Shehab, L. (2026). Hiring for Lean under labor shortages: rethinking "right people" through cognitive diversity. In F. Hamzeh, M. Poshdar, N. P. Garcia-Lopez, & V. Gan (Eds.), *Proceedings of the 34th Annual Conference of the International Group for Lean Construction* (IGLC34) (pp. 934–946). https://doi.org/10.24928/2026/0114

HIRING FOR LEAN UNDER LABOR SHORTAGES: RETHINKING "RIGHT PEOPLE" THROUGH COGNITIVE DIVERSITY

Lynn Shehab[1]

ABSTRACT

Lean construction emphasizes the selection and development of the "right people" to support stable production systems and continuous improvement. However, persistent labour shortages are challenging traditional experience-based hiring practices and increasing workforce heterogeneity across construction projects. In this context, cognitive diversity (differences in information processing, problem-solving, decision-making) has become more prevalent, yet remains unaddressed in hiring and workforce design. This paper argues that cognitive diversity should be recognized as a resource rather than a source of variability to be minimized. Building on Lean principles of respect for people and value generation, the paper critiques conventional hiring approaches that prioritize uniformity over cognitive fit with task demands. A conceptual framework is proposed that reframes "right people" in Lean construction as cognitively complementary individuals whose strengths can be aligned with varying task complexities and production needs. By linking labour shortages, hiring decisions, and cognitive diversity, this paper extends existing Lean discussions on human resource management and workforce planning. The proposed perspective supports adaptive and human-centered Lean systems that enhance productivity while improving worker sustainability and retention. The findings contribute to ongoing debates on Lean implementation by highlighting hiring as a critical leverage point for designing resilient production systems under constrained labour conditions.

KEYWORDS

Cognitive diversity, labour shortage, workforce design, production systems, psychology.

INTRODUCTION

Lean construction emphasizes selecting and developing the "right people" as a prerequisite for stable production systems and continuous improvement (Rooke et al. 2010). Human resources are positioned as central to Lean implementation, supporting reliable workflow, collaborative planning, and learning-oriented project cultures (Liker 2004). However, the meaning of the "right people" is often treated as an abstract ideal rather than a concept grounded in the specific cognitive demands of construction work. Suitability is commonly framed in terms of general competence, experience, or behavioural alignment with organizational norms (Pekuri et al. 2012), implicitly suggesting that a particular type of individual can be universally appropriate across production contexts.

At the same time, the construction industry is experiencing persistent labour shortages that are reshaping hiring practices and workforce composition (Kuo 2024). Aging demographics, limited entry of younger workers, and increasing project complexity have reduced the availability of experienced personnel while expanding reliance on heterogeneous and less

[1] Assistant Professor, Civil and Environmental Engineering Dept., University of Alberta, Edmonton, AB, Canada, lshehab@ualberta.ca, orcid.org/0000-0002-2708-3550

experienced labour pools (Elbashbishy and El-Adaway 2023). Under these conditions, firms increasingly prioritize immediate availability and role coverage (Paucar-Espinoza et al. 2022) over nuanced assessments of how individuals will perform under cognitive load, coordination pressure, and uncertainty. As a result, workforce variability is growing, yet prevailing hiring logics remain rooted in assumptions of interchangeability and uniformity.

Existing Lean literature recognizes the importance of people for system performance (Moradi and Sormunen 2023) but typically conceptualizes workforce suitability in broad and decontextualized terms. Lean construction theory has historically emphasized the reduction of variability as a prerequisite for stable flow and predictable system performance (Koskela 2000). Variability in materials, information, and workflow has been extensively studied as a primary source of waste, disruption, and unreliability, leading Lean practices to prioritize standardization, buffering, and coordination mechanisms to stabilize production (Hamzeh 2009). Within this perspective, human variability is often implicitly treated as a disturbance that must be controlled to maintain flow.

Despite these advances, the theoretical treatment of variability in human capabilities remains limited. Workforce suitability is typically described through general attributes such as competence, collaboration, and openness to change rather than in relation to the specific demands imposed by different tasks and production conditions. This reinforces a one-size-fits-all conception of the "right people" that obscures how task characteristics and human capacities interact. Construction tasks vary widely in their cognitive demands (Shehab et al. 2026), from routine standardized operations to activities requiring real-time judgment, adaptation, and coordination. Performance in such settings depends not only on experience or role, but on how an individual's cognitive strengths align with task requirements and system conditions. As a result, Lean construction lacks a clear theoretical account of how different cognitive capabilities influence variability, stability, and overall system performance, creating a gap between discussions of production control and the design of the workforce that executes it.

Cognitive diversity, defined as systematic differences in how individuals process information, regulate stress, learn, and solve problems, offers a lens for reinterpreting workforce variability. Rather than representing noise to be minimized, cognitive differences shape how work is perceived and executed under pressure, uncertainty, and coordination demands. However, despite growing research on human performance in construction, cognitive diversity remains largely absent from hiring and workforce design discussions in Lean construction. Consequently, human variability is implicitly treated as a disturbance to be controlled through standardization rather than as a structured system characteristic that can support adaptability, learning, and resilience.

