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Construction of the "4C" Curriculum System for Engineering Drawing in Staff Training

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Abstract: Based on an analysis of the current situation of engineering drawing training in Shengli Oilfield, this study innovatively applies the "4C" training instructional design method to the construction of the curriculum system and establishes a hierarchical engineering drawing curriculum system that meets the current enterprise training demands of Shengli Oilfield. Designed in accordance with the four steps of the 4C principle, Connections, Concepts, Concrete Practice, and Conclusions, the system follows three ideas: hierarchical and modularized curriculum content, 4C-based teaching procedures, and 4C-aligned class hour allocation. The whole system embodies the learner-centered philosophy of the 4C training design, and also provides systematic support for the implementation of the 4C classroom teaching method.

Keywords: 4C principle; Engineering drawing; Curriculum system; Training and teaching

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1. Introduction

Engineering drawing is a compulsory subject for skill grading appraisal and skill competitions of major technical types of work in Shengli Oilfield, and has a wide demand in staff training. In recent years, engineering drawing training has been confronted with prominent conflicts between work and study, reduced class hours, and uneven theoretical and practical drawing abilities among trainees. The current engineering drawing curriculum system is derived from academic education and can hardly meet the needs of training development. Therefore, it is necessary to innovate methods and develop a curriculum system adapted to the current training situation, so as to unify the grasp of key content, selection of typical examples, and innovative presentation of classroom content, thereby improving the quality of training and teaching.

2. The 4C training instructional design method

The 4C training instructional design method is a brain-friendly training approach featuring learner-led classes. It has been widely applied in education and training in China in the past decade [1]. The method consists of four steps: Connections, Concepts, Concrete Practice, and Conclusions [2]. This paper innovatively applies the 4C instructional design method to curriculum system construction to build an engineering drawing curriculum system for staff training, exploring ways to improve training effectiveness and quality under the current situation. It provides programmatic and comprehensive guidance for the teaching team to unify curriculum understanding and further explore the classroom application of the 4C teaching method.

3. Construction of the 4C engineering drawing curriculum system for staff training

The 4C teaching method originally targets only classroom teaching. To build an integrated 4C curriculum system and classroom design, we extend and innovate the ideas of the 4C method to all parts of the curriculum system, with a prominent focus on learner-centeredness and result orientation, so as to enhance training effectiveness and quality and support 4C-based classroom design. The model of the 4C-based engineering drawing curriculum system is shown in Figure 1.

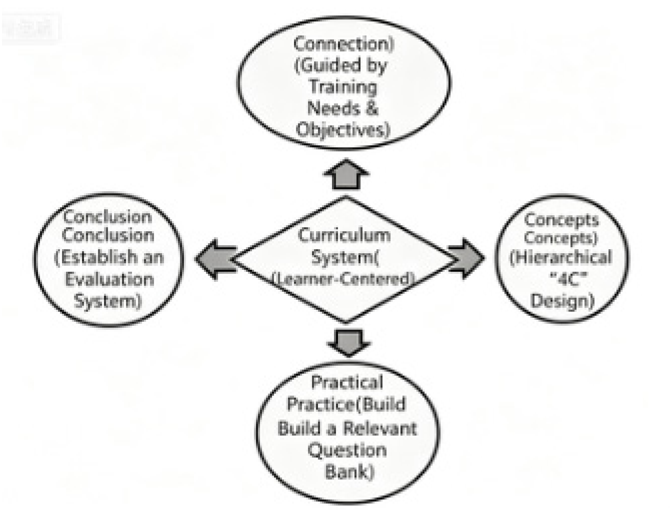

Figure 1. Model of the 4C-based engineering drawing curriculum system.

3.1. Connections

In the construction of the training curriculum system, the "Connections" stage links three aspects: training needs, the training project team, and the original curriculum system. It analyzes and summarizes the deficiencies of the current engineering drawing curriculum system and the direction of improvement, providing a basis for the subsequent "Concepts" stage.

3.1.1. Connection with training needs

Training needs analysis is critical to the construction of the engineering drawing curriculum system and effective teaching. Through surveys at the organizational management, post, and trainee levels, it is found that achieving high scores in skill grading exams and skill competitions is the main training demand.

3.1.2. Connection with the training project team

Through communication with the training project team, relevant training evaluation information is obtained, indicating that a hierarchical curriculum system is an effective way to meet different training projects and objectives.

3.1.3. Connection with the original engineering drawing curriculum system

The original curriculum system, derived from academic education, is overly theoretical, overloaded with knowledge points, teacher-dominated, and lacks sufficient effective practice time, making it unsuitable for current training requirements. Therefore, it is necessary to select course content, keep theoretical knowledge sufficient but appropriate, reflect the 4C teaching philosophy, return more training processes and time to trainees, emphasize concise explanations and extensive practice, and focus on application. This can achieve curriculum objectives while resolving the conflict between work and study.

Through “Connections”, the key principles and tasks for the subsequent curriculum system design are clarified:

(1) The curriculum system shall be consistent with the 4C classroom design philosophy, and fully support the implementation of the 4C teaching method in terms of content and hour allocation.

