Credibility-Regulated Learning in Engineering Commissioning: How Trust Shapes Access to Tacit Knowledge, Voice, and Professional Development

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Abstract

Commissioning—the phase in which engineered systems transition from design to live operation—is one of the most consequential yet least theorised stages of engineering practice. This paper develops a conceptual framework for understanding commissioning as a credibility-regulated learning environment: a setting in which socially conferred judgements of trustworthiness and legitimacy govern access to participation, tacit knowledge, voice, and professional identity formation. Drawing on workplace learning theory, tacit knowledge research, psychological safety scholarship, and engineering identity literature, the paper identifies five interconnected mechanisms through which credibility regulates learning: credibility allocation, participation rights, tacit knowledge flow, interpretation and identity formation, and capability development. The framework proposes that these mechanisms operate as a self-reinforcing cycle, likely producing unequal learning trajectories that disproportionately affect early-career engineers, women, culturally diverse professionals, and career changers. Illustrative survey data from a global study of engineering workplace pressures (N=335, 22 countries across six continents; commissioning subsample n=81) provide contextual support for the plausibility of key propositions. The paper contributes to workplace learning scholarship by naming credibility as a regulatory mechanism in high-stakes professional transitions and integrating participation, tacit knowledge, voice, and identity into a single explanatory model. Practical implications and testable propositions for future empirical research are discussed.

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

1. Introduction

Commissioning is where engineering stops being hypothetical. It is the moment when design assumptions are exposed to the behaviour of a live system, and when uncertainty, time pressure, and organisational complexity collide. The technical demands are well documented. The social dynamics that shape who learn, who speaks, and who develops expertise during this phase are not.

Workplace learning scholarship has made substantial progress in understanding how professionals develop expertise in routine settings. Research has examined communities of practice (Wenger, 1998), workplace affordances and individual engagement (Billett, 2004), the distinction between formal and informal learning (Eraut, 2004; Marsick and Watkins, 2001), and frameworks for expansive versus restrictive learning environments (Fuller et al., 2004; Fuller and Unwin, 2003). More recently, scholars have examined informal learning in complex, uncertain contexts (Lokhtina and Faller, 2024) and the role of tacit knowledge in professional practice (Collins, 2013; Schön, 2017). Less well understood are high-stakes transitional phases—moments when systems move from theoretical to operational states, when uncertainty is acute, and when interpretive authority becomes critical.

Commissioning is precisely such a phase. Yet who gets to participate in its most consequential learning moments is rarely governed by capability alone. In practice, commissioning functions as a credibility-regulated learning environment: a setting where socially conferred judgements of trust, authority, and legitimacy determine not only who is heard but who gets to learn (Tynjälä, 2008; Vanhanen et al., 2026).

In this paper, credibility refers to socially conferred judgements of legitimacy, trustworthiness, and interpretive authority—the basis on which access to participation is granted and whose knowledge is acted upon in high-stakes engineering environments. It is not a personal trait but a socially distributed resource, allocated by teams, organisations, and informal gatekeepers, and shaped by identity, status, and alignment with dominant norms (Billett, 2001; Fricker, 2007; Hatmaker, 2013).

This paper extends workplace learning theory by developing a conceptual framework that explains how credibility—rather than capability alone—regulates access to learning opportunities, with implications for knowledge acquisition and professional development. The sections that follow first establish the methodological approach, then examine why commissioning demands a distinct analytical lens, and finally present the Credibility-Regulated Learning Framework and its implications.