This paper argues that the concept of the "right people" becomes analytically weak when detached from task context and human cognitive capacity. Suitability should not be understood as an intrinsic property of individuals but as an emergent outcome of interactions between task demands, cognitive strengths, and production system conditions. Building on Lean principles of respect for people and value generation, this paper reframes workforce heterogeneity from a liability into a potential resource for stabilizing and adapting production systems under labour constraints.

The contribution of this paper is twofold. First, it introduces cognitive diversity as a system-relevant construct for Lean construction hiring and workforce design, shifting the focus from uniform worker profiles to cognitively complementary capabilities, where the "right people" are understood not as individuals with identical attributes but as individuals whose differing strengths can be aligned with varying task complexities and production conditions. Second, it proposes a conceptual framework that links task demands, cognitive attributes, and Lean system conditions to explain how alignment between human capacity and work requirements can be achieved through hiring and configuration decisions. This paper extends Lean discussions on

human resource management and workforce planning and supports a more adaptive and human-centered interpretation of Lean systems.

METHODOLOGY

This study adopts a conceptual research methodology aimed at reframing workforce suitability in Lean construction and developing a framework linking cognitive diversity, task demands, and production system conditions. The research follows a structured conceptual approach based on a narrative literature review and integrative conceptual synthesis. The research process consisted of three steps. First, a narrative literature review was conducted to establish the context of the study and identify limitations in current Lean construction and workforce management discussions. Literature on construction labor shortages, hiring practices, human performance, and Lean production theory was examined to clarify how workforce suitability is currently conceptualized and to identify gaps related to human variability and system performance. Second, a conceptual integration across domains was performed to introduce cognitive diversity as a system-relevant construct. Research from cognitive science and human performance was combined with Lean construction theory to reinterpret workforce variability not as noise to be minimized but as a structured characteristic that interacts with task demands and production conditions. Third, a conceptual framework was developed to explain how alignment between task demands, cognitive attributes, and Lean system conditions influences production stability and performance. The framework was derived iteratively from the reviewed literature by identifying recurring relationships between human capability, task complexity, and system design. The model assumes that suitability is relational rather than intrinsic, and that workforce configuration acts as an upstream design decision affecting system variability and stability. The framework was refined for internal coherence and consistency with core Lean principles, including flow, variability reduction, and respect for people.

LABOUR SHORTAGES IN CONSTRUCTION

The construction industry is a cornerstone of economic development, supporting the delivery of housing, transportation infrastructure, energy systems, and commercial facilities. Despite sustained growth in activity, the sector is confronting a structural workforce crisis that threatens its capacity to meet current and future demand. Projections indicate that by 2030, the Canadian construction industry will require approximately 500,000 new workers, while facing 85,000 unfilled positions and the retirement of more than one-fifth of its existing workforce (BuildForce Canada 2024). Similar patterns of labour scarcity have been documented across the United States, Europe, and Asia, underscoring the global and persistent nature of the problem (Kim et al. 2020; Kuo 2024; Shiha and El-adaway 2025).

Aging demographics constitute a primary driver of workforce decline, as skilled workers exit the industry faster than they are replaced (Elbashbishy and El-Adaway 2023; Kim et al. 2020). This loss is compounded by the industry’s limited ability to attract younger generations, who often perceive construction as physically demanding, unstable, and misaligned with modern career expectations (Oh et al. 2023; Saad et al. 2022). As a result, the workforce is becoming smaller and less experienced, increasing vulnerability to productivity losses and operational disruptions.

Beyond workforce quantity, labour shortages have altered the composition and capability profile of construction labour. To meet demand, firms increasingly rely on inexperienced workers, cross-trained personnel, and short-term labour pools (Kim et al. 2020; Oh et al. 2023). While these strategies expand supply, they introduce variability in skill levels, learning rates, and task performance. Research has shown that skill shortages are associated with cost overruns, schedule delays, and reduced work quality (Elbashbishy and El-Adaway 2023; Kim et al. 2020).

Moreover, shortages intensify workload pressures on existing crews, leading to longer hours, compressed schedules, and heightened task demands (Kuo 2024; Shiha and El-adaway 2025). These conditions increase exposure to physical and cognitive strain, particularly as projects grow larger, more complex, and more time-sensitive.

Traditional workforce management approaches focus primarily on manpower availability, trade classification, and basic safety compliance (Mitropoulos and Memarian 2013). However, task performance is shaped not only by technical skill but also by cognitive and physiological responses to dynamic site conditions (Lee and Hasanzadeh 2024). Stress (Jebelli et al. 2019), fatigue (Aryal et al. 2017), and cognitive overload have been consistently linked to increased human error and degraded performance. (Namian et al. 2021). Under labour shortages, these risks are amplified, as fewer workers are required to manage higher workloads and more complex tasks. Labour shortages are also localized and uneven across regions and trades, creating mismatches between task demands and available worker capabilities (Oh et al. 2023; Shiha and El-adaway 2025). These mismatches cannot be resolved solely through recruitment or automation (Kim et al. 2020; Saad et al. 2022). Instead, they require production systems that account for human performance constraints under conditions of scarcity.

