

# A Preliminary Study of the Training of Drawing Skills for Civil Engineering Majors in Higher Vocational Colleges Under the “1+X” System

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**Abstract:** Architectural engineering drawing skills are one of the important standards of talent ability that construction enterprises pay attention to. Under the “1+X” system, as a pilot college of “1+X” in higher vocational education, and according to the standards of “Vocational Skill Level Certificate in Architectural Engineering Drawing,” a channel to improve students’ core working skills is explored through the implementation of the teaching reform.

**Keywords:** “1+X” system; Integration of post, class, and certificate; Course group; Digital resource library

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## 1. Introduction

The “National Vocational Education Reform Implementation Plan” has proposed to launch a pilot system of “academic certificate + several vocational skill level certificates” in vocational colleges and applied undergraduate colleges and universities, encouraging vocational college students to actively pursue multiple vocations, while obtaining multi-category vocational skill level certificates <sup>[1]</sup>. In April 2019, four ministries and commissions including the Ministry of Education jointly issued the “Pilot Plan for Implementing the ‘Academic Certificate + Several Vocational Skill Level Certificates’ System in Colleges and Universities,” marking the official implementation of the “1+X” certificate pilot program. Among them, the “Vocational Skill Level Certificate in Architectural Engineering Drawing” has been regarded as one of the “1+X” vocational skill level certificates by the Ministry of Education.

## 2. Significance of cultivating drawing skills in civil engineering majors in higher vocational colleges

The “1+X” system is an innovative initiative introduced by the country for the reform of higher vocational education. The certificate system is not a superposition of two or more certificates, but rather a comprehensive consideration of cultivating high-quality compound and skilled talents who can meet the dynamic needs of various industries <sup>[2]</sup>. An investigation of the job responsibilities of Building Information Modeling (BIM) modelers, architecture designers, engineering cost consultants, project managers, construction technology associates, engineering surveyors, *etc.*, in the construction market has demonstrated that construction drawing reading skills are the focus of attention. The ability to understand construction engineering drawings is an important basis for civil engineering graduates to be competent in their work. At the same time, the knowledge points in the skill standards and examination syllabus of architectural engineering drawing comprehension vocational skill level certification are closely related to

job skills. Therefore, in promoting the “1+X” initiative, higher vocational colleges should deeply integrate the educational function highlighted by “1” and the professional function highlighted by “X,” organically integrate the assessment content into the curriculum system, and ensure that the teaching standards and vocational skills standards complement one another [3].

### 3. Focus on skills training and implement curriculum teaching reform

The skill assessment standards of “Vocational Skill Level Certificate in Construction Engineering Drawing” and “Vocational Skill Level Certificate in Digital Application of Engineering Cost,” as well as the performance of students participating in the certification assessment process are analyzed.

#### 3.1. Improve the training program and re-establish talent standards

Through visits to enterprises, market research was conducted on the representative job demands of construction enterprises. The skill demand for “construction drawing reading” was the highest (Figure 1). Employees should be able to read technical specifications and standard methods on design drawings over a short period of time, understand the correlation between drawings, and find relevant standard atlas through the index symbols [4].

