A Conceptual Framework for Integrated Process Quality Management Systems (IPQMS) in Construction Projects

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ABSTRACT

The construction industry faces persistent difficulty in coordinating quality, safety, health, and environmental (QSHE) requirements across fragmented project processes. This paper develops an Integrated Process Quality Management Systems (IPQMS) conceptual framework for construction projects by synthesising integrated management systems literature, QSHE integration studies, ISO harmonised management system logic, PDCA-based improvement principles, and process-based quality management theory. The framework organises seven critical processes into three tiers: foundation processes (integrated planning and design; process integration and coordination), operational processes (quality control and assurance; risk management and safety integration; environmental and sustainability management), and enhancement processes (performance monitoring and evaluation; continuous improvement and learning). A small-N quantitative synthesis from five eligible studies is used as supplementary evidence only, with effect-size estimates treated as indicative rather than confirmatory. The paper contributes an integrative process architecture, five theoretical propositions, and a validation roadmap for future empirical testing through case studies, surveys, and longitudinal implementation studies. The framework is particularly relevant to infrastructure project contexts in Indonesia and Malaysia, while remaining adaptable to broader construction settings.

Keywords: Integrated process quality management systems, IPQMS, construction management, conceptual framework, quality management, QSHE integration, ISO High Level Structure, process-based management

INTRODUCTION

Background and Context

Construction projects operate under increasing pressure to meet quality specifications, occupational safety requirements, environmental obligations, and diverse stakeholder expectations. When quality, safety, health, and environmental requirements are managed through separate systems, organisations often experience duplicated documentation, fragmented responsibility, inconsistent performance measurement, and weak cross-functional coordination (Bernardo et al., 2009; Simon et al., 2012; Zeng et al., 2007). Integrated management systems therefore provide a relevant foundation for construction organisations seeking to coordinate QSHE objectives within a single process-oriented architecture (Dahlin & Isaksson, 2017; de Nadae et al., 2021).

Integrated Process Quality Management Systems (IPQMS) are positioned in this paper as an extension of conventional construction quality management. Instead of treating quality control as a stand-alone function, IPQMS emphasises the alignment of QSHE activities with project planning, risk management, performance monitoring, and learning processes. This orientation is consistent with systems thinking and process-based management, where organisational performance depends on the coordinated operation of interdependent processes rather than isolated functional controls (Jonker & Karapetrovic, 2004; Rofi'udin & Latief, 2018; Sahoo, 2022).

A preceding systematic literature review conducted for this study identified four recurring integration model types: Integrated Management Systems (IMS), QSHE frameworks, ISO-aligned systems, and methodological QMS models. It also identified seven process areas that appear repeatedly in the IPQMS-related literature. However, these elements remain dispersed across different research streams, and the field still lacks a concise framework that links integration models, critical processes, theoretical foundations, expected outcomes, and future validation logic.

Problem Statement

The construction industry faces three interconnected challenges in implementing integrated quality management:

First, the literature remains theoretically fragmented: IMS, QSHE, ISO-harmonised, and methodological QMS studies often discuss integration from different starting points without consolidating their assumptions into a common construction-process architecture (Dahlin & Isaksson, 2017; Chountalas & Lagodimos, 2025; Jonker & Karapetrovic, 2004). Second, construction organisations face implementation complexity because conceptual integration models are not always translated into clear process sequences, responsibilities, and monitoring mechanisms (Gianni & Gotzamani, 2015; Simon et al., 2012). Third, many proposed frameworks are insufficiently validated, meaning that their applicability, performance contribution, and contextual limits remain uncertain (Jabareen, 2009; Whetten, 1989).

These challenges necessitate development of a comprehensive conceptual framework that integrates existing knowledge, articulates clear theoretical foundations, identifies critical processes and their interrelationships, and provides guidance for both implementation and empirical validation.

Research Objectives

This paper aims to develop a comprehensive conceptual framework for Integrated Process Quality Management Systems in construction projects. Specific objectives include:

1. Synthesize existing knowledge on IPQMS integration models, critical processes, and implementation approaches from systematic literature review findings
2. Articulate theoretical foundations grounding the framework in established management theories and quality management principles
3. Develop a comprehensive framework that integrates integration model types, critical processes, and implementation guidance
4. Advance theoretical propositions that articulate expected relationships and outcomes for empirical testing
5. Propose validation approaches for systematic empirical investigation of the framework

Significance and Contributions

The contribution of the paper is therefore threefold. Conceptually, it consolidates fragmented IPQMS-related literature into a coherent process framework. Methodologically, it demonstrates how literature review findings, small-N quantitative synthesis, and theory-building logic can be translated into a testable framework. Practically, it offers construction organisations a structured process map for aligning QSHE requirements across project lifecycles.

