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Exploration and Practice of Laser Principles and Technology Course Based on the Integration of Professional and Innovation-Education

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Abstract

The course on the principles and technology of lasers, as a core subject in opto-electronics-related majors, plays a crucial role in talent cultivation. To address the issue of insufficient integration between specialized education and innovation and entrepreneurship education, this paper, based on the concept of integrating specialization and innovation, adopted a school-enterprise cooperation model. By clarifying the teaching objectives of the course, reconstructing the teaching content system, reforming teaching methods and means, and establishing a "dynamic" assessment method, this paper explored innovations and practices in the teaching approach to enhance teaching effectiveness. Teaching practice has shown that this teaching model not only effectively grasps theoretical knowledge and key skills but also enhances students' innovative practical abilities. Moreover, it cultivates high-quality innovation and entrepreneurship talents, providing valuable references for professional curriculum reform and practice in higher education institutions.

Keywords

Specialized-innovation integration; laser principles and technology; curriculum development; teaching reform; innovation-entrepreneurship.

1. Introduction

In China, we must uphold science and technology as the primary productive force, talent as the primary resource, and innovation as the primary driver. We should deeply implement the strategy of invigorating the country through science and education, the strategy of making the country strong with talent, and the strategy of driving development through innovation. We need to open up new fields and new tracks for development, continuously shaping new drivers and advantages for development. This indicates that high-quality innovative talents are crucial support for achieving our country's strategy of making the country strong with talent. Accelerating the cultivation of innovative talents is imperative, and the demand for innovative talents in society is becoming increasingly urgent. Universities, as important fronts for talent cultivation, urgently need to explore new educational models, attach importance to curriculum construction and teaching reform, to nurture high-quality talents with an innovative spirit and practical abilities. The concept of integrating specialized education with innovation and entrepreneurship emphasizes the organic integration of professional education and entrepreneurial education, providing new ideas for curriculum reform and the cultivation of innovative talents[1]. Laser technology, as a significant branch of modern information society, is widely applied in industries such as industry, communications, and healthcare[2]. The course on laser principles and technology, as a core component of our university's Electronic Science

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and Technology program, directly impacts the quality of talent cultivation through its teaching quality and effectiveness. Based on this, this article took the course on laser principles and technology as an example to explore curriculum construction and practice based on the concept of integrating specialized education with innovation and entrepreneurship, aiming to provide a reference for professional curriculum reform in universities.

2. The Teaching Status of Laser Principle and Technology Course

The course on the principles and technology of lasers primarily introduces knowledge about the basic principles of lasers, laser characteristics, control and improvement, as well as applications. The content includes the principle of laser generation, the structure and function of lasers, Gaussian beam transformation, laser characteristics and applications, fundamental theories, laser technology, and development trends. However, due to the influence of the teaching environment, traditional teaching in this course has the following issues:

1. Abstract course content: The laser principle and technology course involves a large number of physical concepts and mathematical formulas, which are abstract and difficult to understand for beginners, especially for students with weak foundation in mathematics and physics.

2. Single teaching mode: Teaching is generally based on traditional lectures, with teachers as the center, and there are deficiencies in interaction, mutual evaluation and process assessment, resulting in lack of students interest and enthusiasm for learning.

3. Weak experimental teaching: Generally speaking, the schools hardware conditions for laser principle and technology courses are insufficient, and there is a lack of practical teaching platform, which leads to insufficient experimental teaching links, students lack opportunities for hands-on practice, and it is difficult to combine theoretical knowledge with practical application.

4. Lack of Innovation and Entrepreneurship Education: As the core of optoelectronic technology, laser principles and techniques play a crucial role in innovation and entrepreneurship. However, traditional teaching methods have led to a disconnect between course instruction and innovation and entrepreneurship education. Classroom teaching lacks components for fostering innovation and entrepreneurship, thus failing to effectively enhance students innovative capabilities and problem-solving skills.

In view of some problems in the above teaching, based on the concept of integration of specialization and innovation, the course team carried out the reform and innovation in terms of teaching goal design, content system construction, teaching methods and means, assessment methods, etc., so as to deeply integrate professional education with innovation and entrepreneurship education, so as to improve students innovative practice ability.

3. Course Construction Plan

3.1. Course teaching objectives

The primary task in course development is to set the teaching objectives of the course. Starting from the concept of integrating specialization and innovation, the course team carefully set these objectives across three dimensions: knowledge goals, ability goals, and value goals, aiming to cultivate high-quality talents with solid professional knowledge, outstanding innovative practical skills, and a strong sense of social responsibility.

