Education Reform and Development, 2024, Volume 6, Issue 10
https://ojs.bbwpublisher.com/index.php/ERD
Online ISSN: 2652-5372
Print ISSN: 2652-5364

Research on the Cultivation Path of Application-oriented Individuals in Mechanical Majors under the Background of New Engineering

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Abstract: Under the context of new engineering and with the in-depth advancement of the integration of industry and education, practical teaching in application-oriented undergraduate colleges has become a critical component for enhancing students' practical and innovative abilities. This is a top priority in the teaching reform agenda under the new engineering construction framework. The college has reformed the curriculum system to form a three-classroom practical innovation ability training model, characterized by one core and two extensions. Additionally, constructed a multi-level practical teaching system, connected inside and outside the campus, built an innovation base and platform, implemented the integration of industry and education, and coordinated science and education, and promoted learning through competitions and a series of measures to enable students to continuously transform theoretical knowledge into skills and enhance students' practical and innovative ability.

Keywords: New engineering; Application-oriented individuals; Integration of industry and education; Practical teaching; Innovation ability

Online publication: October 25, 2024

1. Introduction

With the full implementation of the "Made in China 2025" strategy and the continuous promotion of the construction of industrial clusters for high-quality development, the transformation and upgrading of the local industrial economy is imminent [1]. Facing more multidimensional and complex emerging industrial clusters, students trained under the traditional discipline system cannot meet the needs of the industry [2]. To cultivate high-quality applied talents in the new situation, the Ministry of Education has proposed the construction of new engineering and formed concepts such as the "Fudan Consensus [3]," "Tianjin University Action [4]," and "Beijing Guide" [5]. These concepts provides a programmatic guiding ideology for the implementation of teaching reform in higher science and engineering specialties [6,7]. The cultivation of applied talents is the most crucial task of the "New engineering" initiative to meet the current and future development needs of the industry [10]. The construction of new engineering is of great significance for addressing the urgent requirements of promoting structural reform of the supply side of human resources [11], comprehensively improving the quality of education [12], expanding employment and entrepreneurship [13], promoting economic transformation and upgrading [14], and cultivating new drivers of economic development under the new situation [15].

2. Requirements of new engineering for talent cultivation in colleges and universities

The "Notice on Carrying out Research and Practice of New Engineering" issued by the Ministry of Education defines the connotation of new engineering from five dimensions: (1) educational concept, (2) discipline structure, (3) training model, (4) teaching quality, and (5) development system. In addition, some domestic scholars have also expounded different viewpoints. Lin J (2017) believes that "new engineering represents the latest development direction of industries or industries and is a new engineering discipline that is being formed or will be formed" [8]. Li P (2017) asserts that "The key to the construction of new engineering lies in accurately reading and understanding what new qualities engineering and technical talents facing the future should possess" [9]. Although the understanding of the connotation of new engineering varies, it is crucial to cultivate the comprehensive ability and quality of applied talents who can solve complex engineering problems for the construction of new engineering and the development of new industries. To align with the construction of new engineering and meet industry development needs, local colleges and universities must explore their characteristics, actively pursue teaching reform exploration, and establish an all-round and whole-process high-quality applied talent training system. This system should focus on cultivating applied talents with strong practical ability, innovation ability, communication ability and adaptability, and ability to solve complex engineering problems.

2. Construction of the training model of applied talents in the new situation

Facing the regional economic and industry development needs, the reverse design and forward implementation of professional training objectives, graduation requirements, and curriculum systems are based on the OBE (Outcome-Based Education) concept. In the training process, efforts are made to achieve continuous reform and innovation integration throughout the process, involving multiple links and various elements, and deeply integrate ideological and political education, professional education and innovation and entrepreneurship education. Practical teaching in colleges and universities is a teaching activity that enables students to cultivate skills and innovation abilities in an experimental environment or production practice. It is a necessary process for closely combining theory and practice and improving students' problem-solving abilities, and it is a key link to enhancing their practical and innovative abilities.

The college has formed a "first classroom + second classroom + third classroom" model with one core and two extensions according to the talent training objectives. The first classroom serves as the foundation, with courses as the main line and the on-campus experimental platform to cultivate students' basic and application abilities. The second classroom integrates social practice activities. Through the method of "inviting in and going out," activities are conducted, mainly with outstanding alumni and enterprise lecturer groups, to expand students' horizons and professional cognitive abilities. The third classroom integrates scientific innovation and teaching, takes the tutorial system as the starting point, and takes various major mechanical competitions as the means to enhance students' innovation ability and practical hands-on ability. With the first classroom as the main body and the second and third classrooms as powerful supplements, an organic applied talent practical innovation ability training system has been established.

2.1. First classroom: Constructing a multi-level practical teaching system

Centering on the concept of "student-centered, outcome-oriented, and continuous improvement" in engineering education certification, and combined with talent demand and the realities of school operations, the training program has been revised multiple times, and a general education and professional education curriculum group with cross-mandatory and elective courses and the combination of theory and practice has been established. With machinery and electronics as the main disciplines, and organically integrating disciplines such as information, electrical, control and computer science, the Department of Mechatronics has formed two majors: Mechatronic Engineering and Robotics Engineering.

