Agenda

The credibility-regulated learning perspective opens several lines of inquiry that extend beyond commissioning and into engineering practice more broadly.

A critical empirical question remains largely unaddressed: Do credibility dynamics affect commissioning outcomes and plant reliability? The framework developed here suggests that plants with more inclusive participation, equitable distribution of tacit knowledge, and stronger psychological safety should experience better commissioning-phase performance—but this hypothesis requires testing. Researchers could conduct comparative studies of commissioning projects, collecting data on: credibility distribution (who gets access to what?), diversity of perspectives in troubleshooting, voice climate (who speaks up, who is heard?), and commissioning outcomes such as time to stable operations, number of post-startup modifications required, early-life reliability incidents, and commissioning rework costs. Statistical analysis could test whether credibility concentration predicts poorer outcomes, controlling for plant complexity, technology type, and project constraints. Alternatively, researchers could employ quasi-experimental methods to compare commissioning performance before and after interventions designed to distribute credibility more equitably (e.g., structured debriefs, anonymous reporting systems, diverse team compositions). Case studies of commissioning failures could retrospectively examine whether credibility dynamics played a role: Were critical warnings dismissed because they came from low-credibility sources? Did homogeneous teams miss risks that diverse teams might have detected? Linking social dynamics to technical outcomes would provide compelling evidence for why credibility-regulated learning matters beyond equity concerns—it matters for safety, reliability, and organisational performance.

10. Conclusion

Commissioning is often celebrated as the moment when engineering becomes real: where systems are switched on, assumptions are tested, and complex behaviours emerge. Yet this phase is also where the social architecture of engineering is laid bare. Commissioning is not merely a technical process; it is a credibility-dependent learning system in which trust, legitimacy, tacit knowledge, and interpretive authority converge to shape who learns, who leads, and who gets heard.

This paper argues that credibility, rather than competence, frequently governs access to the moments where the deepest learning occurs. These dynamics create patterned inequities: some engineers are positioned to develop rich tacit judgement, while others remain on the margins of the very work that would allow them to grow. The consequences extend beyond individual careers. They affect how risk is detected, how systems behave during early-life operation and how organisations build — or fail to build — distributed expertise.

By naming credibility as a regulatory mechanism, this paper reframes commissioning as an epistemic environment with profound implications for safety, capability and identity. Recognising this does not diminish the technical skill required in commissioning; it highlights the conditions under which that skill is developed, shared and acted upon. Closing the credibility gap is not only a matter of fairness — it is a matter of organisational performance and system resilience.

Statement on the Use of Artificial Intelligence

AI-assisted tools were used solely for language editing and clarity. All intellectual content, analysis, and conclusions are the responsibility of the author(s).

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