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Innovation and implementation of "introducing enterprises to education" to cultivate precision machining technology talents

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Introducing enterprises to education is an effective way to deepen the integration of industry and education. This article explores the implementation of "enterprise-integrated education" in the cultivation of precision machining technology talents. This includes establishing a collaborative teaching team, incorporating enterprise engineers into professional basic and practical training courses, offering interest classes, excellent classes, and precision engineering classes for precision machining. The objective is to amalgamate theoretical instruction with practical application and foster industry-academic collaboration, thereby mastering multi-axis machining technology. The teaching mode of "introducing enterprises into teaching" was evaluated through a questionnaire survey, revealing that it received positive recognition and high satisfaction from students in terms of its implementation effect.

Key words: Vocational education, industry-education integration, cultivation model, talent cultivation.

INTRODUCTION

From the promulgation of the "Vocational Education Law of the People's Republic of China" in May 1996 to its revision in April 2022, as well as the "Implementation Plan for National Vocational Education Reform" (consisting of 20 articles on vocational education) in 2019, all these reflect the national level's emphasis on vocational education and policy support. Among these, the "Opinions on Deepening the Reform of Modern Vocational Education System Construction" in 2022 emphasized the need to adhere to promoting production through education, assisting teaching through production, integrating production and education, promoting cooperation between production and education, and facilitating the formation of a modern vocational education structure and regional layout that is compatible with market demand and industry structure. Vocational education is not merely employment-oriented, nor is it a form of "low-level education". It should be closely linked to industrial transformation and regional development (General Office of the Chinese Communist Party, 2022).

At the national level, vocational education primarily focuses on hierarchical and long-term development. In 2014, the "Decision of the State Council on Accelerating the Development of Modern Vocational Education" proposed exploring the development of undergraduate-level vocational education, marking its first mention in a

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national normative document. Since 2019, the Ministry of Education has approved upgrades for selected higher vocational colleges to become undergraduate vocational schools and has implemented relevant policies. Currently, the positioning of undergraduate vocational education in society and its differentiation from specialized vocational education and undergraduate general education are unclear. Furthermore, further research is needed to deepen our understanding of talent cultivation in undergraduate vocational education.

Higher vocational education is a crucial battleground for cultivating high-quality technical and skilled talents, as well as great craftsmen. The laboratory and training rooms are pivotal sites for practical instruction. Although the quantity and quality of training facilities in vocational colleges have significantly improved, there are still deficiencies in construction and management that result in inadequate training rooms, failing to meet the demands of practical teaching and technical training (Zhang, 2021). Currently, relying solely on vocational colleges to establish large-scale high-end precision machining training bases is challenging. This requires not only the construction of advanced equipment hardware but also the development of a comprehensive curriculum. However, most teachers in vocational colleges teach practical training courses part-time and lack experience in enterprise management and frontline operations, resulting in insufficient operational procedures and skills. As a result, the quality level of practical training project development is relatively low, indicating the need for improvement.

Currently, common models for implementing "introducing enterprises into education" include inviting enterprise experts to collaborate in establishing talent training plans, co-authoring textbooks, and jointly constructing training bases (Gao and Tang, 2021; Li and Zhong, 2021). There are various methods of execution, such as "targeted class training" (Wang, 2019), order-based talent training (Tan, 2020), or specific course-specific development (Guo, 2019). To cultivate precision machining technology talents, high-end precision machining training bases are crucial. Without the participation of enterprises in construction and management, it is difficult to achieve practical results. Therefore, we should further emancipate our minds and increase the implementation of "introducing enterprises into education" (Liu, 2020; Wang, 2019).

Wu Xuemin, the party secretary of Nanjing Vocational University of Industry Technology, pointed out that school-enterprise cooperation should evolve into school-enterprise integration. While consolidating the theoretical foundation, undergraduate vocational education should also emphasize the cultivation of technical abilities to address practical problems. The trained talents should be better adapted to the technical skill requirements of high-end positions. In undergraduate vocational education, professional settings should aim at "two high-ends", namely high-end industries and high-end skills (Wu, 2023).

