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Research on Teaching Reform of Mechanical Drawing Course for Applied Undergraduate Robot Engineering Major

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Abstract: Under the background of national manufacturing transformation and upgrading, the teaching reform of "mechanical drawing" course of robot engineering major is carried out. Based on the training objectives of robot engineering major and the positioning of school, the training direction of this major is optimized. The reform of "mechanical drawing" course is proposed to keep up with the frontier of the discipline and rely on discipline competition and teacher scientific research. On this basis, the curriculum is optimized to reduce the obsolete content of descriptive geometry, enrich the engineering drawing part, rationally arrange the teaching purpose, teaching content and teaching methods of the course according to the requirements of engineering certification, and constantly improve the course scoring standards and the evaluation system of course evaluation standards. The process evaluation gauge, curriculum objective and graduation requirement index points make the curriculum reform and construction achieves good results. The improvement of the teaching quality of mechanical drawing will be promoted through the enhancement of Students' engineering application and innovation ability.

1. Introduction

China's industrial robots have become the world's largest industrial robot application market. China's robot sales overall growth trend year by year, industrial robots in the industrial and non-industrial industry has played an important role, "manufacturing talent development planning Guide" predicts that in 2025, the robot and intelligent manufacturing field talent gap will reach 4.5 million [1, 2]. In order to achieve the strategic task of making China stronger by providing solid talent support, since Southeast University was first approved as a "robot engineering" major in 2016, in the past five years, the application of "robot engineering" major in universities across the country has been in full swing, and the number of colleges and universities has grown significantly.

Robot engineering is a new interdisciplinary engineering major that integrates basic theoretical knowledge and skills of machinery, electronics, information, computer, control and communication. As high-end intelligent equipment, robot is the ultimate ideal of mechanization, informatization and automation integration. It covers the robot system integration and application from the upper part of the industrial chain to the lower part of the industrial chain.

Mechanical drawing is a basic course for robot engineering majors and a forerunner of design courses such as robotics, which cultivates students' ability to imagine spatial shapes and graphic diagrams, as well as their initial ability to draw and read engineering drawings. Understand the expression of engineering drawings, mechanical drawing standards [3, 4]; Implement the national standard of Mechanical Drawing, and cultivate the preliminary ability of drawing and reading engineering drawings. In addition, in the teaching process must also consciously cultivate students' self-learning ability, analysis and problem-solving, as well as serious and responsible work attitude and rigorous and meticulous work style. It is very important to improve students' ability to draw and read engineering drawings and to solve complex engineering problems [5]. Therefore, taking the construction of this course syllabus as an example, this paper analyzes the common problems existing in the traditional syllabus, compiles the syllabus according to the standards of engineering education professional accreditation and graduation requirements, and clarifies the support of the course objectives to the graduation requirements, combined with the analysis of the degree of achievement of curriculum objectives, it provides a basis for the construction of mechanical drawing curriculum under the background of engineering education professional certification.

2. Research methods

Problems existing in traditional teaching materials

2.1 Unclear orientation of course objectives

Course objectives refer to the specific goals and intentions to be realized by the course itself, which is the basis for determining the course content, teaching objectives and teaching methods, and the ultimate destination of the factors such as achievement assessment, teaching achievement evaluation and continuous improvement [6]. In the past syllabus, the orientation of the curriculum goal was not clear, and it did not clearly reflect the orientation of the school, the characteristics of the profession, and what kind of talents should be cultivated. The setting of curriculum objectives is too general, not student-centered, not clear what kind of overall goals students can achieve and what kind of knowledge, ability and quality they have after learning the course. In addition, the orientation of the curriculum goal is not clear, the relationship between the curriculum goal and graduation requirements is not established, and the orientation and role of the curriculum in the professional personnel training system is not reflected.

