

Research on the Auxiliary Learning Mechanism of BIM (Building Information Modeling) Course in the Curriculum System of Architectural Engineering Technology Major

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Abstract: The BIM (Building Information Modeling) course is based on 3D digital technology and integrates various types of information throughout the entire life cycle of buildings. This paper explores the value of integrating various subjects into the BIM course system, seeks BIM solutions in the process of integrating theoretical teaching and practical skills in the cultivation of talents in the field of architectural engineering technology, and explores a new mechanism for evaluating the professional course system. Provide reference opinions for the cultivation of talents in the architectural engineering technology major of vocational education.

Keywords: BIM; Building Information Modeling; Architectural Engineering Technology Curriculum System; Auxiliary Learning.

1. Introduction

The major of Architectural Engineering Technology is a core discipline that aims to cultivate high-quality skilled talents with comprehensive capabilities in architectural engineering design, construction and management. Its curriculum system usually covers three major modules: "basic theory - professional technology - practical application". It includes core courses such as "Architectural Drawing and Reading", "Architectural Construction and Reading", "Architectural Mechanics", "Concrete Structures", "Construction Technology", "Architectural Surveying", and "Project Management of Construction Engineering". However, traditional course teaching has problems such as "obvious disciplinary barriers", "fragmented knowledge", and "disconnection between theory and practice". Students find it difficult to connect scattered knowledge points into a complete engineering logic chain. Especially when dealing with complex construction projects, their learning outcomes are often affected due to insufficient spatial imagination, inefficient information transmission, and weak collaborative ability.

BIM (Building Information Modeling, Building Information Model) technology is based on three-dimensional digital technology and integrates geometric information, physical information, construction information and management information throughout the entire life cycle of construction projects (design, construction, operation and maintenance) Dynamic association and visual expression of data are achieved through parametric models[1]. Integrating the BIM (Building Information Modeling) course into the curriculum system of the architectural engineering technology major is not only an inevitable requirement for the digital transformation of the industry (the Ministry of Housing and Urban-Rural Development has explicitly stated that "by 2025, the proportion of prefabricated buildings in new buildings will reach over 30%, and BIM technology

application will be fully popularized"), but also can be achieved through its "integration, visualization, and collaboration" characteristics[2]. Build a multi-dimensional and full-process auxiliary learning mechanism to help students break through the bottlenecks of traditional learning.

2. Bim Courses Serve as a "Bridge and Link": Connecting Fragmented Knowledge and Strengthening the Integration of the Knowledge System

The traditional courses of the Architectural Engineering Technology major are offered in stages according to the "disciplinary logic". Although there are intrinsic connections among the courses (for example, "Architectural Drawing and Reading" provides the knowledge basis of drawing expression for "Architectural Construction and Reading", and "Architectural Construction and Reading" clarifies the requirements of building construction for "Architectural Construction Technology"), students often view individual courses in isolation during the learning process. It is difficult to establish a "global perspective". The core value of the BIM course lies in mapping scattered course knowledge points onto the same digital carrier through the construction and application of 3D information models [3], thus forming a "model-centered" knowledge network.

2.1. Visual Mapping: Transforming Abstract Theories into Intuitive Models

For instance, when learning the "Three-View Projection Rules" of "Architectural Drawing and Reading", students often make reading errors due to the difficulty in converting the space of two-dimensional drawings. In the BIM course, students directly create 3D building models through software such as Revit, automatically generating floor plans, elevations, and sections that comply with national standards, and verifying the correctness of the projection principle in reverse.

This reverse derivation process from "three dimensions to two dimensions" not only deepens the understanding of drawing rules but also visually demonstrates the "impact of design changes on the drawings of all specialties" through the dynamic adjustment of the model (such as the automatic update of relevant views after modifying the wall thickness), helping students establish the cognitive logic that "drawings are models and models are engineering entities".

