

TEACHING OF ENGINEERING COST PRACTICAL TRAINING COURSES IN APPLIED UNDERGRADUATE INSTITUTIONS

HaoRan Zhou¹, MingYuan Yang¹, MiRen Rong¹, DongYang Geng^{1,2*}, JiaWei Li¹, YiZe An¹, JiaLe Wang¹, ZhuoXi Hu¹, JianMing Guo³

¹*School of Urban Geology and Engineering, Hebei GEO University, Shijiazhuang 050000, Hebei, China.*

²*Hebei Province Underground Artificial Environment Smart Development and Management Technology Innovation Center, Hebei GEO University, Shijiazhuang 050000, Hebei, China.*

³*Hebei Jike Project Management Co., Ltd., Shijiazhuang 050000, Hebei, China.*

Corresponding Author: DongYang Geng, Email: gengdongyang@hgu.edu.cn

Abstract: Addressing issues such as content disconnect from industry standards, disjointed process training, and unrealistic evaluations in engineering cost practical training at applied undergraduate institutions, this study proposes a feasible, verifiable, and sustainable curriculum reform plan. Methodologically, it adopts a competency-based approach to reconstruct five core competency pathways: blueprint interpretation and modeling, quantity takeoff and rule verification, bill of quantities and cloud-based pricing, exam paper design and bid clarification, and version control and archiving. It organizes continuous, end-to-end training through course clusters and project weeks. High-frequency practice and timely error correction are supported by integrating computer labs with online platforms, virtual simulations, and gamified feedback. A chain-of-evidence assessment system—primarily process-based with supplementary outcome evaluations—and random sampling mechanisms ensure teaching quality. Data dashboards drive monthly refinements and semester-long reviews, creating a closed-loop cycle of problem identification, countermeasure development, retrospective analysis, and iterative optimization. Expected outcomes manifest in three dimensions: - Student level: Enhanced initial job readiness and employment alignment, with verifiable and traceable training outcomes. - Faculty and curriculum level: Standardized maintenance of rule and pricing databases, enabling verifiable and scalable course quality. - Industry-academia collaboration level: Mutual validation of course outcomes against professional certifications and job standards, establishing stable external evaluation channels. This study provides a replicable implementation pathway and quantitative management tools for transforming construction cost training from fragmented skill drills to process-oriented outcome delivery.

Keywords: Construction cost training; Curriculum cluster restructuring; Project-based teaching; Evidence chain evaluation; Data-driven improvement

1 INTRODUCTION

With the development of engineering management programs in Chinese universities, an increasing number of institutions have adopted the training of applied professionals as their developmental focus, undertaking the increasingly vital task of cultivating versatile, practice-oriented talents. Traditionally, practical training in engineering cost estimation involved delivering textbook theory followed by hands-on exercises where students performed practical drills. However, traditional classroom-based training methods fail to meet the demands of today's engineering construction industry in terms of technical skills, information technology proficiency, and comprehensive professional competence [1]. This gap is particularly pronounced in highly practical disciplines such as electrical engineering and engineering cost management, where significant discrepancies persist between specialized course content and industry standards. Common issues in both classroom instruction and practical training include a disconnect between theory and practice, overly simplistic teaching approaches, and overly formalized assessment methods. These shortcomings result in students lacking sufficient job adaptability and innovative capabilities. In response to this development, applied universities are vigorously implementing teaching reforms centered on project-driven, job-oriented, and progressive competency development. By redesigning course content, upgrading practical training environments, and applying simulation technologies, classroom teaching shifts from demonstration-based imitation to task-driven approaches, and assessment focuses on process rather than outcomes. This enables cost-related courses to progress systematically through software operation training, BIM modeling, and real-world case studies. This approach builds both knowledge frameworks and professional competency structures in a progressive manner. Furthermore, establishing information platforms transforms teaching from closed to open systems, evolving from isolated training labs to integrated digital learning spaces that combine online and offline elements.

2 NECESSITY AND SIGNIFICANCE OF TEACHING REFORM IN CONSTRUCTION COST PRACTICAL TRAINING COURSES

Construction cost courses represent a highly practical discipline within engineering management curricula. Integrating content from multiple elective subjects—including architectural drawing interpretation, building architecture,

construction techniques, structural engineering, construction organization, and construction cost management—these courses require students to master foundational knowledge across these fields while developing corresponding computational skills. The practical training course in engineering cost serves as an assessment of students' ability to measure and calculate project costs.