Deepening the integration of industry and education is a necessary educational approach for cultivating vocational talents. Currently, research on this integration primarily focuses on policy and mechanism levels. One effective approach to deepen and refine this integration is by incorporating enterprises into education. Against the backdrop of vigorously advocating intelligent manufacturing development, Chinese manufacturing faces both opportunities and challenges. Talent support is essential to achieve the upgrading of the industrial structure and the goals of "Made in China 2025" and "Industry 4.0". Cultivating high-end precision machining technology talents is particularly important in promoting the development of the intelligent manufacturing industry. Therefore, it is necessary to change the traditional teaching mode, enable students to adapt to corporate culture, and master corporate technology as soon as possible, thus shortening the cycle from graduation to becoming high-end technical talents. This is also the ultimate dream and benefit of employers. This article takes the innovative perspective of cultivating precision machining technology talents and explores the specific implementation of "introducing enterprises into education" from various micro links as an entry point.

INNOVATIVE PRECISION MACHINING TECHNOLOGY TALENT TRAINING MODEL OF "INTRODUCING ENTERPRISES INTO EDUCATION"

In order to realize the integration of industry and education, Nanjing Vocational University of Industry Technology and Beijing JingDiao Group have jointly established Beijing Jingdiao College and built a precision machining training base together. The hardware includes five-axis high-precision machining machines and automated production lines. As a leading precision machining enterprise in China, BeiJing JingDiao Technology Group Co., Ltd. possesses significant technological advantages in the intelligent manufacturing industry chain, which provides favorable conditions for "enterprise introduction into education". In that case, a mixed team was composed of enterprise experts and college teachers. The professional courses are conducted by a diverse teaching team. Ongoing discussions have been held since 2020 regarding training standards, content, and instructional models.

In the teaching process, we incorporated enterprise engineering projects and production cases to collaboratively develop textbooks, loose-leaf workbooks, and task lists that cater to practical teaching needs. To enhance the practical operational skills of professional educators, Beijing JingDiao College has offered specialized training in professional competencies to enterprise personnel and relevant instructors from the

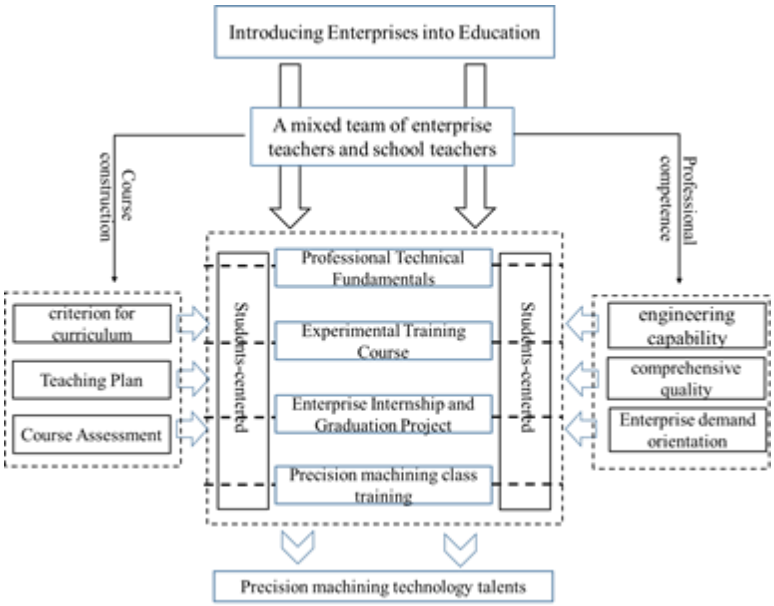

Figure 1. Models for talents cultivation of "Introducing Enterprises into Education" to cultivate precision processing technology talents.

School of Mechanical Engineering who are responsible for conducting hands-on training courses. This includes instruction on JDSoft SurfMill software as well as multi-axis machine tool operation. The mixed team collaboratively engages in practical and professional courses, seamlessly integrating corporate culture, advanced technology, management concepts, and job requirements into the classroom.