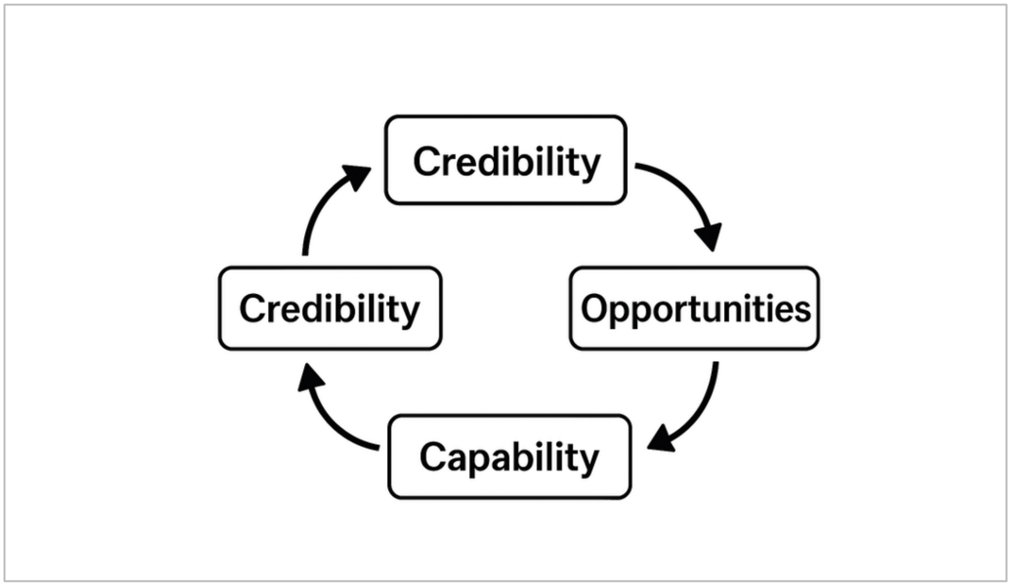

Figure 1. Credibility cycle in commissioning.

Figure 1 illustrates the cyclical relationship between credibility, opportunities, and capability. Engineers perceived as credible gain access to energisations, fault diagnosis, and tacit knowledge flows, reinforcing their credibility. The exclusion path highlights how low-credibility engineers are denied access, limiting development and perpetuating inequity.

2. Methodological Approach: Practitioner-Informed Conceptual Development

This paper develops a conceptual framework through practitioner-informed theoretical synthesis (Jacobs and Park, 2009). The approach follows established precedent for developing workplace learning frameworks from sustained professional engagement (Eraut, 2004; Schön, 2017) and aligns with theory-building contributions in vocational and workplace learning research, where practitioner-grounded theoretical integration extends explanatory models (Nicolini, 2012).

The conceptual development involved four stages. First, analytic pattern identification: synthesising recurrent social dynamics across commissioning contexts that existing workplace learning frameworks did not adequately explain. Second, literature synthesis: systematically connecting observed patterns to established constructs in workplace learning (Billett, 2004; Wenger, 1998), tacit knowledge research (Collins, 2013; Orr, 2016), voice behaviour (Edmondson, 1999; Morrison, 2011) and professional identity formation (Trede et al., 2012). Third, framework construction: organising these mechanisms into an integrated explanatory model. Fourth, implication development: deriving organisational interventions and research propositions.

This paper is a conceptual, theory-building contribution grounded in practitioner insight and supported by illustrative survey evidence. It does not claim to present empirical validation. The framework should be understood as a theoretical proposition requiring testing through interviews, observations, and comparative studies across commissioning projects and analogous high-stakes professional transitions. The limitations of a single-practitioner perspective are acknowledged. The value of this approach lies in its capacity to identify mechanisms, grounded in sustained professional engagement and integrated with established theory, that merit systematic empirical investigation.

Survey findings from a global study of engineering workplace pressures (N=335, 22 countries across six continents; commissioning subsample, n=81) are presented at three points in the paper as contextual illustrations. The survey design and analysis are reported in full in Ayres et al. (2026). Figures cited here illustrate the plausibility of framework propositions, not to validate them.

1. 3. Why Commissioning Demands a Credibility Lens

Commissioning has long been framed as a technical milestone: verify the installation, energise the system, troubleshoot defects, and stabilise operations. This framing obscures what commissioning also is: a socially dense, judgement-heavy, knowledge bottleneck in which learning is intense but access to that learning is socially regulated.

Three features distinguish commissioning from the routine workplaces examined in most workplace learning research and establish why a credibility-specific lens is required.

