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# *Construction and Implementation of an Integrated Teaching Model for CNC Lathe, CNC Milling, and Multi-Axis Machining*

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***Abstract:*** With the advent of the Industry 4.0 era, CNC technology education faces new challenges and opportunities. This research conducts an in-depth analysis of the educational needs in CNC lathe, CNC milling, and multi-axis machining technologies, discussing the crucial role of an integrated teaching model in enhancing teaching efficiency and meeting industrial demands. By systematically constructing and implementing this model, this paper aims to address current challenges in educational processes, such as maintenance of technical equipment, insufficient teaching resources, and lack of faculty training. The study shows that by integrating teaching resources, improving laboratory facilities, implementing faculty training programs, and designing student incentive mechanisms, it is possible to effectively enhance teaching quality and meet industry demands.

## 1. Introduction

In the context of rapid global economic development and technological progress, CNC technology, as a core technology in manufacturing, has a direct impact on industrial productivity and innovation capacity. Especially in the fields of CNC lathe, CNC milling, and multi-axis machining, high-quality technical education is one of the key factors in enhancing national competitiveness. However, issues such as aging equipment, outdated teaching materials, and insufficient faculty strength in educational practices severely restrict the quality and effectiveness of education. Therefore, researching and implementing an integrated teaching model is not only necessary to enhance teaching efficiency but also essential to meet the rapidly changing industrial demands.

## 2. Current Status of CNC Technology Education

### 2.1. Educational Needs for CNC Lathe, CNC Milling, and Multi-Axis Machining Technologies

With the rapid development of manufacturing technology, the application of CNC technology has become the core of modern manufacturing systems. Specifically, CNC lathes, CNC milling, and multi-axis machining technologies, as key equipment for high-precision and high-efficiency production, require high levels of operational skills and theoretical knowledge. The educational demand for these technologies exhibits several characteristics: firstly, the industry urgently needs

technically skilled personnel with practical capabilities and innovative thinking; secondly, with the updating and upgrading of technology, there is a higher demand for timely updates in educational content; thirdly, with the spread of intelligent manufacturing and automated production, there is an increasing demand for technically skilled personnel with multi-skilled, cross-functional abilities. Therefore, educational institutions need to continuously optimize teaching content and methods to adapt to rapidly changing technological demands.

### 2.2. Industry Development Trends in CNC Lathe, CNC Milling, and Multi-Axis Machining Technologies

Currently, CNC technology is developing towards intelligence, precision, and networking. Specifically, intelligence is reflected in the deep integration of CNC systems with information technology, such as remote monitoring and maintenance of equipment via the Internet of Things; precision is reflected in the continuous improvement of machining accuracy and efficiency, especially in the growing application demands in fields like aerospace and automotive manufacturing; networking focuses on the integration of production management and data exchange. These trends not only drive the innovation of CNC technology itself but also pose new challenges for technical education, requiring educators not only to teach operational skills but also to enhance students' information technology capabilities and systematic thinking.

### 2.3. The Key Role of Integrated Teaching Models in Enhancing Teaching Efficiency and Meeting Industrial Needs

Integrated teaching models, by combining theoretical knowledge with practical operations and using project-based teaching, greatly enhance the targeted and practical effectiveness of teaching[1]. This model emphasizes the close integration of practice and theory, not limited to traditional classroom teaching but more through practical training projects that simulate actual work environments. For example, by engaging in real production tasks, students learn CNC programming, equipment operation, and quality control skills while completing specific products. Additionally, integrated teaching models can better adapt to new demands brought by technological advancements in the industry, such as introducing the latest industrial technologies and equipment through corporate collaboration projects, allowing students to engage with industry frontiers during their learning process. Overall, integrated teaching models play a crucial role in enhancing teaching efficiency and meeting industrial needs, effectively bridging the gap between education and industry demands.

## 3. Construction and Implementation of Integrated Teaching Models for CNC Lathe, CNC Milling, and Multi-Axis Machining

### 3.1. Design of Teaching Models

In the design of integrated teaching models for CNC lathe, CNC milling, and multi-axis machining technologies, the core goal is to create a comprehensive educational environment that merges theoretical knowledge with practical operations, classroom learning with simulated work scenarios. This model focuses on interactive, project-driven teaching methods aimed at deepening students' understanding and mastery of theoretical knowledge through practical operations. For this purpose, the teaching model design adopts a modular course structure, each module focusing on a core technology or operation, with specific project tasks to reinforce learning objectives.

Furthermore, the teaching model emphasizes incorporating elements of competitions and team collaboration to inspire students' innovation and collaborative abilities. As students solve practical

problems, not only does this promote the effective integration of theory and practice, but it also cultivates their strategies and team collaboration skills in facing complex industrial challenges. This teaching strategy not only enhances the interactivity and enjoyment of teaching but also provides students with valuable hands-on experience for their future careers.