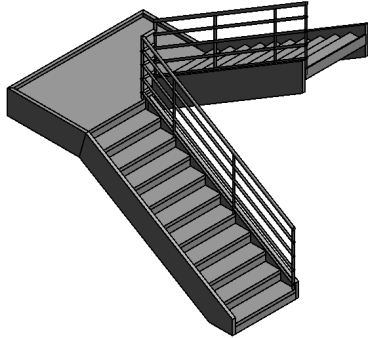


Figure 1. Three-dimensional information model of the staircase

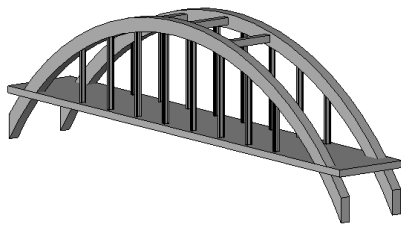


Figure 2. Three-dimensional information model of the arch bridge

For instance, the course "Building Construction and Drawing Recognition" involves the design and connection relationships of components such as foundations, walls, doors and Windows, floor slabs, and stairs. In traditional teaching, it relies on detailed two-dimensional node drawings for explanation, making it difficult for students to understand the spatial overlap logic between components. The BIM course directly builds building models through parametric component libraries (such as prefabricated stairs and prefabricated exterior walls). Students can "disassemble" any component to view the internal structure (such as the arrangement of steel bars at beam-column joints and the stacking sequence of waterproof layers), and even simulate the walking path of a person inside the building through the roaming function, intuitively feeling the impact of structural design on the usage function. This "what you see is what you get" learning approach transforms abstract construction principles into interactive three-dimensional scenes, significantly enhancing the efficiency of knowledge internalization.

2.2. Parametric Association: Revealing the Logical Linkage of Knowledge Across Courses

The core feature of the BIM model is "parameter-driven". For instance, when the cross-sectional dimensions of a certain beam are modified (from 300mm in width to 400mm), the associated data such as the amount of concrete used, the area of the formwork, and the load transfer path will be automatically updated. And it is simultaneously reflected in the structural calculation book of the "Building Structure and Drawing Recognition" course, the formwork erection plan of

the "Building Construction Technology" course, and the material list of the "Building Engineering Measurement and Valuation" course. This mechanism of "one modification, global response" enables students to clearly recognize that any design change in any link of construction engineering (such as structural selection, material replacement) will trigger a chain reaction, and further understand that "each professional course does not exist in isolation but is an organic whole that works collaboratively around the engineering goal."

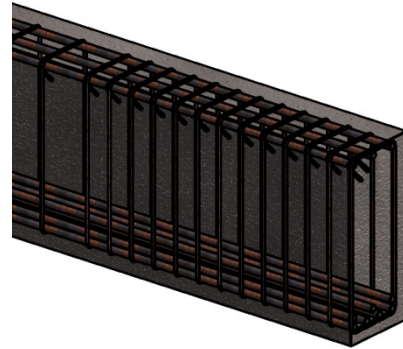


Figure 3. Solid rendering model of beam reinforcement.

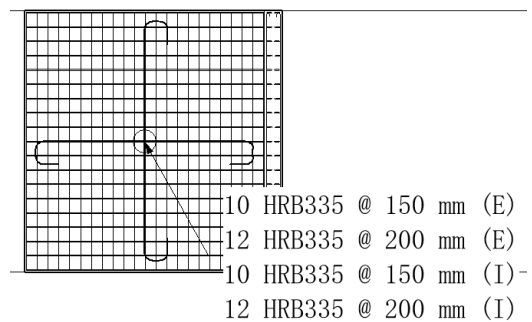


Figure 4. Three-dimensional planar model of shear wall reinforcement

Take the comprehensive case of "Frame Structure Residential Design" as an example: In the BIM course, students need to first determine the cross-sectional dimensions of beams and columns based on the force analysis in "Building Mechanics", then plan the room division according to the functional layout in "Building Construction and Drawing", and finally select the appropriate formwork support system through "Building Construction Technology". All decisions must be verified in the same model (for example, if the beam height is too high, it may lead to insufficient indoor clear height, and the structural plan needs to be adjusted). This closed-loop learning process of "design - verification - optimization" helps students break the "single-course thinking pattern" and establish a systematic knowledge framework of "overall planning and local optimization".