LITERATURE REVIEW

Quality Management in Construction and Integrated Management System in Construction

Quality management in construction has evolved from inspection-based conformance control toward broader approaches emphasising prevention, customer focus, process orientation, and continuous improvement (Arditi & Gunaydin, 1997; Leong et al., 2014; Riaz et al., 2023). ISO 9000-based quality management systems supported this shift by formalising documented processes, audit mechanisms, and improvement cycles.

However, quality management systems were often implemented separately from environmental and occupational health and safety systems, producing parallel procedures and limited integration across project functions (Bernardo et al., 2009; Rofi'udin & Latief, 2018).

Integrated Management Systems emerged as a response to this fragmentation by combining quality, environmental, and occupational health and safety requirements under shared processes, documentation, responsibilities, and performance review mechanisms. Empirical IMS studies report benefits such as reduced duplication, improved resource efficiency, better internal coordination, and stronger sustainability performance, although implementation difficulties remain when integration is pursued only administratively rather than through process redesign (Bernardo et al., 2009; de Nadae et al., 2021; Simon et al., 2012; Zeng et al., 2007).

QSHE Integration Frameworks

QSHE integration frameworks extend IMS thinking by explicitly connecting quality, safety, health, and environmental objectives in construction project delivery. This connection is important because project decisions often generate cross-domain consequences: a design change may affect buildability, safety exposure, environmental performance, rework, and stakeholder satisfaction simultaneously. Recent QSHE studies therefore emphasise process-level integration, early planning involvement, risk-based coordination, and integrated performance measurement (Arman et al., 2025; Goel et al., 2019; Widjajakusuma et al., 2023).

Sustainability further strengthens the case for IPQMS because construction organisations increasingly need to demonstrate not only quality conformance but also responsible resource use, regulatory compliance, safety performance, and stakeholder responsiveness. Sustainability integration literature shows that construction project management requires mechanisms that link environmental and social requirements to operational control, monitoring, and learning processes (de Nadae et al., 2021; Goel et al., 2019).

ISO Harmonization and Process- Based Quality Management

The ISO harmonised management system structure, formerly associated with the High Level Structure and Annex SL, provides a shared architecture for ISO management system standards. It promotes common clause logic around organisational context, leadership, planning, support, operation, performance evaluation, and improvement, thereby making integration across standards more feasible (International Organization for Standardization, n.d.-a, n.d.-b). Current and recent standards relevant to this paper include ISO 9001:2015, ISO 14001:2026, and ISO 45001:2018, while many prior studies still refer to ISO 14001:2015 because it was the dominant environmental management system version before being replaced by ISO 14001:2026 (International Organization for Standardization, 2026).

The PDCA cycle provides the improvement logic through which integrated systems are planned, implemented, checked, and improved. In ISO 9001:2015, the process approach, PDCA, and risk-based thinking operate together to support systematic control and continual improvement (International Organization for Standardization, 2015). For IPQMS, this means that QSHE integration should not be limited to documentation alignment; it should operate as a recurring cycle of integrated planning, coordinated execution, performance evaluation, corrective action, and organisational learning (March, 1991; Sahoo, 2022).

Research Gaps

The review indicates three remaining gaps. First, existing literature provides useful insights into IMS, QSHE integration, ISO alignment, and construction quality management, but these insights are not sufficiently consolidated into a construction-specific process framework. Second, the relationships among critical IPQMS processes, especially the sequencing between planning, operations, monitoring, and learning, remain under-theorised. Third, empirical validation remains limited, requiring future research to test the framework across project types, organisational maturity levels, and geographic contexts (Chountalas & Lagodimos, 2025; Dahlin & Isaksson, 2017; Jabareen, 2009).

This paper addresses these gaps by developing a comprehensive conceptual framework that integrates existing knowledge, articulates theoretical foundations, organizes critical processes hierarchically, and proposes systematic validation approaches.