These trends reveal that the construction labour shortage is not merely a numerical deficit, but a human-system problem rooted in the interaction between workforce characteristics, task complexity, and production pressures. As younger generations hesitate to join the industry and experienced workers retire, construction systems are increasingly dependent on heterogeneous and cognitively strained workforces. Yet prevailing management and digital frameworks continue to treat labour primarily as a quantitative resource rather than as a performance-limited component of the production system.

From a Lean construction perspective, such conditions can be understood as a source of increased variability that threatens flow stability and system reliability. Lean production theory emphasizes that predictable workflow depends on reliable task completion, coordination among participants, and the reduction of variability across production units (Ballard 1999; Hamzeh 2009; Koskela 2000). Variations in workforce availability, experience, and capability reduce the reliability of commitments and increase the likelihood of interruptions, rework, and schedule instability. Under labour shortages, these effects become more pronounced, as production systems must operate with limited capacity while facing increasing task complexity. Addressing the workforce crisis therefore requires moving beyond manpower counts and toward models that explicitly consider human capabilities as part of production system design rather than as external constraints.

CURRENT HIRING STRATEGIES AND THEIR LIMITATIONS

Construction hiring practices remain largely guided by proxies such as trade background, years of experience, and immediate availability. These criteria reflect long-standing assumptions that workers with similar credentials and exposure will perform similarly once deployed within production systems (Pekuri et al. 2012). From a Lean construction perspective, however, production performance depends on the reliability of task execution and the ability of participants to make and keep commitments within coordinated workflows (Ballard 1999; Koskela 2000). Variability in workforce capability can propagate through linked production activities, reducing flow stability and increasing the likelihood of delays and rework. Under conditions of labour shortage and increasing task complexity, experience alone becomes an unreliable indicator of performance, meaning that hiring decisions directly influence the level of variability introduced into the production system.

Research in safety and human performance shows that outcomes depend on not only formal qualifications but on how workers interact with task demands and system constraints. Work should be designed according to the competence and capacity available in the workforce, as

performance emerges from interactions between task complexity, production pressure, and human judgment (Aslesen et al. 2013). Similarly, subcontractor performance is strongly influenced by participation in planning and coordination processes rather than by technical trade expertise alone (Ribeiro et al. 2017). Despite this evidence, hiring decisions remain largely disconnected from there considerations, relying on role labels and availability rather than on how individuals engage cognitively with dynamic work environments.

Current practices therefore assume workforce interchangeability. Lean process improvements often focus on logistics and sequencing while treating workers as standard units of labor, with limited attention to individual differences in how tasks are perceived or execute (Honório et al. 2014) From a Lean production theory perspective, variability cannot be eliminated solely through process design if system demands exceed available capabilities (Koskela 2000). When workforce characteristics are not aligned with task requirements, variability is transferred to the execution stage, appearing as unreliable task completion, coordination difficulties, and increased need for buffers and corrective actions (Ballard 1999). Hiring decisions therefore influence production stability even though they are rarely treated as part of production system design.

Empirical research also show that workforce selection is often guided by heuristics that prioritize familiarity over functional fit. Similarity and experience biases favor candidates resembling existing team members, reinforcing uniformity and narrowing the range of accepted profiles (Paucar-Espinoza et al. 2022). These tendencies are increasingly misaligned with the characteristics of the emerging workforce, whose motivations, expectations, and ways of working are more diverse (Hatoum et al. 2022) . However, hiring practices continue to emphasize conformity to traditional roles, discouraging individuals whose cognitive styles differ from established norms.

At the theoretical level, Lean construction literature acknowledges the importance of people but often frames suitability in broad terms, such as competence, collaboration, and openness to change (Pekuri et al. 2012). These attributes are rarely considered in relation to the specific cognitive demands imposed by different production contexts. As a result, hiring strategies prioritize predictability over alignment between human capabilities and task requirements, creating tension with Lean’s principle of respect for people and with the need for reliable flow. Reconceptualizing hiring as part of production system design therefore requires moving beyond uniform worker profiles toward assembling cognitively complementary capabilities that match task demands and production conditions.

COGNITIVE DIVERSITY AS A LEAN RESOURCE

Cognitive diversity refers to systematic differences in how individuals perceive information, process stimuli, regulate stress, learn from experience, and solve problems. These differences are not random but arise from stable variations in underlying cognitive abilities such as memory, processing speed, visual reasoning, decision speed, and problem-solving strategies (Schneider and McGrew 2012). The Cattell-Horn-Carroll (CHC) theory of cognitive abilities provides a well-established taxonomy for describing this diversity, organizing cognition into broad and narrow abilities that shape how people attend to information, adapt to novelty, and perform under pressure (Schneider and McGrew 2012). In construction contexts, such abilities directly influence how workers and engineers interpret drawings, recognize hazards, coordinate with others, and respond to unexpected conditions (Clevenger et al. 2020; Shehab et al. 2025).