3. Bim Courses as "Practical Carriers": Bridging the Gap Between Theory and Application, and Enhancing the Ability to Solve Engineering Problems

The training objective of the Architectural Engineering Technology major is to cultivate compound talents who "understand design, excel in construction, and are capable of management". However, in the traditional curriculum system,

there is often a "time lag" and "scene disconnection" between theoretical teaching (such as the derivation of architectural mechanics formulas and the explanation of construction technology principles) and practical teaching (such as on-site internships and course design). It is difficult for students to directly apply what they have learned in class to the complex situations of real projects. The BIM course embeds theoretical knowledge into the solution process of specific engineering problems by building a "virtual engineering environment", providing students with a practical platform for "safe trial and error and repeated iteration".

3.1. Virtual Simulation: Expose and Solve Potential Engineering Problems in Advance

In traditional construction technology courses, students can only understand engineering accidents such as "collapse of high formwork support systems" and "pipeline collisions leading to rework" through case analysis, lacking intuitive cognition [4]. In the BIM course, students can conduct "construction simulation" and "collision detection" through software such as Navisworks. For instance, when simulating the concrete pouring process of a certain high-rise building, the software can automatically calculate the load distribution of the formwork support system based on the model. If the parameter Settings are unreasonable (such as excessive spacing between vertical rods), the system will directly prompt the risk of "insufficient bearing capacity". When conducting the comprehensive layout of mechanical and electrical pipelines, the BIM model can quickly detect the spatial conflict positions between air ducts and water pipes, as well as electrical pipelines (such as a 200mm overlap between an air duct and a fire sprinkler pipe at a certain point), and generate an optimization and adjustment plan.

This "proactive risk prediction" mechanism enables students not only to master "how to do it" (the construction process steps), but also to have a deeper understanding of "why to do it this way" (the safety and economic logic behind it). For instance, when students were simulating the masonry construction of a certain residential building, they found through the BIM model that "there were no reserved positions for structural columns on both sides of the door and window openings". If the construction was carried out in the traditional way, it would be necessary to drill walls and plant bars in the later stage, which not only affected the quality but also increased the cost. By adjusting the masonry brick arrangement scheme in the model (synchronizing the design of structural columns and walls), not only the seismic requirements of the structure were met, but also the later rework was reduced. Such practices enable students to truly experience the engineering thinking of "theory guiding practice and practice nourishing theory".

3.2. Collaborative Work: Cultivate the Awareness of Teamwork and Full-Process Management

Construction engineering is a typical multi-disciplinary collaborative project (architecture, structure, water supply and drainage, electrical and other specialties need to be advanced simultaneously), but in traditional courses, the contents of each specialty are taught separately, and students lack the experience of cross-disciplinary collaboration. The BIM course simulates the collaborative workflow of real

projects through the "multi-disciplinary model integration" function (such as integrating the wall models of the architecture major, the beam, slab and column models of the structural major, and the pipeline models of the mechanical and electrical major on the same platform). Students are grouped to play different professional roles (such as architects, structural engineers, and construction workers), and complete their respective tasks in the shared model. And through functions such as "collision check", "progress simulation", and "Engineering quantity statistics", real-time communication and coordination are carried out[5].

For instance, in a certain teaching case, students majoring in architecture designed an arc-shaped facade, but students majoring in structural engineering found during the modeling process that "the height of the beam section in the arc-shaped area was too large, affecting the interior space effect." Through the instant messaging and version management functions of the BIM platform, the two groups of students jointly adjusted the plan (changing the arc-shaped beams to variable cross-section beams and optimizing the decorative lines on the building's exterior walls), and ultimately met the architectural aesthetic requirements while ensuring structural safety. This kind of "model-based collaborative work" not only trains students' professional skills, but also cultivates their teamwork ability of "putting themselves in others' shoes, sharing information and taking responsibility together", which is precisely the core quality that future construction engineering technicians must possess.

4. Bim Courses As "Evaluation Tools": Dynamic Feedback on Learning Outcomes and Optimization of Teaching Strategies

Traditional course evaluation mainly relies on "paper-based tests" (theoretical knowledge) and "course design drawings" (practical achievements), and there are problems such as "emphasizing results over processes" and "single evaluation dimensions" (for example, it is unable to quantify students' spatial imagination ability and collaborative communication ability). The BIM course provides multi-dimensional learning feedback for teachers and students by recording the operation data of students during the process of model creation, parameter adjustment, and problem-solving (such as the number of modifications, collision detection pass rate, and model fineness), and combining process evaluation with result evaluation.