First, commissioning concentrates high-value tacit knowledge. Engineers rely on sensory interpretation, embodied experience, and undocumented heuristics to understand system behaviour (Hager, 2011; Hutchins, 2006; Orr, 2016). This knowledge cannot be accessed through manuals; it requires repeated exposure, trust, and participation in real events. Research shows that tacit knowledge is transmitted through informal mentoring and storytelling, but these pathways depend heavily on trust and perceived legitimacy (Collins and Evans, 2007; Collins, 2013). When credibility determines access to these moments, tacit knowledge becomes unevenly distributed. In routine settings, tacit knowledge accumulates gradually through repeated practice and collegial interaction (Billett, 2014; Eraut, 2004). In commissioning, the window for acquiring critical tacit knowledge is compressed into days or weeks, and opportunities are frequently unrepeatable: a first energisation, a specific fault condition, or an emergency shutdown occurs once. Lave and Wenger's (1991) concept of legitimate peripheral participation assumes that newcomers gradually move toward full participation as they demonstrate competence. Commissioning disrupts this trajectory because the stakes and time pressure mean that gatekeepers must make rapid allocation decisions about who participates, and these decisions are disproportionately shaped by credibility rather than demonstrated capability. The learning environment is therefore simultaneously high-value and high-exclusion: the highest-value learning moments may be those from which low-credibility engineers are most likely to be excluded.

Second, credibility operates as a filter for participation. Across engineering workplaces, credibility is not granted equally. Women, culturally diverse engineers, and those who deviate from dominant communication norms often face higher thresholds for recognition (Cech and Blair-Loy, 2019; Faulkner, 2009; Fouad et al., 2017). Credibility functions as an epistemic filter, determining whose knowledge counts as legitimate (Fricker, 2007). In commissioning, where teams are temporary and cross-organisational, assumptions about competence travel fast and harden quickly into unequal learning trajectories. Survey data is consistent with this picture: commissioning engineers reported a higher burden than peers in other roles, with 86.4% reporting pressure to work beyond contracted hours and 81.5% working beyond formal role boundaries (Ayres et al., 2026). In environments operating this far outside formal structures, access to core work tends to be shaped by informal credibility rather than job description.

Third, voice under uncertainty is credibility-loaded. Commissioning risk is often first detected by those closest to the technical work, but voice behaviour depends on psychological safety and perceived legitimacy (Edmondson, 1999; Nembhard and Edmondson, 2006). In a global survey, 22.2% of commissioning engineers reported that mistakes were treated harshly (Ayres et al., 2026). More striking, qualitative analysis revealed that commissioning engineers reported experiences of professional invisibility at 13 times the rate of engineers in other roles (10.4% vs 0.8%, Fisher's exact, $p=.005$). When credibility determines whose observations are treated as authoritative, the range of signals available to the team may narrow, compromising safety (Hale et al., 2015; Weick and Sutcliffe, 2001). Morrison (2011) distinguishes between promotive voice and prohibitive voice, noting that prohibitive voice carries greater interpersonal risk. In commissioning, the most safety-critical voice behaviour—flagging anomalies, questioning procedures, challenging assumptions—is prohibitive and therefore most vulnerable to credibility filtering. Dekker (2017) argues that drift into failure occurs not through dramatic errors but through the gradual normalisation of deviance, a process that accelerates when only a narrow band of interpreters are licensed to define what counts as "normal."

These three features—concentrated tacit knowledge, credibility-filtered participation, and credibility-loaded voice—make commissioning a credibility-dependent learning system in which social judgements regulate access to technical knowledge. The following sections present the Credibility-Regulated Learning Framework that explains how this regulation operates.

2. 4. The Credibility-Regulated Learning Framework

The mechanisms identified above do not operate independently: they form an integrated, self-reinforcing system. The framework consists of five interacting layers, each shaped by credibility dynamics. These are presented below in the sequence in which they typically operate, though in practice they interact recursively.