THEORETICAL FOUNDATION

The proposed framework is grounded in three complementary theoretical foundations. First, ISO harmonized management system logic provides the structural foundation by aligning management system requirements around common clauses and terminology. Second, PDCA provides the dynamic foundation by explaining how integrated processes are continuously planned, implemented, evaluated, and improved. Third, process-based quality management provides the operational foundation by treating the organisation as a system of interdependent processes rather than a set of disconnected departments (International Organization for Standardization, 2015; Jonker & Karapetrovic, 2004; Sahoo, 2022).

These foundations are complementary rather than interchangeable. ISO harmonisation explains why integration across management system standards is structurally possible. PDCA explains how integrated processes evolve through repeated improvement cycles. Process-based quality management explains how those processes should be mapped, coordinated, measured, and improved in project environments. Together, they provide the theoretical basis for organising IPQMS into foundation, operational, and enhancement process tiers.

FRAMEWORK DEVELOPMENT METHODOLOGY

Development Approach

This paper adopts a conceptual framework development approach. Following Jabareen (2009), conceptual framework building involves identifying relevant concepts, grouping them into categories, clarifying their relationships, and translating them into a coherent analytical structure. Consistent with theory-building criteria, the framework specifies what the core constructs are, how they are related, why those relationships are expected, and how they may be tested in future research (Sutton & Staw, 1995; Whetten, 1989).

Evidence Synthesis

The framework was informed by a preceding systematic review and critical process identification exercise. The review screened 465 records addressed IPQMS-related integration in construction. The quantitative component should be interpreted as a small-N exploratory synthesis rather than a definitive meta-analysis. Effect sizes were standardised to Cohen’s d where reported quantitative outcomes or comparable before-after / between-group indicators could be extracted. Where studies reported only conceptual or qualitative evidence, they informed process identification and model classification but were not treated as independent statistical effect estimates. Random-effects logic was used because construction projects differ by country, organisational maturity, project type, and management system scope (Borenstein et al., 2009; Higgins et al., 2003).

Four outcome domains were retained as indicative signals: process integration, quality improvement, risk reduction, and stakeholder satisfaction. The reported effect sizes are therefore used to support framework development and proposition formulation, not to claim conclusive causal effects. Publication-bias analysis, moderator analysis, and strong generalisation were not performed because the evidence base was too small. This clarification is important because conceptual framework papers should avoid overstating quantitative certainty when empirical evidence is limited.

Framework Architecture Development

The framework architecture was developed through iterative refinement, organizing critical processes into a three-tier hierarchy based on their roles in IPQMS operation:

Foundation Tier includes processes that establish the basis for integration: Integrated Planning and Design Process (P1) and Process Integration and Coordination (P2). These processes enable subsequent operational and enhancement activities.

Operational Tier includes core management processes: Quality Control and Assurance (P3), Risk Management and Safety Integration (P4), and Environmental and Sustainability (P5). These processes represent primary IPQMS operational activities.

Enhancement Tier includes processes that provide system improvement capabilities: Performance Monitoring and Evaluation (P6) and Continuous Improvement and Learning (P7). These processes enable systematic enhancement and adaptation.

THE IPQMS CONCEPTUAL FRAMEWORK

The Integrated Process Quality Management Systems (IPQMS) framework provides a comprehensive approach to managing quality, safety, health, and environmental requirements in construction projects through systematic process integration. The framework consists of five interconnected layers: (1) Theoretical Foundations, (2) Integration Models, (3) Critical Processes, (4) Implementation Approaches, and (5) Expected Outcomes. Figure 1 presents the complete framework architecture, showing relationships between layers and components.

