Article

Transforming Talent Development for Construction Bidding and Contract Management in Today's Educational Context: An Education-Centered Perspective

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Abstract: Against the backdrop of higher-quality development and strengthened whole-process governance in construction, project bidding/procurement and contract management are becoming increasingly standardized, digitalized, and risk-oriented. In parallel, education systems are accelerating reforms centered on learners, Outcome-Based Education (OBE), Project-Based Learning (PBL), and industry-education integration. This dual transformation exposes limitations in conventional teaching, which often relies on clause explanation and static case discussion: misalignment with up-to-date regulations and e-procurement practices, insufficiently authentic practice scenarios, limited cross-role collaboration training, and assessment systems overly focused on final exams rather than process evidence and professional competencies. This paper adopts an education-centered lens with bidding and contract management as the professional context. It proposes an integrated "competency-scenario-assessment" framework and practical pathways including modular curriculum redesign, longitudinal project-based practice, integration of digital toolchains, co-teaching with dual mentors from academia and industry, industry-style reviews, and multi-source assessment emphasizing compliance and risk governance. Implementation challenges-resources, data compliance, faculty development, and quality assurance-are also discussed. The study provides actionable references for universities and vocational institutions to enhance graduates' readiness for e-bidding environments and complex contract risks.

Keywords: bidding; procurement; contract management; OBE; PBL; industry-education integration; risk governance; e-procurement

Published: 25 December 2025

1. Introduction

Bidding and contract management constitute core components of the governance framework in construction projects, extending across the entire project lifecycle from requirement formulation and market competition to contract execution, performance monitoring, variation management, and dispute resolution. As a key interface between technical solutions and institutional arrangements, this field plays a decisive role in shaping project efficiency, compliance, and value realization. Its professional character is reflected not only in familiarity with laws and regulations, standard contract documents, and procedural rules, but more fundamentally in the capacity to coordinate multiple project objectives while managing uncertainty and risk [1].

In practical terms, professionals engaged in bidding and contract management must continuously balance competing objectives, including construction schedules, quality requirements, cost control, safety management, and environmental considerations. Decisions made at the bidding stage influence contractor selection, risk allocation, and incentive structures, while contractual arrangements affect project execution, change handling, and claims resolution [2]. The complexity of these interactions requires

practitioners to move beyond mechanical rule application toward informed judgement based on evidence, context, and anticipated consequences.

Recent developments in the construction industry have further elevated these requirements. The widespread adoption of electronic bidding systems, full-process consulting services, integrated delivery models such as engineering-procurement-construction and design-construction integration, as well as data-supported supervision mechanisms, has reshaped traditional workflows. Under these conditions, the industry increasingly expects professionals who not only understand contract clauses and can prepare compliant bid documents, but who also demonstrate strong capabilities in cross-party collaboration, documentation and evidence management, risk identification and control, and compliance assurance. Equally important is the ability to make decisions that are explainable and traceable, particularly in situations characterized by incomplete information and evolving project constraints.

At the same time, higher education has been undergoing sustained reform. Outcome-based education frameworks emphasize clearly articulated learning outcomes and alignment between teaching activities and assessment. Real-world, task-driven instructional approaches seek to bridge the gap between classroom learning and professional practice, while digital technologies provide new forms of support for instruction, practice, and evaluation. These developments collectively challenge traditional teaching models that prioritize content coverage over competence formation and that separate theoretical instruction from practical application.

Against this backdrop, a critical question emerges: how can talent development systems for bidding and contract management be reconstructed within contemporary educational frameworks so as to achieve systematic alignment among curriculum content, practical learning contexts, and evaluation mechanisms? Addressing this question is essential for ensuring that graduates are not only knowledgeable about rules and procedures, but also capable of applying professional judgement and contributing effectively to complex construction project environments.

2. New Changes in the Field of Bidding and Contract Management in the Current Educational Environment

The field of bidding and contract management is undergoing notable transformation under the combined influence of educational reform and industry evolution. Changes in learning environments reshape how professional competencies are cultivated, while shifts in industry practice redefine the capabilities expected of graduates. Understanding these dual changes is essential for aligning curriculum design with contemporary professional requirements [3].

2.1. Educational Environment: Ability Orientation, Contextualization, and Digitalization

Current reforms in engineering education display three interrelated characteristics. First, there is a strengthened emphasis on competency-based and outcome-oriented education. Teaching objectives are increasingly framed not in terms of "covering knowledge points," but in terms of developing verifiable and assessable competencies. For bidding and contract management courses, this implies a shift from memorization of regulations and standard clauses toward the cultivation of analytical judgement, procedural awareness, and decision-making ability under constraints.