As the construction industry undergoes structural transformation from factor-driven to digital, lean, and full-lifecycle management-driven approaches, new methodologies such as full-process engineering consulting, BIM forward design, cloud-based pricing, and cost big data are rapidly permeating entry-level positions. However, some applied undergraduate institutions persist with outdated training models—manual quantity surveying, demonstration-based instruction, and end-of-term one-time assessments—Course content often fails to align with current pricing standards, regional price data, and authentic project cases. Teaching activities remain disconnected from job requirements, creating a mismatch between what students learn and what employers need. This disconnect results in low entry-level competency and puts institutions at a disadvantage in professional accreditation and employer evaluations. Therefore, comprehensive cost estimation training courses are essential for thoroughly assessing and enhancing students' abilities in: - Reading drawings - Quantity surveying - Cost estimation

1.1 Educational Management and Quality Assurance

Current talent development demands that course objectives, teaching processes, and learning outcomes be auditable, verifiable, and traceable. Traditional outcome-based final assessments struggle to demonstrate students' competency development trajectories in critical areas such as modeling, quantity surveying, cost estimation, verification, and deliverable production. They also fail to support the process-based evaluation, continuous improvement, and closed-loop management emphasized by professional accreditation. Consequently, cost engineering training courses must reconstruct their evaluation systems. This involves incorporating learning process data, version records, standard verification, and review reports into grade composition, establishing a quality management framework centered on evidence chains. This ensures methodological alignment between curriculum reform, professional accreditation, and teaching evaluations.

2.2 Industry and Job Requirements

The entry threshold for cost positions has shifted from basic calculation skills to accurate and rapid computation, verification capability, and collaboration proficiency [2]. This demands a classroom transition from static knowledge to dynamic competency, and from fragmented operations to end-to-end processes. Practical training must be organized around medium-to-large-scale, fully-featured engineering projects, integrating: - Drawing interpretation and BIM modeling - Quantity takeoff and standard verification - Bill of quantities compilation and cloud-based pricing - Deliverable documentation and bid clarification This ensures students complete high-frequency, repeatable assignments and reflections within near-real business workflows. Through this process-oriented training, students' tool usage is consistently embedded within problem-solving contexts, preventing mere tool operation proficiency. Simultaneously, it cultivates cross-disciplinary collaboration and engineering ethics awareness, shortening the adaptation period from campus to project site [3].

2.3 Institutional Environment and External Constraints

The integration of academic credentials with vocational skill certification drives the coordinated restructuring of curricula, job roles, and assessment frameworks [4]. Deconstructing certification standards into course objectives and teaching tasks, embedding assessment criteria into routine instruction and intensive practice, and exploring approaches like certification-based assessment and integrated course-role-competition-certification systems enhance learning purposefulness and external recognition without increasing overall student workload. More importantly, the process-oriented training and standardized assessment of certificates provide schools with a competency description framework shared with industry. This transforms students' course grades, competition results, and certificate levels into more comparable signals in the job market, enhancing the social recognition of talent cultivation.

2.4 Comprehensive Significance at the Institutional Level

The reform of engineering cost training courses will drive systematic upgrades across course clusters, resource repositories, and faculty teams [5]. Courses are no longer isolated units but modular chains structured around job competencies. Teaching units—such as drawing interpretation and modeling, quantity calculation and verification, bill of quantities pricing, price database management, and compliance review—interconnect to form a teaching production line where data and documentation flow seamlessly. Supporting resources—drawing packages, quantity calculation templates, price databases, anomaly case libraries, and micro-lecture scripts—accumulate through iterative refinement, becoming sustainably updatable public assets. Instructors transition from lecturers to project coaches and quality reviewers, collaborating with enterprises in task design and assessment standard development. This fosters dual-qualified faculty teams and school-enterprise partnerships, creating a virtuous cycle among teaching, technical services, and applied research.

2.5 Student Development and Social Services

This reform enables the robust development of observable, scalable, and progressive professional competencies within the school. Students produce verifiable tangible outcomes—such as bill of quantities, pricing documents, comparative calculations, and process logs—while gaining transferable skills like problem definition, evidence organization, standardized calculation management, and collaboration through iterative practice. These deliverables directly align with employers' job specifications and process standards through outcome-based evidence, enhancing employment compatibility and post-employment retraining capacity. Concurrently, institutions undertake real-world projects and leverage platform-based tools to deliver technical services for local governments and the social construction sector, amplifying professional social impact while elevating the quality of on-campus teaching and practical platforms.