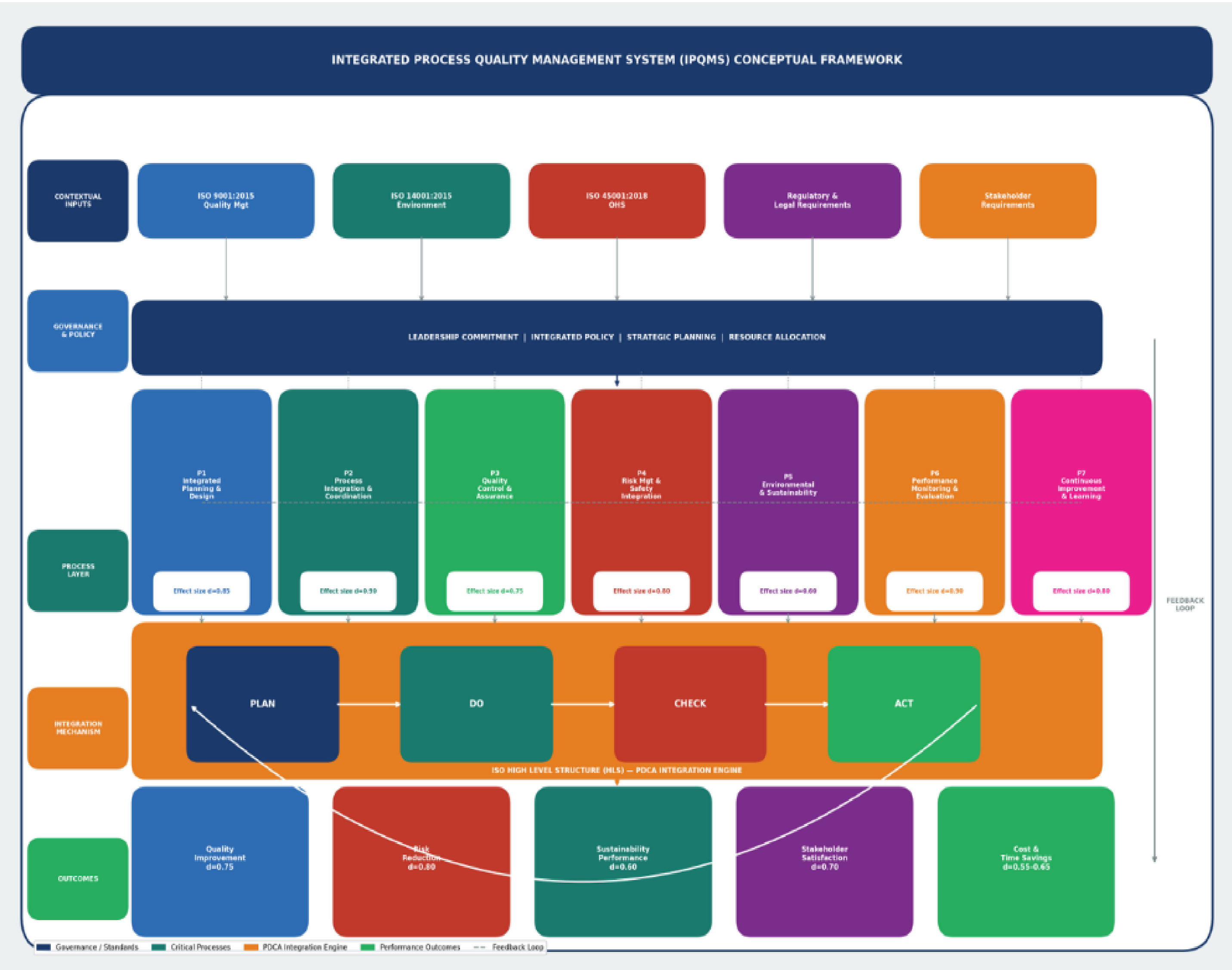

Figure 1: IPQMS Conceptual Framework Overview

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Critical Processes

The framework organises seven critical processes into a three-tier hierarchy. Foundation processes establish the integration basis: P1 Integrated Planning and Design and P2 Process Integration and Coordination. Operational processes execute core controls: P3 Quality Control and Assurance, P4 Risk Management and Safety Integration, and P5 Environmental and Sustainability Management. Enhancement processes provide feedback and learning: P6 Performance Monitoring and Evaluation and P7 Continuous Improvement and Learning. Figure 2 shows the process flow across the project lifecycle.

The seven IPQMS processes are not intended to represent isolated activities but differentiated process functions within an integrated construction management system. Each process has a distinct role in transforming fragmented QSHE requirements into coordinated project controls, performance evidence, and continuous improvement. To minimise conceptual overlap, the processes are distinguished according to their primary function: requirement integration, process coordination, operational control, risk integration, environmental-sustainability control, performance evaluation, and organisational learning. This distinction is important because integrated management systems often fail when processes are only administratively combined but not conceptually differentiated or operationally sequenced.