4.1 Credibility Allocation

Credibility in commissioning is typically allocated by organisational actors and informal gatekeepers rather than earned solely through demonstrated competence. Senior engineers determine whose judgement is trusted in pre-commissioning meetings; 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., 2009). 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, handover meetings, daily toolbox talks, and energisation planning. At each stage, credibility serves as a filter governing participation and exposure to tacit knowledge (Collins, 2013). Significantly, credibility allocation tends to operate invisibly. It is framed as "experience" but may reflect 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 (Faulkner, 2009; Morrison, 2023). These judgements are naturalised as "team chemistry," masking bias and reinforcing stereotypes.

As used in this framework, credibility is analytically distinct from related constructs. It differs from trust, which describes a relational expectation of reliability, and from status, which reflects positional rank within a hierarchy. Credibility, as defined here, refers specifically to the socially conferred judgement that an individual's knowledge and interpretations warrant being acted upon in consequential situations. It is narrower than legitimacy, which encompasses broader institutional recognition, and more situationally contingent than authority, which derives from formal role assignment. The construct is preferred here because it captures the informal, often invisible, mechanism through which access to learning is regulated in environments where formal credentials may be equivalent but social recognition is not.

4.2 Participation Rights

Participation in commissioning is not simply about being present; it is about being positioned where decisions are made and knowledge is generated. Engineers with full participation rights are invited into control rooms during energisation, given hands-on time with equipment, asked for input during troubleshooting, included in debrief sessions, and added to emergency call lists. These moments represent the primary sites where tacit knowledge and trust are forged (Vailasseri et al., 2021; Wenger, 1998).

The distribution of rights is subtle but decisive. Invitation versus permission ("You should join us" versus "You can watch if you want"), explicit inclusion versus passive exclusion, active mentoring versus sink-or-swim—each signals a credibility judgement (KPMG, 2023). Professional identity develops through repeated participation and recognition (Carlone and Johnson, 2007; Ibarra, 1999). When engineers are excluded, they miss critical one-time learning moments, fail to build relationships formed under shared stress, and risk being developed as "helpers" rather than engineers. The mechanism is invisible: exclusion feels natural while inclusion feels earned, but access is distributed by credibility rather than competence (Fuller and Unwin, 2003).

4.3 Tacit Knowledge Flow

Tacit knowledge—the invisible craft of commissioning—transfers through proximity, observation, questioning, shared failure, and storytelling (Collins and Evans, 2007). Standing beside an expert during diagnosis, watching how they read instrument patterns, or asking "Why did you check that first?" builds interpretive fluency.

Collins and Evans (2007) distinguish between contributory expertise, which requires hands-on practice, and interactional expertise, which can be acquired through sustained dialogue with practitioners. Commissioning demands contributory expertise: the ability to diagnose by sound, feel, and pattern cannot be developed through conversation alone. This has a critical implication for environments regulated by credibility. Even engineers who develop interactional expertise through reading and observing remain unable to perform the diagnostic work that builds credibility, because they have been denied the hands-on participation required for contributory knowledge. The result is a double bind: credibility is needed to access the experiences that build competence, but competence is needed to be granted credibility. Orr's (2016) ethnographic work on technicians demonstrates how storytelling functions as a vehicle for tacit knowledge transfer within trusted communities; those outside the trust network are excluded not only from the stories but also from the interpretive context that makes them meaningful.

Yet tacit knowledge is frequently gatekept. Diagnostic cues, embodied system feel, timing instincts, undocumented workarounds, and war stories circulate only among those deemed credible (Eraut, 2000; Orr, 2016). Engineers excluded from control rooms, relegated to peripheral tasks, or left out of informal debriefs miss these high-value learning moments. Because tacit knowledge requires repeated exposure and pattern recognition, exclusion is likely to create enduring capability gaps that become difficult to remediate later.

4.4 Interpretation and Identity Formation

Interpretation in commissioning is not simply a technical act; it is a socially consequential practice that shapes professional identity. Engineers trusted to interpret system behaviour develop confidence and legitimacy; those excluded remain uncertain about their role and competence (Ashforth and Humphrey, 1993; Trede, 2009). Being trusted to interpret signals membership in the commissioning community, while having interpretations dismissed, marks one as peripheral. Interpretive authority thus becomes a proxy for professional inclusion.