Second, contextualized learning has gained prominence as a core instructional approach. Project-based learning, task-driven instruction, and case-based analysis place students in real or highly simulated scenarios that resemble professional practice. Within such contexts, knowledge is not treated as static information but as a resource to be applied, tested, and refined through action. For bidding and contract management education, contextualization requires learners to engage with realistic procurement processes, contract negotiation scenarios, and performance management tasks, thereby

strengthening their understanding of role coordination, responsibility boundaries, and procedural logic.

Third, educational digitalization now serves as a foundational condition rather than a supplementary tool. Online learning platforms, virtual simulations, learning analytics, and blended teaching models expand the teaching space from a single classroom to a multi-dimensional system that integrates online and offline, as well as virtual and physical, learning environments [4]. These developments enable repeated practice, data-informed feedback, and flexible learning pathways. At the same time, they demand careful instructional design to ensure that digital tools support, rather than replace, conceptual understanding and professional reasoning. Together, these changes require bidding and contract management courses to move beyond explaining systems and methods and to provide structured opportunities for students to practice evidence awareness, risk assessment, and coordinated decision-making in simulated or real procurement and contract execution processes.

2.2. Industry Background: Electronic Procurement, Compliance Supervision, and Risk Governance

Parallel to educational reform, the construction industry has experienced substantial changes in bidding and contract management practice. One prominent feature is the widespread adoption of electronic bidding and procurement systems, which has significantly increased requirements for process standardization, information accuracy, and data traceability. Digital platforms record each procedural step, reducing discretion while increasing accountability and transparency across procurement activities.

At the same time, procurement systems and regulatory supervision have become more stringent. Greater emphasis is placed on fair competition, procedural compliance, and full-process traceability, which elevates the importance of documentation, auditability, and standardized workflows. Contract management has also evolved from a focus on contract signing toward comprehensive performance management. This shift highlights dynamic coordination across change management, claims handling, payment administration, schedule control, and quality and safety oversight throughout the project lifecycle [5].

Dispute resolution practices increasingly rely on complete evidence chains and well-organized process records rather than on post hoc argumentation alone. As a result, professional competencies in bidding and contract management now exhibit a composite structure that combines rule comprehension, process execution, data and evidence management, and collaborative governance. These industry trends generate clear educational demands for interdisciplinary training, strong practical capabilities, and a high level of compliance awareness, reinforcing the need for curricula that integrate technical knowledge with procedural discipline and professional judgement.

3. Current Problems: Typical Breakpoint of Teaching of Bidding and Contract Management

Despite ongoing curriculum reform efforts, the teaching of bidding and contract management still exhibits several typical breakpoints that weaken the effectiveness of talent cultivation. These problems are manifested not only in outdated content and fragmented instructional design, but also in the limited authenticity of practice teaching and misaligned evaluation mechanisms. Together, they constrain students' ability to develop integrated professional competence.

3.1. Insufficient Content Updating and Weak System Integration

In some programs, course content continues to rely heavily on traditional paper-based bidding documents and static contract clauses. Instruction often emphasizes formal document structures and standard clauses interpretations, while systematic training

related to digital procurement platforms, structured data fields, procedural nodes, and audit priorities remains limited. As a result, students may become familiar with document formats but lack understanding of how information flows through contemporary electronic procurement systems and how compliance and traceability are ensured in practice.

In addition, although bidding and contract management courses are typically offered alongside subjects such as engineering economics, project management, and legal regulations, they are often taught in parallel rather than in an integrated manner. The absence of a shared project framework prevents students from connecting knowledge across courses. Consequently, learners may find it difficult to form a holistic understanding of the professional workflow that links procurement decision-making, contract strategy formulation, performance control, and risk management. This fragmentation weakens their ability to reason across stages and to anticipate the downstream implications of early-stage decisions.

3.2. Insufficient Authenticity of Practice Teaching and Absence of Role Synergy

Practical teaching in bidding and contract management frequently remains limited to isolated tasks, such as preparing tender documents or conducting single-case analyses. These activities, while useful for introducing basic skills, do not adequately reflect the complexity of real professional practice. Comprehensive simulations covering the full process-from prequalification, clarification meetings, and bid submission to bid evaluation, contract negotiation, performance monitoring, and dispute resolution-are rarely implemented in a coherent and continuous manner.

Moreover, the multi-stakeholder collaboration that characterizes real-world bidding and contract management is seldom represented in classroom settings. Interactions among owners, tendering agencies, bidders, evaluation experts, supervisors or consultants, cost engineers, and legal personnel are often simplified or omitted. Without exposure to these role interactions, students have limited opportunities to develop competencies in communication, negotiation, coordination, and collaborative governance. As a result, graduates may possess technical knowledge but lack the interpersonal and organizational skills required to operate effectively in complex project environments.