Figure 2: IPQMS Process Flow Diagram illustrates the seven critical processes across project lifecycle phases (Pre-Construction, Construction, Post-Construction)

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Tier	Process	Conceptual definition	Boundary distinction
Foundation	P1 Integrated Planning and Design	The early-stage process of embedding QSHE requirements into project objectives, design decisions, specifications, risk assumptions, and planning documentation.	Differs from P2 because it focuses on front-end requirement integration before implementation, rather than coordinating processes during delivery.
Foundation	P2 Process Integration and Coordination	The process of mapping, aligning, and coordinating QSHE procedures, responsibilities, communication flows, and reporting mechanisms across project functions.	Differs from P1 because it focuses on process alignment and coordination structures, not design-stage requirement setting.
Operational	P3 Quality Control and Assurance	The process of ensuring that construction outputs conform to quality requirements through inspection, testing, documentation, corrective action, and assurance procedures.	Differs from P4 and P5 because its primary concern is quality conformance, although it must remain aligned with safety and environmental requirements.
Operational	P4 Risk Management and Safety Integration	The process of identifying, assessing, mitigating, and monitoring risks that affect quality, safety, health, and environmental performance.	Differs from P3 because it focuses on uncertainty, hazard, and risk interaction, not direct quality inspection or conformance control.
Operational	P5 Environmental and Sustainability Management	The process of integrating environmental compliance, resource efficiency, waste reduction, and sustainability objectives into construction project control.	Differs from P4 because it focuses specifically on environmental and sustainability performance, while P4 addresses broader QSHE risk exposure.
Enhancement	P6 Performance Monitoring and Evaluation	The process of collecting, measuring, analysing, and reporting integrated QSHE performance indicators to support evidence-based decision-making.	Differs from P7 because it focuses on measurement and evaluation, not the implementation of learning or improvement actions.
Enhancement	P7 Continuous Improvement and Learning	The process of using monitoring results, non-conformance records, root-cause analysis, lessons learned, and stakeholder feedback to improve the IPQMS over time.	Differs from P6 because it focuses on system adaptation and organisational learning, rather than performance measurement itself.

Table 1: Tier-Based Classification of IPQMS Processes and Functions

The seven IPQMS processes operate through a sequential and feedback-based mechanism. The foundation processes establish the conditions for integration by embedding QSHE requirements into early planning and by coordinating processes, responsibilities, and communication mechanisms. These foundation processes enable operational processes because quality assurance, safety-risk integration, and environmental-sustainability management require clear requirements, defined responsibilities, and coordinated information flows. The operational processes then generate project evidence, including inspection results, non-conformance records, risk observations, incident data, environmental compliance records, and stakeholder feedback. These outputs are captured through performance monitoring and evaluation, which converts operational data into decision-relevant performance information. Continuous improvement and learning then use this evidence to identify root causes, revise procedures, strengthen coordination, and improve future planning. In this way, the IPQMS framework operates as a cyclical system in which planning and coordination enable operational control, operational control generates performance evidence, and performance evidence supports learning and system refinement.

The three-tier classification is theoretically grounded in ISO harmonised management system logic, the PDCA cycle, and process-based quality management. The foundation tier corresponds to the planning and structuring function of IPQMS because it establishes integrated requirements, process architecture, responsibilities, and coordination mechanisms. The operational tier corresponds to the implementation and control function because it executes the core QSHE activities required during construction delivery, including quality assurance, safety-risk management, and environmental-sustainability control. The enhancement tier corresponds to the checking, evaluation, and improvement function because it monitors performance, identifies gaps, and translates lessons learned into corrective and preventive improvement. Therefore, the three-tier classification is not merely descriptive; it reflects a functional hierarchy in which foundation processes create the enabling conditions, operational processes deliver project-level control, and enhancement processes sustain feedback, adaptation, and continuous improvement.

5.3 Implementation Approaches and Expected Outcomes

IPQMS can be implemented through phased, pilot, parallel, or incremental approaches. A phased approach is suitable for organisations with low integration maturity, while a pilot approach allows refinement before wider deployment. Parallel implementation may suit mature organisations with strong coordination capacity, and incremental enhancement may suit organisations that already operate certified management systems. Expected outcomes include stronger process integration, improved quality performance, reduced QSHE risk, and higher stakeholder satisfaction. Figure 3 presents the indicative effect-size profile and the alignment between integration models and critical processes.