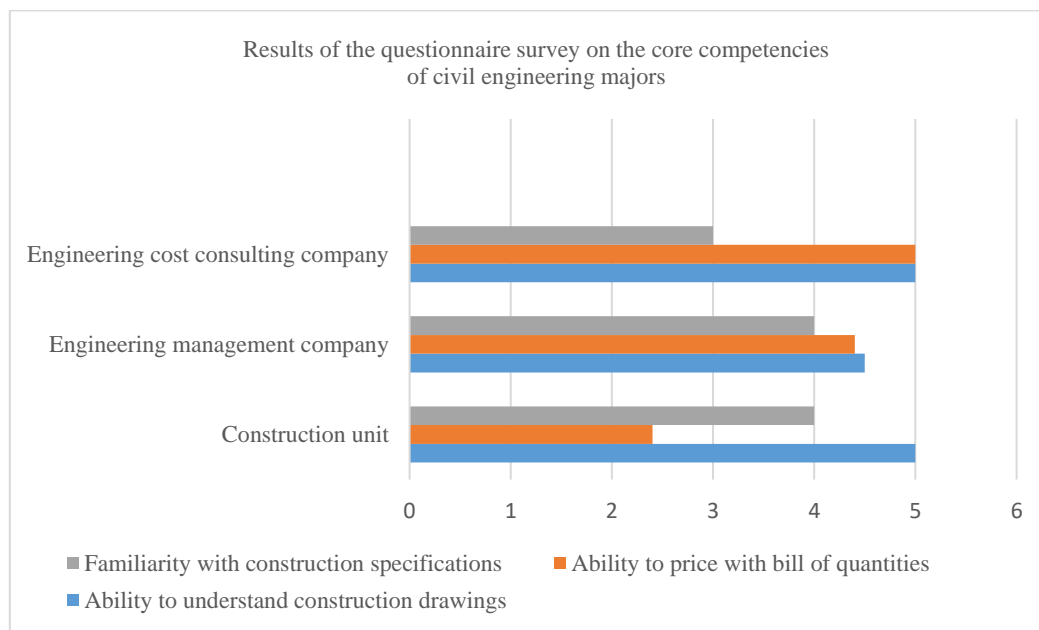


Figure 1. Construction enterprises survey on students’ core skills

In addition, in the face of the development of the digital construction market, BIM-skilled talents will be prized. However, architectural engineering drawing skills remain an important basis for their modeling capabilities. The college has revised the personnel training standards in the talent training program for civil engineering, emphasizing the description of skills for engineering cost majors: (i) the skill to draw and read construction drawings and (ii) the skill to prepare BIMs. Beginning from the goal of skills training, a four-in-one talent training model (project tasks-driven, position, class, certificate, and competition) is formulated, so as to meet the standards of talent training. Breaking through the curriculum-centered teaching model, the college established a professional learning field based on professional positions and typical project tasks, created a learning situation that integrates teaching, learning, and doing [5], combined posts and courses, replaced exams with certificates, and vigorously carried out drawing comprehension skill competitions, so as to achieve the goal of “promoting teaching and learning through competitions.”

### 3.2. Implement the integration of courses and certificates, rebuild the course system, and form course groups

The “+” sign in the “1+X” system refers to the integration of courses and certificates, not just the superposition of “1” and “X.” Therefore, the reconstruction of the course system, the establishment of course groups, the integration of the teaching content, and the achievement of an in-depth integration of job-course certificates in line with the skill standards of construction engineering drawing vocational skill level certification are inevitable. The “1+X” construction engineering drawing vocational skill level certificate examination is comprehensive and has a wide range of content, with different levels of difficulty. For students majoring in engineering cost in higher vocational colleges, due to the increasingly complex background of students and different learning bases, the cultivation of construction drawing skills cannot be achieved simply by relying on a single course. It is necessary to break down the knowledge points and integrate skill points into multiple professional courses to realize a synergistic effect.

Through research, in consideration of the actual situation of the college, the courses “Introduction to Engineering Cost,” “Understanding and Making of Architectural Engineering Drawing,” “Architectural CAD,” and “Steel Bar Leveling Method and Picture Recognition and Calculation” are combined into a course group according to the curriculum system in the talent training plan. The main idea is to cultivate students’ architectural drawing recognition skills. The courses are combined to facilitate communication and exchange between teachers in the course group. Through this, teachers are kept abreast of students’ learning progress and skills mastery, thus serving the integration of course certificates.

### 3.3. Revise the teaching standards of the course group and modularize the knowledge points

#### 3.3.1. Integrate the teaching content and modularize teaching

In the process of establishing the course group, the general course objectives are formulated, the “1+X” certification standards of construction engineering drawing professional skill level certification are fully adhered to, the key points and difficulties in teaching are summarized, and teaching modules are formed. The integration of different knowledge points from multiple courses is realized from superficial to deep, and each knowledge point is summarized into multiple independent knowledge systems. This contributes to students’ learning and improves their learning efficiency. See **Table 1** for details.

**Table 1.** “1+X” list of modular teaching design for construction engineering drawing recognition skills and documentary evidence integration

Course title	Teaching module	Key points of quality, knowledge, and ability training	“1+X” module
Introduction to Engineering Cost	(i) Preliminary understanding of building structure	(i) To be familiar with the concept of construction projects, construction procedures, and engineering categories (ii) To master the composition of building structures, types, and applications of building materials	Understand the drawing
Understanding and Making of Architectural Engineering Drawing	(i) Descriptive geometry (ii) Understanding and making construction drawings	(i) To be familiar with drafting norms, and be able to apply the principles of geometric drawing to plane figures	Understand the drawing