### 3.2. Course Settings and Practical Operations

Course settings should comprehensively cover key areas such as CNC programming basics, machine tool operation skills, CAD/CAM software applications, and multi-axis machining technologies, aiming to systematically develop students' core skills. To ensure students fully understand the basic concepts and operational principles, each course combines theoretical learning with practical operations. The theoretical part provides the necessary technical background and theoretical foundation, while practical operations involve students directly in the actual operation process, allowing them to deeply understand and apply the knowledge learned[2].

Especially in CNC milling courses, students start with the basics of milling theory and gradually transition to performing milling projects from simple to complex. This progressive learning model helps students gradually build confidence and skills in actual operations. To simulate a real work environment, schools should establish training bases that meet industrial standards, providing students with a learning place close to actual production environments and ensuring that the teaching content closely aligns with industry demands, thus enhancing the practical value and effectiveness of education.

## 4. Main Challenges Encountered in the Implementation Process

### 4.1. Difficulties in Operation and Maintenance of Technical Equipment

In the implementation of CNC lathe, CNC milling, and multi-axis machining technology education, the operation and maintenance of equipment face multiple challenges. Due to their high precision requirements and complex operating characteristics, these devices require frequent maintenance to remain in good condition, especially after prolonged use. However, maintenance costs are high and, coupled with a lack of skilled technical personnel, it is challenging for schools to continuously maintain these educational machine tools in optimal working conditions.

Furthermore, with rapid technological advancements, existing outdated equipment often fails to meet new educational demands, especially when introducing the latest technologies and teaching methods. Upgrading these high-end devices requires significant financial investment, representing a substantial financial burden for educational institutions. Thus, equipment upgrades and maintenance are major challenges in teaching implementation, limiting the updating of teaching content and the richness of students' learning experiences.

### 4.2. Insufficient Teaching Resources and Laboratory Development

The lack of teaching resources and outdated laboratory facilities are significant factors limiting the quality of education and students' learning efficiency in many institutions. Currently, teaching resources are overly focused on traditional theoretical learning, lacking sufficient modern teaching aids and materials that effectively integrate theory with practical application. This issue is particularly evident in the teaching of CNC lathe, CNC milling, and multi-axis machining technologies, where traditional teaching resources fail to meet the practical operation demands of these high-tech fields.

Additionally, laboratory facilities are often outdated and lack the variety of equipment necessary to support practical teaching across all required technologies. This prevents comprehensive skill

training for students, limiting their holistic development in CNC technologies. The lack of suitable laboratory environments and equipment not only hinders the teaching process but also slows down students' adaptation to and mastery of new technologies[3].

### 4.3. Lack of Teacher Training and Technical Support

Teachers are the core executors of educational activities, and their professional capabilities directly determine the quality and effectiveness of teaching. Currently, one of the major issues faced by many educational institutions is the insufficient training of teachers, especially in terms of updating their knowledge of new technologies and teaching methods. The absence of systematic training programs makes it difficult for teachers to master and impart advanced CNC technologies, affecting the cutting-edge nature of teaching content and limiting innovation in teaching methods.

Furthermore, when teachers encounter equipment malfunctions or technical issues during teaching, they often cannot conduct effective instruction due to a lack of necessary technical support. This lack of support not only increases teachers' workload but also affects students' learning progress and the overall efficiency of educational activities. Therefore, the lack of professional development for teachers and technical support are crucial issues that need immediate resolution in current educational implementations.

### 4.4. Lack of Student Engagement and Practical Skills

The lack of student engagement and practical skills poses significant challenges in the implementation of CNC technology education. Due to the complexity and challenging nature of CNC technology, many students experience apprehension, which acts as a psychological barrier, reducing their motivation and willingness to engage in the learning process. A lack of interest and motivation somewhat suppresses students' ability to deeply understand and master the technology, affecting the ultimate realization of teaching effectiveness.

Moreover, the current teaching model often features a disconnect between theory and practice, making it difficult for students to translate classroom-learned theoretical knowledge into practical skills. The scarcity of practical opportunities and the lack of real-world work environment experiences severely limit students' ability to develop hands-on skills and solve practical problems. This not only affects their skill enhancement but also restricts their preparation and adaptability for future careers.

### 4.5. Imperfect Course Evaluation and Effectiveness Monitoring Methods

In CNC technology education, the imperfection of course evaluation and effectiveness monitoring methods constitutes a significant teaching challenge. The current evaluation system primarily focuses on theoretical assessments, which inadequately evaluates students' practical operational skills and innovative capabilities. This biased evaluation method fails to fully reflect students' comprehensive skills and practical abilities, thus impacting the true and comprehensive assessment of teaching quality.

Additionally, the lack of an effective feedback mechanism means that during the teaching process, both teachers and students struggle to receive timely improvement suggestions and necessary support[4]. This situation restricts timely adjustments and optimization of the teaching process, hindering continuous improvement and enhancement of teaching quality. The absence of immediate feedback not only slows the pace of teaching improvements but also makes it difficult to achieve expected outcomes in teaching innovation and effectiveness enhancement.