This mechanism connects to broader scholarship on professional identity formation. Trede et al. (2012) argue that professional identity develops through a combination of practice, recognition, and belonging. In commissioning, all three are credibility-contingent: practice depends on being assigned hands-on tasks, recognition depends on having interpretations accepted, and belonging depends on being included in the team's informal social fabric. Ibarra (1999) describes how professionals experiment with "provisional selves" as they develop identity in new roles; credibility deficits truncate this experimentation by denying engineers the feedback loops needed to test and refine emerging professional identities. Gherardi (2001) further shows how gender intersects with workplace learning, with women in technical fields often required to perform additional identity work to be recognised as legitimate practitioners. In commissioning, where team composition is temporary, and first impressions are disproportionately consequential, this additional identity burden is amplified.

The long-term consequences are significant. Engineers who experience interpretive inclusion come to see commissioning as "their work," pursue commissioning roles, and progress into senior positions. Those excluded may avoid commissioning pathways, transition into less interpretive roles, or leave the field entirely—a pattern of attrition that narrows the demographic and epistemic range of commissioning teams (Sahin-Dikmen et al., 2020; Tonso, 2006).

4.5 Capability Development and Organisational Outcomes

The framework proposes that the cumulative effect of these mechanisms is likely to be unequal capability development. Engineers on high-credibility trajectories experience rapid skill acquisition, build strong networks, and are positioned for leadership. Those on low-credibility trajectories face stalled development, isolation, and eventual stagnation or departure (Billett, 2020; Colley et al., 2012). Over time, this is likely to produce expertise bottlenecks: key-person dependencies, fragile institutional memory, and reduced interpretive diversity (Eraut, 2007; Trede et al., 2012).

Critically, the capability gap may begin to resemble a competence gap, appearing to justify the original allocation. Organisations may conclude that excluded engineers "weren't ready"—a self-fulfilling prophecy that obscures the social production of unequal outcomes (WGEA, 2024).

4.6 The Framework as a System

The framework proposes a cyclical dynamic: credibility allocation shapes participation rights, which govern the flow of tacit knowledge, which shapes identity and interpretation, which produces uneven capability, which 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.

5. Implications for Capability, Identity, and System Safety

The credibility-regulated learning framework proposes patterned consequences across three domains.

5.1 Uneven Capability Development

The framework extends Billett's (2004) concept of workplace affordances by showing how credibility acts as a filtering device, determining who receives invitations to high-learning activities. While Billett emphasises the relational interdependence between affordances and individual engagement, commissioning reveals that affordances are not equally offered: credibility mediates access even when individual capability and motivation are equivalent. Fuller and Unwin (2003) identify participation breadth as a key feature of expansive learning environments; in commissioning, credibility determines whether engineers experience expansive or restrictive participation. Eraut (2004) emphasises that professional expertise develops through repeated exposure to challenging situations combined with reflection-in-action. The framework proposes that, in commissioning, this exposure is itself credibility-regulated, potentially stratifying the accumulation of tacit knowledge.

Crucially, these divergent trajectories compound over time. An engineer who is included in an early energisation gains not only technical knowledge but also a narrative of participation that reinforces their credibility in subsequent allocation decisions. Conversely, an engineer excluded from early events lacks both the knowledge and the participation history, making future inclusion less likely. Gambheer and Acharya (2024) and Rangraz and Pareto (2021) have shown that workplace learning in complex environments depends on iterative cycles of challenge and reflection; the framework proposes that credibility filtering may disrupt these cycles for excluded engineers before they can begin. The implication is that small initial differences in credibility allocation can produce large and durable differences in capability, a dynamic that existing workplace learning frameworks do not adequately explain because they assume that affordances, while relationally mediated, are not systematically withheld from identifiable groups.