Lean construction has historically concentrated on controlling process variability through standardization, flow stabilization, and waste elimination. While this focus has yielded significant gains in material and information flows, human cognitive variability has largely remained outside the scope of Lean system design (Shehab and Hamzeh 2023). Lean tools implicitly assume that people will interact with standardized processes in consistent ways, even

though empirical evidence shows that individuals differ substantially in how they perceive task demands, manage cognitive load, and sustain attention over time (Clevenger et al. 2020). As a result, variability reduction has been pursued primarily at the process level, while variability in human performance has been treated as noise rather than as a structured system characteristic.

Recent construction research demonstrates that cognitive diversity materially shapes project performance. Agent-based modelling studies show that teams composed of individuals with different cognitive profiles exhibit higher adaptability and more robust problem-solving when exposed to disruptions and uncertainty (Shehab et al. 2025). Differences in improvisation ability, collaboration capacity, and physiological tolerance affect how quickly teams recover from disturbances and how effectively they coordinate under time pressure. These findings indicate that performance emerges from interactions between task demands and cognitive traits rather than from uniform compliance with standardized procedures.

At the individual level, empirical studies further reveal that task performance depends on the alignment between cognitive capacity and task complexity (Shehab et al. 2026). Experimental evidence shows that stress, cognitive load, and performance follow nonlinear patterns as task demands increase, with optimal performance occurring when task difficulty matches an individual's cognitive capabilities. When cognitive demands exceed a worker's capacity, error rates rise and safety degrades; when demands fall below, underutilization and disengagement may occur. These dynamics suggest that cognitive differences influence not only how tasks are executed but also how value is created and preserved in production systems.

From a Lean perspective, such findings challenge the implicit treatment of human variability as a deviation from standard performance. Instead, cognitive diversity can be reframed as a system resource that supports adaptability, learning, and resilience. Lean systems depend on continuous problem solving and learning at all organizational levels. These functions require varied cognitive contributions, including rapid decision making, pattern recognition, creative reasoning, and social coordination. A cognitively homogeneous workforce may execute routine tasks efficiently but is less equipped to handle new situations or systemic disruptions. In contrast, cognitive heterogeneity expands the range of responses available to the system, enhancing its capacity to absorb shocks and generate improvements.

This perspective aligns with Lean's principle of respect for people, which emphasizes developing human potential rather than merely constraining human behaviour. Research shows that different workers exhibit distinct stress responses and learning patterns even when performing identical tasks (Shehab et al. 2026) Ignoring these differences forces individuals to conform to process expectations that may exceed their cognitive limits, creating conditions of overburden (muri) and undermining system stability (Shehab and Hamzeh 2023). Recognizing cognitive diversity, by contrast, enables task design and workforce organization to accommodate differences in how people engage with work.

Reframing cognitive diversity as a resource does not imply abandoning standardization. Rather, it implies redefining what is being standardized. Instead of standardizing people to fit processes, Lean systems can standardize around task requirements while allowing flexible allocation of cognitively complementary individuals. This shift preserves Lean's commitment to flow and stability while extending it to include human-system fit.

In this sense, cognitive diversity functions as latent system capacity. It enables production systems to adapt under uncertainty, supports collective learning, and mitigates the performance degradation associated with cognitive overload. When acknowledged and intentionally accommodated, cognitive differences enhance rather than undermine Lean objectives. They transform variability from a disturbance to be eliminated into a source of adaptive capability.

These findings suggest that Lean construction has reached a conceptual boundary: while material and informational variability are actively managed, human cognitive variability remains largely unmanaged. Integrating cognitive diversity into Lean thinking reframes

workforce heterogeneity as an asset that can be leveraged to support value generation and continuous improvement. This reframing sets the foundation for reconceptualizing how people are selected, assigned, and developed within production systems, shifting the meaning of the "right people" from uniform profiles to cognitively complementary contributors aligned with task demands and system conditions.

CONCEPTUAL FRAMEWORK: ALIGNING COGNITIVE STRENGTHS WITH TASK DEMANDS

This section proposes a conceptual framework (Figure 1) that links task demands, cognitive strengths, and Lean system conditions to explain how alignment can be achieved through workforce configuration. The framework conceptualizes performance as an emergent property of how human cognitive capacity is distributed and situated within production systems, rather than as an intrinsic attribute of individuals.

