

A LEAN FRAMEWORK FOR MODERN METHODS OF CONSTRUCTION WORKFORCE TRANSITION IN AUSTRALIA

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ABSTRACT

Modern Methods of Construction (MMC) are gaining momentum globally as a response to construction productivity challenges and housing shortages. While previous research has documented changes required in business models, supply chains, and production processes to facilitate MMC adoption, recent studies reveal that MMC demands new skillsets across the built environment value chain and new roles that differ from traditional construction occupations. Yet formal qualification systems have been slow to respond, creating misalignment between what MMC requires and what education systems can deliver. This paper proposes a lean framework for MMC workforce transition that addresses three systemic challenges: qualification systems that cannot keep pace with industry needs, occupational boundaries that inhibit cross-functional skill development, and governance structures that impede coordinated response. Drawing on lean principles supported by platform thinking, the framework is designed to embed responsiveness into workforce development. The framework is grounded in two applied research projects conducted in partnership with skills organisations, vocational education providers, and industry peak bodies in Australia. While focused on the Australian context, the paper situates these challenges within international MMC adoption trends, offering insights for other jurisdictions. The paper contributes to Lean Construction scholarship by integrating lean and platform thinking for MMC workforce development.

KEYWORDS

Modern methods of construction, industrialised construction, lean construction, platform thinking, construction education.

INTRODUCTION

Modern Methods of Construction (MMC) are gaining momentum globally as a response to persistent construction productivity challenges and housing shortages. Jurisdictions including the UK, Germany, Sweden, Japan, Singapore, and Australia have prioritised MMC to improve efficiency, sustainability, and workforce capacity (Farmer, 2016; Lessing et al., 2005). By manufacturing building elements off-site within integrated production systems, MMC offers greater predictability, higher quality, and workforce diversification (López-Guerrero et al., 2022). Yet despite policy support, adoption rates remain limited. Among the barriers identified in the literature—supply chain fragmentation, regulatory misalignment, and cultural resistance—skills shortages and mismatches have emerged as particularly critical constraints (Farmer, 2016; Soltani et al., 2025a).

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These skill challenges operate at two levels. First, MMC demands skillsets distinct from traditional construction, including Design for Manufacturing and Assembly (DfMA), logistics coordination, digital fabrication, and cross-functional collaboration across design-production-installation interfaces (Onyia, 2025). Second, MMC requires new roles that have no direct precedent in traditional construction. Lessing (2006) identified the need for a “process owner” with authority to manage continuous improvement and oversee technical and process platform development. While recent research has begun mapping competency needs across traditional built environment disciplines (Ginigaddara et al., 2022), the nature of these emerging roles and their educational implications remains underexplored.

Compounding this knowledge gap, systematic educational responses to MMC skill demands remain fragmented and insufficient in scale (Solin et al., 2025). Current Vocational Education and Training (VET) frameworks remain anchored to traditional on-site work contexts, failing to provide formal recognition for the factory-based production roles essential to MMC. Similarly, higher education programs in construction professional programs often privilege traditional design considerations over manufacturing principles and DfMA integration (Onyia, 2025). The result is a structural misalignment, where the educational systems most needed to enable MMC transformation are resistant to the paradigm shift MMC requires.

This paper argues that Lean Construction principles, supported by platform thinking, offer a pathway to resolve this misalignment. Lean Construction focuses on value delivery, waste elimination, and continuous improvement (Bassanino et al., 2008) while platform thinking introduces principles of modularity and standardised interfaces (Maxwell & Aitchison, 2017; Robertson & Ulrich, 1998). These methodologies form a theoretical basis for a MMC workforce transition framework designed to synchronise industry skill demands with educational provision. Drawing on two applied research projects conducted in partnership with skills organisations, VET providers, and industry peak bodies in Australia, this paper addresses the following research question: How can a Lean framework, supported by platform thinking, enable workforce transition towards MMC? The scope of this framework involves the broader VET–HE ecosystem. While VET receives particular attention due to its acute barriers, the framework’s platform architecture bridges vocational and higher education through stackable credentials that enable pathways for both trade workers and professionals seeking to upskill.