Driven by the triple pressures of industrial upgrading, institutional reform, and quality governance, reforming engineering cost training is imperative. Its value lies in a three-dimensional reconstruction of the training system, quality system, and ecosystem: using job standards to drive curriculum design, leveraging information platforms to support processes, and employing evidence chains as the driving force for evaluation and improvement. By anchoring competency standards—including practical execution, accuracy, and verifiability—in unified data calculations, comprehensive process documentation, and traceable mechanisms, applied undergraduate engineering cost talent development can truly align with field requirements, serve market needs, and maintain sustained competitiveness within a rapidly evolving industry landscape.

3 SHORTCOMINGS OF TRADITIONAL CONSTRUCTION COST TRAINING COURSES

3.1 Disconnect Between Teaching Content and Industry Standards

For a long time, traditional construction cost training has primarily relied on simple drawings and outdated case studies. Project backgrounds have mostly focused on standard brick-concrete or standard frame structures, with little exposure to high-frequency engineering elements such as basements, pile foundations, prefabricated construction, complex roofing, and MEP installations. Furthermore, textbooks matching the latest measurement and pricing standards, regional pricing, and bill of quantities rules are severely outdated. Instructional materials predominantly use reference unit prices and obsolete fee standards instead of current market rates. Consequently, students' work habits remain rooted in textbook paradigms, lacking the preparatory skills needed to adapt to and integrate with the latest standards on actual project sites. This mismatch between content and standards renders outcomes difficult to equate with actual requirements, thereby compromising comparability, verifiability, and deliverability. The bill of quantities and pricing documents generated during training rarely pass final tender evaluation and bid clarification procedures. Additionally, influenced by traditional educational concepts, instructors habitually focus on explaining principles and demonstrating operations before practical training, fostering excessive student dependence. This teaching model struggles to cultivate students' initiative and creativity.

3.2 Disconnect Between Teaching Methods and Process Training

Methodologically, traditional training remains centered on teacher demonstrations combined with manual quantity calculations and fragmented software demos, lacking comprehensive, end-to-end project-based training. Students are often fragmented into isolated skills: they can draw components in software, perform quantity takeoffs, and apply pricing, but lack continuous experience spanning from drawing interpretation and modeling to standardized quantity calculation rules, anomaly data handling, bill of quantities compilation, cloud-based pricing, and final output verification and archiving. More critically, quantity calculation rules and standards are not documented or preserved as templates. Insufficient process logging and version control make recalculation difficult and obscure accountability. Teaching organization remains dominated by demonstration-imitation approaches, with insufficient project-based tasks, real-world scenario-based problems, and interdisciplinary collaboration training. Software is treated as a button-pushing tool rather than a process-oriented platform. Students lack strategies for modeling complex work scenarios, judging standard conflicts, and resolving anomalous data, often becoming passive upon entering the workforce—capable of point operations but hesitant to make judgments.

3.3 Distorted Evaluation Mechanisms and Practical Environments

At the evaluation level, traditional approaches overemphasize end-of-term tests or final presentations, while process documentation carries insufficient weight. This fails to demonstrate competency development trajectories or quality consistency. Common practices like substituting reports for hands-on work mask critical issues such as measurement errors, omissions, and standard inconsistencies. Review processes become superficial, lacking project-audit-style sampling and retrospective corrections. In practical environments, outdated computer lab hardware/software and software versions, insufficient account authorizations, and low utilization of online resources and simulation platforms persist. Limited integration of real-world data and standardized processes from industry-academia collaborations results in a significant gap between training scenarios and actual workplace conditions. Furthermore, the unclear correspondence between courses and professional certifications, coupled with the failure to decompose certification standards and integrate them into regular teaching, results in a disconnect between courses, job roles, competitions, and certifications [6]. This teaching model struggles to cultivate students' initiative and creativity.

4 SPECIFIC PATHWAYS FOR REFORMING CONSTRUCTION COST PRACTICAL TRAINING COURSES

4.1 Goal Alignment and Curriculum System Reconstruction

This section integrates competency objectives, course cluster restructuring, class hour allocation, and resource upgrades into a unified design to avoid fragmented implementation. First, establish a competency-based learning outcomes framework guided by job competency requirements. Five core competencies—drawing interpretation and modeling, quantity takeoff and rule verification, bill of quantities and cloud-based pricing, deliverable documentation and bid clarification, and version control and archiving—are translated into verifiable learning outcomes. Examples include independently completing steel reinforcement quantity takeoff with verifiable details for projects involving underground structures and shear walls, and generating complete bills of quantities and pricing documents within regional price database parameters. Next, map certification competency points to course objectives, creating a three-way alignment checklist of course goals, job tasks, and certification requirements. This serves as the unified basis for teaching, training, and assessment.