In terms of value objectives, the curriculum centers on student development, focusing on cultivating students awareness of serving the country through science and technology and their spirit of serving society. Through course study, students can establish correct values and possess strong qualities in optoelectronic system engineering, meeting the demand for innovative application-oriented talents in an information-based society. At the same time,

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relying on the Optoelectronic Innovation Design Studio and professional experimental platforms, advanced and challenging training is strengthened to enhance students' entrepreneurial and innovative thinking as well as comprehensive practical skills.

In terms of knowledge objectives, the course aims to deepen students' understanding of laser working principles, resonant cavities, and laser oscillation theories. On this basis, students will master important laser technologies such as Q-switching, mode selection, and frequency stabilization. Through the course, students will learn to innovate and optimize laser designs, expand their application fields, and lay a solid theoretical foundation for innovation and entrepreneurship.

In terms of competency goals, the course is guided by the National College Student Optoelectronic Design Competition and organizes school-level optoelectronic design contests to stimulate students' interest in learning. On this basis, the faculty integrates research articles from teachers and cutting-edge scientific papers, grounded in industry contexts, to cultivate students' ability to solve complex engineering problems in optoelectronics. Through course study, students can innovatively identify, analyze, and address laser application issues that intersect with industries such as healthcare, machinery, and materials, thereby laying a solid foundation for becoming innovative and applied talents in the optoelectronic field and preparing them for future entrepreneurship.

3.2. Course content system

Based on the concept of integration between specialization and innovation, the course on laser principles and technology constructs a content system with four major modules: basic theory, key technologies, comprehensive application, and innovative practice. The modular design not only ensures the systematic nature of professional knowledge in laser principles and technology but also further strengthens and enhances students' innovative practical abilities.

In the foundational theory module, the course covers 15 topics including the basic principles of lasers, resonator theory, and laser oscillation theory, focusing on deepening students 'understanding of laser principles. Through systematic learning, students can grasp the fundamental laws governing laser generation, transmission, and control, laying a solid theoretical foundation for subsequent technical applications and innovative practices. In the key technology module, teaching is centered around laser characteristics, integrating the concept of continuous improvement, and explaining techniques for further enhancing and controlling these characteristics, known as laser technology, which includes Q-switching, mode selection, and frequency stabilization. By analyzing case studies in depth, students can better understand the principles of key technologies and apply them simply, thereby developing their ability to solve practical engineering problems. In the comprehensive application module, teaching adopts case-based and project-based methods, using real-world applications of lasers in industries such as medicine and machinery as teaching content to emphasize laser characteristics and broaden students' knowledge. Through interdisciplinary integration, students can gain a deeper understanding of the application features of lasers, thus fostering innovative thinking and cross-disciplinary practical skills. In the innovation practice module, the course relies on national college student optoelectronic design competitions, faculty research projects, and industry backgrounds, conducting practical teaching through case studies and projects.

3.3. Innovation of teaching methods and means

To achieve the goal of integrating specialized and creative teaching, the Laser Principles and Technology course employs a variety of teaching methods and means to stimulate students' interest in learning, foster innovative thinking, and enhance practical skills. In foundational theory instruction, granular and analog teaching methods are fully utilized to simplify complex

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concepts, helping students gain a deeper understanding of basic theories. For key technology sections, interactive and flipped classroom models are extensively used to ensure students master relevant technologies proficiently. Teachers guide students through practical cases such as laser cutting and laser dancing, organizing discussions and problem-solving activities. For example, when explaining Q-switching technology, teachers analyze its application in laser beauty treatments to encourage students to think about technical principles and optimization methods. This approach further enhances students' ability to identify and solve problems, laying a solid foundation for cultivating innovative practical skills. In comprehensive application sections, case-based, project-based, and virtual simulation methods are adopted. Using laser engraving as an entry point, these methods integrate electronic information, automatic control, and medical technologies. Through video presentations, problem introductions, and case analyses, students are guided to design projects and conduct virtual simulations. This teaching method further promotes the development of students' innovation and practical abilities. In the innovative practice section, teachers rely on national college student optoelectronic design competition questions and research projects from their teams to implement case-based and problem-oriented teaching. By participating in real projects, students can closely combine theoretical knowledge, key technologies, and innovative practices, thereby enhancing their innovative practical skills.

3.4. Reform of assessment methods

To comprehensively evaluate students learning outcomes and emphasize higher-order and challenging tasks, the course team has established a “living” assessment method that stresses diversity and process-oriented evaluation. The course assessment consists of six parts: final test, project design, classroom performance, assignments, mid-term tests, and innovation expansion. Among these, the final test accounts for 20%, primarily assessing students mastery of basic theories and key technologies; project design accounts for 30%, involving team-based laser application projects to evaluate students teamwork, innovation levels, and entrepreneurial capabilities; classroom performance accounts for 16%, assessing students understanding and mastery of difficult concepts through attendance, random questioning, and in-class exercises; assignments account for 12%, reinforcing learned knowledge; mid-term tests account for 12%, evaluating learning outcomes at different stages; innovation expansion accounts for 10%, scoring based on students participation in major innovation projects, academic competitions, and published papers. In the project design assessment, elements such as serving the country through science and technology, social service, and innovative practice are integrated, using a combination of teacher evaluation and peer review, each accounting for 50%. This assessment method is no longer a one-time decision-making process; it not only focuses on students knowledge acquisition and professional skills but also emphasizes their innovative practical abilities and qualities, while fostering a sense of social responsibility and teamwork.

