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# Integration of International Vision: Research on New Intelligent Multi-Projection Method Conversion and Its Combination with Teaching

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**Abstract:** Engineering drawings serve as a universal technical language for international engineering collaboration. In China, drafting courses primarily focus on the first-angle projection method as stipulated by national standards, and the lack of instruction in third-angle projection has resulted in students' weak international technical communication skills. This study, supported by the New Intelligent Multi-Projection Conversion Aligned with International Standards (X202510742180), clarifies the necessity of teaching third-angle projection. It proposes a teaching reform plan that integrates modern information technology. By constructing a 3D resource library to compare the two projection methods, developing AR interactive tools, designing gamified training modules, and implementing digital formative assessment, this study transforms abstract knowledge of projection into an intuitive learning experience. It addresses issues such as students' limited spatial imagination and low motivation to learn, providing practical insights and implementation pathways for the internationalization of engineering drawing courses.

**Keywords:** Architectural engineering drawing; First-angle projection; Third-angle projection; International perspective; Teaching improvement

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## 1. Introduction

Driven by globalization and the digital transformation of the construction industry, China's construction sector is participating in international competition with unprecedented depth and breadth. From Belt and Road infrastructure projects to multinational design cooperation and overseas engineering consulting, Chinese architectural engineers must carry out seamless technical collaboration with global peers. In this context, engineering drawings, as the most fundamental technical medium in design, construction, and management, directly determine the efficiency and quality of international cooperation through their standardization.

The International Organization for Standardization (ISO) and major construction markets, including the United States, Japan, and Europe, adopt third-angle projection as the fundamental method for engineering drawings [1]. This system has become the universal technical language of global engineering. In contrast, Chinese national standards such as the Unified Standard for Architectural Drawing (GB/T 50001) require first-angle projection [2]. This difference is not only a technical rule variation but also reflects deeper divergences in engineering thinking and expression habits between the East and the West.

At present, the teaching of Engineering Drawing in Chinese universities is seriously inconsistent with international demands. Most universities focus only on first-angle projection, while third-angle projection is merely mentioned briefly, lacking systematic theory, comparative analysis, and practical training. Graduates usually need to spend much time re-learning third-angle projection at work, and may even misread drawings, reducing work efficiency and engineering quality.

From an educational research perspective, this gap reveals a structural contradiction between engineering education and industry needs. Relevant studies show that architecture-related curricula lag behind industrial development, especially in digital technology and alignment with international standards. Students master basic drafting skills but cannot adapt to diverse international engineering environments. This problem appears in freshman foundational courses, when students fail to develop an open mindset compatible with both domestic and international standards.

Against this background, this undergraduate innovation project focuses on practical problems in third-angle projection teaching. Instead of developing complex commercial software, it uses existing digital tools to design a teaching scheme that fits freshmen's cognition and can be integrated into the current curriculum. By transforming research results into practical teaching resources, this study promotes the internationalization of architectural drawing education and better prepares students for global engineering competition [3].

## 2. Core differences between first-angle and third-angle projection and their educational value

The essential difference between first-angle and third-angle projection lies in the projection system structure, leading to divergent view layout logic and cognitive modes. Clarifying these differences is the basis for third-angle teaching and projection conversion [4]. Mastering third-angle projection is significant for cultivating students' international engineering literacy.

### 2.1. Fundamental differences and cognitive characteristics of the two projection systems

In the spatial projection system of engineering drawing, three projection planes (front V, horizontal H, profile W) divide space into eight quadrants (I–VIII) with origin O as the center (**Figure 1**).

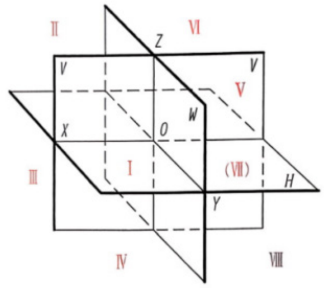


**Figure 1.** The formation of eight octants.

The fundamental difference comes from geometric structure, resulting in an opposite view layout. From cognitive psychology, the two methods represent distinct spatial thinking modes.