BACKGROUND

INTERNATIONAL CONTEXT: MMC ADOPTION AND WORKFORCE IMPLICATIONS

The challenges of aligning workforce development with MMC adoption are shared across jurisdictions facing common pressures: housing shortages, labour constraints, and productivity decline. Yet implementation outcomes vary considerably, shaped by institutional configurations and the responsiveness of education systems. Sweden and Germany represent some of the most advanced cases. Sweden accounts for approximately 84% prefabrication in residential construction (Lessing & Brege, 2018). This reflects decades of investment following the Million Homes Programme (1965–1975) and a long history of prioritising timber construction suited to its climate and forest resources (Maxwell & Aitchison, 2016). Germany, a mature manufacturing country, has driven MMC through automation, industrialised production, and lean principles, drawing on post-war experience of rebuilding housing stock rapidly at scale. Both countries have developed VET systems characterised by strong industry-education linkages, where work-based learning is central and industry actively shapes curriculum content (Wolter, 2023). This structure enables responsiveness to technological change and alignment between emerging skill demands and training provision, facilitating relatively seamless transitions from education into the labour market.

Other jurisdictions have pursued more centralised approaches. Singapore, through stronger governmental intervention over the past decade, has not only mandated MMC adoption in public housing but also generated coordinated workforce development initiatives. Singapore's approach is highly centralised and government-led, deeply integrated with broader industry transformation goals (Soltani et al., 2025b). The emphasis on DfMA, digitalisation, and sustainability reflects a skills-first, data-driven approach to MMC workforce development.

By contrast, the United Kingdom and Australia illustrate some systemic implementation challenges. In the UK, despite significant policy attention (Farmer, 2016), qualification pathways for factory-based production roles remain underdeveloped. Australia faces similar challenges. While MMC adoption is increasingly prioritised in industry and policy discourse, systematic attention to education provision has only recently begun to emerge (Ginigaddara et al., 2022).

These international experiences reveal successful MMC adoption requires parallel transformation of workforce development systems. Countries with strong industry-education linkages and responsive qualification mechanisms demonstrate greater capacity to align skills supply with industry demand. Where such alignment is absent, skills gaps risk constraining MMC scaling more significantly than technological or regulatory barriers alone (Onyia, 2025).

THE AUSTRALIAN CASE: TRADITIONAL PATHWAYS AND EMERGING SKILL DEMANDS

Australia's VET system operates within a competency-based framework (Qualification Reform Design Group, 2024). While this approach has strengths in standardisation and quality assurance, it presents structural challenges for MMC workforce transition (BuildSkills Australia, 2025). Competencies are typically treated as fixed rather than dynamic, and qualifications are designed around established occupational boundaries. When new industry needs emerge, the response is often to create new qualifications rather than to enable flexible movement across existing pathways (Qualification Reform Design Group, 2024). This occupationally siloed structure contrasts sharply with what MMC demands, including multi-skilled workers capable of operating across design, manufacturing, and assembly, and tradespeople comfortable in factory settings.

Exacerbating this structural rigidity is the significant decline of Australia's manufacturing sector over recent decades (Beer, 2018). The closure of automotive factories, once centres of Lean Manufacturing expertise, has weakened the national knowledge base in production principles, continuous improvement, and process optimisation (Beer, 2018). Unlike Sweden and Germany, where manufacturing and construction have developed in closer proximity, Australia lacks a ready pipeline of workers with factory-based production experience who might transfer into MMC contexts. The Lean thinking that supports MMC productivity gains is less embedded in Australian industry culture than in countries with stronger manufacturing traditions.

Further complicating the picture is fragmented governance. Responsibility for VET is shared between state and federal governments, often resulting in inconsistent implementation, duplicated efforts, and slow responses to emerging industry needs (Qualification Reform Design Group, 2024). Unlike Singapore's centralised coordination (Solin et al., 2025), Australia lacks a unified mechanism for rapidly aligning qualification development with industry transformation. The result is a workforce development system that, while effective for stable occupational categories, struggles to support the cross-functional, transferable and adaptive skillsets that MMC requires.

