Education Insights

Review

Integrating Civil Engineering and Architecture Education in Today's Learning Environment

Xinyang He [1,*] and Xia Wang [1]

[1] Hainan Vocational University of Science and Technology, Haikou, Hainan, China
* Correspondence: Xinyang He, Hainan Vocational University of Science and Technology, Haikou, Hainan, China

Abstract: Civil engineering and architecture jointly shape the built environment, yet their educational traditions often evolve in parallel: civil engineering emphasizes analysis, safety, codes, and constructability, while architecture prioritizes spatial experience, aesthetics, and human-centered design. Contemporary industry transformation-driven by digital delivery (BIM and data platforms), low-carbon mandates, resilience requirements, prefabrication, and collaborative procurement-demands graduates who can communicate across disciplines and make integrated decisions under real constraints. Meanwhile, the educational environment is increasingly characterized by outcome-based education, project-based and studio-based learning, hybrid delivery, and evidence-oriented assessment. However, many programs still suffer from curricular silos, limited authentic collaboration, inadequate digital and sustainability integration, and assessment models that reward isolated artifacts rather than verified competence. Taking education as the primary theme and the civil-engineering-architecture interface as the contextual background, this paper proposes a Competency-Studio-Project-Evidence (CSPE) framework. The framework aligns (1) an integrated competency matrix (systems thinking; structural and building-systems literacy; digital collaboration; sustainable and resilient design; risk, safety, and ethics; and project governance), (2) a sequence of interdisciplinary studios and project lines that mirror the lifecycle of built projects, and (3) evidence-based assessment through rubrics, portfolios, multi-stakeholder juries, and reflective documentation. Practical pathways are provided for curriculum mapping, co-teaching, industry partnerships, virtual collaboration, and quality assurance. The paper aims to offer actionable guidance for universities and vocational institutions seeking to cultivate professionals capable of designing, engineering, and delivering safe, inclusive, sustainable, and data-informed buildings and infrastructure.

Keywords: civil engineering education; architecture education; interdisciplinary studio; BIM; sustainability; resilience; competency-based education; portfolio assessment

Received: 21 December 2025
Revised: 08 February 2026
Accepted: 21 February 2026
Published: 28 February 2026

1. Introduction

The built environment is a socio-technical system where architectural intent, engineering performance, construction methods, and long-term operation interact. Buildings and infrastructure must satisfy structural safety and code compliance while also supporting human comfort, accessibility, cultural meaning, and economic feasibility [1]. As a result, civil engineers and architects routinely work within the same project ecosystem, exchanging information about form, structure, building services, materials, costs, schedules, and risk. Despite this reality, their educational pathways have often remained partially segregated in curriculum logic, teaching methods, and assessment norms [2].

This separation is increasingly misaligned with contemporary demands. Industry trends such as Building Information Modeling (BIM) collaboration, integrated project delivery, low-carbon and circular material strategies, and resilience-oriented design require graduates to reason across disciplinary boundaries. Graduates must be able to translate design intent into engineering models, interpret engineering constraints in architectural language, and negotiate trade-offs among performance, cost, time, and user experience [3].

At the same time, educational systems are undergoing transformation toward outcome-based education (OBE), authentic learning, and evidence-based assessment. Students are expected to demonstrate competence through realistic tasks rather than reproduce knowledge in decontextualized examinations [4]. These shifts provide an opportunity to redesign the civil engineering-architecture interface within education, but they also introduce challenges related to coordination, resources, and academic governance [5].

This paper addresses three questions: (a) What changes in today's educational environment make interdisciplinary built-environment education more feasible and necessary? (b) What typical gaps exist between current curricula and the integrated competence demanded by practice? (c) How can institutions implement a coherent framework that links competencies, studios/projects, and evidence-oriented assessment?