3.5. Teaching characteristics and innovation

The course on laser principles and technology, guided by the concept of integrating specialization and innovation, has developed distinct teaching characteristics and innovative points. First, in terms of curriculum reform, the course is divided into four major modules: basic theory, key technology, comprehensive application, and innovative practice, covering 15 topics and 61 knowledge points. By deepening industry-education integration, it includes more cutting-edge scientific papers and teaching cases, broadening both the depth and breadth of the content. Second, regarding teaching methods, a blended model combining online and offline instruction, as well as classroom lectures and group discussions, is adopted. Various teaching approaches such as granularization, research feedback, and case-based learning are integrated to enhance interaction and peer evaluation, highlighting the central role of students. Finally, to

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truly reflect students qualities and abilities, a diversified system based on OBE (Outcome-Based Education) [3] and PBL (Project-Based Learning) [4] concepts has been established in the assessment process. The process assessment was combined with the result assessment, and the students' innovation ability and practical ability were taken as part of the assessment. For example, achievements from student participation in activities like the Challenge Cup, major innovation projects, and academic competitions were included in the assessment scope, encouraging students to actively engage in innovation.

4. Practice Results and Implications

Through the construction and practice of courses based on the concept of integration between specialized and innovative education, significant teaching achievements have been made in the Laser Principles and Technology course. First, students' innovation and entrepreneurship capabilities have significantly improved. In national competitions such as the National College Students' Optoelectronic Design Contest, Internet+, and College Students 'Innovation and Entrepreneurship Experiment Program, students have won over 10 national awards and nearly 40 provincial or ministerial-level awards. Several teachers have received national and North China region outstanding guidance awards, and the school has been honored with awards for excellent organization. Second, students' awareness and ability to innovate have noticeably increased. They actively participate in major innovation training projects, securing 2 national-level, 4 provincial-level, and nearly 20 university-level approvals; students have published nearly 20 papers in domestic and international academic journals. Furthermore, the course's development has facilitated deep cooperation between the school and enterprises and promoted the integration of industry and education. Relying on the Ministry of Education's Collaborative Talent Cultivation Project, the course team has established close partnerships with optoelectronic companies like Daheng New Era and Wuhan Tianzhiyi. By jointly building laboratories and developing teaching cases, cutting-edge industry technologies were integrated into course instruction, enhancing students' engineering practice skills. For example, the "Virtual Simulation Experiment of Optical Systems" project developed in collaboration with Wuhan Tianzhiyi enables the adjustment of laser resonators, measurement of Gaussian beam characteristic parameters, and mode analysis, effectively addressing equipment shortages in experimental teaching. Lastly, the course has cultivated more outstanding innovation and entrepreneurship talents. Since its inception, many graduates have successfully started businesses in the optoelectronics field, becoming industry leaders. For example, graduates such as Liu Feng, Hu Kangjia, and Hou Heqian have been recommended to prestigious institutions like the Chinese Academy of Sciences, Dalian University of Technology, and Xi 'an University of Electronic Science and Technology for further studies. Entrepreneurial representative Liang Xiangguang founded Suzhou Guanglinda Electronics Technology Co., Ltd., which has achieved annual sales of hundreds of millions yuan and become a leading supplier of optoelectronic equipment in China. Finally, course development has promoted teacher growth and course outcomes. The course team won the Outstanding Organization Award at the North China Regional Competition of the National College Students' Optoelectronic Design Contest, with multiple individuals receiving national, North China regional, and university-level innovation and entrepreneurship guidance awards. Professor Di Zhigang, the course leader, was honored as a Model of Teacher Ethics in Tangshan City, a Teaching Master at North China University of Science and Technology, and received the First-Class Excellent Teacher Award. The course has also been recognized as a Provincial Specialized Innovation Integration Course, a University-Level First-Class Course, a Characteristic Course, and an Excellent Classroom Award.

5. Conclusion

Based on the concept of integrating specialized and innovative education, the construction of laser principles and technology courses has effectively enhanced students' innovation and entrepreneurship capabilities as well as their overall quality by clarifying course objectives, optimizing teaching content, innovating teaching methods, and reforming assessment approaches. The results of practical explorations in the course indicate that integrating specialization and innovation is an effective approach to cultivating innovative and practical talents, providing valuable references for professional curriculum reforms in higher education institutions.

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