THE CASE FOR A NEW WORKFORCE TRANSITION APPROACH

The international and Australian experiences outlined above point to a consistent set of challenges: qualification systems that cannot keep pace with industry needs, occupational boundaries that inhibit cross-functional skill development, and governance structures that impede coordinated response. These are systemic problems that cannot be resolved through the creation of additional standalone qualifications. What might be required is a framework that embeds responsiveness into educational systems, and consequently, the design of qualification and workforce development itself.

THEORETICAL FRAMEWORK

LEAN CONSTRUCTION PRINCIPLES IN EDUCATION

Lean thinking originated in manufacturing, most notably through the Toyota Production System, before being adapted to construction through the work of Koskela (1992). Koskela (1992) reconceptualised construction as a production system comprising transformation, flow, and value generation. Koskela's central thesis was that this reconceptualisation allows managers to not only focus on the conversions (which are the value-added activities) but also to reduce flows, which are constantly ignored in traditional construction and represent waste (waiting for materials, moving equipment, inspecting work). From this thesis, Koskela derived key lean principles that include: defining value from the customer's perspective, eliminating waste, optimising flow, implementing pull systems, and pursuing perfection through continuous improvement. These principles have demonstrated significant impact on construction productivity, quality, and project delivery timelines (Ballard et al., 2002).

The application of Lean Construction extends beyond production and construction process. Bassanino et al. (2008) developed an industry-led educational framework, demonstrating that training programmes designed around industry-defined value better align with workforce needs while eliminating non-value-adding content. Applied to workforce development for MMC, Lean Construction reframes several persistent problems. First, *value* is defined from the perspective of industry and learners. A qualification adds value only if it produces skills that industry requires and learners can deploy. Second, *pull* replaces push: rather than supplying qualifications based on existing institutional capacity and then seeking demand, a lean approach responds to actual skill demands as they emerge from industry practice. Third, *continuous improvement* through feedback loops between education and industry ensures that qualifications evolve alongside technological and process change. This contrasts with traditional VET systems where qualifications are periodically reviewed on fixed cycles, often lagging significantly behind industry transformation (Bassanino et al., 2008). Lean Construction thus provides a philosophy for responsive workforce development. However, it does not prescribe the structural elements through which responsiveness is achieved. For this, platform thinking offers a complementary theoretical lens.

PLATFORM-BASED EDUCATION

The platform concept originated in manufacturing. Robertson and Ulrich (1998, p. 20) defined a product platform as “the collection of assets (i.e., components, processes, knowledge, people and relationships) that are shared by a set of products”. Platforms allow mass customisation—producing differentiated products without excessive resource consumption—by balancing commonality (which drives efficiency) with distinctiveness (which meets diverse market needs) (Robertson & Ulrich, 1998). In MMC, platform approaches have been adopted to standardise processes while enabling product variety, particularly in Sweden (Lessing, 2006; Maxwell & Aitchison, 2017). For workforce development in particular, platforms also function as mechanisms for accumulating and sharing knowledge across projects, addressing

construction's traditional reliance on tacit knowledge and informal transfer between workers (Styhre & Gluch, 2010).

Three platform principles translate directly to workforce development. First, *modularity* enables credentials to function as interchangeable components that can be recombined across occupational boundaries. Second, *standardised interfaces* enable coordination across fragmented governance. As standardised component interfaces allow parts from different suppliers to connect, standardised learning outcomes allow credentials from different providers and jurisdictions to articulate coherently. Third, *separation of platform development from delivery* allows qualification frameworks to be continuously improved without disrupting training provision.

In conjunction, Lean Construction principles and platform thinking provide a theoretical basis for workforce development systems capable of supporting MMC transition. Lean Construction ensures that the system remains oriented toward industry-defined value, responds to emerging demand through pull, and improves continuously. Platform thinking provides the structural elements, based on modularity, standardised interfaces, and governance separation, through which that responsiveness is operationalised.

RESEARCH DESIGN

This study draws on applied research (Hedrick et al., 1993) conducted through two projects investigating the skills and workforce implications of MMC and corresponding education needs. Both projects were undertaken in partnership with Building 4.0 CRC, a Cooperative Research Centre funded by the Australian Government with the aim of transforming the construction sector through digitalisation, industrialisation, and sustainability. The projects were conducted in collaboration with skills organisations, vocational education providers, and industry peak bodies. Both projects originated from these partners' inquiry into how workforce development could align with emerging MMC demands, and what would be required on behalf of policymakers and education providers to support this alignment (Hedrick et al., 1993).