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Course title	Teaching module	Key points of quality, knowledge, and ability training	“1+X” module
Understanding and Making of Architectural Engineering Drawing		(ii) To be able to apply the projection principle to correctly express the three-dimensional (3D) views of complex 3D objects, such as superimposed composites and intersecting composites (iii) To master the basic theory of axonometric projection, and be able to use axonometric projection to draw axonometric drawings (iv) To master the drawing of cross-sectional diagrams, and be able to comprehensively read cross-sectional diagrams (v) To master the understanding of architectural construction drawings	
Architectural CAD	(i) Architectural CAD operation commands (ii) Architectural construction drawing and structural construction drawing	(i) To be familiar with the basic settings of the drawing environment (ii) To be able to skillfully and correctly use the drawing commands and modify the toolbar (iii) To be able to draw building plan, elevation, section, and detailed drawings as required	Make the drawing
Steel Bar Leveling Method and Picture Recognition and Calculation	(i) Understanding 16G steel bar flat method atlas (ii) Understanding construction drawings of building structures	(i) To master the structure of foundation reinforcement and the anchorage structure of column (wall) longitudinal reinforcement in the foundation (ii) To master the section size, elevation, and reinforcement structure of columns, beams, and slabs (iii) To master the section size, elevation, and reinforcement structure of the shear wall (iv) To master the section size, elevation, and reinforcement structure of stairs	Understand the drawing

### 3.4. Situational teaching of multiple courses using the same case to enhance the systematicness of skill training

In order to realize the integrity of the knowledge system and improve students' cognitive ability, the same set of architectural construction drawings should be used throughout the teaching process of the course group to complete the reading and drawing of construction drawings.

The course “Introduction to Engineering Cost” is taken as an example. For freshmen who lack professional knowledge, they should begin from the structural composition of construction projects, define the elements of construction projects, and clarify the basic procedures of project construction and the role of construction drawings in project management. In this process, various video materials, such as virtual building construction process, micro videos of construction sites, *etc.*, can be used to help students understand the construction process of architectural structures, enhance the three-dimensional (3D)

awareness of space, and lay a solid foundation for the course “Understanding and Making of Architectural Engineering Drawing.” In this process, on the one hand, students can directly perceive the working environment and objects of the major, define job responsibilities, and develop their interest in learning. On the other hand, the majority of freshman courses are public courses, and the basic knowledge of architectural structure and building materials enriches students’ knowledge structure.

The course “Understanding and Making of Architectural Engineering Drawing” is divided into two parts: (i) drawing and (ii) drawing comprehension. In the study, descriptive geometry is the focus of teaching. Students need to have good spatial imagination ability. For students who do not have strong spatial intelligence, it will be difficult for them to master descriptive geometry, which requires teachers to have strong classroom mobilization ability. Therefore, physical demonstrations and light and shadow effects are used during the teaching process to help students understand the relationship between points, lines, surfaces, and combinations, as well as projection methods from different angles, and guide students to think actively and practice. In order to realize the integration of teaching, learning, and doing, teachers can use micro-class resources to strengthen trivial knowledge points, and students can determine what they need according to the picture. At the same time, teachers can upload questions from architectural drawing comprehension competitions onto the “Architecture Cloud Class” platform and assign in-class and after-class tasks, so that students can verify and consolidate what they have learned. Through experiences in directing city-level drawing comprehension competitions, the teaching content can be adjusted in a timely manner, and targeted explanations can be given. In the learning of architectural drawing, teachers can first provide a complete set of architectural drawings to the students for them to copy and draw. By copying and drawing architectural drawings, the following requirements are met: (i) skillfully use the learning platform to view 3D models of corresponding parts from different perspectives, and understand the relationship between drawings and 3D models; (ii) be familiar with the elements of architectural construction drawings; (iii) be familiar with architectural drawing specifications.

Third, the course “Steel Bar Leveling Method and Picture Recognition and Calculation” explains the implementation method of reinforcement drawing in architectural drawing. This course plays a pivotal role in the engineering cost curriculum. It lays the foundation for the reading of architectural engineering drawings and engineering cost BIM. At the same time, this course has high requirements on the quality of teachers and is taught by experienced teachers. During the teaching process, teachers can use the BIM software to explain reinforced concrete components, such as foundation, columns, beams, slabs, stairs, and other steel structure methods; enhance students’ understanding of the reinforcement configuration specifications of reinforced concrete components through visual domains; and familiarize students to the node forms of the flat method atlas of different structural members. The addition of BIM software teaching, a new teaching method, has eased the embarrassment of “talking about stratagems on paper” in traditional teaching. Through a 3D viewing angle, students can visually observe the relationship between different components in the architectural structure, the anchoring method of steel bars, *etc.* By uploading questions obtained from architectural drawing comprehension competitions onto the “Architecture Cloud Class” platform and assigning in-class and after-class tasks, students can verify and consolidate what they have learned.