2. Contemporary Educational and Industry Context

Two sets of changes-educational and industrial-are reshaping expectations for civil engineering and architecture graduates [6]. Educationally, institutions increasingly adopt learning-outcome frameworks that specify observable capabilities, encourage student-centered learning, and combine online and in-person instruction. Methodologies such as project-based learning and studio pedagogy emphasize iterative design, peer critique, and reflective documentation, creating a natural fit for interdisciplinary learning [7].

Industrially, built-environment delivery is shifting from document-based, sequential workflows to data-rich, collaborative processes. BIM-based coordination supports clash detection, quantity takeoff, constructability review, and lifecycle asset management. Sustainability agendas push projects toward energy efficiency, low-carbon materials, and transparent reporting. Resilience concerns require design that anticipates hazards such as earthquakes, flooding, extreme heat, and supply-chain disruption. Procurement models increasingly reward collaboration and early contractor involvement, which elevates the importance of communication, negotiation, and systems thinking [8].

These trends collectively imply that the education of civil engineers and architects should not only deliver disciplinary depth, but also cultivate shared literacy, collaboration competence, and the capacity to make trade-offs with explicit evidence and ethical awareness.

3. Typical Discontinuities in Current Programs

3.1. Curricular Silos and the Failure of System Integration

Most contemporary AEC (Architecture, Engineering, and Construction) programs are structured around "disciplinary silos"-isolated pedagogical blocks such as structural mechanics, material science, architectural history, and studio design. While this allows for deep dives into specific technical niches, it fails to provide a framework for sustained integration. Students often master these subjects in isolation but experience a "cognitive gap" when required to synthesize them. For instance, a student may excel in a structures exam and a design studio simultaneously, yet struggle to apply structural logic to a complex spatial form. This fragmentation results in designs that are conceptually strong but technically unfeasible, as students lack the iterative experience of converting a high-level concept into a buildable, code-compliant, and structurally sound solution [9].

3.2. Asymmetric Literacy and Cross-Disciplinary Communication Gaps

There is a profound asymmetry in the fundamental literacy of architecture and engineering students. Architecture curricula often prioritize aesthetic expression and spatial experience, providing only a qualitative understanding of load paths and structural performance [10]. Conversely, civil and structural engineering programs focus heavily on quantitative analysis and optimization, often at the expense of design thinking, user-centric requirements, or representational communication. This imbalance creates a "language barrier" in professional practice. When architects cannot speak the language of performance and engineers cannot navigate the nuances of design intent, the result is a breakdown in communication. This leads to inefficient design iterations, where engineers are relegated to "fixing" an architect's vision rather than co-creating an integrated system from the project's inception.

3.3. Inadequate Training in Professional Collaboration and Soft Skills

While the industry moves toward Integrated Project Delivery (IPD) and Building Information Modeling (BIM) workflows, teamwork in academia remains largely an implicit skill rather than a teachable competence. Real-world projects require sophisticated interdisciplinary coordination, version control, conflict resolution, and meeting facilitation. However, in most degree programs, "collaboration" is simply assigned rather than managed. Students are rarely taught how to negotiate technical trade-offs, manage shared digital models across disciplines, or document decision-making processes transparently. Without formal training in these collaborative protocols, graduates enter the workforce ill-equipped to handle the social and organizational complexities of modern construction projects, where interpersonal dynamics are just as critical as technical calculations.

3.4. Limited Authenticity of Practice and the Absence of Constraints

A significant disconnect exists between the "vacuum" of the classroom and the high-stakes environment of professional practice. Academic projects often lack the hard constraints that drive real-world innovation: strict budget ceilings, rigorous building code reviews, site-specific environmental limitations, and procurement timelines. Even internships are often observational, shielding students from the consequences of professional judgment. Without exposure to these "authentic constraints," students do not learn how to prioritize requirements or engage in meaningful trade-off analysis. The absence of iterative feedback loops-where a design must be defended against a cost consultant or a zoning official-prevents students from developing the resilience and resourcefulness required to navigate the messy realities of the built environment.