The first project focused on identifying industry skill needs through three methods: a market review of MMC education programs across Australia and internationally (see, Solin et al., 2025); a national online survey of 43 MMC-engaged companies across design, manufacturing, and assembly; and 20 semi-structured interviews with industry practitioners, education providers, and representatives from unsuccessful MMC ventures, complemented by site visits to 16 companies across five Australian states. The second project focuses on developing a training and qualification framework to address these skill needs, involving 5 visits to peak bodies, education providers, and key policymakers.

The lean framework presented in this paper was not part of either project's original scope. Rather, the need for this framework became evident to the authors during thematic analysis of interview and consultation data (Ritchie & Spencer, 1994), as findings repeatedly pointed to systemic barriers—temporal mismatches, occupational boundary constraints, and governance fragmentation—that could not be resolved through traditional qualification development. The framework therefore represents a synthesis of empirical patterns identified across both projects, integrated with lean and platform thinking principles drawn from the literature.

Results are presented in two sections. The first establishes the empirical foundation, synthesising findings from both projects: MMC workforce demands (drawing primarily on Project 1) and a stakeholder analysis of value and waste perceptions (drawing primarily on Project 2). These findings reveal a structural misalignment between MMC skill demands and the capacity of existing qualification frameworks to respond, providing the rationale for the lean framework presented in the second section.

FINDINGS: EMPIRICAL FOUNDATIONS

MMC WORKFORCE DEMANDS

MMC transforms skill requirements across the entire built environment value chain (see **Error! Reference source not found.**). Empirical findings reveal that MMC demands skills that differ from traditional construction competencies (Ginigaddara et al., 2022). Underpinning these phase-specific requirements are foundational skills that distinguish MMC from traditional construction, including process-oriented thinking informed by lean principles, systems thinking that enables coordination across the value chain, and digital literacy as a baseline rather than specialist skill.

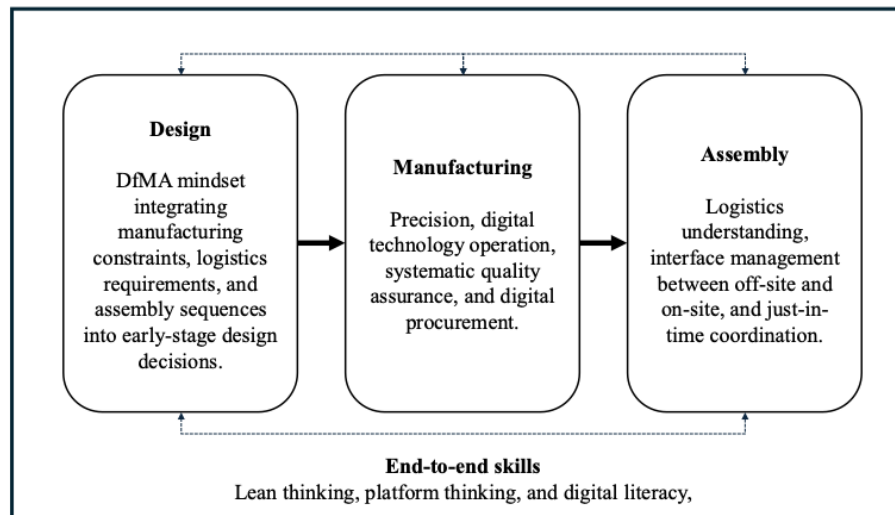


Figure 1: MMC skills demands

Besides phase-specific skills, the findings reveal the emergence of new occupational profiles that challenge existing qualification structures. Multi-skilled roles prepare workers for multiple related occupations within MMC settings rather than narrow trade specialisation. As one operations manager explained, the goal is to “maximise their scope to keep them on site longer” by combining tasks across production sequences. Moreover, “grey-collar” roles have emerged that require hybrid competencies bridging traditional blue-collar technical execution with white-collar cognitive and coordination capabilities. As one participant explained: “There is a skill set that is a combination of blue-collar carpentry... and a manufacturing skill set that you need to find a way to marry together. And there's not many people that have a background like that”. These roles—such as DfMA coordinators, manufacturing quality controllers, and BIM-enabled tradespeople performing clash detection—demand both hands-on problem-solving and high-level systems thinking. Current qualification frameworks, which maintain strict divides between vocational and professional pathways, fail to cultivate these hybrid skills, creating a structural barrier to workforce development despite clear industry demand.