3.3. Evaluation Systems Emphasizing Summative Assessment over Process Evidence and Professional Qualities

Bidding and contract management is inherently process-oriented, and the quality of professional performance is often reflected in the organization of evidence, the rigor of risk argumentation, the completeness of process documentation, and the effectiveness of communication and collaboration. However, when evaluation systems rely primarily on closed-book final examinations, these dimensions are difficult to assess in a meaningful way.

Under such assessment regimes, students tend to narrow their learning objectives to memorizing clauses, reproducing procedural steps, or applying standard templates. Important professional qualities, including compliance awareness, ethical judgement, risk anticipation, and traceable decision expression, receive insufficient attention. The lack of process-based and formative assessment reduces incentives for students to engage in reflective learning and iterative improvement, thereby limiting the development of competencies that are critical for real-world bidding and contract management practice.

4. Theoretical Framework: Constructing an Integrated Training Model of "Ability-Situation-Evaluation"

To bridge the educational environment with industry evolution, this paper proposes an integrated "Competency-Situation-Evaluation" training model: (1) Competency Dimension: Centered on job competencies, it develops core capabilities including rule

comprehension and compliance, procurement planning and documentation, review logic and data presentation, contract strategy and performance control, risk and dispute resolution, as well as communication, collaboration, and professional ethics; (2) Situation Dimension: Using real or highly simulated engineering projects as platforms, it embeds competency requirements into complete process task chains; (3) Evaluation Dimension: Evidence-based, it establishes a combined formative and summative evaluation system involving multi-party participation from instructors, peers, and industry professionals, with traceability achieved through learning portfolios.

5. Transformation Path and Teaching Design: Training Program for Electronic Procurement and Full Process Performance

5.1. Modular Reconstruction of Curriculum: From Knowledge Terms to Competency Matrix

It is recommended to restructure course content into competency-based modules aligned with graduation requirements: ① Institutional and Contractual Framework (legal framework for bidding and tendering, regulatory rules, integrity and professional ethics); ② Procurement Planning Module (selection of procurement methods, qualification criteria, bid evaluation design and risk assessment); ③ Document Preparation Module (tender document structure, bill of quantities and technical specifications, bid response strategies and pricing logic); ④ Evaluation and Awarding Module (compliance review, scoring logic, anomaly identification and evaluation records); ⑤ Contract and Performance Module (contract condition systems, payment/changes/claims/schedule management, performance documentation and evidence management); ⑥ Dispute Resolution Module (dispute prevention, negotiation mediation, arbitration and litigation logic with evidence chain). The key to modularization lies in minimizing content duplication and gaps, translating learning outcomes into observable behavioral performance.

5.2. Project-Based Learning (PBL) with Integrated Process: Connecting Procurement and Contract Execution Through a Single Project

Centered on a typical construction project, this curriculum designs a cross-week and even cross-semester task chain: beginning with procurement planning and tender document preparation, progressing to bid document organization and clarification, then moving to bid evaluation simulation and contract negotiation, and finally extending to change management, certification, payment, and claim settlement during contract execution. Through phased milestones and iterative submissions, students develop systematic thinking and evidence awareness through multiple rounds of feedback. To enhance authenticity, complex scenarios can be constructed using desensitized engineering data, parametric cases, and "role-playing + situational scripts".

5.3. Integration of Digital Tool Chain: The "Tool-Process-Evidence" Synergy in Electronic Bidding and Contract Information Management

Digital integration should prioritize competency development over simplistic software operation training. A three-tier framework can be established: 1) **Tool Layer**: Electronic bidding platform workflows, bill of quantities (BQ) and quotation software, document collaboration and version control; 2) **Process Layer**: Training on clarifying questions, maintaining bid opening records, drafting contract negotiation minutes, and approving changes, all guided by platform nodes and contractual terms; 3) **Evidence Layer**: Emphasizing data traceability and document chain management, requiring every decision to include rationale, risk assessment, and approval pathways, thereby creating verifiable learning outcomes. Where feasible, virtual simulations of "bid evaluation rooms", "negotiation tables" and "performance review meetings" should be implemented to reduce costs while increasing training frequency.

