

# Teaching Practice of Mechanical Drawing Based on Engineering Education Accreditation

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**Abstract:** *This paper presents a teaching design and practice of the mechanical drawing course guided by the core concept of engineering education accreditation. We improves the teaching methods of the mechanical drawing classroom from three aspects of "student-centered", "outcomes-oriented", and "continuous improvement". Each graduation requirement is achieved through teaching activities. We strengthen practical teaching, focus on the learning process, and implement the continuous improvement by reforming assessment of learning effectiveness.*

**Keywords:** *engineering education accreditation, outcomes-oriented, continuous improvement, project teaching method.*

Engineering education accreditation is the guarantee system for engineering education quality internationally, and an important foundation for realizing international mutual recognition of engineering education and engineer qualifications. In 2016, China became an official member of the Washington Accord [1]. The criteria for accrediting engineering programs is established according to the principle of substantial equivalence, which is the requirements of the Washington Accord, from the beginning of building the engineering education accreditation system. The core of the criteria is to confirm the established quality standards which are required for engineering graduates to acquire industry recognition. It is a kind of eligibility assessment oriented to training objectives and graduation outcomes. It is closely linked to international standards in the following seven aspects: students, graduation requirements, continuous improvement, curriculum, faculty, and institutional support in the general criteria of China accreditation performed by China Engineering Education Accreditation Association [2]. The basic idea for engineering education accreditation is "student-centered", "outcomes-oriented", and "continuous improvement".

Discipline and investment are always the criteria of higher education in teaching implementation, curriculum setting, assessment and evaluation. The original teaching design of mechanical drawing course is reviewed according to the current criteria of engineering education accreditation. Students cannot meet the graduation requirements for engineering education accreditation who are cultivated by the teaching methods centered on "teaching". Due to the rapid development of network information technology, the channels for students to acquire knowledge have been changed tremendously. Teaching design centered on "learning" which is aimed at cultivating students to have the ability of independent learning and potential innovation is brought forward for teaching reforms. Teaching design and practice of mechanical drawing course should be implemented under the guidance of the concept of engineering education accreditation, that is student-centered, outcomes-oriented, continuous improvement-insisted. We implement the criteria of engineering education accreditation into the teaching process of mechanical drawing course by optimizing course

content and evaluation mechanisms. Project teaching method is selectively performed. And the practical teaching part is increased according to the graduation requirements. Students' comprehensive quality will be promoted by strengthening students' creative thinking, opening up online teaching resources, and carrying out project-based teaching practices.

## 1 . TEACHING DESIGN OF MECHANICAL DRAWING COURSE ORIENTED TO OUTCOMES

Our education mainly emphasized on how teachers taught well in the past, but now engineering education accreditation emphasizes how students learn. Reverse thinking mode is adopted in the instructional design process based on outcomes-oriented. Training objectives is determined by industrial development and business needs. We modify course system, teaching requirements and contents according to graduation requirements which is determined by training objectives.

Course setting for non-mechanical students in their first semester is established with reference to the training goals based on engineering education accreditation. We apply graduation requirements into the mechanical drawing course and establish the relationship matrix between graduation requirements and the mechanical drawing course, as shown in Table 1.

Table 1 Level of Coverage of Graduation requirements in Mechanical Drawing Course[3]

Graduation requirements based on Engineering Education Accreditation Criteria		Mechanical Drawing
1	Apply knowledge of mathematics, science, engineering to solving complex engineering problems	M
2	Apply basic principles of mathematics, natural science and engineering science to identify, formulate and analyze complex engineering problems by means of literature research, in order to obtain effective conclusions.	H
3	Ability to design a system, component, or process to meet desired needs within realistic constraints such as social, health, security, law, culture, and the environment, and to reflect innovative consciousness in the design process.	H
4	Ability to study complex engineering problems based on scientific principles and scientific methods, including designing experiments, analyzing and interpreting	L

	data, and obtaining reasonable and effective conclusions through information synthesis.	
5	Ability to develop, select and use appropriate technologies, resources, modern engineering tools, and information technology tools for complex engineering problems, including prediction and simulation of complex engineering problems, and understand their limitations.	M
6	Ability to analyze and evaluate the impact of professional engineering practices and complex engineering problem solutions on society, health, safety, law, and culture, and to understand the responsibilities that should be assumed based on background knowledge of relevant engineering.	M
7	Ability to understand and evaluate the impact of engineering practices on the environment and sustainable development of society.	L
8	Ability to understand and comply with engineering professional ethics and norms in engineering practice, and fulfill responsibilities with the humanities and social sciences literacy, sense of social responsibility,	L
9	Ability to assume the roles of individuals, team members, and leaders in multidisciplinary teams.	L
10	Ability to communicate with industry peers and the public effectively on complex engineering issues, including writing reports ,designing contributions , presenting statements and expressing or responding to instructions clearly, and ability to communicate in a cross-cultural context with an international perspective.	L