The curriculum structure replaces standalone training courses with integrated course clusters organized in a natural input-to-output sequence: - Drawing Recognition & Modeling as the entry point - Quantity Takeoff & Verification as the transitional phase - Bill of Quantities & Pricing as the integration stage - Exam Paper Creation & Bid Clearance as the delivery phase - Version Management & Archiving running throughout the entire process. Outputs from preceding modules directly serve as inputs for subsequent ones, eliminating skill silos. The course structure adheres to a 2:3 theoretical-to-practical ratio. Key modules combine consecutive classroom sessions with computer lab work, incorporating project weeks for end-to-end closed-loop training. Within project weeks, fixed points are established for component list freeze, rule/standard consistency checks, and pricing document review, ensuring students experience the complete business chain. Resources uniformly employ equivalent real-world project drawing packages covering complex structures and MEP systems. These are complemented by regional pricing databases and quantity calculation rule templates, establishing a foundational essential resource list and unified naming conventions for easy comparison and spot checks.

4.2 Teaching Implementation and Platform Support

This section integrates project-based implementation, platform-based support, cross-course coordination, and industry-academia competition-certification synergy into an executable pathway bridging classroom learning to workplace readiness. Instruction centers on a single semester-long project, progressing through task briefs, phase reviews, issue rectifications, and final archiving and delivery [7]. Within each group, three roles are assigned: primary responsibility, review, and archiving. The primary role handles modeling, quantity takeoff, and draft checklist creation. The reviewer conducts secondary checks against rule templates and documents issues. The archivist manages version logs and evidence organization. After each review, a problem rectification completion form must be submitted, specifying the responsible party, corrective measures, and verification methods to establish traceable quality records.

Computer labs handle core process training in modeling, quantity takeoff, and pricing [8]. Online platforms manage previews, assignment submissions, process logging, and quizzes, while virtual simulations aid in complex construction reading and error reenactment [9]. Gamified training with automated scoring provides real-time accuracy rates, omission lists, and conflicting criteria locations, enabling instructors to assign targeted remedial tasks. To prevent course silos, each course is linked to at least one cross-course task. This requires directly importing component lists generated from drawing recognition and modeling into the quantity takeoff and verification modules. Verified rule templates and version logs are then passed to the bill of quantities and pricing modules. The final output is archived in a unified format, creating a complete evidence chain from data to documentation. For external collaboration, invite enterprises to co-develop training lists and scoring criteria, incorporating real-world data cases and process standards. Break down industry competition problems into classroom exercises and stage quizzes, bridging classroom learning, practical training, competitions, and internships [10]. In mature courses, adopt certification-based assessment to achieve two-way validation between course outcomes and external certifications.

4.3 Evaluation System, Documentation Archiving, and Continuous Improvement

Evaluation, documentation, and improvement are integrated into a unified quality management framework. Performance is assessed through both process and outcome metrics, with process evaluation accounting for no less than half of the total score. Process metrics cover attendance, milestone achievements, stage reviews, peer verifications, defect remediation records, etc. Outcome metrics encompass bill of quantities, pricing documents, tender materials, and bid clarification reports. Each component features explicit scoring criteria and exemplars to minimize subjective grading. All critical stages require traceable, auditable documentation. Archival packages include rule templates, naming conventions, version logs, review records, issue resolution forms, data files, and report bundles. The school implements random sampling for consistency checks, error/omission rates, and compliance verification, incorporating findings into course quality reports.

Continuous improvement is driven by data dashboards. After each teaching cycle, metrics such as accuracy rates, omission rates, inconsistency counts, review discovery rates, certification pass rates, and job-skill alignment are

generated. Components and rules with high-incidence issues are updated with case studies and templates. Class schedules and training intensity are adjusted for groups with inconsistent learning outcomes. Revised resources and rules are implemented the following semester, creating a closed-loop system of identifying problems, implementing solutions, conducting reviews, and updating processes. To ensure operational effectiveness, establish mechanisms for software version and pricing database updates, implement monthly minor iterations and semester-long major reviews, unify account authorization and computer lab configurations, dynamically assess certificate recognition levels, and promptly adjust course-to-certificate mapping ratios. This prevents excessive focus on tool operation and evaluation deviation from objectives, ensuring competency development and evidence chain construction remain central.

