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Teaching Reform and Practice of Chemical Instrumentation and Automation based on Accreditation Engineering Education Standards

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Abstract: These Engineering education accreditation centers on the core concepts of "student-centered, outcome-oriented, and continuous improvement", emphasizing the cultivation of students' engineering practice abilities and innovative thinking. Against this backdrop, the Chemical Instrumentation and Automation course, as a core course in the chemical engineering discipline, urgently requires teaching reform to meet the requirements of engineering education accreditation and cultivate engineering and technical talents that meet industry demands.

Keywords: Engineering Education Certification, Chemical Instrumentation and Automation, Teaching Reform, Practical Ability, Innovative Ability.

1. Introduction

Engineering education certification is an internationally recognized quality assurance system, aiming to ensure that engineering education meets industry needs and cultivate engineering and technical talents with global competitiveness [1]. Since China joined the Washington Accord in 2016, the engineering education in universities has gradually been aligned with international standards. As a core course in the chemical engineering major, Chemical Instrumentation and Automation urgently needs to be reformed to meet the certification standards [2].

With the development of intelligent manufacturing and Industry 4.0, the demand for automation and intelligence in the chemical industry is increasing day by day. The traditional teaching mode of Chemical Instrumentation and Automation has been difficult to meet the requirements of modern industry for high-quality talents.

Currently, there are problems such as the disconnection between theory and practice and the insufficient innovative ability of students in teaching. The teaching content and methods have not fully reflected the core concepts of engineering education certification, such as "student-centered" and "outcome-based" [3].

Against the backdrop of engineering education certification, the teaching reform of Chemical Instrumentation and Automation is not only an inevitable requirement to adapt to international standards, but also an important measure to improve the quality of talent cultivation and serve the development of the industry. Through reform, it is possible to comprehensively improve the quality of engineering education and help China move forward from a large country in engineering education to a powerful one.

2. Research Status at Home and Abroad

2.1. Domestic Research Status

Domestic research focuses on the updating and integration of curriculum content, emphasizing the combination of theory and practice. For example, some universities have integrated cutting-edge technologies such as intelligent manufacturing and Industry 4.0 into the curriculum. At the same time, they have strengthened the interdisciplinary integration of chemical instrumentation and automation technologies to enhance the practicality and frontiers of the curriculum [4, 5].

Domestic scholars actively explore new teaching models such as case-based teaching, project-driven teaching, and flipped classroom, and pay attention to cultivating students' engineering practical ability and innovative ability[6]. Domestic universities have strengthened laboratory construction and school-enterprise cooperation to promote the reform of practical teaching [7].

Domestic research also focuses on the reform of the teaching evaluation system, emphasizing process evaluation and diversified evaluation to comprehensively reflect students' learning achievements and ability development..

2.2. Foreign Research Status

The foreign engineering education certification system (such as ABET) is already relatively mature. The teaching reform of the Chemical Instrumentation and Automation course focuses on a close combination with industry needs. Foreign universities generally adopt the "outcome-based" education model, emphasizing the cultivation of students' abilities.

Foreign universities pay attention to integrating the latest technologies (such as artificial intelligence, big data, and the Internet of Things) into the curriculum to maintain the frontiers of the teaching content.

Foreign scholars widely adopt teaching methods such as problem-based learning (PBL), cooperative learning, and flipped classroom, and pay attention to cultivating students' autonomous learning ability and teamwork ability. Foreign universities attach importance to school-enterprise cooperation. Through internships, joint cultivation, and other methods, they improve students' practical abilities, and focus on process evaluation and ability-oriented evaluation.

3. Research Methods and Contents

3.1. Journal Style

By reviewing relevant literatures on engineering education certification at home and abroad, as well as the teaching reform of chemical instrumentation and automation, we can understand the research status, development trends, and successful experiences, providing a theoretical basis for the reform. Conduct a comparative analysis of the differences in curriculum settings, teaching methods, practical teaching, and evaluation systems of chemical instrumentation and automation courses in universities at home and abroad. Draw on advanced experiences to optimize the reform plan. Design questionnaires to survey the needs and opinions of students, teachers, and enterprises regarding curriculum content, teaching methods, and practical links, providing data support for the reform. Select typical universities at home and abroad or curriculum reform cases, analyze their successful experiences and existing problems, providing practical references for the reform. Implement the reform plan in teaching practice. Through the cyclic process of "plan-action-observation-reflection", continuously adjust and optimize the reform measures. Design comparative experiments to compare the effects of the traditional teaching mode and the teaching mode after the reform, verifying the effectiveness of the reform plan.

3.2. Research Contents

3.2.1. Curriculum System Optimization

Update the curriculum content and integrate cutting-edge technologies such as intelligent manufacturing and Industry 4.0. Strengthen the interdisciplinary integration of chemical instrumentation and automation technologies to enhance the practicality and frontiers of the curriculum. Design a modular curriculum structure to meet the learning needs of different students.