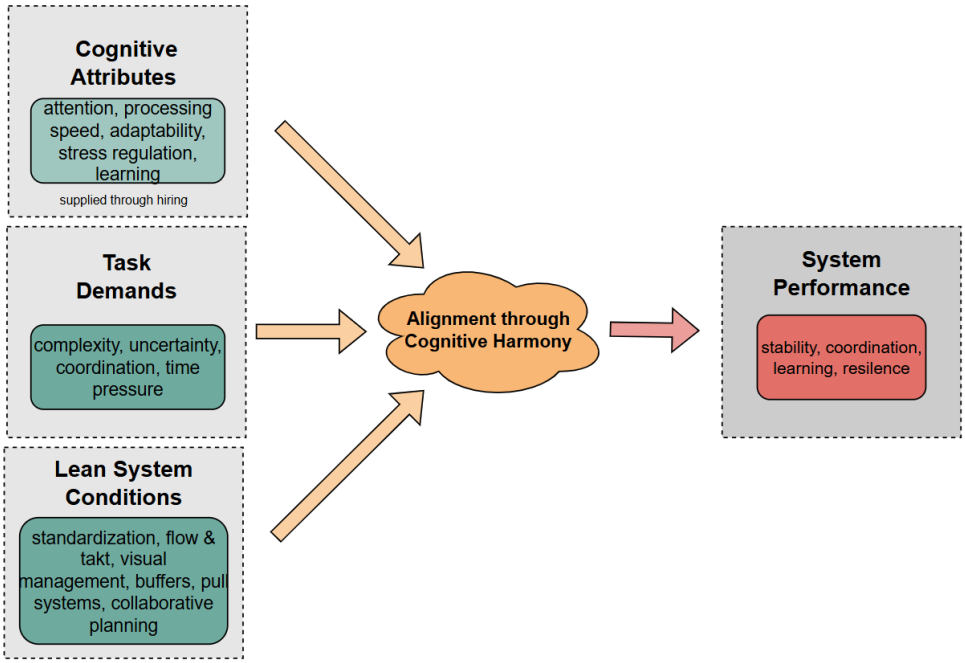

Figure 1: Conceptual framework diagram for cognitive diversity hiring

CORE COMPONENTS OF THE FRAMEWORK

The framework consists of three interdependent elements: (1) task demands, (2) cognitive attributes, and (3) Lean system conditions.

Task demands refer to the cognitive requirements imposed by work activities. Construction tasks vary substantially in their need for attention, interpretation, anticipation, and coordination. Some tasks are routine and highly specified, requiring sustained vigilance and procedural compliance. Others involve uncertainty, frequent interruptions, or complex interdependencies, requiring rapid judgment, adaptation, and problem solving. Task demands can therefore be characterized by attributes as complexity, uncertainty, time pressure, and coordination intensity.

Cognitive attributes describe stable differences in how individuals process information, regulate stress, learn from experience, and solve problems. These include capacities such as working memory, processing speed, pattern recognition, decision latency, and tolerance for cognitive load. Individuals differ not only in the magnitude of these abilities but also in their configuration of strengths and limitations. These profiles influence how people interpret instructions, anticipate hazards, and respond to disruptions.

Lean system conditions encompass the organizational and process features that structure work execution, including standardization, flow control, buffers, visual management, and collaborative planning practices. These conditions shape how much discretion individuals have, how information is presented, and how deviations are managed. While Lean systems aim to stabilize material and information flows, they also structure the cognitive environment in which work is performed.

ALIGNMENT AS THE BASIS OF PERFORMANCE

Within the proposed framework, alignment is understood as a system property shaped upstream through workforce selection and configuration. While task design and process structure influence cognitive demand, hiring determines what cognitive capacities are available to meet that demand. Performance therefore depends on how the cognitive attributes supplied through hiring interact with the demands imposed by tasks under given system conditions.

When hiring produces a workforce whose cognitive strengths are compatible with task requirements, individuals are more likely to operate within their cognitive limits, coordination becomes more reliable, and learning can occur without destabilizing flow. Conversely, misalignment arises when hiring supplies cognitive profiles that are systematically mismatched with task demands. Placing individuals suited to routine execution in highly adaptive roles increases overload and error, while assigning highly adaptive individuals to low-variability tasks can lead to underutilization and disengagement. In both cases, the mismatch originates in how people are selected and positioned within the system. This reframing challenges the assumption that suitability is an intrinsic property of individuals. Instead, suitability becomes relational and contingent on the interaction between what hiring introduces into the system and what tasks require from it. Alignment is thus expressed through system performance rather than individual adequacy. Persistent instability reflects incompatibilities between available cognitive capacity and task requirements, making alignment the cognitive condition under which stable flow, reliable coordination, and sustained learning can occur.

To illustrate the implications of the proposed framework, two scenarios demonstrate how alignment or misalignment between task demands, cognitive attributes, and Lean system conditions can influence production system performance. In a takt-controlled environment, a worker selected based on trade experience is assigned to a task requiring rapid coordination and adaptation to changing conditions. Although technically qualified, limited tolerance for time pressure and high information load leads to delays and coordination errors, forcing variability to be absorbed at the human level and reducing workflow reliability. In contrast, in a collaborative planning setting, individuals with strengths in anticipation, abstraction, and stress regulation participate in lookahead planning and pull-based commitments. Because cognitive capacities match the demands of the task, commitments are more reliable, coordination improves, and flow remains stable with fewer corrective adjustments.