3.5. Assessment Models that Overemphasize Products over Evidence

Traditional assessment methods in design and engineering education tend to reward the "final deliverable"-the polished rendering or the completed calculation set-rather than the quality of the reasoning process. This creates a "deliverable mindset," where students prioritize the visual or numerical output over the underlying logic. Current grading rubrics often fail to evaluate "risk thinking," the ability to justify decisions with empirical data, or the evaluation of sustainability trade-offs. When the "why" is sacrificed for the "what," students lose the opportunity to develop transferable competence. They may learn how to produce a specific set of drawings for a specific critic, but they struggle to adapt their decision-making framework to new, unfamiliar contexts where the answers are not found in a textbook but must be derived from evidence-based reasoning.

4. The Competency-Studio-Project-Evidence (CSPE) Framework

To bridge the structural discontinuities identified in current pedagogical models, this paper proposes the Competency-Studio-Project-Evidence (CSPE) Framework. This framework redefines interdisciplinary integration not as an elective "add-on," but as the core structural logic of the curriculum. The CSPE model operates on the principle of "constructive alignment," ensuring that learning objectives, pedagogical environments, and assessment methods are synchronized to produce industry-ready graduates. Rather than simply adding more isolated courses, the framework reorganizes the learning process to ensure students repeatedly generate evidence of integrated decision-making under realistic constraints.

4.1. Competency: The Integrated Matrix

The foundation of the framework is the definition of a "shared DNA" between architecture and engineering. This is operationalized through an Integrated Competency Matrix (see Table 1), which identifies the essential knowledge bases and skills required across both disciplines. This matrix moves beyond narrow disciplinary silos to categorize competencies into three layers: Shared Literacy, Higher-Order Capabilities, and Professional Value Dimensions.

Table 1. Example Integrated Competency Matrix for Civil Engineering-Architecture Education.

Competency Domain	Observable Performance	Typical Evidence (Artifacts)	Assessment Focus
Systems Thinking & Problem Framing	Defines stakeholders, constraints, and success metrics; models interactions among structure, space, environment, cost, and schedule	Problem brief; stakeholder map; constraint log; success metrics	Clarity; completeness; realism
Structural & Building-Systems Literacy	Explains load paths; selects structural systems; coordinates structural and MEP implications with architectural intent	Concept structural scheme; calculation notes; coordination sketches	Correctness; transparency of assumptions
Design Communication & Representation	Communicates intent across disciplines using drawings, narratives, and prototypes; responds to critique with revisions	Design boards; iteration history; critique responses	Coherence; responsiveness; communication quality
Digital Collaboration (BIM/Coordination)	Maintains model integrity; manages versions; performs clash checks; extracts quantities for feasibility checks	BIM model; clash report; issue log; quantity takeoff	Coordination quality; traceability
Sustainability & Resilience Integration	Evaluates environmental impacts and hazard performance; justifies low-carbon and resilient strategies	Lifecycle reasoning; energy/daylight concept; hazard scenario checks	Evidence quality; trade-off reasoning
Risk, Safety, Ethics & Governance	Identifies safety and ethical risks; aligns decisions with codes and professional	Risk register; code compliance checklist with rationale; decision records	Safety mindset; ethical justification; compliance logic

responsibility; documents decisions

As defined in the matrix, the framework does not aim to erase disciplinary boundaries; instead, it clarifies how they overlap. For example, while an architecture student focuses on the spatial and qualitative logic of a structural system, an engineering student addresses its quantitative optimization and performance specifications. By establishing this common language early in the curriculum, the CSPE framework ensures that every design exercise is anchored in specific, measurable professional outcomes. This matrix serves as the pedagogical "North Star," providing a clear roadmap for what students must know and be able to do before entering the workforce.

4.2. Studio and Project Lines: The Simulated Lifecycle

The second component shifts the focus from theoretical knowledge to applied practice through a sequence of interdisciplinary Studio and Project Lines. These are designed to mirror the actual lifecycle of a built environment project-moving from initial problem framing and conceptual design to engineering feasibility, coordination, and constructability analysis. Unlike traditional studios that often exist in a vacuum, these project lines introduce "authentic constraints" such as building codes, budget ceilings, and material limitations.