With a student-centered approach, we merge employment with education by taking enterprise job requirements into account when formulating professional plans and outlines. The mixed team jointly undertakes practical and professional courses, integrating corporate culture, advanced technology, management concepts, and job requirements into the classroom. We prioritize students as the center, combining employment with education, considering the job requirements of enterprises when formulating professional plans and outlines, and guiding teaching accordingly. The mixed team collaboratively engages in practical and professional courses, incorporating corporate culture, cutting-edge technology, management concepts, and job requirements into the classroom. By placing student development at the core, we integrate education and employment by incorporating enterprise job requirements into our professional plans and curricula, aligning our teaching methods accordingly. The models for talent cultivation are shown in Figure 1. Combining course construction with professional literacy cultivation, we carried out precision engineering class training with the goal of cultivating more outstanding talents in precision machining technology.

TEACHING MODE OF PROFESSIONAL BASIC TECHNOLOGY COURSES UNDER THE GUIDANCE OF "INTRODUCING ENTERPRISES INTO TEACHING"

For the professional courses in mechanical manufacturing and automation, the "Comprehensive Training of Product Manufacturing Process and Equipment" integrates knowledge and skills from courses such as "Mechanical Manufacturing Processes," "Machine Tool Fixture Design," and "Mechanical CAD/CAM Technology." The aim is to cultivate students' comprehensive abilities in completing processing process design, special fixture design, digital manufacturing, and CNC precision machining for actual machine elements. However, comprehensive practical training often faces challenges such as inadequate equipment or insufficient teacher expertise. By incorporating enterprises into the teaching process and inviting their engineers to participate and provide support, these obstacles can be effectively overcome. The teaching mode is shown in Figure 2. Theoretical teaching, skill training, and job practice are equally emphasized, providing students with sufficient online resources. Theoretical teaching and practical training align with professional standards and production needs.

Multi-axis CNC linkage machining technology represents the pinnacle of CNC machining capabilities. Currently, the teaching cases used in the course of Multi-axis CNC Linkage Machining Technology in this specialty are all derived from or abstracted from actual enterprise cases. These cases retain elements that reflect the characteristics of multi-axis machining and precision

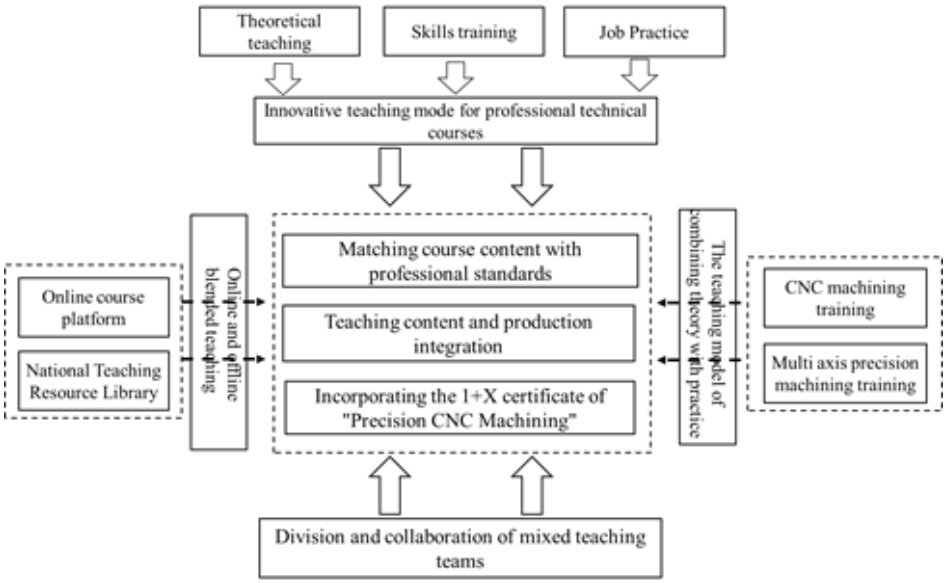

Figure 2. Teaching mode of mixed team.