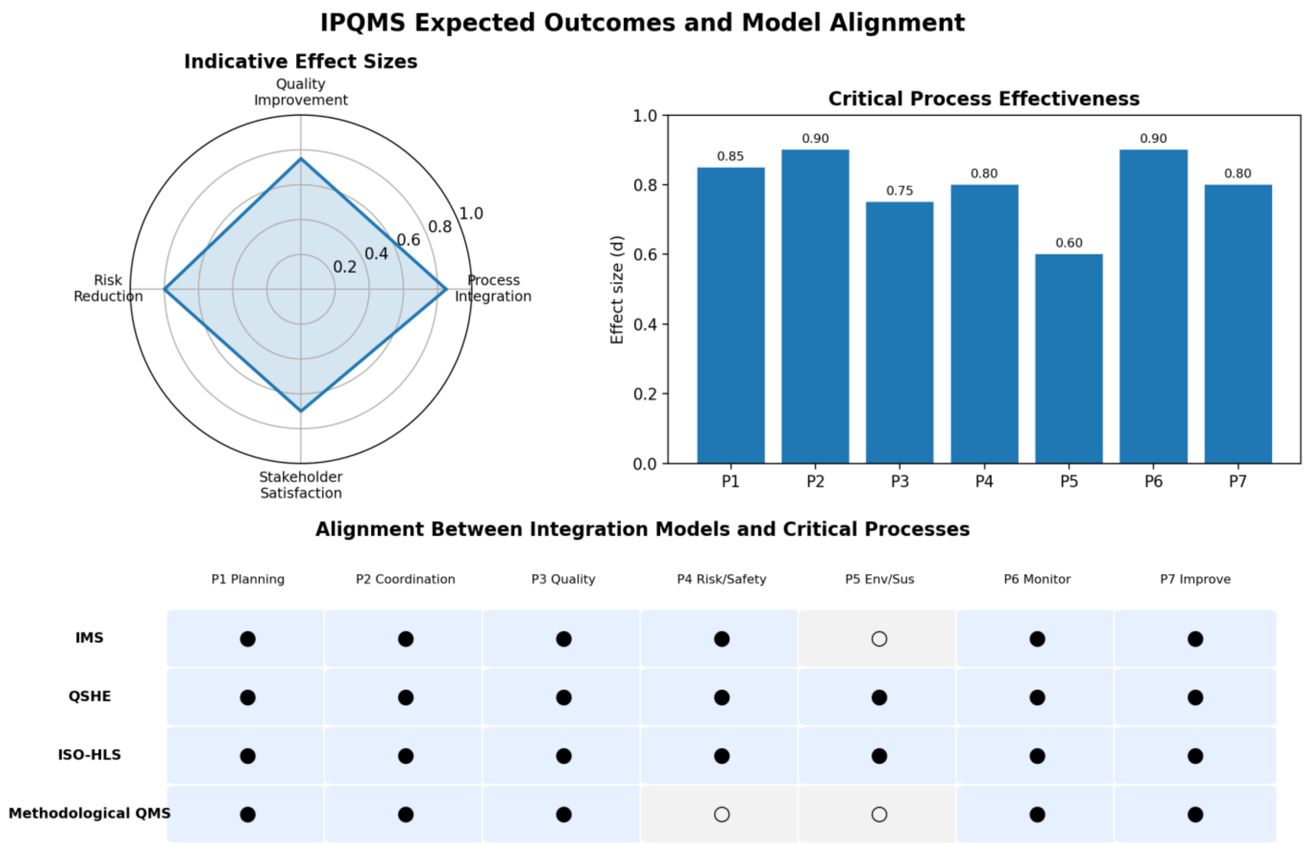

Figure 3: IPQMS expected outcomes and alignment between integration models and critical processes.

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THEORETICAL PROPOSITIONS

Five propositions are advanced to clarify the framework's theoretical logic and guide future empirical testing.

Proposition 1: Foundation processes are positively associated with the effectiveness of operational IPQMS processes. Integrated planning and process coordination establish the requirements, roles, and communication structures needed for effective operational control (Arditi & Gunaydin, 1997; Jonker & Karapetrovic, 2004; Sahoo, 2022).