In the traditional syllabus, the teaching content is generally written in accordance with the structure of chapters and sections of textbooks, and sometimes the compilation of the syllabus is mainly modified by referring to the syllabus of key universities in China, and the teaching content is not formulated from the actual situation of schools, majors and students, resulting in the teaching content cannot accurately correspond to graduation requirements, and it cannot truly achieve the goal of talent training [7, 8]. The teaching content in the syllabus is often designed subjectively by teachers according to the content of the textbook or teaching experience, lacking the collective discussion and collaboration of professional teaching teams, and lacking curriculum compatibility, cohesion and interoperability.

2.2 The teaching method does not reflect the student-centered

The syllabus is a programmatic document that guides "teaching" and "learning", while the traditional syllabus attaches too much importance to "teaching" of teachers and neglects "learning" of students [9]. The teaching form is simple, and the teaching is mainly taught through theory, while the course of mechanical drawing has high requirements for students' spatial imagination ability.

For engineering students who major in non-traditional machinery, it is relatively difficult to understand the content of assembly view and shape conception. If the teaching method is single, it is not conducive to students' grasp of the key and difficult points of knowledge. In the teaching process, teachers and students lack necessary communication and interaction, and students are more passive to accept the knowledge taught by teachers, lack of thinking about the learning content and goal, and lack of understanding and application of knowledge.

2.3 Teaching evaluation cannot fully reflect the achievement of curriculum objectives

The emphasis of teaching evaluation reflected in the traditional syllabus is inclined, mainly reflecting the summative evaluation of teaching level with teachers as the main body, while the evaluation that effectively measures whether students achieve the expected results is insufficient, and does not judge the teaching effect by the learning effect of students, which goes against the teaching concept of "student-centered" [10]. The course of "Mechanical Drawing and" lays emphasis on practice, and its teaching evaluation type should attach importance to the implementation of formative evaluation. Through regular evaluation of students' learning results in the teaching process, the teaching activities that have not reached the teaching goal can be adjusted, improved and perfected quickly and timely, which is conducive to ensuring the realization of the teaching goal.

3. Results

Preparation of curriculum syllabi and other related contents under the engineering education professional certification system.

According to the guiding opinions of the College of Mechanical and Electrical Engineering on the revision of the 2023 version of undergraduate professional talent training program, the teaching syllabus of "Mechanical drawing" is designed and revised through the in-depth interpretation of the national standards for the teaching quality of robot engineering and the professional certification of engineering education, and combined with the actual teaching situation of robot engineering. The preparation of the teaching syllabus follows the three core requirements of "student-centered", "production-oriented" and "continuous improvement". The teaching design and teaching arrangement closely focus on the achievement of talent training objectives and students' graduation requirements, formulate specific and detailed course objectives, and select optimized teaching content and reasonable teaching methods according to the course objectives. According to the curriculum objectives, the assessment method is formulated, and the learning effect of students is grasped in real time through scientific and reasonable teaching evaluation, so as to promote the continuous improvement of curriculum teaching.

3.1 Composition elements and content arrangement of the syllabus

The course syllabus mainly includes course information, course objectives, teaching content, teaching methods and methods, prerequisite courses, teaching materials and bibliography, teaching evaluation, teaching resources, etc. The basis of the course of "Mechanical drawing" shows the status and role of the course in the training of professional talents, as well as the nature and purpose of the course, so as to clarify the responsibilities of teachers and the tasks of students, so as to enhance the initiative of students in learning, and then better regulate and guide teaching and learning. Courses under the professional certification of engineering education must specify the target points of graduation requirements corresponding to the course objectives in the course opening objectives. According to the guideline that each graduation standard is divided into 1~4

secondary index points, the first step of the outline construction is to establish the support degree relationship between the course and the 12 graduation requirements stipulated in the engineering education certification standard. After team discussion, the course of "Mechanical Drawing" sets 4 course objectives, and establishes the correlation degree and weight corresponding to the course objectives and graduation requirements and index points. In addition to making the course objectives effectively support the graduation requirement index points, the course teaching team comprehensively considers the internal relationship between the "mechanical drawing" course and the course system, and constructs the index point matrix from the two levels of course teaching content and course system, reflecting the scientificity and implement ability of the corresponding matrix between the course system and the graduation requirement index points. Teachers can organize teaching content, choose teaching methods, design assessment and methods according to the allocation relationship between curriculum teaching objectives and training program objectives, so that students can clearly understand what course learning is helpful to improve their abilities and qualities, and enhance their learning initiative.