Fourth, in “Architectural CAD,” the architectural drawings copied in the course “Understanding and Making of Architectural Engineering Drawing” are used to produce electronic drawings. Students must be aware of the value of transformation between copied construction drawings and electronic construction drawings. Before class, teachers can upload learning tasks and supporting micro-lecture materials onto the “Architecture Cloud Class” platform. In class, teachers can use task-driven methods, while students are encouraged to form study groups. By analyzing problems, they can clarify the learning tasks and complete practical training tasks. In the process, each study group would transition from passive to active learning,

thus gaining learning experiences. In addition, due to the restrictions of factors, such as safety management regulations at the construction site, students cannot enter the construction site all at once for observation. Therefore, including micro videos of construction sites in the teaching process can help students understand the construction process of construction projects, clarify the principles and methods of drawing construction plans of frame columns, and improve students' enthusiasm for learning.

### 3.5. Diversified evaluation methods

The courses in the course group are offered in the first year of university. Students' sense of professional acquisition has a certain impact on subsequent professional course learning. Therefore, curriculum evaluation focuses on the evaluation of students' knowledge, skills, and professional quality. It is composed of two parts: process evaluation and result evaluation. Process evaluation is composed of three parts (teaching platform system evaluation, teacher evaluation, and self-evaluation), highlighting the diversity of evaluation, while result evaluation is based on students' written test scores and the results of the skill certification, mainly examining students' mastery of knowledge points.

## 4. Teaching effect

In promoting the "1+X" skill certification work, the core goal is to cultivate students' architectural engineering drawing skills. Through a series of teaching reforms, both teachers and students have gained a lot.

### (i) Improvement in knowledge structure

By participating in the "1+X" skill certification teacher training, professional teachers will come to understand the development trend of advanced technology in the construction field, strengthen their professional skills, and fill in the gaps in their knowledge reserve.

### (ii) Improvement in teaching ability

In the process of promoting teaching reform, the relatively comprehensive knowledge points of the course content pose a challenge to teachers. Teachers prepare lessons collectively and use the teaching platform as well as a large number of digital resources to complete the teaching content. During this process, teachers would have strengthened their communication, understood the learning situation of students, and explored more effective teaching methods.

### (iii) Improvement in teaching effect

In October 2022, 50 students from the college were involved in the "1+X" digital application of engineering cost vocational skill-level (intermediate) certification. During the training process, the students' ability to understand pictures was relatively good.

### (iv) Improvement in students' sense of professional gain

The "Certificate of Vocational Skills in Digital Application of Engineering Cost" is one of the BIM skill certifications, which requires students to have high comprehensive ability in drawing comprehension. A questionnaire survey was conducted on the 50 students involved in the skills certification. The students showed more professional self-confidence; 90% of the students felt that their understanding of architectural drawings had improved to a certain extent; 70% felt that their ability to calculate project cost had improved and that they have a clearer understanding of the calculation of the bill of quantities; 85% felt that their ability to produce structural construction drawings had improved; 80% felt that they had gained a new understanding of the atlas of steel bar flat method.

The comparison of the teaching effect of engineering cost major before and after the teaching reform is shown in **Table 2**.

**Table 2.** Comparison of teaching effect before and after the teaching reform

Components	Before teaching reform	After teaching reform
“1+X” skill certificate	2020 “1+X” Architectural Engineering Drawing Skills Certification	2022 Vocational Skill Level Certificate for Digital Application of Engineering Cost (intermediate level)
Teaching content	Independent course content	Course group modular teaching
Teaching platform	Traditional teaching	Architecture cloud class
Education resources	PowerPoint courseware	Digital resource library
Certification pass rate	65%	100%
Student satisfaction	70%	100%

## 5. Teaching reflection

In order to enhance the skill of civil engineering majors in architectural drawing comprehension, the key is to effectively integrate the knowledge points of multiple courses in the implementation of the teaching reform and construction of course groups under the “1+X” system. The integrated course content has comprehensive knowledge points and high learning intensity. Teachers use a series of digital library resources to complete their teaching tasks. Since the interests of students are not consistent in the teaching of each course, there is a contagion effect caused by poor course learning: the suppression of students’ enthusiasm results in the failure to achieve the expected learning effect, and students are prone to knowledge faults, which are not conducive to the learning of subsequent courses.

In conclusion, in the cultivation of architectural drawing comprehension skills for students majoring in civil engineering, classroom teaching should be linked to the “1+X” vocational skill-level certification system standard, using a combination of real and virtual models, as well as conceptual knowledge and practical training operations, along with the course environment. Along with practical training, online course resource platforms, offline classroom teaching, and other teaching methods can better stimulate students’ learning initiative and independent thinking ability. The cultivation of architectural engineering drawing skills is a gradual process, which requires good cooperation between teachers and students. In the current digital environment, how to use advanced teaching methods and digital resources in teaching will be another matter to be addressed for teachers.

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## Disclosure statement

The author declares no conflict of interest.

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