ROLE OF LEAN PRINCIPLES IN SUPPORTING ALIGNMENT

Lean principles do more than structure production processes; they implicitly define the cognitive demands that work systems impose on people. In this sense, Lean design choices shape what kinds of human capabilities are required for stable and adaptive performance. Hiring therefore becomes an upstream mechanism through which production systems acquire the cognitive capacity needed to function under given task and flow conditions. Rather than being external to production design, hiring can be understood as a system input that supplies the human capabilities implied by Lean task structures.

Standardization reduces ambiguity by specifying task sequences, timing, and information requirements. Cognitively, it shifts effort from interpretation toward execution and monitoring, favoring strengths related to sustained attention and procedural consistency. At the same time,

standardized systems create predictable instances in which deviations must be detected and resolved, requiring pattern recognition and rapid judgment. When hiring provides only one dominant cognitive profile, the system becomes brittle. Standardization therefore generates differentiated cognitive needs across tasks, implying that hiring for uniform profiles risks misalignment between task demands and available human capacities.

Visual management conveys information that would otherwise have to be remembered or inferred. Visual cues convert abstract process states into perceptual signals, reducing working memory and interpretation burdens. This broadens the range of cognitive profiles that perform reliably, as performance depends less on internal recall and more on situational recognition. From a hiring perspective, visual systems reduce dependence on narrow cognitive traits and support heterogeneous individuals whose strengths align with perceptual and coordination demands. Lean environments can thus accommodate diversity rather than screen it out.

Flow control and takt-based production regulate the pace and rhythm of work. Stable flow reduces cognitive load associated with reprioritization and task switching, enabling individuals with strengths in consistency and temporal discipline to perform effectively. However, tasks exposed to interruptions and coordination pressures require tolerance for uncertainty and adaptive reasoning. Hiring based solely on experience overlooks these distinctions and assumes that pacing tolerance and flexibility are interchangeable traits. Lean flow design thus differentiates the kinds of cognitive contributions required across the system.

Buffers and slack protect not only material flows but also cognitive capacity. Time buffers and work-in-process limits prevent variability from cascading into overload. When buffers are absent, individuals absorb variability cognitively through rapid improvisation and multitasking. Hiring strategies that assume unlimited adaptability shift the burden of variability absorption system design to individuals. Buffering thus signals that cognitive feasibility is a design concern, and workforce composition must supply capacities compatible with these protective structures.

Pull systems and reliable promises embed feasibility into production commitments by allowing teams to signal readiness and constraints. This presupposes the presence of individuals capable of situational judgment and anticipation. If hiring focuses only on technical exposure or role familiarity, the cognitive capacity needed for discretion under pull conditions may be unevenly distributed. Pull mechanisms therefore depend on cognitive strengths that support self-regulation and informed commitment.

Collaborative planning practices like phase scheduling and lookahead planning, require abstraction, foresight, and negotiation. These impose cognitive demands distinct from physical execution. Lean systems contain both execution-oriented and anticipatory cognitive work, often within the same roles. Hiring for uniform profiles risks concentrating these demands on individuals whose strengths may not lie in planning or coordination. Assembling cognitively complementary individuals allows these functions to be distributed across interactions.

Continuous improvement (kaizen) relies on noticing deviations, generating alternatives, and testing adjustments, which require creativity, analytical reasoning, and learning. Lean’s learning cycles therefore benefit from cognitive diversity even when execution is standardized. Hiring that filters for uniformity limits the range of perspectives available for improvement.

Lean principles generate structured patterns of cognitive demand rather than eliminating human involvement. Standardization, flow, buffers, pull, and collaboration specify distinct modes of engagement with work, ranging from procedural execution to anticipatory reasoning and collective sensemaking. These modes define the kinds of cognitive work embedded in the production system and clarify why hiring for cognitive complementarity, rather than uniform profiles, is essential for achieving alignment between human capacity and task demands. To make the proposed framework operational, Table 1 summarizes how current hiring criteria assume specific cognitive capabilities and relates Lean activities to the cognitive demands.

The proposed perspective does not contradict Lean's emphasis on variability reduction but reframes where variability should be managed. Lean seeks to minimize uncontrolled variability in workflow and execution, not differences in human capabilities. Cognitive diversity can enhance stability when aligned with task demands and supported by system design. Mechanisms such as standardization, visual management, buffers, and pull commitments structure work, externalize information, and limit error propagation. Under these conditions, diversity does not increase system variability but redistributes it in a controlled way, allowing different strengths to be used effectively. Instability arises not from diversity itself, but from misalignment between cognitive capacity, task demands, and production conditions.