3.2 Standardize course objectives according to graduation requirements

The arrangement of the course teaching content must ensure the realization of the course objectives. After establishing the corresponding relationship between the curriculum objectives and graduation requirements indicators, the curriculum teaching team will point the curriculum teaching content to the standard requirements of talent training goals when compiling the syllabus, taking into account the connection between each course in the curriculum system and its own independence, and considering the teaching status and teaching tasks of this course from the overall perspective.

Mechanical drawing is a compulsory basic technical course for mechanical majors. It is a discipline that studies the graphic method and graphic method of space geometry problems, and the theory and method of solving space geometry problems as well as drawing and reading engineering drawings. It enables students to master the basic principles and methods of projection, and cultivates students' ability of space form imagination and plane diagram, providing basic principles and basic methods for engineering drawing.

Through the study of this course, students will have the following abilities **(Table 1)**:

Course objective 1. Master the definition, application occasions, drawing characteristics and marking rules of various drawing representations, and have certain ability to read pictures.

Course objective 2. Master the selection of views and dimensioning of parts drawings, the method of viewing parts drawings, and understand the casting process structure, machining process structure, surface roughness, dimensional tolerance, etc. Have the ability to combine theory with practice and cross-disciplinary analysis of problems.

Course objective 3. Be able to correctly understand the definition and application of standard parts and common parts, master the marking of ordinary threads and pipe threads, the connection drawing of threads and threaded connectors, and the drawing of gears, keys and pins. Ability to integrate subject knowledge.

Course objective 4. Understand the function and content of the assembly drawing, and be able to draw and read the assembly drawing of medium complexity correctly (the assembly should have about 10 non-standard parts). The assembly drawing you read should be more complex than the drawing. Basic engineering drawing and reading skills, as well as the ability to analyze and solve problems.

Table 1: Curriculum objectives and graduation requirements

Graduation requirement	Graduation requirements break down indicator points	Course objective
1.Engineering knowledge	1-1 Master the knowledge of mathematics and natural science, have the foundation of engineering problem expression, establish mathematical models for specific objects and solve.	Course objective 1
	1-2 Master the basic and professional knowledge of robot structure, and be able to describe the function and performance of units (components) or systems.	Course objective 3
	1-3Master the basic and professional knowledge of mechanical manufacturing, and be able to describe the basic principles, methods and processes of mechanical manufacturing process.	Course objective 2
	1-4 Master the basic and professional knowledge of electromechanical, transmission and control, and be able to analyze and evaluate the operation and control of mechanical systems.	Course objective 4
2.Problem analysis	2-1 Use the scientific principles and technical methods of the professional direction to identify and judge the key links of complex mechanical engineering problems.	Course objective 3
	2-2 Apply natural science and engineering expertise to express complex mechanical engineering problems.	Course objective 4
	2-3 Through the literature search and research of complex mechanical engineering problems, analyze the influencing factors of the process, seek a variety of solutions, and obtain effective conclusions.	Course objective 5
3.Design/develop solutions	3-1Be able to set technical indicators for a given mechanical engineering problem, design or develop systems, units (components) or processes that meet specific needs, form technical solutions, and evaluate the rationality of the solutions.	Course objective 2
	3-2 Master the basic principles and methods of technological innovation, reflect the consciousness of innovation in the design process, and comprehensively consider social, health, safety, legal, cultural and environmental factors in the design scheme.	Course objective 3
4.research	4-1For complex mechanical engineering problems, have the ability to operate mechanical engineering experiments.	Course objective 3
	4-2 Be able to use scientific methods to analyze complex engineering problems, select research routes according to problem characteristics, design and implement experimental schemes.	Course objective 2
	4-3 Master the observation, measurement and data acquisition methods of experimental results and the use of tools, process and analyze experimental data, and form effective experimental conclusions.	Course objective4