In this environment, learning occurs through an iterative "critique-and-negotiation" loop. Students from different backgrounds must work together to resolve conflicts between aesthetic intent and technical necessity. This process fosters "systems thinking"-the ability to understand how a decision in one domain, such as changing a facade material, ripples through the structural and environmental performance of the entire building. By simulating the pressures of real-world practice, the framework forces students to move beyond the execution of tasks toward the management of complex, multi-stakeholder design processes.

4.3. Evidence: Authentic Assessment and Portfolios

The final pillar of the framework is a transition from product-oriented grading to Evidence-Based Assessment. In most traditional programs, students are rewarded for the visual polish of a final deliverable. In contrast, the CSPE model prioritizes the quality of the reasoning process and the empirical justification for design decisions.

Students are required to compile an "Evidence Portfolio" that documents their decision-making journey throughout the project. Key evidence includes BIM coordination logs (demonstrating how interdisciplinary clashes were resolved), risk registers (identifying potential structural or safety failures), and sustainability trade-off analyses (justifying material choices with carbon and cost data). Rubrics are specifically designed to evaluate the transparency of collaboration and the clarity of assumptions. This approach discourages a "deliverable-only" mindset, instead cultivating a habit of professional accountability. Graduates are thus equipped not only to produce high-quality work but also to provide the technical, ethical, and data-driven rationale behind it.

5. Curriculum Design Pathways

An integrated curriculum must be carefully engineered to preserve disciplinary depth while simultaneously building a shared backbone that supports professional collaboration. Rather than a random collection of courses, the curriculum should follow a progressive "Pathways" structure: Shared Foundation → Integrated Studios → Disciplinary Specialization → Interdisciplinary Capstone. This roadmap ensures that students develop a robust professional identity while gaining the fluency required to work across boundaries.

5.1. Shared Foundation: Building a Common Language

In the early stages of the curriculum, the focus should be on creating a "Shared Foundation" through joint modules. These modules cover fundamental topics such as geometry and representation, material behavior, structural principles, building physics, and life safety codes. The intent is not to dilute the specific expertise of architects or engineers, but to establish a common technical vocabulary. By learning the first principles of load paths or thermodynamics together, students reduce the "coordination friction" that often plagues interdisciplinary projects later in their careers.

5.2. Integrated Studios and Bridging Courses: Synthesizing Logic

Mid-stage learning transitions into Integrated Studios, where architectural design pedagogy is merged with engineering feasibility checkpoints. In these bridging courses, students are no longer permitted to treat "design" and "technical performance" as separate tasks. A design proposal must be accompanied by a clear structural sizing logic, an egress and accessibility strategy, and an analysis of construction sequencing. This stage trains students to see technical constraints not as obstacles to creativity, but as drivers of rigorous and responsible design.

5.3. Digital Thread: BIM as a Continuous Workflow

Building Information Modeling (BIM) and digital coordination should function as a continuous "Digital Thread" woven throughout the entire curriculum, rather than being relegated to a one-time software course. Students should practice model-based collaboration, issue tracking, and automated data extraction in every semester. As they progress, the complexity of these digital environments increases, introducing concepts of model governance, data interoperability, and the use of the model as a single source of truth for decision-making.

5.4. Interdisciplinary Capstone: Simulating Professional Delivery

The final-year Interdisciplinary Capstone serves as the ultimate simulation of professional project delivery. As shown in Table 2, this year-long sequence forces teams of architecture and engineering students to move through a complete project lifecycle. They must engage in iterative reviews with "external stakeholders"-such as industry mentors, code officials, and community representatives-to defend their trade-offs between cost, carbon footprint, safety, and user experience. The capstone ensures that the "Evidence-Based Assessment" described earlier is applied to a project of realistic scale and complexity.

Table 2. Example Interdisciplinary Studio/Project Line (One Academic Year).