machining to better meet classroom teaching requirements. Additionally, the courses in this major are challenging and highly practical. Under the organization of a mixed teacher team, progressive talent training programs such as precision machining interest classes, excellent classes, and precision engineering classes are carried out. This ensures that students can effectively manage their time for optimal learning. After the training, students proficiently master the utilization of 5-axis CNC programming software and the operation skills of 5-axis machining centers. They also make significant progress in fixture design, tool application, and process parameter optimization. They successfully integrate theory and practice, skillfully applying their process knowledge in practical situations.

To enhance the connection between professional basic courses and practical courses, specialized classes like "Mechanical CAD/CAM Technology" and "Mechanical CAM" use a blended teaching approach. Instructors from both sides collaborate on course preparation, evaluation, and assessment. Through theoretical knowledge and practical training, these students establish a solid foundation for the 1+X certificate, skills competitions, and employment. With a combination of theoretical knowledge and practical training, these students establish a strong foundation for obtaining the 1+X certificate, participating in skills competitions, and seizing employment opportunities.

METHODOLOGY

Survey questionnaire on the effectiveness of teaching models

To foster high-end precision machining and manufacturing talents, the mixed teaching team has undertaken exploration and innovation in the teaching approach. We carried out a questionnaire survey to assess the effectiveness of the "introducing enterprises into teaching" model. This survey involved 60 students who recently received professional courses from enterprise instructors, along with practical training in CNC machining and precision manufacturing. The primary questions of the questionnaire are outlined in Table 1.

RESULTS

Based on the questions in Table 1, the percentage results of option selection were used to generate Figure 3. The outcomes of the survey questionnaire indicate that the teaching model of "introducing enterprises into teaching" has been well received by most students and has achieved a high level of satisfaction. The knowledge and skills imparted by enterprise experts have laid a solid foundation for their future engagement in the precision manufacturing industry. As many as 90% of students expressed their desire to continue participating in practical courses on "introducing enterprises into teaching." However, there are still very few students who have chosen different options, and this outcome might be related to their level of interest in and recognition of the major.

DISCUSSION

This paper discusses the implementation mode of "integrating enterprises into education" and provides an illustrative example for developing the talent training approach in vocational education, specifically focusing on

Table 1. Questionnaire question and corresponding options.

Numbers	Questionnaire question	Options, number of students who have selected this option		
1	Is it necessary to introduce enterprise experts to participate in classroom teaching?	Necessary, 56	General,2	Undesired, 2
2	Does the knowledge and skills taught by enterprise experts meet the requirements for engaging in precision manufacturing related professions?	Relevant, 56	General,4	Irrelevant, 0
3	What is the overall evaluation of the implementation of the course task of "introducing enterprises into education"?	Satisfaction, 58	General, 0	Dissatisfactory, 0
4	Do you wish to continue implementing the "Introducing Enterprises into Education" practical course in the next session?	Desirable, 54	General, 6	Undesirable, 0
5	Are you willing to work in the mechanical manufacturing industry after graduation?	Willing, 56	Uncertain, 0	Unwilling, 4