3.3 Course assessment methods and scoring standards

Table 2: Bidirectional detail table of test paper propositions

preface	score	content	competency hierarchy				type	difficulty factor
			memory	comprehend	apply	analyze		
1	16	Point and line projection	√	√		√	W	0.14
2	16	Line surface projection position	√	√	√	√	F	0.14
3	12	Intersecting line	√	√	√	√	W	0.18
4	16	Axonometric drawing	√	√	√	√	W	0.21
5	20	Combination of three views	√	√	√	√	F	0.35
6	20	Part analysis	√	√	√	√	Y	0.32

Table 3: Course grade assessment method

Assessment method / Course objective	Normal score 40%		The final exam is 60%	Curriculum sub-objective achievement evaluation method
	Normal operation (Full score: 30)	Experimental performance (out of 10)		
Course objective 1	20	20	65	Sub-goal achievement degree={40%× (Average score/total score)+60%×(The sub-objective questions are level Average/sub-target total question score)
Course objective 2	10		27	
Course objective 3	15	30	8	
Course objective 4	5		5	

The course assessment mainly includes homework, drawing experiment and final exam. Among them, the usual homework accounted for 30%, the experimental score accounted for 10%, and the

final exam score accounted for 40%. The specific bidirectional detail table of test paper propositions (Table 2), course grade evaluation method (Table 3), course grading standard (Table 4), and course goal achievement evaluation report (Table 5).