First-angle projection (European method, E-method) follows observer–object–plane. The object is inside a transparent box; the observer is outside, with sight passing through the object to the plane. After unfolding, the left view is on the right of the front view, and the top view is below, conforming to intuitive cognition [5].

Third-angle projection (American method, A-method) follows observer–plane–object. The plane lies between the observer and the object; sight passes through the plane to the object. After unfolding, the left view is on the left of the front view, and the top view is above.

From cognitive load theory, the main difficulty is reconstructing the established spatial framework, which easily causes cognitive conflict. Without proper resolution, it reduces learning efficiency and understanding depth.

To further clarify the spatial positional relationship between the observer, the object, and the projection planes in the two projection systems, **Figure 2** shows a comparative schematic diagram of the first-angle and third-angle projection principles. It intuitively presents the different observation logic and view generation mechanisms, making the theoretical content easier for students to understand and master.

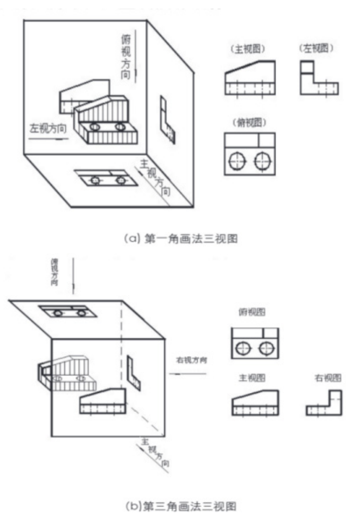


**Figure 2.** Comparison of first-angle projection and third-angle projection in orthographic views.

## 2.2. Case analysis of first-angle and third-angle projection

Two typical cases, combined with the view layout and practical architectural drawings, are analyzed to clarify the conversion logic for teaching reference.

(1) Case 1 Orientation comparison of six views under two projection methods

In first-angle projection, six views are generated: front view A (east to west), rear view F (west to east), left view D (north to south), right view C (south to north), top view B (top to bottom), bottom view E (bottom to top) (**Figure 3**). In third-angle projection, rules are nearly reversed: front and rear views remain unchanged; left and right views are swapped; top and bottom views are swapped (**Figure 4**).

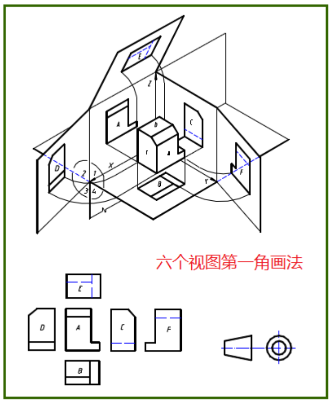


**Figure 3.** First-angle projection.

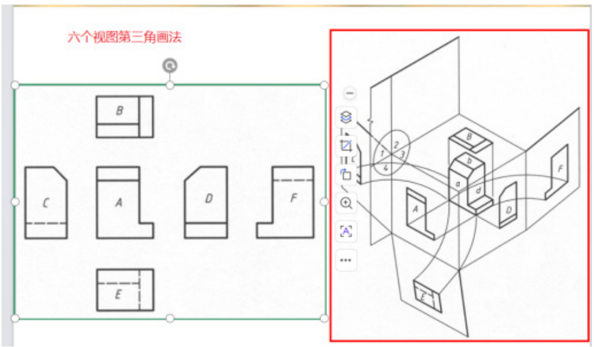


**Figure 4.** Third-angle projection.

Summary: The front and rear views remain unchanged in position and shape; the left–right and top–bottom views retain their shapes but swap positions (**Table 1**).