STAKEHOLDERS ANALYSIS: VALUE AND WASTE IN THE CURRENT EDUCATIONAL SYSTEMS

The lean framework requires an understanding of who the stakeholders are, what they value (i.e., what they seek from workforce development), and what they perceive as waste in the current system. **Error! Reference source not found.** presents an analysis of four stakeholder groups central to MMC workforce development.

Table 1: Stakeholder value and waste analysis

Stakeholder	Description	Value	Waste
Industry (MMC-engaged companies)	Design consultancies, manufacturers, builders, and developers engaged in MMC across the value chain.	- A workforce capable of navigating the “Digital-to-Physical” pipeline. - Workers must possess transferable skills that bridge manufacturing (DfMA) with on-site assembly and integration.	- No accessible training pathways to address skill gaps. - A multi-year development cycle for formal qualifications makes content obsolete before delivery. - Occupational boundaries that prevent hiring multi-skilled workers.
	Predominantly small firms with constrained resources for workforce development. Architecture, engineering, construction management, and quantity surveying programs delivered through accredited professional degrees. Subject to professional accreditation requirements.	- Graduates capable of industry-relevant practice. - Interdisciplinary curriculum integration - Pathways for articulation with VET.	- Disciplinary silos maintained through separate accreditation regimes. - Curriculum privileges traditional considerations over manufacturing principles. - Graduates with software skills but lacking DfMA understanding - Limited credit transfer from VET.
RTOs (Registered Training Organisations)	Technical and Further Education Institutions and RTOs delivering nationally recognised qualifications.	- Clear quality assurance frameworks. - Employer confidence in qualification standards.	- Prescriptive training content limits contextualisation. - Significant capital investment required for emerging technologies - Compliance-driven and risk-averse culture discourages innovation.
Non-RTOs (Informal training providers)	Industry bodies, and private training providers delivering short courses, micro-credentials, and product-specific training outside the formal system.	- Speed-to-market for new training content. - Flexibility to respond to emerging industry needs.	- System limits recognition and portability of credentials. - No reliable mechanism to assess quality or relevance. - Skills acquired may not transfer across employers or jurisdictions.

The findings above establish the empirical foundation, revealing that MMC demands skills and roles that existing qualification frameworks cannot adequately develop, and that stakeholders across the ecosystem perceive significant waste in current systems. The following section presents a lean framework, informed by platform thinking, developed in response to these empirically identified barriers.

LEAN FRAMEWORK PROPOSAL FOR MMC WORKFORCE TRANSITIONS

The empirical findings presented above reveal a structural misalignment between what MMC requires and what existing workforce development systems can deliver. The skills MMC demands cannot be adequately cultivated through qualification frameworks organised around narrow occupational categories, delivered through fragmented provider networks operating in isolation, and governed by multi-year accreditation cycles that lag industry evolution. As the background section described, these challenges are not unique to Australia, they reflect systemic tensions observed across international jurisdictions attempting MMC workforce transitions. However, the responses documented in more mature MMC markets (e.g., Germany's system integrating industry and education and Singapore's skills-first frameworks) suggest potential solutions for transformation. The framework proposed draws on Lean Construction principles and platform thinking, as established in the theoretical foundation, to address these systemic challenges **Error! Reference source not found.**