Table 4: Course grading criteria

Course objective	Scoring standard			
	90-100	75-89	60-74	0-59
	optimal	good	Medium/pass	flunk
1. Master the definition, application occasions, drawing characteristics and labeling rules of various drawing representations, and have a certain ability to recognize drawings.	Be able to master the definition, application occasions, drawing characteristics and marking rules of various drawing representations, and have a strong ability to read pictures.	Be able to master the definition, application occasions, drawing characteristics and marking rules of various drawing representations, and have a strong ability to read pictures.	Master the definition, application occasions, drawing characteristics and marking rules of various drawing representations, and have a certain ability to recognize drawings.	Unable to master the definition, application occasions, drawing characteristics and labeling rules of various drawing representations, the ability to recognize drawings is weak.
2. Master the selection of views and dimensioning of parts drawings, the method of viewing parts drawings, and understand the casting process structure, machining process structure, surface roughness, dimensional tolerance, etc. Have the ability to combine theory with practice and cross-disciplinary analysis of problems.	Proficient in the selection of views and dimensioning of parts drawings, the method of viewing parts drawings, understanding the casting process structure, machining process structure, surface roughness, dimensional tolerances, etc. Have a strong theory and practice, interdisciplinary analysis of the ability.	Proficient in the selection of views and dimensioning of parts drawings, the method of viewing parts drawings, understanding the casting process structure, machining process structure, surface roughness, dimensional tolerances, etc. Have the ability to combine theory with practice and cross-disciplinary analysis of problems.	Master the selection of views and dimensioning of parts drawings, the methods of viewing parts drawings, and understand the casting process structure, machining process structure, surface roughness, dimensional tolerance, etc. Have a certain degree of theory and practice, interdisciplinary analysis of problems.	I failed to master the selection of views and dimensioning of part drawings and the method of viewing parts drawings, and understood the casting process structure, machining process structure, surface roughness, dimensional tolerance, etc., in the parts drawings. Do not have the ability to combine theory with practice and cross-disciplinary analysis of problems.
3. Be able to correctly understand the definition and application of standard parts and common parts, master the annotation of ordinary threads and pipe threads, the connection drawing method of threads and threaded connectors, and the drawing method of gears, keys and pins. Ability to integrate subject knowledge.	Able to master the definition and application of standard parts and common parts, master the annotation of ordinary thread and pipe thread, thread connection drawing, gear, key, pin and other drawing methods. Strong ability to integrate disciplinary knowledge.	Able to master the definition and application of standard parts and common parts, master the annotation of ordinary thread and pipe thread, thread connection drawing, gear, key, pin and other drawing methods. Ability to integrate subject knowledge.	Basic proficiency in the definition and application of standard parts and common parts, master the annotation of ordinary thread and pipe thread, thread connection drawing, gear, key, pin drawing. Have a certain ability to integrate subject knowledge.	Failed to master the definition and application of standard parts and common parts, master the annotation of ordinary threads and pipe threads, the connection drawing method of threads and threaded connectors, and the drawing method of gears, keys and pins. Do not have the ability to integrate subject knowledge.
4. Understand the role and content of the assembly drawing, and can correctly draw and read the assembly drawing of medium complexity (the assembly should have about 10 non-standard parts). The assembly drawing you read should be more complex than the drawing. Basic engineering drawing and reading skills, as well as the ability to analyze and solve problems.	Proficient in the role and content of the assembly drawing, can correctly draw and read the assembly drawing of medium complexity (assembly parts should have about 10 non-standard parts). The assembly drawing you read should be more complex than the drawing. Have strong engineering drawing and reading ability, as well as the ability to analyze and solve problems.	Proficient in the role and content of the assembly drawing, can correctly draw and read the assembly drawing of medium complexity (assembly parts should have about 10 non-standard parts). The assembly drawing you read should be more complex than the drawing. Have engineering drawing and reading ability, as well as the ability to analyze and solve problems.	Basic grasp of the role and content of the assembly drawing, can correctly draw and read the assembly drawing of medium complexity (assembly parts should have about 10 non-standard parts). The assembly drawing you read should be more complex than the drawing. Have certain engineering drawing and reading ability, as well as the ability to analyze and solve problems.	Unable to master the role and content of assembly drawing, can correctly draw and read assembly drawing of medium complexity (assembly parts should have about 10 non-standard parts). The assembly drawing you read should be more complex than the drawing. The drawing and reading ability of the project is weak.

Table 5: Evaluation report of achievement degree of course objectives in Mechanical Drawing

I. Curriculum objective evaluation basis				
Assessment link	Course objective1	Course objective 2	Course objective 3	Course objective 4
Homework (problem book)	√	√	√	√
Class performance and attendance, drawing	√	√	√	√
Final examination	√	√	√	√

Ii Distribution of final assessment of course objectives						
Question number	One (out of 16)	Two (out of 16)	Three (out of 12)	Four (out of 16)	Five (out of 20)	Six (out of 20)
Course objective 1	√	√				
Course objective 2		√	√			
Course objective 3			√	√	√	
Course objective 4					√	√