Table 1: Linking hiring criteria, cognitive attributes, and Lean system demands

Current hiring criterion	Implicit cognitive assumption	Lean activity / system condition	Dominant cognitive demands
Years of experience	Experience ensures good performance	Standardized work / routine execution	Sustained attention, procedural consistency
Trade background	Trade defines capability	Multi-trade coordination / flow	Coordination capacity, communication
Availability / manpower need	Any worker can fill the role	Pull-based commitments	Anticipation, judgment, self-regulation
Prior Lean exposure	Lean knowledge ensures reliability	Collaborative planning / lookahead	Abstraction, foresight, negotiation
Software / technical skills	Tool skill ensures productivity	Visual management / digital control	Situational awareness, information processing
Familiarity with team	Similar people work better together	Continuous improvement (Kaizen)	Creativity, analytical reasoning, learning
General competence	One profile fits all tasks	Takt / flow control	Temporal discipline, pacing tolerance
Flexibility / adaptability	Workers can absorb variability	Buffer / variability management	Stress regulation, prioritization

CONCLUSION

This paper reconsidered how Lean construction conceptualizes workforce suitability under conditions of persistent labor shortages and increasing workforce heterogeneity. While Lean emphasizes selecting the "right people," prevailing hiring practices continue to rely on experience, trade background, and availability as proxies for suitability, overlooking how individuals actually interact with task demands and production pressures. By introducing cognitive diversity as a system-relevant construct, human variability was reframed from a disturbance to be minimized into a potential resource for adaptability, learning, and resilience. A conceptual framework was proposed that links task demands, cognitive strengths, and Lean system conditions to explain how performance emerges from alignment rather than from individual adequacy. Within this perspective, the "right people" are understood as cognitively complementary individuals whose strengths can be aligned with varying task complexities and production needs, shifting the focus from idealized worker profiles to productive relationships between people, tasks, and systems. This view positions workforce design as part of production system design. Hiring, assignment, and development decisions become upstream mechanisms through which production systems acquire the cognitive capacity needed to function under uncertainty and constraint. Lean principles can therefore be interpreted not only as tools for managing material and information flows, but also as mechanisms that structure cognitive effort

through standardization, visual management, flow regulation, buffers, pull systems, and collaborative planning. This interpretation preserves Lean's commitment to flow and waste reduction while extending it to include human-task fit as a design objective. The contribution of this work is conceptual, calling for a shift in how suitability is theorized in Lean construction and encouraging future research on task-cognition alignment and its interaction with production planning and control. The proposed perspective also suggests directions for empirical research and practical application. Future studies may examine measurable indicators of alignment between task demands, cognitive attributes, and Lean system conditions, such as task complexity, coordination intensity, error frequency, workflow reliability, and commitment fulfilment. Testable propositions include that system stability improves when cognitive strengths are aligned with task requirements, and that Lean mechanisms such as standardization, visual management, buffers, and pull-based commitments moderate the effect of cognitive variability on performance. From an industry perspective, the framework can inform hiring criteria, role allocation in collaborative planning and takt-controlled production, and management practices for cognitively diverse crews, supporting workforce design as an integral part of production system design rather than an administrative function.

REFERENCES

Aryal, A., A. Ghahramani, and B. Becerik-Gerber. 2017. "Monitoring fatigue in construction workers using physiological measurements." Automation in Construction, 82: 154–165. Elsevier B.V. https://doi.org/10.1016/j.autcon.2017.03.003.

Aslesen, S., E. Sandberg, S. Stake, and T. Bølviken. 2013. "Integrating safety analyses in production planning and control–a proposal." In: *21st Annual Conference of the International Group for Lean Construction*. Fortaleza, Brazil.

Ballard, G. 1999. "Improving work flow reliability." In: *Proceedings of the 7 th Annual Conference of the International Group for Lean Construction*, 275–286.

BuildForce Canada. 2024. "Canada's Construction Sector Is Poised To Grow Through 2033." https://www.buildforce.ca/en/press-release/canadas-construction-sector-is-poised-to-grow-through-2033/.

Clevenger, C., M. Abdallah, N. Clements, K. Byun, S. Aristizabal, M. Russell, M. Beauregard, and J. Raman. 2020. "Studying Physical and Cognitive Status of Construction Workers." In: *Construction Research Congress*, 649–657.

Elbashbishy, T., and I. H. El-Adaway. 2023. "Skilled Worker Shortage across Key Labor-Intensive Construction Trades in Union versus Nonunion Environments." *Journal of Management in Engineering*, 40 (1). https://doi.org/10.1061/JMENEA.

Hamzeh, F. 2009. "Improving Construction Workflow- The Role of Production Planning and Control." Doctoral Dissertation, UC Berkeley. https://doi.org/10.13140/RG.2.1.1182.9286.

Hatoum, M. B., A. Ammar, H. Nassereddine, and G. Dadi. 2022. "Preparing construction employers for the gen-Z workforce: a case study." In: *30th Annual Conference of the International Group for Lean Construction, IGLC 2022*, 808–819. The International Group for Lean Construction.

Honório, R. T., J. Martins, C. Da Costa, and S. M. B. Serra. 2014. "Evaluation of Supply and Service of Steel Assembly of Structures." In: *Proc. 22nd Ann. Conf. Int. Group for Lean Construction*.

Jebelli, H., B. Choi, and S. Lee. 2019. "Application of Wearable Biosensors to Construction Sites. I: Assessing Workers' Stress." *Journal of Construction Engineering and Management*, 145 (12): 04019079. https://doi.org/10.1061/(asce)co.1943-7862.0001729.