5.4. Dual Mentors from University and Enterprise and Industry Review: Introducing Real Standards into Classroom

Establish a dual-mentor system integrating academic and industry experts: In-house mentors oversee curriculum design, competency benchmarks, and closed-loop evaluation, while industry mentors provide sector standards, case study libraries, and authentic review perspectives. Critical milestones incorporate industry review sessions-such as compliance audits for tender documents, bid evaluation meetings, and contract negotiation risk assessments-exposing students to real-world professional challenges. Through the iterative cycle of "review feedback → revisions → resubmission," students develop professional communication skills and continuous improvement capabilities.

5.5. Compliance and Risk Governance Embedded: Prioritize Professional Ethics, Integrity and Risk Awareness

Bidding and contract management inherently involve public interest, fair competition, and integrity risks. The course should embed compliance and professional ethics as mandatory requirements in tasks, such as identifying risks of unreasonable qualification conditions, bid rigging, bid evaluation deviations, abnormal quotations, unbalanced contract terms, and claim failures due to lack of evidence during contract performance. Students are required to provide risk lists, control measures, and compliance justifications in their proposals, which will be incorporated into the scoring criteria to integrate value judgment with technical decision-making.

5.6. Multi-dimensional Evaluation System: Ability Evaluation from "Score" to "Evidence Chain"

The recommended approach combines formative assessment, summative assessment, and multi-stakeholder evaluation. Formative assessment focuses on process evidence, including task breakdowns, version iteration records, meeting minutes, risk analysis, and data substantiation. Summative assessment evaluates final deliverables such as tender documents, bid submissions, bid evaluation reports, contract clause optimization plans, performance control reports, and defense presentations. Multi-stakeholder evaluation incorporates peer reviews and corporate mentor assessments to enhance authenticity and fairness. Additionally, a learning portfolio is established to ensure traceable competency evidence, facilitating student career showcases and institutional quality improvement （Table 1）.

Table 1. Example of mapping "competency-situation-evidence".

Core competence	Teaching Scenario/Tasks	Evaluate evidence
Procurement Planning and Compliance	Select a procurement method, set qualification conditions, and bid evaluation methods	Business plan, compliance basis, risk list and control measures
Document preparation and presentation	Prepare bidding documents and bid responses, and organize clarifications and Q&A sessions	File structure integrity, clarification records, and version comparison notes
Review logic and data awareness	Simulate bid opening to identify abnormal bids and scoring deviations	Bid evaluation report, anomaly analysis, scoring sheet, and review records
Contract Strategy and Performance Control	Contract Negotiation and Clause Optimization,Designing	Negotiation minutes, clause comparisons, performance plans, and document lists

	Performance Control Mechanism	
Claims and Dispute Resolution	Claiming Strategy under the Situation of Project Delay and Change	Claim report, evidence chain, timeline, liability analysis and alternatives

6. Difficulties in Implementation and Countermeasures

6.1. Resources and Platform: Investment Pressure of Digital and Simulation Teaching

The development of e-bidding platforms, simulation training systems, and case libraries requires dedicated investment. A phased implementation strategy is recommended: begin with 1-2 core courses or a specific discipline as pilot projects to establish reusable project scripts, assessment tools, and resource templates, then gradually extend to entire academic clusters. When selecting tools, prioritize open interfaces and scalable platforms to prevent system silos.

6.2. Data and Compliance: Boundary Governance of University-Enterprise Collaboration

Enterprise data involves trade secrets and data security. Cooperation should establish a data classification and desensitization mechanism, specifying purposes, permissions, and retention periods. In teaching, more parameterized cases and typical question banks can be used to reduce reliance on original full datasets, ensuring authenticity while lowering compliance risks.

6.3. Faculty Development: Dual Improvement of Engineering Practice Ability and Teaching Design Ability

Teachers must not only stay updated with the latest industry workflows and toolchains, but also master pedagogical approaches like Problem-Based Learning (PBL), Outcome-Based Education (OBE), and rubric-based assessment. To enhance engineering competencies, they can participate in corporate internships, co-develop curricula, jointly build case libraries, and attend industry training programs. Additionally, instructional design training should be implemented to transform practical experience into teachable and measurable resources.

7. Conclusion

Amid the convergence of evolving educational environments and industry transformations, the cultivation of talent in construction project bidding and contract management must transition from "textbook instruction + template drills" to "competency development + scenario-driven learning + evidence-based evaluation". The "competency-scenario-evaluation" integrated framework proposed in this paper emphasizes position-specific competency as the core driver, employs integrated project-based learning to deliver end-to-end procurement and contract performance training, leverages digital toolchains and industry reviews to enhance authenticity, cultivates professional ethics through compliance and risk governance, and achieves traceability and continuous improvement via diversified evaluation systems and learning portfolios. Future research should align with institutional positioning and regional industrial characteristics to further explore empirical assessments of curriculum reforms and quality assurance mechanisms.

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