**Table 1.** Position comparison of views between first-angle and third-angle projection

| View in first-angle projection | Position change relative to the front view |
|---|---|
| Front view | Center, unchanged |
| Left view | Left in first-angle → right in third-angle |
| Right view | Right in first-angle → left in third-angle |
| Top view | Below in first-angle → above in third-angle |
| Bottom view | Above in first-angle → below in third-angle |
| Rear view | Rear, unchanged |

(2) Case 2 Projection conversion from first-angle to third-angle based on actual drawings

Taking an actual building drawing as an example, the core logic lies in the conversion from observer coordinates to building coordinates. In first-angle projection, the east elevation refers to the view observed from east to west, while in third-angle projection, it represents the drawing of the eastern wall. The drawing name remains the same, and only the layout position is adjusted in accordance with third-angle standards (**Figure 5**) [6].

**Figure 5.** The east wall of the building.

### 2.3. Multiple educational values of mastering the third-angle projection

Teaching the third-angle projection method has significance beyond technical instruction:

It is foundational for international engineering literacy. With the widespread application of BIM and the deepening of global collaboration, engineers must be able to read foreign technical documents proficiently; it is a basic skill for international projects. Comparison and conversion deepen understanding of projective geometry, grasping mathematical principles and spatial laws to improve engineering thinking and spatial imagination [7]. It is a cross-cultural technical communication practice, helping students understand Western systems and adapt to diverse environments. Solving conversion problems trains spatial thinking, logical reasoning, and innovation, enhancing comprehensive ability for complex engineering problems [8].

## 3. Teaching improvement scheme for third-angle projection

Considering freshmen's weak spatial imagination and basic knowledge but strong digital ability, a practical and replicable scheme is proposed from four dimensions: resources, tools, training, and assessment, forming a complete teaching ecosystem [9].

### 3.1. Construction of a hierarchical 3D digital teaching resource library

A hierarchical 3D digital resource library visualizes abstract projection knowledge:

(1) Primary module: basic geometries and simple components for principles

(2) Intermediate module: typical joints and units for comprehensive reading

(3) Advanced module: complete building cases for real scenarios

Models use AutoCAD and SketchUp, with comparison animations showing 3D-to-2D generation. The library is modular, online accessible, and downloadable [10].

### 3.2. Development of an interactive AR-assisted learning tool

AR provides a new approach with core functions:

(1) Drawing-model recognition: scanning third-angle drawings displays corresponding 3D models in real time.

(2) Multi-level exploration: basic (rotation, scaling); advanced (perspective); expert (disassembly).
(3) BIM integration: compatible with Revit, CAD, free switching between projections.
(4) Intelligent prompts: clicking parts highlights models with explanations.
It is a mobile app for mainstream devices, with a teacher management background [11].

### 3.3. Design of a gamified projection conversion training system

Gamification improves motivation with three modules:
(1) Projection Detective: identify projection types and resolve conflicts in scenarios.
(2) View Puzzle: reassemble scattered view segments into correct expressions.
(3) Quick Recognition: judge types under time limits with scores and leaderboards.
Points, badges, and progressive difficulty enhance achievement and proficiency [12].

### 3.4. Implementation of a digital formative assessment system

A digital formative assessment replaces traditional outcome evaluation [13]:
(1) Digital portfolio: records AR interactions, training scores, and works.
(2) AI evaluation: detects errors and gives revision suggestions.
(3) Multi-criteria assessment: balances accuracy, progress, exploration, and innovation.
(4) Peer review: mutual evaluation under teacher guidance.

## 4. Conclusion

This study constructs a 3D digital resource library, an AR interactive tool, a gamified training system, and a digital formative assessment, forming a complete teaching ecosystem. It overcomes abstract difficulties in third-angle teaching, builds a bridge between 2D drawings and 3D space, and improves teaching interest and effectiveness. The scheme adapts to freshmen and ordinary university conditions, with simple tools, controllable cost, and strong popularization value, helping students build a knowledge system compatible with national and international requirements. In the future, we will follow digital and international trends of the construction industry, optimize content and methods, and promote the in-depth international reform of architectural drafting education to cultivate new-era architectural engineers with a global vision.

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## Disclosure statement

The authors declare no conflict of interest.

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