Kim, S., S. Chang, and D. Castro-Lacouture. 2020. "Dynamic Modeling for Analyzing Impacts of Skilled Labor Shortage on Construction Project Management." *Journal of Management in Engineering*, 36 (1). https://doi.org/10.1061/(asce)me.1943-5479.0000720.

Koskela, L. 2000. "An exploration towards a production theory and its application to construction." VTT Technical Research Centre of Finland. http://www.inf.vtt.fi/pdf/.

Kuo, Y. C. 2024. "Interactive relationships among factors influencing skilled labor shortages in the construction industry." *Engineering, Construction and Architectural Management*. Emerald Publishing. https://doi.org/10.1108/ECAM-01-2024-0053.

Lee, K., and S. Hasanzadeh. 2024. "Understanding Cognitive Anticipatory Process in Dynamic Hazard Anticipation Using Multimodal Psychophysiological Responses." *Journal of Construction Engineering and Management*, 150 (4): 1–18. https://doi.org/10.1061/jcemd4.coeng-13896.

Liker, J. K. 2004. *The Toyota Way - 14 Management Principles from the World's Greatest Manufacturer*. McGraw-Hill, NY.

Mitropoulos, P., and B. Memarian. 2013. "Task Demands in Masonry Work: Sources, Performance Implications, and Management Strategies." *Journal of Construction Engineering and Management*, 139 (5): 581–590. https://doi.org/10.1061/(asce)co.1943-7862.0000586.

Moradi, S., and P. Sormunen. 2023. "Implementing Lean Construction: A Literature Study of Barriers, Enablers, and Implications." *Buildings*, 13 (2). MDPI. https://doi.org/10.3390/buildings13020556.

Namian, M., F. Taherpour, E. Ghiasvand, and Y. Turkan. 2021. "Insidious Safety Threat of Fatigue: Investigating Construction Workers' Risk of Accident Due to Fatigue." *Journal of Construction Engineering and Management*, 147 (12): 1–18. https://doi.org/10.1061/(asce)co.1943-7862.0002180.

Oh, H. J., S. Chang, and B. Ashuri. 2023. "Patterns of Skill Sets for Multiskilled Laborers Based on Construction Job Advertisements Using Web Scraping and Text Analytics." *Journal of Management in Engineering*, 39 (3). https://doi.org/10.1061/jmenea.meeng-5243.

Paucar-Espinoza, A. F., A. A. Erazo-Rondinel, P. Arroyo, and L. A. Salazar. 2022. "Reducing Bias in The Hiring Process Through Choosing By Advantages: A Case Study." In: *30th Annual Conference of the International Group for Lean Construction, IGLC 2022*, 1087–1098.

Pekuri, A., M. Herrala, A. Aapaoja, and H. Haapasalo. 2012. "Applying Lean in construction–cornerstones for implementation." In: *Proceedings of the 20th Annual Conference of IGLC*.

Ribeiro, F. S., D. B. Costa, and P. A. Magalhaes. 2017. "Phase Schedule Implementation and The Impact for Subcontractors." In: *25th Annual Conference of the International Group for Lean Construction (IGLC)*. Heraklion, Greece.

Rooke, J. A., S. Sapountzis, L. J. Koskela, R. Codinhoto, and M. Kagioglou. 2010. "Lean Knowledge Management: The Problem of Value." In: *18th Annual Conference of the International Group for Lean Construction*.

Saad, S., W. S. Alaloul, S. Ammad, and A. H. Qureshi. 2022. "A qualitative conceptual framework to tackle skill shortages in offsite construction industry: a scientometric approach." *Engineering, Construction and Architectural Management*, 29 (10): 3917–3947. Emerald Publishing. https://doi.org/10.1108/ECAM-04-2021-0287.

Schneider, J., and K. McGrew. 2012. "The Cattell-Horn-Carroll (CHC) model of intelligence v2.2: A visual tour and summary." *Contemporary Intellectual Assessment: Theories, Tests, and Issues*, 99–144.

Shehab, L., and F. Hamzeh. 2023. "Zooming Into Workers' Psychology and Physiology Through a Lean Construction Lens." In: *30th Annual Conference of the International Group for Lean Construction (IGLC)*, 92–103. Lille, France.

Shehab, L., G. Lee, and F. Hamzeh. 2025. "Beyond Data : Conceptualizing Human-Centric Digital Twins for the Future of Construction." In: *Joint CSCE Construction Specialty & CRC Conference*, CON 4-1-CON 4-11.

Shehab, L., G. Lee, and F. Hamzeh. 2026. “Minds at Work: A Design for an Experimental Approach to Assessing Cognitive Abilities in Construction.” *Journal of Construction Engineering and Management*, 152 (1). https://doi.org/10.1061/JCEMD4.COENG-16638.

Shiha, A., and I. H. El-adaway. 2025. “Localized Multivariate Statistical Assessment of United States Construction Labor Shortages.” *Journal of Construction Engineering and Management*, 151 (8). American Society of Civil Engineers (ASCE). https://doi.org/10.1061/jcemd4.coeng-15702.