5 CONCLUSION

This paper addresses challenges in engineering cost training at applied undergraduate institutions by establishing a goal-oriented pathway. This framework involves: Reconstructing course clusters aligned with objectives, Implementing full-process project-based execution with platform support, Prioritizing process-based assessment while preserving evidence chains, Driving continuous improvement through data dashboards.

Transforming disorganized skill training into deliverable, verifiable, and traceable process competencies. Through five-pronged advancement—drawing interpretation and modeling, quantity and rule verification, bill of quantities and cloud-based pricing, exam creation and bid clarification, version management and archiving—coupled with process control via project week reviews, critical milestone evaluations, and closed-loop issue tracking, students' entry-level job readiness and employability become tangibly measurable. Course quality achieves verifiable, replicable standards, faculty resources undergo standardized updates, and a stable channel of industry-standard mutual validation is established. Constraints such as required software/hardware investments, teacher role redefinition, and fluctuating certification recognition are mitigated through governance rhythms of monthly minor iterations and semester-long comprehensive reviews. Institutionalized measures—including unified account permissions, standardized computer lab configurations, and continuous integration of real-world data cases—enable organizational flexibility and sustained pedagogical gains. This ultimately transforms cost engineering training from outcome-focused demonstrations to process-documented, workflow-delivered outcomes.

COMPETING INTERESTS

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REFERENCES

- [1] Hu Shiting. Research on Teaching Reform of Practical Training Courses in Engineering Cost Management Based on BIM Technology. *Journal of Hubei Open Vocational College*, 2023, 36(06): 154-156. DOI: CNKI:SUN:HBHS.0.2023-06-057.
- [2] Yin Yilin, Niu Yiqi, Ke Hong, et al. Research on the Pathway for Constructing Competency Standards for Engineering Cost Specialists: A Case Study of Tianjin University of Technology. *Higher Architectural Education*, 2023, 32(03): 63-74. DOI: CNKI:SUN:JANE.0.2023-03-008.
- [3] Feng Jianxin. Practice and Exploration of Ideological and Political Education in Engineering Cost Specialty Courses at Higher Vocational Colleges: Taking the "Engineering Cost Control" Course as an Example. *Heilongjiang Education (Theory and Practice)*, 2023(04): 38-40. DOI: CNKI:SUN:HJLL.0.2023-04-011.
- [4] Yu Hailong, Wang Yinghua, Shao Wenshuai. Teaching Reform Practice of Engineering Cost Specialty Courses in Applied Undergraduate Institutions Under the 1+X Certificate-Credential Integration Model. *Journal of Hubei Open Vocational College*, 2024, 37(21): 187-189. DOI: CNKI:SUN:HBHS.0.2024-21-081.
- [5] Xiao Qin. Teaching Reform of Engineering Cost Specialty Courses Based on Applied Talent Cultivation. *New Curriculum Research*, 2024(24): 49-51. DOI: CNKI:SUN:XKCY.0.2024-24-016.
- [6] Li Jiaman. Exploring Teaching Reform Models for Engineering Cost Courses Based on "Competition-Driven Instruction". *Shaanxi Education (Higher Education)*, 2023(10): 79-81. DOI: 10.16773/j.cnki.1002-2058.2023.10.008.
- [7] Yan Ling, Huo Shuangshuang, Deng Jiaojiao. Research on Competency-Oriented Workshop-Based Practical Teaching: A Case Study of the Engineering Cost Program at Tianjin University of Technology. *Modern Educational Technology*, 2014, 24(06): 113-121. DOI: CNKI:SUN:XJJS.0.2014-06-018.
- [8] Cao Ruijuan. Teaching Practice of Engineering Cost Courses Based on GTJ Software. *Integrated Circuit Application*, 2023, 40(07): 342-343. DOI: 10.19339/j.issn.1674-2583.2023.07.152.
- [9] Yu Fang, Jing Tao, Chen Xu. Application Research of BIM Technology in Engineering Cost Practical Training Courses. *Modern Information Technology*, 2018, 2(01): 190-192. DOI: CNKI:SUN:XDXX.0.2018-01-073.

- [10] Huang Zhen. Teaching Reform of Engineering Cost Practical Training Courses Based on Discipline Competition Incentives. *Light Industry Science and Technology*, 2018, 34(04): 146-147.