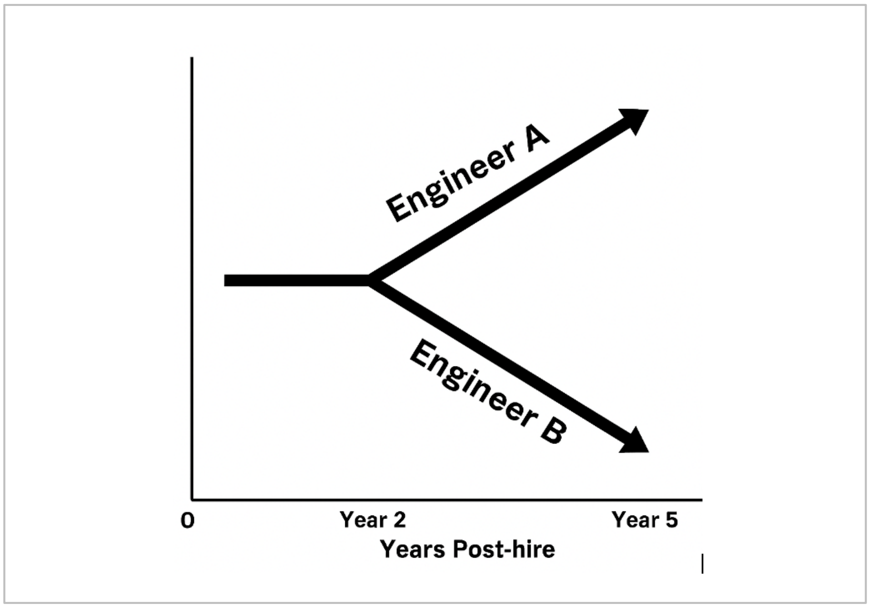

Figure 2. Divergent career trajectories shaped by credibility allocation.

Figure 2 compares two engineers over a five-year period. Engineer A receives early credibility, leads energisations, gains tacit knowledge, and progresses to a senior role. Engineer B is assigned documentation tasks, excluded from energisation access, and exits commissioning. This is an analytic illustration of divergent trajectory types, not an empirical longitudinal model.

5.2 Distorted Risk Detection

Safety in commissioning depends not only on detecting anomalies but on whether those anomalies are believed and acted upon. The framework proposes that the credibility dynamics described in Section 4 distort this process: risk information is filtered through a credibility lens that amplifies trusted voices while discounting others (Dekker, 2017; Edmondson, 1999). Research on "safety listening" suggests that failures often arise not from silence but from selective hearing—warnings are voiced but discounted if the messenger lacks legitimacy (Hale et al., 2015; Weick and Sutcliffe, 2001).

The framework proposes that credibility filtering may operate as a hidden mechanism upstream of the procedural and communication failures that incident investigations typically identify. Perrow (2011) argues that complex systems generate "normal accidents" through unexpected interactions between tightly coupled components. The credibility-regulated learning framework adds a social dimension to this analysis: when interpretive authority is concentrated among a narrow group, the range of interactions that the team can recognise and respond to may be correspondingly narrow. Reason's (1990) Swiss cheese model identifies latent conditions that allow hazards to propagate through organisational defences. Credibility-based voice suppression functions as precisely such a latent condition—invisible under normal operating conditions but capable of allowing hazards to pass through detection layers when the engineer closest to the anomaly lacks the credibility to interrupt the workflow. This positions credibility dynamics not merely as an equity concern but as a system safety variable that warrants inclusion in commissioning risk assessment.

5.3 Identity Damage and Attrition

The credibility-regulated learning environment may carry a significant emotional toll. Engineers who must constantly prove their competence may experience exhaustion and hypervigilance (Detert and Edmondson, 2011). Social exclusion—being left out of control room discussions or debrief sessions—can foster isolation and self-doubt even among highly qualified staff (Ashforth and Humphrey, 1993). Over time, these pressures may erode confidence and fracture professional identity.

Attrition is consistent with predictable patterns. Some engineers leave commissioning for other technical roles; others exit engineering entirely; a third group remains but disengages—"quitting in place" (Tucker and Edmondson, 2002). Attrition appears disproportionately concentrated among women, minorities, and career-changers—groups already navigating heightened credibility thresholds (Fouad et al., 2017; WGEA, 2024). One likely consequence is a workforce that becomes increasingly homogeneous, potentially reinforcing existing biases and reducing interpretive diversity.