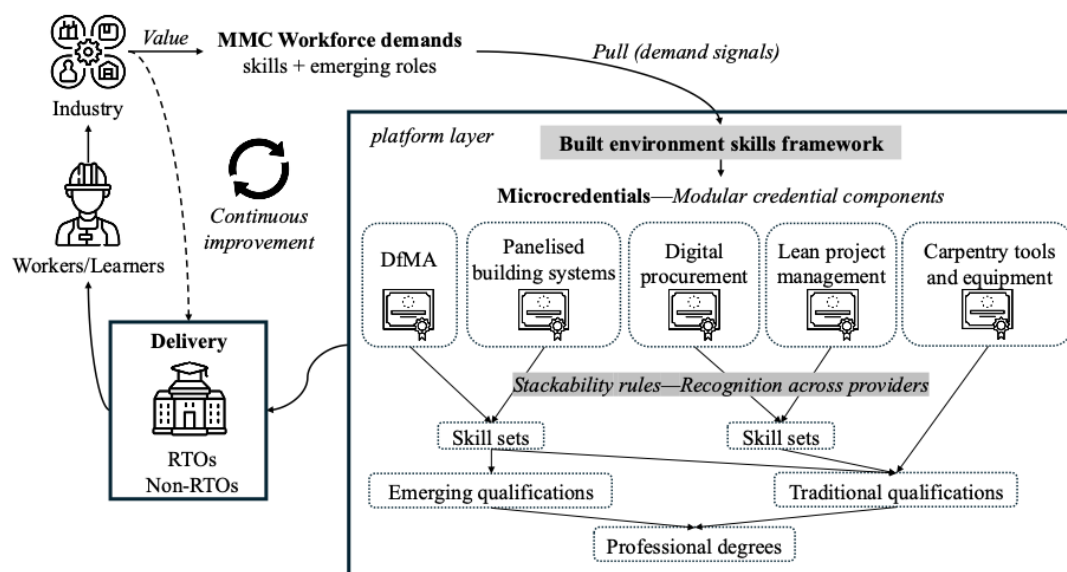


Figure 2: A lean framework for MMC workforce transitions.

LEAN CONSTRUCTION PRINCIPLES APPLIED

The framework operationalises three lean principles identified in the theoretical foundation: *value*, *pull*, and *continuous improvement*. Consistent with Koskela's (1992) reconceptualisation of construction as a production system focused on value creation and waste elimination, the framework begins by defining *value* from the perspective of stakeholders. **Error! Reference source not found.** established that industry, workers, higher education providers, RTOs, and non-RTOs each hold distinct but overlapping interests. Industry values workers with job-ready skills, workers value portable credentials supporting career progression, education providers value sustainable delivery models with clear quality assurance (**Error! Reference source not**

found.). A lean system must reconcile these perspectives rather than privileging one over another.

The stakeholder analysis also identified waste across the current system, including temporal delays between skill need identification and qualification delivery, occupational boundaries preventing cross-functional skill development, recognition gaps leaving informally acquired skills invisible, and coordination failures across fragmented governance structures. These forms of waste become the targets for elimination through the new proposed framework's design.

Pull reverses the traditional sequence of qualification development. Rather than forecasting future needs, developing qualifications over multi-year cycles, and then seeking demand; a pull-based system responds to evidence-based industry needs. The framework establishes a demand-signal mechanism through which MMC workforce demands (**Error! Reference source not found.**) directly inform credential development. When industry identifies specific skill gaps, this triggers development of corresponding micro-credentials rather than requiring redesign of entire qualifications. The “Built Environment Skills Framework” functions as the primary mechanism for translating demand signals into credential specifications—a skills-first, data-driven approach similar to Singapore’s SkillsFuture framework, which enables rapid identification of emerging skill requirements and corresponding training responses.

Continuous improvement embeds feedback loops between industry, education providers, and workers/graduates, enabling the system to evolve alongside technological and process change. As Bassanino et al. (2008) demonstrated in applying lean principles to educational framework design, industry engagement must extend beyond initial curriculum development to incorporate ongoing refinement based on graduate outcomes and emerging practice. The framework positions industry not only as a source of demand signals but as an active participant in delivery through work-based learning, industry placements for educators, and co-designed assessment, which ideally are also recognised through credentials and skills frameworks. These approaches could be informed by industry engagement initiatives established within Germany and Sweden (Maxwell & Aitchison, 2016).

PLATFORM PRINCIPLES ENABLING RESPONSIVENESS

Platform thinking provides the structural foundation through which Lean Construction principles are operationalised. Robertson and Ulrich’s (1998) definition of platforms as shared assets enabling mass customisation—balancing commonality with distinctiveness—translates directly to workforce development. The framework incorporates three platform principles: *modularity*, *standardised interfaces*, and *separation of platform development from delivery*.