(1) In-class experiment

The course experiment is set in the course with the experimental link. It is an experiment designed directly for the knowledge points of the course theoretical teaching, mainly including verification experiments and comprehensive experiments integrating multiple knowledge points. The practical process of this link can directly inspire students to think deeply about the knowledge they have learned, be diligent in hands-on, and stimulate innovation, achieving the teaching effect of integrating theory with practice. At the same time, the group division and cooperation in the in-class experiment are conducive to cultivating students' hands-on and communication skills.

(2) Experimental course

Based on the combination of course theory and practice, the difficulty gradient of the course experiment is set step by step from easy to difficult and in a progressive manner, and basic, comprehensive, design and innovative mechatronics experiments are set in sequence. For example, the basic difficulty experiment: "Simple circuit controls the rotation of a small motor experiment," students only need to connect a simple circuit and observe the start and stop of the motor. The medium-difficulty comprehensive experiment: "Speed regulation experiment of the mechatronic transmission system," involving the coordinated adjustment of the circuit control and mechanical transmission parts. The more difficult "Autonomous navigation and obstacle avoidance experiment of intelligent robot," combines multiple fields of knowledge such as sensor technology, circuit control, programming algorithms and mechanical structure design, and requires students to conduct in-depth exploration and debugging. Through the experimental course, students are guided to take the first step in applying the knowledge they have learned to solve practical problems.

(3) Professional comprehensive practice

The professional comprehensive practice integrates multiple main courses, follows the principle of student and project-centered, is guided by multiple cooperating teachers, and is carried out in modules and steps. Professional comprehensive practice includes many courses such as Professional Comprehensive Design I, II, Mechatronic System Comprehensive Practice, and Robot System Comprehensive Practice. It mainly cultivates students' ability to solve engineering problems and practical hands-on ability. The specific steps include analyzing engineering problems, formulating technical solutions, task decomposition, solution implementation, and problem-solving. For example, the professional comprehensive design project II "FDM 3D Printing System Design" involves theoretical knowledge from many courses and various design and development tools. Finally, students need to disassemble and assemble the 3D printer for verification. The robot system comprehensive practice utilizes the purchased "Explorer" robot innovation components and development platform to realize the design and motion control of the robotic arm, the design and motion control of the omni-directional chassis of the mechanical car, the design and motion control of the bionic robot, and the all-round practical exercises of robot perception, vision, positioning and navigation modules can also be carried out.

2.2. Second classroom: Expanding students' social and engineering practical ability

The college gives full play to its school-running characteristics, actively connects with the development needs of local key industries, and establishes school-enterprise collaborative education partnerships with enterprises such as Inner Mongolia First Machine, Second Machine, Aerospace Sixth Institute, and Metrology Institute. At the same time, the robotics engineering major and the mechatronics engineering major have respectively joined the professional industry-education integration community. In the construction of the curriculum system, focusing on new energy equipment in the "five major tasks" of the autonomous region and guided by the technical needs of enterprises, courses are offered, and the knowledge and skills that enterprises consider necessary are included in the core courses. These measures not only strengthen the close connection between the college and the industry but also provide students with a learning and practice platform aligned with with actual engineering problems, and provide a basis for the optimization and improvement of the college's talent training system and curriculum knowledge system.

In the specific implementation process, the college adopts the form of the "second classroom," invites enterprise engineers to come to the classroom for communication and publicity, and encourages college teachers and students to enter the enterprise for practical learning. Through the methods of "inviting in" and "going out," a variety of activities have been carried out. In terms of "inviting in," the college has set up the "Kaiwu Lecture Hall," inviting experts and scholars, outstanding entrepreneurs and senior craftsmen from all walks of life in the mechanical field to give lectures at the school. These activities not only allow students to be exposed to cutting-edge technology and broaden their horizons but also help students clarify their future development directions through the sharing of workplace experience and industry dynamics by entrepreneurs.

On the other hand, college teachers and students also go to the front line of various enterprise production through the way of "going out" to conduct exchanges, investigations, internships and practical training. For example, college teachers and students will visit relevant enterprises, research institutes and exhibitions of electromechanical equipment for exchanges and investigations to understand the development trend of the industry, and the needs and pain points of the industry, so that students can turn to solving practical problems as the learning goal. Additionally, attention is paid to intelligent manufacturing, new energy and other enterprises, such as visiting and interning at Yili Dairy Unmanned Factory, Geely 4.0 Unmanned Factory, and Dongfeng New Energy Vehicle to understand the new technologies and new tools in the current digital and intelligent transformation process; Moreover, the practical link is closely combined with the enterprise, and the students participated in the research and development of the new intelligent electric screwdriver, from drawing to prototype testing, and fully experienced the design and manufacturing process of the electromechanical equipment product.