11	Understand and master project management principles and economic decision methods and apply them in a multidisciplinary environment.	L
12	Ability to learn continuously and adapt to development with the awareness of self-learning and lifelong learning.	M

"Mechanical Drawing" is an essential technical basic course for undergraduate students of science and engineering which is characterized with combining theory and practice. As the first basic professional technical course, it plays an important role in training students to master the learning methods of professional technology courses, and cultivating rigorous style and responsible attitude. The teaching goals are mainly: (1) Master the basic principles of the orthographic projection method and use it to express spatial elements: point, line, plane; (2) Draw and read engineering drawings; (3) Cultivate spatial imagination, ideas and modeling capabilities[6].

Taking the measurement and control technology and instrument major as an example, there are two main indicators of graduation requirements of this course: First, comprehending basic knowledge and principles of measurement and control, electronics, machinery, information technology and other engineering, and being able to analyze the working principle of simple electromechanical equipment and identify simple faults. Second, Having the ability to express mechanical components and equipment structures correctly using drawing software. We set the teaching goal of Mechanical Drawing specifically as: (1) Comprehend the basic knowledge of mechanical drawing, train students to have the spatial imagination ability and to solve complex engineering problems. (2) Master the basic skills and methods for drawing and reading engineering drawings, and be capable to consult the relevant contents of the mechanical design manual. (3) Learn the basic methods of computer graphics and be able to use CAD software to create three-dimensional model and draw engineering drawings skillfully.

## 2. FOCUSING ON STUDENT-CENTERED COURSE PRACTICE

The graduation requirements for engineering education accreditation are specific descriptions of the knowledge and abilities that students should have possessed when they graduated. It is the learning achievement that should be achieved when students complete their studies. The considerations of teaching is not what teachers want to teach, but what students need to learn to achieve their goals. Therefore, we apply a project teaching method to implement students-centered teaching practice.

The project teaching method refers to a method that integrates theoretical knowledge and practice focused on a specific teaching content in order to realize the established teaching goals. It is a kind of method which is characterized with project-driven, practice-oriented, reasonable guidance of teachers, students as a subject to carry out for learning. The teaching project aims at elaborating abstract theories and scattered knowledge difficulties concretely through project cases. It provides a more open and expressive platform for students' learning and thinking, enriches the connotation of teaching, helps students to improve their interests in learning and develops students' ability to analyze and solve problems[4].

Take the example of the shape analyzation of complex objects, the project teaching method includes five steps:

(1) Designing and proposing project task

The selection is the key to the implementation of the project teaching method. The project should cover as much of the content of a certain chapter as possible and combine several difficulties. The task that is closely related to the current learning topic should be chosen as the center of learning. It makes students to deal with a real problem that needs to be resolved immediately. The student's original knowledge and experience can be activated through the solution of the task.

In the teaching goal of the shape analyzation of complex objects, the following aspects should be mastered: combination and cutting process, the difference between intersecting, tangent, and flush of surface adjacency of an object, selection of the projection direction of the front view, three-view projection principles and intersection of objects.

Therefore, we design a model, as shown in fig.1 below. The task is required for constructing three view drawing:

- a. Select appropriate scales and drawing sheet;
- b. Decide the front view;
- c. The expression scheme is reasonable, the content is complete, and the projection is correct.
- d. Appropriate dimensions ;
- e. Standard manual drawing;
- f. Complete 3D model and engineering drawing using CAD software.