Survey data provides quantitative texture to these patterns. Analysis of blame attribution across 335 engineers found significant gender differences: men attributed project failures to leadership or management at nearly twice the rate as women (53% vs 31%, $\chi^2 = 13.82$, $p < .001$, $V = .203$) (Ayres et al., 2026). This differential is suggestive rather than direct evidence but is consistent with the framework's proposition that engineers carrying credibility deficits may be less willing to attribute failure upward, as doing so risks compounding their marginalisation. Age-related patterns were similarly pronounced—engineers aged 55–64 attributed failures to commissioning at 16.7%, compared with 0% among the 18–24 cohort ($\chi^2=14.43$, $df=5$, $p=.013$, $V=.208$) (Ayres et al., 2026), suggestive of the proposition that early-career engineers, operating with the least accumulated credibility, may be less able to name commissioning as a systemic source of pressure. These attribution patterns warrant further investigation with designs capable of testing the proposed causal mechanisms directly.

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	Narrower range of signals detected; 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

6. Conceptual Contributions

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

6.1 Naming credibility as a regulatory mechanism in engineering work

Engineering scholarship has focused extensively on competence, expertise, and the transfer of technical knowledge (Billett, 2014; Eraut, 2004). What has been less visible is the role of credibility in governing access to the conditions under which capability develops. By identifying credibility as a regulatory mechanism, this paper proposes a reframing of commissioning from a neutral technical phase to a socially mediated learning environment. This extends Fricker's (2007) concept of epistemic injustice into engineering practice, showing how testimonial credibility deficits produce unequal learning opportunities and unequal recognition of knowledge. It also builds on Billett's (2004, 2001) work on workplace affordances by proposing that credibility is a central mediating variable determining which affordances engineers actually receive. While Billett emphasises that workplace affordances are relational—shaped by both what the workplace offers and what the individual brings—the framework developed here proposes that in high-stakes, time-pressured environments, organisational allocation decisions dominate individual agency: credibility gatekeeping may override individual motivation, capability, and engagement.

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

Commissioning is typically studied through reliability engineering, risk management, or formal processes. Participation, voice, tacit knowledge flow, and identity formation have been examined as separate topics in workplace learning research (e.g., Billett, 2004;

Collins, 2013; Edmondson, 1999; Trede et al., 2012). This paper synthesises these constructs into an interdependent system regulated by credibility judgements, offering a coherent explanation for persistent disparities in commissioning capability that single-construct analyses cannot provide. Specifically, voice research alone cannot explain why some engineers remain silent (because it does not account for how credibility restricts the tacit knowledge needed to formulate credible observations); tacit knowledge research alone cannot explain why knowledge remains unevenly distributed (because it does not examine the credibility judgements that govern access to knowledge-generating experiences); and identity research alone cannot explain differential attrition (because it does not connect identity formation to the participation structures that shape it). The integrated framework reveals these as mutually reinforcing mechanisms within a single system.

6.3 Linking credibility dynamics to system interpretation and early-life reliability

Commissioning failures are often attributed to technical oversight, incomplete procedures, or interface problems. This paper proposes that social dynamics—especially credibility filtering—quietly structure how anomalies are interpreted, which warnings are acted on, and how system drift is detected. This links credibility-regulated learning to early-life reliability, proposing it as a potential contributing factor in commissioning debt and long-tail system failures. This extends safety scholarship (Dekker, 2017; Perrow, 2011) by identifying a social learning mechanism that operates upstream of the procedural and communication failures that incident investigations typically identify. Where Hollnagel's (2018) Safety-II framework emphasises understanding why things go right as well as why they go wrong, the credibility-regulated learning framework highlights that "going right" in commissioning depends on whose interpretations are available to the team. Organisations that rely on a narrow credibility band for sensemaking may appear to function well under routine conditions but lack the interpretive diversity needed to detect novel failure modes.