(2) A hierarchical curriculum system shall be established according to different training needs, with clear objectives and target trainees for each level.

(3) Hierarchical workbooks matching the curriculum system shall be compiled to support the “Concrete Practice” stage in 4C classroom design.

3.2. Concepts

“Concepts” in the 4C teaching method refer to the essential content that trainees must master in training. When applied to curriculum system construction, it is extended to the sorting, integration, and optimization of teaching modules, key and difficult knowledge points, and supporting teaching strategies.

Based on the principles and points summarized in the “Connections” stage, the training curriculum system is constructed in line with three approaches: hierarchical and modular curriculum content, 4C-based classroom teaching procedures, and 4C-aligned class hour allocation.

3.2.1. Hierarchical and modular design of curriculum content

Combined with the requirements of skill grading appraisal and skill competitions, the curriculum knowledge points are optimized and arranged as follows:

(1) Deletion of knowledge points: Remove content irrelevant or weakly related to training needs, such as assembly drawings and representations of standard fasteners except threads [3].

(2) Optional knowledge points: Set some content as optional according to training duration and needs, such as analysis of planar figures and reading of composite drawings.

(3) Integration of knowledge points: Simplify and integrate closely related knowledge, such as the projection relationships of points, lines, and planes.

(4) Special drawing practice: Emphasize skill mastery for staff training, so sufficient class hours for practice must be guaranteed.

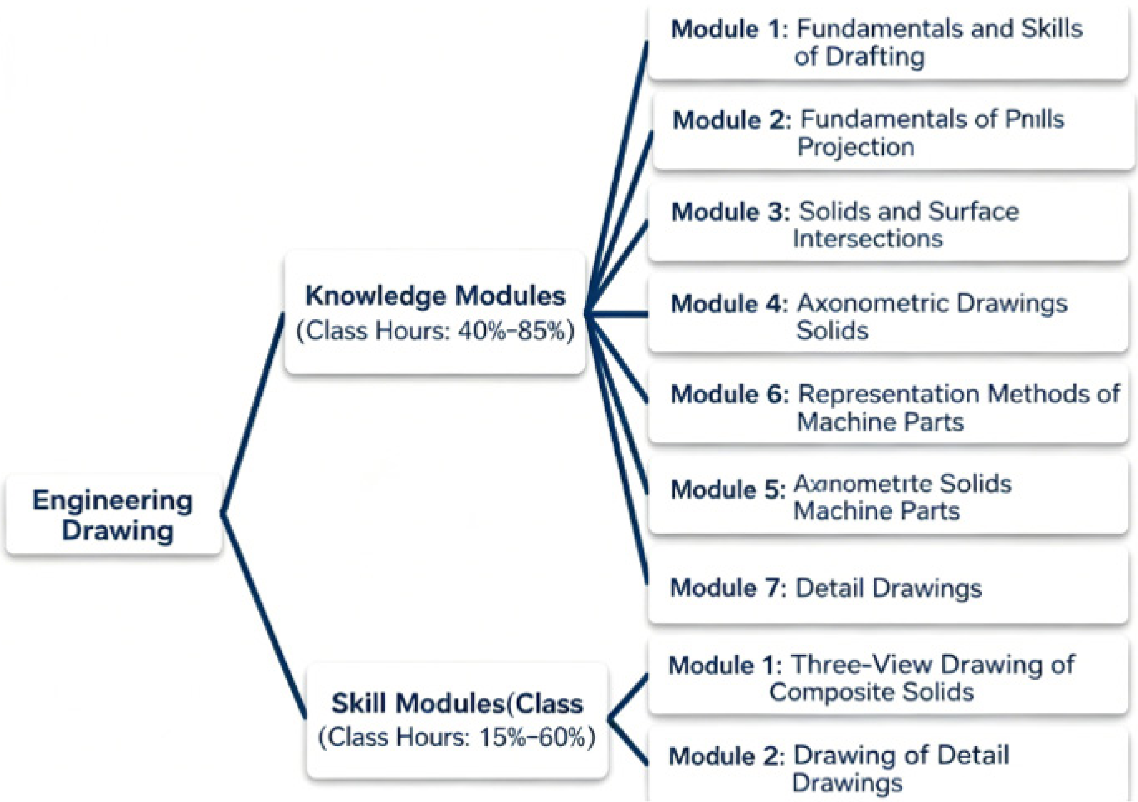

Figure 2. Framework of the new engineering drawing curriculum system.

Based on the above ideas, the teaching content of engineering drawing is sorted into 7 knowledge modules and 2 skill modules. The skill modules reflect the integration of theory and practice in engineering drawing teaching. The allocated class hours vary by project, generally no less than 15% of total hours and up to 60%.

According to different training needs, the curriculum system is divided into three levels: Elementary, Intermediate, and Advanced, each corresponding to different modules, as shown in Table 1.