Stage	Primary Tasks	Integrated Decision Points	Deliverables
Studio I: Concept & Constraints	Site analysis; stakeholder needs; concept massing; initial structural typology	Form vs. load path; daylight vs. envelope; program vs. egress	Concept package; constraints log; preliminary structural concept
Studio II: Feasibility & Coordination	Engineering feasibility; BIM coordination; code and safety review	System choice vs. cost; coordination vs. spatial quality	Coordinated BIM model; feasibility memo; code checklist
Studio III: Constructability & Delivery	Construction sequencing; temporary works thinking; materials and prefabrication strategy	Schedule vs. quality; prefabrication vs. design flexibility	Construction plan; method statement; updated model and quantities

Capstone Review: Evidence & Reflection	Evaluation of performance, carbon, risk; portfolio and defense	Trade-off justification; professional responsibility	Portfolio; presentation; reflection report

6. Teaching and Learning Methods

Interdisciplinary studios are fundamentally driven by a model of co-teaching and role-based teamwork. By pairing architecture faculty, who lead design inquiry and critique, with civil engineering faculty, who guide structural reasoning, codes, and feasibility, the curriculum ensures a holistic educational experience. Within this framework, student teams adopt explicit professional roles—such as design lead, structural lead, BIM coordinator, sustainability analyst, or documentation manager. These roles are rotated periodically to ensure that every student develops a balanced set of competencies across both the creative and technical domains of the project.

The evaluation process is further enhanced by transforming the traditional architectural critique into a system of structured feedback. By incorporating explicit engineering checkpoints—including assumption transparency, load path articulation, risk identification, and constructability narratives—the critique becomes a rigorous mechanism for integrated reasoning. This approach moves the dialogue beyond purely aesthetic evaluation, challenging students to justify their creative visions through the lens of technical viability and structural logic.

To bridge the gap between theory and practice, the curriculum emphasizes hands-on design-build projects and prototyping. The process of constructing small-scale prototypes or full-scale assemblies turns abstract coordination into a tangible learning experience. Through these physical interventions, students are exposed to the nuances of material behavior, tolerances, and sequencing challenges. This practical engagement not only improves their "constructability thinking" but also fosters a deeper respect for workmanship, precision, and site safety.

Finally, the learning environment is modernized through the use of simulation and virtual collaboration tools. Digital whiteboards, virtual design reviews, and model-based issue tracking systems allow teams to collaborate effectively across different schedules and physical locations. Furthermore, simulation-based training provides a safe yet immersive environment for students to encounter construction safety hazards and emergency scenarios. This allows them to build essential risk awareness and response competence without the physical dangers associated with a live construction site.

7. Evidence-Based Assessment and Quality Assurance

Assessment should prioritize verifiable competence in integrated decision-making. A portfolio-based approach is particularly suitable because it captures both products and reasoning. A well-designed portfolio can include: problem framing documents; design iterations; structural concept narratives; calculation notes with assumptions; BIM issue logs; code and safety checks with rationale; sustainability and resilience analyses; and reflective commentary on teamwork and ethical decisions.

Rubrics should be explicit about criteria and performance levels. Beyond correctness, rubrics can evaluate: (a) transparency of assumptions and limitations; (b) quality of trade-off reasoning; (c) coordination traceability (who decided what, when, and why); (d) safety and ethical awareness; and (e) communication effectiveness to different stakeholders.

Quality assurance should operate at two levels. At course level, instructors review evidence artifacts and provide formative feedback. At program level, institutions can maintain curriculum-to-competency mapping, collect stakeholder feedback (students, industry, external reviewers), and track outcomes such as graduate placement and performance in interdisciplinary roles. This governance cycle helps sustain reform and prevents integration from becoming dependent on individual enthusiasm.