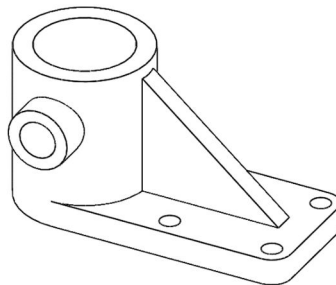


Fig.1 The axonometric projection of an object

(2) Implementation of project plan

In the assignment of task, teacher demonstrates the dynamic model of the object and analyzes its structure including composition of the object, relative position and surface adjacency of each part, the choice of the front view, selection of dimensional references. Students complete each part of the project independently and the process is phased to: manual three views drawing for 3 class hours, dimensions for 2 class hours, CAD 3D model and engineering

drawing for 3 class hours.

Teacher should find common problems timely during the process and proposes necessary references to learners. Generally, students will do research and discuss with teammates and correct errors before next step.

(3) Evaluation of the assignments

In the evaluation section, specific rules and score details are formulated, as shown in Table 2:

Table 2 Project assignment mark sheet

No.	Criteria	Score	Self evaluation	Group evaluation	Teacher evaluation
1	Reasonable layout of the views and appropriate scale	15			
2	Reasonable expression scheme and correct projection	30			
3	Standard drawing line and writing, neat drawing paper	15			
4	Correct, complete and appropriate dimensions	20			
5	Capable of making 3D model and engineering drawing	10			
6	Capable of drawing axonometric drawing	10			
Total Score					

(4) Displaying and discussing good cases

The fourth step is discussion and exchange of works. A few representative assignments are selected and the designers report their drawing procedure to the class. They evaluate their own works and then others give their comments to them. There are two purposes of evaluation for the learning results through the process: first is the evaluation of the solution and results, second is the evaluation of students' self-learning and cooperative work ability.

**3. REFORMING ASSESSMENT METHODS FOR STRENGTHENING CONTINUOUS IMPROVEMENT**

Engineering education accreditation focuses on educational outcomes and results. "Output-based" evaluation method is an extremely effective means to promote classroom education reform. The traditional assessment method is to calculate the final examination score and the semester assignments according to a certain proportion. However, under the background of engineering education accreditation, this method cannot reflect students' comprehensive abilities effectively. In order to achieve the 12 graduation requirements, it should be put emphasis on the evaluation of teaching and students' learning process and outcomes [5].

The course is mainly based on classroom lectures, supplemented by class discussions, literature reviews, project caseworks, and extracurricular assignments. The assessment includes four teaching sessions: homework assignments, project case assignments, class discussions, and final exams which pays more attention to the learning process and reduces the proportion of final exam results. The ratio is as shown in Table 3

Table 3 Ratio of teaching session

teaching session	Ratio
final exam	40%
homework assignment	20%
project case 1	10%
project case 1	10%
project case 1	10%
class discussion	10%
total	100%

The students are demanded to evaluate the learning effect of the course and to comment on the support of the course section or knowledge module to the graduation requirements when they finish the course. The evaluation table is shown in Table 4. We revise the teaching plan and improvement measures for the next school year to improve the teaching quality continuously with reference of student's comments.

Table 4 Level of Coverage of graduation requirements for mechanical drawing course content

Course content	Level of coverage of graduation outcomes
Chapter 1 Basic knowledge and skills of engineering drawing	1 ( ) 2 ( ) 3 ( ) 12 ( )
Chapter 2 The projection of Point, Line, Plane	2 ( ) 3 ( )
Chapter 3 The project of an Object	2 ( ) 3 ( )

Chapter 4 The three views of an Object	1 ( ) 2 ( ) 3 ( )
Chapter 5 Axonometric drawing	1 ( )
Chapter 6 Common expressions of mechanical parts	1 ( ) 5 ( ) 6 ( )
Chapter 7 Standard parts and gears	1 ( )
Chapter 8 Part drawings	1 ( ) 5 ( ) 6 ( )
Chapter 9 Assembly drawings	1 ( ) 5 ( ) 6 ( )
Chapter 10 Computer Aided Draughting	5 ( ) 12 ( )

Note: H-high coverage, M-Medium coverage

#### 4. Conclusion

The teaching design and practice is carried out under the guidance of the concept of engineering education accreditation, which is student-centered, outcome-oriented and continuous improvement. Each graduation outcome is guaranteed to achieve through every teaching activity. The outcome-oriented curriculum design is completed by integrating project case method into the teaching process. Continuous improvement accreditation idea is implemented by reforming the evaluation of course assessment methods.

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