3.2.2. Innovation of Teaching Methods

Introduce new teaching models such as case-based teaching, project-driven teaching, and flipped classroom. Adopt problem-based learning (PBL) to cultivate students' ability to solve complex engineering problems. Utilize information technology (such as virtual simulation and online courses) to enrich teaching methods.

3.2.3. Reform of Practical Teaching

Strengthen laboratory construction and introduce a virtual simulation experiment platform. Deepen school-enterprise cooperation and establish internship bases and joint cultivation mechanisms. Design comprehensive and innovative experimental projects to improve students' practical ability and engineering literacy.

3.2.4. Improvement of the Evaluation System

Establish a diversified evaluation system, focusing on process evaluation and ability-oriented evaluation. Introduce students' self-evaluation, peer evaluation, and enterprise evaluation to comprehensively reflect students' learning achievements. Design scientific and reasonable evaluation indicators to ensure the objectivity and fairness of evaluation results.

3.2.5. Enhancement of Teachers' Abilities

Strengthen teacher training to improve their teaching level and scientific research ability. Encourage teachers to participate in enterprise practices to enhance their engineering practical experience. Establish a teacher teaching development center to promote communication and cooperation among teachers.

3.2.6. Cultivation of Students' Abilities

Focus on cultivating students' engineering practical ability, innovative ability, and teamwork ability. Through project-driven teaching and practical activities, improve students' comprehensive quality. Provide personalized learning support to meet the diverse needs of students.

3.3. Research Steps

3.3.1. Preliminary Investigation

Through literature research and questionnaire surveys, understand the current teaching situation and reform needs. Analyze successful cases at home and abroad to determine the reform direction and key points.

3.3.2. Plan Design

Formulate plans for curriculum system optimization, innovation of teaching methods, reform of practical teaching, and improvement of the evaluation system. Design an experimental research plan and determine the specific contents and implementation steps of the comparative experiments.

3.3.3. Plan Implementation

Implement the reform plan in teaching practice and collect relevant data and feedback information.

Through action research methods, continuously adjust and optimize the reform measures.

3.3.4. Effect Evaluation

Evaluate the effect of the reform plan through experimental research and questionnaire surveys.

Analyze the evaluation results, summarize the reform experience and existing problems.

3.3.5. Summary and Promotion

Write a research report to summarize the reform achievements and experiences. Promote successful experiences and provide references for the teaching reform of chemical instrumentation and automation in other universities.

4. The Correlation between Certification Standards and Courses

4.1. The Core Standards of Engineering Education Accreditation

The core standards of engineering education certification emphasize student-centeredness, outcome orientation, and continuous improvement, aiming to cultivate high-quality engineering and technical talents that meet industry needs. Through a scientific and reasonable curriculum system, a high-quality teaching faculty, sufficient support conditions, and an effective management system, schools can continuously improve the quality of education and achieve the internationalization and modernization of engineering education.

4.2. The Correspondence between Course Objectives and Graduation Requirements

Against the backdrop of engineering education certification, the objectives of the Chemical Instrumentation and Automation course should be closely aligned with the graduation requirements to ensure that students can achieve the expected abilities and qualities through the course study. The following is the corresponding relationship between the

course objectives and graduation requirements:

Table 1. The corresponding relationship between curriculum objectives and graduation requirements

Curriculum Objectives	Graduation Requirements
Master the basic principles and knowledge of chemical instrumentation and automation.	Engineering Knowledge
Have the ability to select, install and maintain chemical instruments.	Problem Analysis, Design/Development of Solutions, Use of Modern Tools
Have the ability to design and debug automation systems.	Design/Development of Solutions, Research, Use of Modern Tools
Have the ability to solve complex engineering problems.	Problem Analysis, Design/Development of Solutions, Research
Have the ability of teamwork and communication.	Individual and Teamwork, Communication

By clarifying the corresponding relationship between the objectives of the Chemical Instrumentation and Automation course and the graduation requirements, it is possible to ensure that the curriculum content, teaching methods, and evaluation system are developed around the graduation requirements, effectively supporting students in achieving the expected abilities and qualities. This not only helps to improve the quality of the course but also provides a guarantee for cultivating high-quality engineering and technical talents that meet industry needs.

5. Implementation Cases and Effect Analysis of Teaching Reform

Against the backdrop of engineering education certification, the implementation process of the teaching reform of Chemical Instrumentation and Automation requires systematic planning and step-by-step promotion to ensure the effectiveness and sustainability of the reform measures. The following is the specific implementation process:

5.1. Preliminary Preparation

Establish a reform team: Form a reform team composed of professional leaders, course teachers, enterprise experts, and student representatives, who are responsible for the planning, implementation, and evaluation of the reform. Understand the current situation: Through literature research, questionnaire surveys, and interviews, understand the current teaching situation, industry needs, and student feedback. Analyze successful cases: Analyze successful cases at home and abroad to determine the reform direction and key points. Formulate a reform plan: According to the research results, formulate a detailed reform plan, including curriculum system optimization, innovation of teaching methods, reform of practical teaching, and improvement of the evaluation system. Clearly define the reform objectives, implementation steps, and time nodes.