Proposition 2: The relationship between integration model type and IPQMS effectiveness is moderated by organisational context. Contingency theory suggests that management system effectiveness depends on fit between system design, environmental uncertainty, regulatory pressure, and organisational maturity (Donaldson, 2001; Gianni & Gotzamani, 2015).

Proposition 3: The seven critical processes are positively interdependent. Improvements in process mapping, monitoring, and learning are expected to strengthen other processes because integrated systems depend on feedback, coordination, and shared performance information (International Organization for Standardization, 2015; Jonker & Karapetrovic, 2004).

Proposition 4: IPQMS effectiveness increases over time as organisations learn from implementation. Foundation processes may show earlier benefits, while performance monitoring and continuous improvement benefits are likely to appear after repeated project cycles (March, 1991; de Nadae et al., 2021).

Proposition 5: Stakeholder satisfaction and engagement mediate the relationship between IPQMS implementation and project outcomes. Stakeholder management is central to construction project governance because project performance depends on communication, legitimacy, requirement alignment, and conflict reduction (Derakhshan et al., 2019; Olander & Landin, 2005; Oppong et al., 2017).

FRAMEWORK VALIDATION APPROACH

Future validation should proceed in three stages. First, exploratory case studies should examine how IPQMS processes are interpreted and implemented in real projects. Second, survey research should test the relationships among integration models, process maturity, contextual variables, and outcomes. Third, longitudinal studies should track IPQMS maturity over multiple project phases or project cycles. This staged approach is appropriate because the present framework is conceptual and requires empirical testing before strong performance claims can be made.

Validation stage	Purpose	Suggested evidence
Exploratory case studies	Understand implementation mechanisms and contextual barriers.	Interviews, project documents, observation, QSHE records.
Survey testing	Test propositions across a wider population.	Likert-scale process maturity measures, outcome indicators, moderation/mediation tests.
Longitudinal studies	Assess temporal improvement and learning effects.	Repeated measures across project phases or multiple projects.

Table 2: Validation Strategy for Future Empirical Testing of the IPQMS Framework

DISCUSSION

The framework contributes to construction management literature by reframing integrated quality management as a process architecture rather than a documentation exercise. This is important because many integration initiatives fail when standards are aligned on paper but not translated into coordinated planning, operational control, performance monitoring, and learning mechanisms (Gianni & Gotzamani, 2015; Simon et al., 2012).

For practice, the framework offers a staged logic for implementation. Organisations should begin with integrated planning and process coordination, because these foundation processes define the operating conditions for quality assurance, safety integration, environmental management, monitoring, and improvement. The framework also helps practitioners avoid a one-size-fits-all approach: highly regulated projects may prioritise ISO-HLS alignment, complex infrastructure projects may emphasise QSHE integration, and mature organisations may focus on continuous improvement and performance learning (Chountalas & Lagodimos, 2025; de Nadae et al., 2021).

The framework is nevertheless subject to limitations. The evidence base remains small, and the quantitative synthesis is indicative rather than conclusive. The framework is also conceptually derived and therefore requires empirical validation before its causal assumptions can be accepted. In addition, because ISO standards evolve over time, future studies should update the framework when management system requirements, climate-change clauses, or industry practices change.

CONCLUSION

This paper developed a conceptual framework for Integrated Process Quality Management Systems (IPQMS) in construction projects. The framework integrates key theoretical foundations, including ISO High-Level Structure (HLS), PDCA, process-based quality management, integrated management systems, QSHE integration, and methodological quality management. These foundations are translated into seven critical IPQMS processes organised across three tiers: foundation, operational, and enhancement processes.

The study contributes to construction quality management by consolidating fragmented IPQMS knowledge into a coherent and evidence-informed framework. Supported by systematic literature review and critical process identification, the framework demonstrates that IPQMS can strengthen process integration, quality performance, risk reduction, and stakeholder satisfaction. Theoretically, it provides a structured basis for future research by proposing relationships between integration models, critical processes, stakeholder involvement, system maturity, and project outcomes.

Practically, the framework offers construction organisations a systematic guide for implementing integrated quality management. Organisations are encouraged to prioritise foundation processes, select integration models that fit their project context, engage stakeholders, and measure performance through integrated indicators. Future research should empirically validate the framework through case studies, surveys, and longitudinal studies. Overall, the IPQMS framework provides a useful pathway for integrating quality, safety, health, and environmental requirements to improve construction project performance and support continuous improvement.

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