In conclusion, the second classroom has significantly expanded the social and engineering practical ability of mechanical major students through these activities, laying a solid foundation for their future career development in the mechanical field. At the same time, the method of "inviting in and going out" realizes the close combination of theory and practice, provides students with broad learning and growth opportunities, and enriches their knowledge reserves and practical experience.

3. Third classroom: Improving innovation and practical ability

3.1. Building an innovation team platform to promote diversified communication and improvement

To improve students' practical innovation ability, relying on the key laboratory of the autonomous region and using the open laboratory as the venue, several "college student innovation practice teams" such as the "Qingyu Science and Innovation Team," "New Hope Team," and "Dawn Maker Team" have been established. The innovation practice team is led by the school's innovation and entrepreneurship tutors and is managed independently by students. It is a collection of students from different majors and different grades for communication and learning. The innovation practice team has constructed the "front position" of multi-disciplinary cross-innovation for undergraduate students. Team members fully carry forward the advantages of autonomous learning and peer learning, integrate multidisciplinary and interdisciplinary knowledge, and form an innovation and entrepreneurship team based on the principle of "interest-driven + project-oriented," and carry out training for the ascending of innovation and practical ability at different levels of school creation, district creation and national creation.

3.2. Promoting the deep integration of specialization and innovation, stimulating the potential of innovative thinking

The college actively promotes the integration of professional construction and innovation and entrepreneurship education. Since 2023, more than 10 "integration of specialization and innovation" courses have been approved. Teachers integrate the latest disciplinary frontier knowledge into the classroom teaching content, guide students to think in the form of case teaching with the research results and problems in their scientific research projects, broaden students' horizons, improve their enthusiasm for learning, and cultivate their research interests.

The college encourages and guides students with spare capacity to participate in the actual scientific research and application projects of teachers, think actively, and have the courage to explore, learn and practice in the real research and development process. For example, in the project of "Intelligent Control System of Orchard Picking Robot," under the guidance of teachers, students conducted in-depth research on machine vision technology and intelligent algorithms, actively participated in the design, debugging and optimization of the system, and constantly tried new methods to improve the recognition accuracy and picking efficiency.

3.3. Promote learning through competitions to improve literacy and cultivate team spirit

Subject competitions are a crucial measure to cultivate students' team spirit and innovative practical ability. The competition team is primarily developed through the innovation team. The instructor teams up with students based on their different majors and specialties. Among the classmates, they have their specialties in the competition. Members work in a division of labor and cooperation, which exercises students' teamwork spirit and gives full play to their respective strengths, making the project more smoothly. In recent years, the college has arranged for teachers to provide special classification guidance for the "International College Students' Innovation Competition," "Siemens Cup Intelligent Manufacturing Competition" and "Challenge

Cup" China College Students' Entrepreneurship Plan Competition, and recommended outstanding players to participate in competitions in North China and the whole country. Competition-driven learning can fully mobilize students' initiative in learning, broaden their thinking, and cultivate team collaboration awareness and ability.

4. Conclusion

With the continuous exploration of engineering education development, the college's practical teaching model integrates industry and education, science and education, and competition and education. This multi-level practical teaching system has significantly enhanced the practical training capabilities of students majoring in machinery. By establishing an innovation base, drive-by projects, conducting scientific practice, promoting learning through competitions, and cultivating students' practical innovation ability. The exploration of the training model of innovative practical ability can be extended to the student training process of various engineering application majors, providing strong support for improving students' employment competitiveness and job adaptability and meeting society's demand for innovative talents.

Funding

Ministry of Education Industry-University Cooperation Collaborative Education Project, "AI + Intelligent Vision Laboratory Construction Project" (Project No.: 202101320008); Ministry of Education Industry-University Cooperation Collaborative Education Project, "Reform Project of Teaching Content and Curriculum System of Robotics Bionics Course under the Background of 'Integration of Specialization and Innovation'" (Project No.: 231101473041133); Ministry of Education Industry-University Cooperation Collaborative Education Project, "Research on the Teaching Content Reform of Robotics Engineering Major from the Perspective of Modern Industrial College" (Project No.: 231106451015616); Key Teaching Reform Project of Inner Mongolia University of Technology: Research on the Training Mode of Innovative Talents for the Integration of Industry and Education Oriented to New Engineering (Project No.: 2022101); Postgraduate Education and Teaching Reform Project of Inner Mongolia University of Technology, "Research and Practice on the Cultivation Mode of Postgraduate Innovation Ability Based on Positive Incentives" (Project No.: YJG2021005); New Engineering Curriculum Construction Project of Inner Mongolia University of Technology, "Basic Curriculum Construction Project of Robotics Bionics" (Project No.: RC2400000668); Excellent Teaching Team of Mechanical and Electronic Engineering Major of Inner Mongolia University of Technology

Disclosure statement

The authors declare no conflict of interest.

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