Iii. Evaluation result of course teaching quality (final score of Robot Engineering major in 2020)					
Course objective	Assessment key points, realization ways, evaluation methods	Assessment method	Total points	Average score	Degree of achievement of curriculum objectives
Course objective 1	Assessment points: Master the basic knowledge and basic principles of mechanical graphics Implementation approach: Combining the theoretical knowledge of robot engineering, teachers give classroom explanations, and students complete the task of learning basic theoretical knowledge related to three views through assignments, classroom tests, and final tests. The course assessment is realized through the way of homework, drawing and final closed book examination. Evaluation methods: 10 points for online homework, accounting for 20% of the total score; 10 points for classroom test, accounting for 10% of the total score; 25 points for classroom performance and attendance, accounting for 10% of the total score; The multiple choice questions of the final exam, which account for 15 points of the final exam, account for 60% of the total grade. (Regular grades account for 40% of the total grade, and final grades account for 60% of the total grade)	homework	10	8.03	0.739
		Classroom test	10	9.35	
		Classroom performance and attendance	25	25	
		End of term	15	6.30	
Course objective 2	Key points of assessment: Ability to analyze and solve practical engineering problems Implementation approach: Through discussion and heuristic teaching methods, some problems are given in class and discussed in groups and items to guide students to think and discuss how to solve the practical problems of robot structure engineering. Through the rain class online homework, online test and final closed book examination and other ways to achieve the course assessment. Evaluation methods: 20 points for homework, 20 points for classroom tests, 25 points for classroom performance and attendance; The multiple choice and fill-in-the-blank questions on the final exam will account for 19 points on the final exam. (Regular grades account for 40% of the total grade, and final grades account for 60% of the total grade)	homework	20	16.06	0.700
		Classroom test	20	15.75	
		Classroom performance and attendance	25	25	
		End of term	19	12.54	
Course objective 3	Assessment key points: systematic grasp of basic knowledge, principles and problem solving methods Implementation approach: Teaching basic knowledge and principles, citing a large number of engineering practice problems, combined with teachers' own research experience and research projects, case teaching. In homework, in-class tests and final closed book exams, design cases for students to analyze to complete the assessment. Evaluation methods: 30 points for homework, 40 points for class test, 25 points for class performance and attendance; The multiple choice, fill-in and truth-answer questions of the final exam account for 51 points of the final exam. (Regular grades account for 40% of the total grade, and final grades account for 60% of the total grade)	homework	30	24.1	0.762
		Classroom test	40	31.51	
		Classroom performance and attendance	25	25	
		End of term	45	38.88	
Course objective 4	Assessment key points: logical thinking, calculation analysis and expression ability Implementation approach: In classroom teaching, teaching methods such as teaching, inspiration, discussion and case study are comprehensively applied to improve students' logical thinking, calculation analysis and expression ability. In homework, in-class tests and final closed book exams, design cases for students to analyze to complete the assessment. Evaluation methods: 40 points for homework, 30 points for class test, 25 points for class performance and attendance; Final comprehensive question analysis and calculation questions, accounting for 30 points of the final exam. (Regular grades account for 40% of the total grade, and final grades account for 60% of the total grade)	homework	40	32.13	0.734
		Classroom test	30	23.63	
		Classroom performance and attendance	25	25	
		End of term	30	19	

Iv. Course summary and improvement measures
Course summary: The main goal of the course is to cultivate students' logical analysis ability and comprehensive computing ability, so that students can initially apply the theoretical knowledge of this course to analyze, design and solve some practical engineering problems. The achievement degrees of the four course objectives are 0.739, 0.700, 0.762 and 0.734 respectively, indicating that students have a general grasp of basic knowledge points and the ability to solve practical engineering problems. The average course goal achievement degree is 0.734, indicating that some students need to strengthen their in-depth understanding of basic knowledge points involved in the course. Improvement measures: In the next round of teaching, problem solving training should be strengthened in the teaching content, the derivation process should be diluted, more engineering cases should be introduced, students' interest in learning should be aroused, students should be encouraged to participate in innovative practice activities and science and technology competitions after class, and experimental design ability should be improved.

4. Conclusions

Engineering education professional certification is an effective means to improve the quality of professional personnel training. As an important part of professional certification course system, mechanical drawing course is an important support to realize professional training goal and graduation requirement. In view of the common problems of curriculum outline and teaching methods, this paper compiles teaching objectives according to the specific standards and graduation

requirements of engineering education. The courses and teaching methods arrange reasonably. The reform and construction of the curriculum has achieved good results by constantly improving the grading standard, the grading system, the process evaluation scale, the target points of the curriculum and the graduation requirements. Through the analysis of the degree of achievement of the 20-grade robot students' curriculum goal, it provides some reference value for the reform of the teaching content of mechanical drawing. In the future, the graphics teaching and research department will continue to improve the teaching according to the characteristics of different professional training objectives, so as to better support the realization of the training objectives.

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