4.1. Process Data Tracking: Accurately Identify Weak Points in Learning

BIM software (such as Revit and Glodon BIM5D) can automatically record students' operation logs. For example, in the "Building Model construction" task, the system will count the creation time of basic components such as "walls, columns, and beams" by students and the number of parameter input errors. In the "Collision Detection" task, record the types of conflicts discovered by students (structure-mechanical and electrical conflicts account for 60%, building-mechanical and electrical conflicts account for 30%) and their resolution efficiency. By analyzing these data, teachers can accurately identify students' weak points (such as a student's insufficient understanding of the logic of structural force, resulting in an unreasonable design of beam sections; a student's lack of construction experience and failure to

recognize the conflict risks of pipeline pre-buried positions), and then adjust the teaching focus (such as adding special training on "structural-construction collaborative design").

4.2. Visualization of Model Outcomes: Visually Present the Growth Trajectory of Capabilities

Unlike traditional course designs that only require the submission of two-dimensional drawings, BIM courses require students to submit a complete digital outcome that includes "three-dimensional models + bill of quantities + construction progress simulation + operation and maintenance information". Teachers can visually assess the improvement process of students from "basic modeling ability" to "comprehensive application ability" by comparing their models at different stages (for example, the initial model only contains basic geometric information, while the later model integrates material properties, construction process parameters, and equipment operation and maintenance data). For instance, a student's residential model created at the beginning of the course could only meet the "appearance expression", but in the later stage of the course, they were able to generate a "concrete usage statistics table", "masonry brick layout diagram", and "5D construction schedule plan (including cost and resource allocation)" based on the model, and use Navisworks to simulate the flow construction process of "main structure - secondary structure - decoration project". This "visible growth trajectory" not only enhances students' sense of achievement in learning, but also provides a basis for teachers to adjust the teaching pace (such as introducing 5D-BIM applications in advance).

5. Conclusion

The BIM (Building Information Modeling) course does not exist in isolation within the curriculum system of the Architectural Engineering Technology major. Instead, it has established an auxiliary learning system centered on models and oriented towards capabilities through three major mechanisms: "knowledge integration bridge", "practical application carrier", and "dynamic evaluation tool". It not only addresses the pain points in traditional courses such as "fragmented knowledge", "disconnection between theory and practice", and "weak collaborative ability", but also conforms

to the trend of digital transformation in the construction industry, cultivating students' comprehensive qualities of "understanding design, being proficient in construction, capable of management, and able to innovate". In the future, with the deep integration of BIM technology with the Internet of Things and big data (such as CIM urban information model and smart construction site management), the role of BIM courses in the professional curriculum system will be further strengthened, becoming a key engine for promoting the high-quality development of architectural engineering technology professional education.

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References

- [1] Liu Zhen. "Construction of the Curriculum System for Higher Vocational Architectural Engineering Technology Major: Based on the Background of Internet +BIM", *Journal of Liaoning Higher Vocational Education*, 2019 (3) : 60-63.
- [2] Zhu Jing, Zhang Yongqiang "Analysis on the Reform Measures of the Curriculum System for the Higher Vocational Construction Engineering Technology Major ", *Vocational Education Science and Technology*, 2021 (33) : 129-130.
- [3] Liu Zhen. "Research on the Innovation of Higher Vocational Education Curriculum System under the Background of 1+X Certificate: Taking the Architectural Engineering Technology Major as an Example ", *Journal of Liaoning Higher Vocational Education*, 2024 (4) : 1-5.
- [4] Guo Yu. "Research on the Reconstruction of the Curriculum System of Pilot Specialties Implementing the "1+X" Certificate System: Taking the Architectural Engineering Technology Specialty as an Example", *Science & Technology and Innovation*, 2021, (22) : 153-156.
- [5] Li Haizong, Fei Fanke. "Research on the Innovation and Entrepreneurship Curriculum System of Higher Vocational Colleges: Taking the Architectural Engineering Technology Major as an Example ", *Architecture and Culture*, 2022 (06) : 13-15.