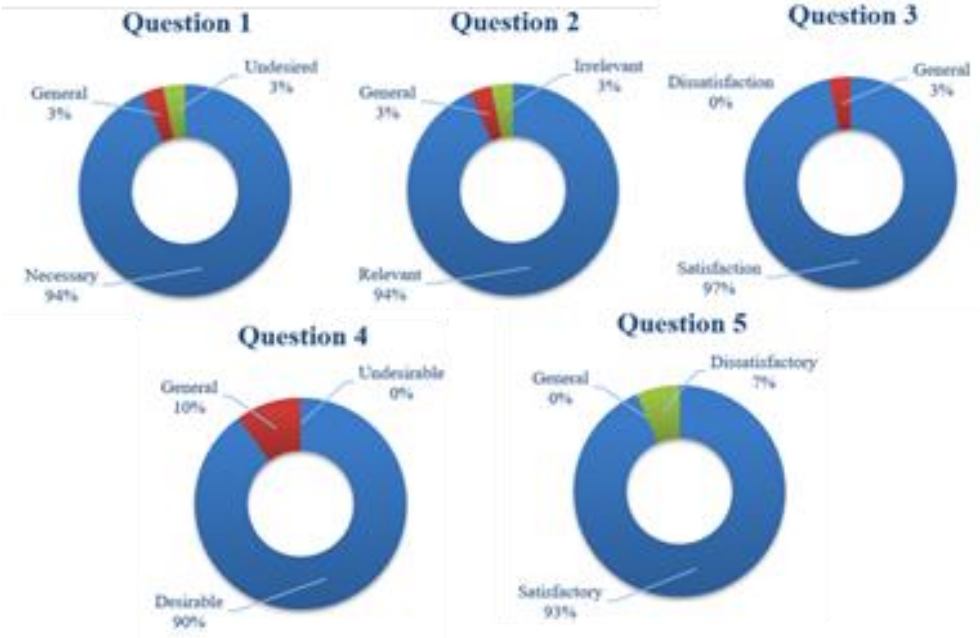

Figure 3. Results of survey questionnaire on the implementation effect of the teaching mode of "introducing enterprises into education".

cultivating precision machining technology talents. The objective is to nurture skilled professionals in vocational education who can meet the demands of high-level manufacturing roles. Enterprise teachers within the mixed teaching team not only deliver vocational skills training to school educators but also actively participate in teaching foundational professional courses and practical training sessions. By doing so, the establishment of a mixed teaching team facilitates the timely introduction of new technologies into educational institutions, enabling continuous updates to teaching content and fostering a group of teachers with robust practical abilities and extensive experience. For students, the involvement of enterprises provides exposure to cutting-edge technology, allowing them to learn through hands-on applications. This greatly enhances their learning enthusiasm and boosts teaching efficiency, a correlation consistent with the findings of the student survey questionnaire. The integration of practical teaching into real-world production within schools elevates students'

skill levels and learning progress. Simultaneously, for enterprises, it enhances their visibility and societal contributions while nurturing and creating a pool of potential employees.

However, it's crucial to acknowledge the limitations of enterprise teachers. While they possess practical technical skills, it's important to note that they might lack formal professional training and exhibit certain deficiencies in educational methodologies. Hence, the provision of training programs for enterprise teachers becomes essential. Furthermore, establishing an effective government policy framework and a viable standard system, including a performance evaluation mechanism that encompasses production-education integration standards, is necessary. Strengthening laws and regulations related to industry-education integration and enhancing the implementability of relevant provisions is vital. Establishing a well-functioning cooperation mechanism for industry-education integration, taking into account the interests of both educational institutions and enterprises, is also imperative.

Additionally, vocational colleges should incorporate diversification, three-dimensionality, and openness into the structure of their educational systems while constructing the teaching evaluation mechanism. In future research, our focus will extend to tracking and investigating graduates who work in the mechanical manufacturing industry. This will help us establish a closed-loop system of talent cultivation and application, shaping a replicable talent cultivation model.

Conclusion

Advancing vocational education through deepening the integration of industry and education, as well as implementing the "introduction of enterprises into education," is crucial. This article explores innovative approaches to incorporating enterprises into education for the purpose of cultivating precision machining technology talents. By forming a mixed teaching team and providing training in multi-axis machine tool machining operations to departmental teachers, the practical skills of full-time educators have been enhanced. Enterprise engineers are actively involved in teaching professional foundational courses and practical training, achieving a seamless bridge between theoretical knowledge and hands-on application. Simultaneously, courses of different levels such as precision machining interest classes, excellence classes, and precision engineering classes are offered to progressively enhance students' proficiency in Multi-axis machining technology. This prepares them for involvement in 1+X certificate examinations, skills competitions, and future employment prospects. A questionnaire survey on the implementation impact of the "Introducing Enterprises into Education" model revealed that it has garnered high praise and recognition.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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