5.2. Curriculum System Optimization

Update curriculum content: Integrate cutting-edge technologies such as intelligent manufacturing and Industry 4.0 into the curriculum to maintain the frontiers and practicality of the teaching content.

Strengthen interdisciplinary integration: Strengthen the interdisciplinary integration of chemical instrumentation and automation technologies to enhance the comprehensiveness of the curriculum.

Design a modular curriculum structure: Divide the curriculum content into several modules, with each module corresponding to specific knowledge and ability requirements. Provide elective modules to meet the personalized learning needs of students. Formulate a curriculum syllabus: According to the requirements of engineering education certification, formulate a detailed curriculum syllabus, clarifying the curriculum objectives, teaching content, teaching methods, and evaluation methods.

5.3. Innovation of Teaching Methods

Introduce case-based teaching: Select typical enterprise cases, and through case analysis, help students understand the application of theoretical knowledge in actual engineering. Adopt project-driven teaching: Design comprehensive projects, enabling students to apply the knowledge they have learned in the projects and solve actual engineering problems. Cultivate students' teamwork ability through group cooperation. Implement flipped classroom: Move some teaching content to before class, and complete it through online courses and self-directed learning. Focus on discussion, practice, and problem-solving in class to enhance students' sense of participation and initiative. Utilize information technology: Introduce a virtual simulation experiment platform to provide rich experimental resources and practical opportunities. Use an online learning platform to support students' self-directed learning and interactive communication.

5.4. Reform of Practical Teaching

Strengthen laboratory construction: Update experimental equipment and build an advanced laboratory for Chemical Instrumentation and Automation. Introduce a virtual simulation experiment platform to provide diversified experimental projects. Deepen school-enterprise cooperation: Establish internship bases with enterprises to provide real engineering practice opportunities. Invite enterprise experts to participate in curriculum design and teaching to enhance the practicality of the curriculum. Design comprehensive experimental projects: Design interdisciplinary comprehensive experimental projects to cultivate students' comprehensive application ability and innovative ability. Improve students' practical ability and engineering literacy through experimental projects.

5.5. Improvement of the Evaluation System

Establish a diversified evaluation system: Adopt a combination of process evaluation and summative evaluation to comprehensively reflect students' learning achievements. Introduce self-evaluation, peer evaluation, and enterprise evaluation: Enhance the objectivity and fairness of the evaluation. Design scientific and reasonable evaluation indicators: According to the curriculum objectives and graduation requirements, design specific evaluation indicators to ensure the scientificity and effectiveness of the evaluation results. Identify the existing problems and improvement spaces in teaching through the evaluation results. Implement a continuous improvement mechanism: Establish an effective feedback mechanism to collect the opinions and suggestions of students, teachers, and enterprises. Regularly evaluate the teaching effect and

continuously optimize the curriculum settings, teaching methods, and evaluation system.

5.6. Enhancement of Teachers' Abilities

Strengthen teacher training: Organize teachers to participate in training on engineering education certification and teaching reform to improve their teaching level and scientific research ability. Encourage teachers to participate in enterprise practices to enhance their engineering practical experience. Establish a teacher development center: Establish a teacher teaching development center to provide teaching resources and support, and promote communication and cooperation among teachers. Improve teachers' teaching ability and reform awareness through teaching seminars and experience sharing.

5.7. Cultivation of Students' Abilities

Focus on engineering practical ability: Through experiments, internships, and project-driven teaching, improve students' engineering practical ability. Provide rich practical opportunities to enhance students' hands-on ability and the ability to solve practical problems. Cultivate innovative ability: Through comprehensive experimental projects and scientific research activities, cultivate students' innovative thinking and innovative ability. Encourage students to participate in science and technology competitions and innovative projects to improve their comprehensive quality and competitiveness. Improve teamwork and communication ability: Cultivate students' teamwork ability through group projects and team cooperation. Provide communication skills training to enhance students' expression and communication ability.

5.8. Evaluation of Implementation Effects

Collect feedback information: Through questionnaire surveys, interviews, and symposiums, collect the feedback information of students, teachers, and enterprises. Analyze the feedback information to identify the successful experiences and existing problems in the reform. Evaluate the reform effect: Through comparative experiments and data analysis, evaluate the effect of the reform plan. Adjust and optimize the reform measures according to the evaluation results to ensure the continuous improvement of the reform.

6. Conclusion

The research on the teaching reform of Chemical Instrumentation and Automation against the backdrop of engineering education certification has achieved remarkable results. The quality of the course has been improved, and the abilities and qualities of students have been enhanced. Through systematic reform measures, universities can cultivate high-quality engineering and technical talents that meet industry needs, and promote the internationalization and modernization of engineering education. In the future, it is necessary to continuously optimize the reform measures, strengthen the participation of teachers and students, deepen school-enterprise cooperation, and ensure the continuous improvement and long-term effectiveness of the reform.

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