Table 1. Hierarchical framework of the engineering drawing curriculum system

Curriculum Level	Basic Knowledge & Ability Objectives	Main Teaching Modules & Knowledge Points	Target Trainees	Recommended Hours
Elementary	Knowledge:1. Master national drawing standards. Master orthographic projection principles3. Master methods for drawing 3 views of composite solids. Ability: 1. Basic spatial imagination. Draw and dimension 3 views of common composite solids	Module 1: Drawing standards & dimensioning. Module 2: Formation & correspondence of 3 views. Module 3: Projection of revolution solids, cutting & intersection lines. Module 4: Combination types, drawing & dimensioning of composite solids Skill: Drawing 3 views of composite solids	Trainees with zero foundation or for technician assessment	24–40
Intermediate	Knowledge:1. Master projection of cut solids & special lines/planes 2. Master drawing of various intersection lines. Ability: 1. Strong spatial imagination. Draw 3 views of complex composite solids. Analyze drawings via line-plane & form analysis	Module 1: Standards, dimensioning, geometric drawing & planar figure analysis. Module 2: 3 views, projection of points/lines/planes. Module 3: Projection of revolution/cut solids & intersection lines. Module 4: Composite solids: combination, drawing, dimensioning & reading Skill: Drawing 3 views of composite solids	Trainees for senior technician assessment & oilfield skill competitions	24–80

Advanced	Knowledge:1. Master component representation methods. Master simplified thread drawing 3. Master part drawing & dimensioning. Ability: 1. Excellent spatial imagination. Select proper representations & correctly draw & dimension part drawings	Modules 1–4 (Intermediate requirements) Module 5: Isometric drawing Module 6: Views, sections, cuts, simplified & stipulated representations Module 7: Thread drawing, part structure, view selection, dimensioning & typical part drawing Skill: Part drawing	Trainees for Sinopec & other high-level competitions	40–160

3.2.2. 4C-based design of classroom teaching procedures

On the basis of hierarchical modularization, the key knowledge points in each module are framed using the 4C classroom teaching design method, guiding teachers to develop detailed and personalized 4C lesson plans.

3.2.3. 4C-aligned design of class hour allocation

The successful implementation of the 4C method requires scientific and reasonable hour allocation. The learner-centered strategy demands higher precision in time control, so advanced planning must be made in the curriculum system design.

Table 2. 4C Teaching & hour allocation for "Combination Types of Composite Solids"

Course Content	Knowledge Point	Connections	Concepts	Concrete Practice	Conclusions
Combination Types of Composite Solids (50 min)	Composition of composite solids (5 min)	Connect to a bolt: How is it structured? (1 min)	3 types: superposition, cutting, combination (most frequently tested) (2 min)	Discuss the structure of a common oilfield part (1 min)	Understand 3 types; combination type is key (1 min)
	Form analysis method (5 min)	Relate to efficient working methods (1 min)	Concept of form analysis (2 min)	Analyze real exam questions (1 min)	Basic method for drawing & dimensioning (1 min)
Surface connection (key point) (40 min)	Surface connection of composite solids	Relate to real-life object connections (2 min)	3 relations: coincidence, tangency, intersection (25 min)	Complement missing lines & multiple-choice questions (10 min)	Summary: coincidence=no line; tangency=smooth; intersection=visible line (3 min)

Table 2 shows the preliminary 4C teaching and hour design for "Combination Types of Composite Solids" in Module 4. Recommended hours are assigned, and key and difficult points are marked. Teachers can refine each lesson based on their own style, ensuring genuine application of the 4C method. This format can be extended to all knowledge points in the seven modules.

3.3. Concrete practice

In the 4C method, "Practice" means trainees actively practice new skills or participate in learning activities. Engineering drawing is highly practical; the core goal is to draw standard engineering drawings within a specified time. Integration of theory and practice is the main teaching approach. In the "Practice" stage, targeted and representative in-class exercises are designed based on the compiled hierarchical workbooks to strengthen practice effectiveness.

3.4. Conclusion

According to the 4C instructional design and Kirkpatrick's Four-Level Evaluation Theory, an evaluation system is constructed from four dimensions: trainee reaction (reaction level), learning effect, behavioral change (learning level), and training outcome (result level) [4]. It is applied in actual training to test the effectiveness of the new curriculum system.

4. Application of the new engineering drawing curriculum system

The new curriculum system has been applied to multiple training programs and achieved good results. For example, in technician skill appraisal training for major types of work in Shengli Oilfield, under the same teaching objectives [5], class hours for engineering drawing range from 12 to 32 hours across different types of work.

Using the 4C-based curriculum system, teachers design lessons flexibly according to given hours, implementing the learner-centered and "combination of explanation and practice" philosophy and ensuring training quality.

The new curriculum system was evaluated via a questionnaire in training courses for oil extraction, gathering and transportation, downhole operation workers, etc. The overall satisfaction rate reached 95% [6].

5. Conclusion

The 4C-based engineering drawing curriculum system for staff training embodies the learner-centered core idea in the arrangement of knowledge modules, curriculum objectives, and class hours [7]. It fully supports the classroom implementation of the 4C teaching method by considering its application requirements in advance [8–10]. The curriculum system has demonstrated strong adaptability and operability in multiple training programs. It also provides a proactive exploration of how advanced training methods can contribute to curriculum system construction, and offers a reference for optimizing other traditional courses for adult education.

Disclosure statement

The author declares no conflict of interest.

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