8. Implementation Challenges and Mitigation Strategies

While the benefits of an integrated curriculum are clear, several structural and operational challenges must be addressed to ensure successful adoption. Timetabling and credit alignment represent a significant hurdle, as architecture studios and engineering courses often follow disparate academic rhythms and credit models. Institutions can mitigate these friction points by establishing shared studio blocks and synchronized assessment windows. By aligning deliverable calendars, departments can ensure that students from both disciplines are available for intensive collaboration during critical project phases without conflicting with their core disciplinary requirements.

Faculty capacity and professional development are equally critical, as co-teaching requires substantial coordination and a shared pedagogical vision. Teaching across boundaries demands that faculty move beyond their comfort zones. Institutions should support this transition through targeted training in Outcome-Based Education (OBE) mapping, rubric design, and portfolio-based assessment. Furthermore, industry immersion programs for faculty can help bridge the gap between academic theory and evolving professional practices, ensuring that the curriculum remains responsive to current industry needs.

The management of tool ecosystems and digital governance is a technical requirement that often requires significant institutional investment. Effective BIM collaboration depends on consistent software, hardware, and data standards. Universities should establish clear model governance protocols-such as naming conventions, versioning controls, and issue-tracking workflows-to prevent technical friction during team projects. Where high licensing costs create barriers, institutions can explore cloud-based virtual labs and strategic educational agreements to provide students with the scalable infrastructure necessary for modern digital collaboration.

Finally, addressing authenticity, ethics, and community impact is vital when projects involve real sites and external stakeholders. Using real-world contexts introduces ethical responsibilities, particularly when student work affects local communities. Institutions must adopt clear guidelines for stakeholder engagement, data protection, and responsible communication. This ensures that student projects do not produce unrealistic promises or unintended social harm, but instead serve as a rigorous exercise in professional accountability and social responsibility.

9. Conclusion

The integration of civil engineering and architecture education is increasingly necessary in a learning environment that values competence, authenticity, and evidence, and in an industry that demands digital collaboration, sustainability, resilience, and coordinated delivery. The proposed CSPE framework provides a practical pathway: define integrated competencies, organize learning around interdisciplinary studios and project lines, and assess competence through evidence-rich portfolios and transparent rubrics. Institutions that adopt this approach can better cultivate graduates who not only design and analyze, but also collaborate, justify trade-offs responsibly, and deliver built-environment outcomes that are safe, inclusive, sustainable, and aligned with societal needs.

References

1. P. Walker, "Teaching for quality learning at university," *Higher Education*, vol. 49, no. 4, pp. 535-538, 2005.
2. E. F. Crawley, J. Malmqvist, S. Östlund, and D. R. Brodeur, "Rethinking engineering education: The CDIO approach," *Boston, MA: Springer US*, 2007.
3. R. Sacks, C. Eastman, G. Lee, and P. Teicholz, "BIM handbook: A guide to building information modeling for owners, designers, engineers, contractors, and facility managers," *John Wiley & Sons*, 2018.
4. D. A. Kolb, "Experiential learning: Experience as the source of learning and development," *FT press*, 2014.

5. J. Acosta, J. Ubidia, M. A. Guerra, V. Guerra, and C. Gallardo, "Work in Progress: Collaborative Environments in Architecture and Civil Engineering Education-Case Study," In *2022 ASEE Annual Conference & Exposition.*, August, 2022.
6. A. M. Salama, "Spatial design education: New directions for pedagogy in architecture and beyond," *Routledge*, 2016.
7. Z. Ma, "Research on the Implementation Path of Ideological and Political Education in Civil Engineering and Architecture Major Courses from the Perspective of Critical Thinking," *Advances in Educational Technology and Psychology*, vol. 7, no. 17, p. 131, 2023.
8. M. Rieckmann, "Education for sustainable development goals: Learning objectives," *UNESCO publishing*, 2017.
9. D. A. Schön, "The reflective practitioner: How professionals think in action," *Routledge*, 2017.
10. C. B. Iturbe, L. L. Ochoa, M. J. Castello, and J. C. Pelayo, "Educating the engineer of 2020: Adapting engineering education to the new century," In *INTED2009 Proceedings*, 2009, pp. 1110-1121.