6.4 Establishing operationalisable constructs for future research

The framework offers constructs—credibility allocation, participation rights, tacit knowledge flow, interpretive authority, and capability 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. The paper establishes commissioning as a learning environment worthy of direct investigation, rather than as a transitional stage in construction or operations management. Credibility allocation, for example, could be measured through network analysis of who is invited to participate in key commissioning events; participation rights could be tracked through structured observation of task distribution; and tacit knowledge flow could be assessed through interviews mapping knowledge sources and mentoring relationships. The framework thus provides not only a theoretical contribution but a practical research architecture for the empirical programme it calls for.

7. Practical Implications and Organisational Interventions

The framework suggests that interventions targeting specific layers of the credibility-regulated learning cycle may disrupt the self-reinforcing dynamics identified above. Three categories of intervention follow logically from the framework mechanisms.

Structured participation rights address the credibility allocation and participation layers (Sections 4.1–4.2). Rather than leaving participation to informal allocation, organisations can implement rotation protocols ensuring all engineers participate in energisations, fault-finding, and control room activities within their first 12 months. Shadowing requirements can structure how senior engineers include juniors in troubleshooting conversations, making reasoning explicit. Debrief inclusion can be formalised to prevent lower-credibility engineers from being excluded from after-action reviews. These interventions face real implementation challenges: time pressure, contractor fragmentation, informal hierarchies, and perceived risk of slowing delivery are precisely the conditions that defeat formal inclusion structures. Realistic implementation therefore requires embedding these practices within existing project workflows rather than adding them as separate requirements. Drawing on Fuller and Unwin's (2003) expansive learning framework, organisations can audit commissioning practices to identify restrictive features—such as informal, credibility-based task allocation—and implement expansive practices, including broader participation rights.

Voice protection mechanisms address the voice and interpretation layers (Sections 4.3–4.4). The framework predicts that credibility filtering suppresses prohibitive voice most severely; interventions that decouple the messenger from the message may counteract this effect. Anonymous reporting systems allow engineers to flag concerns without exposing their credibility. Structured solicitation—actively asking lower-status team members for input before higher-status members speak—counteracts credibility-based filtering (Nembhard and Edmondson, 2006). Post-event analysis that examines whether warnings were voiced but went unheard, and listening audits that track which concerns are investigated versus dismissed, can reveal patterns of credibility bias that would otherwise remain invisible (Morrison, 2011).

Mentoring and knowledge transfer protocols address the tacit knowledge flow layer (Section 4.3). Documented mentoring assigns mentors with explicit responsibility for tacit knowledge transfer, not just task supervision. Making tacit knowledge explicit where possible—through structured storytelling, diagnostic reasoning logs, and annotated case histories—can reduce dependence on informal credibility networks for knowledge access (Collins and Evans, 2007; Eraut, 2000).

8. Future Research Directions

The framework generates three priority empirical questions. First, does credibility concentration predict poorer commissioning outcomes—longer time to stable operations, more post-startup modifications, greater early-life incidents? Second, do interventions that redistribute participation rights measurably improve both learning equity and system reliability? Third, do credibility-regulated dynamics operate similarly in analogous high-stakes professional transitions—such as surgical teams, flight crews, and incident command systems—and do commissioning-derived interventions transfer across those contexts? These questions are amenable to mixed-methods investigation combining ethnographic observation, network analysis, and longitudinal tracking of participation and capability development.

9. Conclusion

Commissioning is one of engineering's most consequential and least theorised phases. This paper has proposed that commissioning operates as a credibility-regulated learning environment in which socially conferred judgements of trustworthiness govern access to participation, tacit knowledge, voice, and professional identity formation. The Credibility-Regulated Learning Framework identifies five interconnected mechanisms—credibility allocation, participation rights, tacit knowledge flow, interpretation and identity formation, and capability development—that form a self-reinforcing cycle proposed to produce systematically unequal learning trajectories. These dynamics have implications not only for individual professional development but for organisational capability, workforce diversity, and system safety. Recognising that credibility does not equal competence is the first step toward designing commissioning environments that develop the full range of available talent and detect the full range of available signals.

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