Modularity is achieved through micro-credentials and skill sets that work as building blocks. Unlike current qualifications that must be redesigned entirely to incorporate new content, modular components can be developed, updated, or reconfigured in response to specific demand signals. The micro-credentials shown in Figure 2—DfMA, panelised building systems, digital procurement, lean project management—are derived directly from the MMC workforce demands identified in the empirical findings (**Error! Reference source not found.**). This creates a traceable link from industry need to credential specification that operationalises the *pull* principle.

These modular components stack both vertically and horizontally. Vertical stackability enables clusters of micro-credentials to accumulate toward skill sets, and skill sets toward full qualifications—whether emerging qualifications designed specifically for MMC contexts (such as multi-skilled trade credentials) or traditional qualifications augmented with MMC-specific components. Horizontal stackability enables credentials acquired in one context to be recognised in adjacent disciplines, supporting the workforce mobility between manufacturing and construction sectors that MMC demands. Both forms of stackability ultimately articulate

toward professional degrees, bridging the VET and higher education fragmentation that the empirical findings identified as a barrier to cultivating “grey-collar” roles.

Standardised interfaces enable this stackability by ensuring that modular components articulate coherently across providers and jurisdictions. The “Built Environment Skills Framework” establishes common learning outcome specifications and recognition protocols. These specifications function similarly to the standardised component interfaces in building platforms that allow parts from different suppliers to connect reliably (Lessing, 2006; Maxwell & Aitchison, 2016).

Finally, *separation of platform development from training delivery* addresses a key dysfunction identified in the stakeholder analysis. The framework distinguishes between platform development—the ongoing refinement of credential specifications, stackability rules, and recognition frameworks—and training provision by RTOs, non-RTOs, and higher education institutions. Platform development incorporates continuous improvement through industry feedback and emerging skill identification; training delivery draws on current platform specifications without being destabilised by every platform update. This separation enables responsiveness at the system level while maintaining stability at the delivery level (Robertson & Ulrich, 1998).

The proposed framework differs from existing approaches to MMC workforce development. Existing approaches to MMC workforce development are based on fixed competence frameworks (Ginigaddara et al., 2022) that feed into qualification systems designed around predetermined occupations reviewed on multi-year cycles (Qualification Reform Design Group, 2024). By contrast, the lean-platform framework treats skills as dynamic: lean thinking provides the improvement philosophy (Bassanino et al., 2008), while platform thinking provides the structural architecture (Robertson & Ulrich, 1998) through which responsiveness is operationalised.

CONCLUSIONS

This paper has proposed a lean framework for MMC workforce transition by integrating Lean Construction and platform thinking into educational systems. While these principles have been applied separately in adjacent fields, this is the first application to MMC workforce development. This paper demonstrates how value, pull, and continuous improvement can guide the design of responsive qualification systems. Grounded in theory and informed by two applied research projects in Australia, the framework addresses three systemic challenges: qualification systems that cannot keep pace with industry needs (through pull-based development and modularity), occupational boundaries that inhibit cross-functional skill development (through horizontal stackability and VET-HE articulation), and governance structures that impede coordinated response (through standardised interfaces and platform-delivery separation).

Several limitations suggest directions for future research. The framework is theoretically grounded and empirically informed but has not yet been implemented. However, it is not purely speculative, it emerged from empirical findings that confirmed both the systemic barriers and the need for a responsive approach. Future research should pilot framework components, such as the demand-signal mechanisms and modular credential structures, within specific MMC contexts to assess practical feasibility and refine design specifications. Additionally, while the framework addresses the VET-HE ecosystem, further work is needed to elaborate the articulation mechanisms between vocational and higher education, particularly around mutual recognition and accreditation pathways for grey-collar roles. Despite these limitations, the framework responds to an urgent need. MMC adoption is constrained not only by technological, regulatory, and supply chain barriers, but also by workforce capability gaps. Educational systems tied to traditional occupational categories cannot produce the multi-skilled and

adaptable workers that MMC requires. By embedding responsiveness into workforce development systems, the proposed lean framework offers a pathway to resolve this constraint.

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