## 5. Strategies for Addressing Issues Encountered in the Implementation Process

### 5.1. Technical Training and Support for Equipment Operation and Maintenance

To address difficulties in the operation and maintenance of technical equipment, it is crucial to establish a professional equipment maintenance team. Providing regular technical training for teachers and technicians can enhance their understanding of the latest CNC technology trends, and improve their skills in equipment maintenance and troubleshooting. Such training helps the maintenance team to effectively resolve equipment issues, ensuring continuous operation and stability of the devices, thereby minimizing teaching disruptions due to equipment failures.

Additionally, establishing partnerships with equipment suppliers is an effective strategy to ensure the quality of equipment maintenance. Through such collaborations, educational institutions can directly receive technical support and professional services from suppliers, which not only provides timely technical assistance but also ensures that equipment is maintained and updated to the highest standards. This strategy helps to enhance overall equipment management efficiency and ensures the smooth conduct of teaching activities.

### 5.2. Integration of Teaching Resources and Improvement of Laboratory Facilities

To address the lack of teaching resources and outdated laboratory facilities, it is first necessary to integrate resources by establishing shared platforms to optimize the existing resource allocation. This integration can improve the efficiency of resource use, ensuring that all teaching activities receive the necessary support. Moreover, to better meet the demands of teaching and industrial development, educational institutions should consider investing in the modernization and expansion of laboratory facilities, incorporating multifunctional and high-precision CNC machines and related measurement and testing equipment.

Further, enhancing the digital infrastructure of laboratories is also a key measure to improve teaching quality. By introducing virtual simulation systems, students can be provided with more extensive practical operation opportunities, allowing them to learn and apply CNC technology in simulated work environments. This practical experience not only deepens students' understanding of the technology but also enhances their problem-solving capabilities, thus increasing the practicality and effectiveness of teaching.

### 5.3. Implementation of Teacher Training Programs and Technical Consultation Services

To address the lack of teacher training and technical support, educational institutions should regularly organize professional technical training and industry seminars for teachers. These activities aim to keep teachers' skills up-to-date and ensure alignment with industry standards, thereby enhancing their professional level and teaching effectiveness[5]. Regular training and seminars help teachers continuously update their knowledge base, mastering the latest technological trends and teaching methods.

Additionally, it is recommended to establish a technical consultation service system for teachers, offering comprehensive online and onsite technical support. This support service is designed to help teachers quickly resolve technical issues encountered during the teaching process, reduce teaching interruptions, and enhance the overall quality of teaching activities. By implementing these measures, educational institutions can ensure that teachers are effectively equipped to handle various challenges in teaching while also enhancing the professionalism and practicality of teaching.

### 5.4. Student Motivation Mechanisms and Practical Project Design

To enhance students' learning enthusiasm and practical skills, educational institutions should design a series of challenging and innovative practical projects. These projects should enable students to learn and grow through solving real-world problems, thereby not only enhancing their technical skills but also strengthening their problem-solving abilities. Through hands-on operation and project implementation, students can gain a deeper understanding of theoretical knowledge and apply it to practical work, which is key to improving teaching outcomes.

Furthermore, to further stimulate students' interest and participation, it is suggested to introduce various student motivation mechanisms. For example, providing scholarships, organizing skill competitions, and offering internship opportunities are effective ways to encourage students to actively participate in learning and practical activities. These incentives not only enhance students' motivation but also significantly improve their professional skills and readiness for employment. This comprehensive approach helps students develop holistically, laying a solid foundation for future career success.

### 5.5. Development of Course Evaluation Systems and Improvement of Effectiveness Monitoring Mechanisms

To address the issue of imperfect course evaluation and effectiveness monitoring methods, it is suggested to establish a comprehensive course evaluation system. This system should include feedback from students, teachers, and industry experts, and cover comprehensive assessments of practical outcomes. By collecting opinions and evaluations from various perspectives, the effectiveness of teaching activities can be more accurately measured, ensuring the comprehensiveness and fairness of the evaluation process[6].

Additionally, modern information technology tools, such as data analysis and online feedback systems, should be used to monitor and analyze teaching effectiveness in real-time. This technological application can help educational managers and teachers to stay informed about teaching progress and students' learning statuses, allowing for timely adjustments to teaching content and methods to ensure alignment with predetermined goals. Through continuous monitoring and immediate adjustments, teaching quality and learning outcomes can be effectively enhanced.

## 6. Conclusion

This study has effectively addressed several challenges encountered in educational practice through the development and implementation of an integrated model for CNC lathe, CNC milling, and multi-axis machining technology education. Throughout the implementation process, significant progress was made in the continuous operation and maintenance of technical equipment, the adequacy and renewal of teaching resources, professional development of teachers, and enhancement of student skills. However, the course evaluation and effectiveness monitoring systems still require further improvement. Future research should focus on the trends of smart manufacturing and the industrial internet, further integrating modern information technologies to advance CNC technology education towards higher efficiency and intelligence. Additionally, strengthening international cooperation and exchange, and adopting advanced educational concepts and methods are essential to maintaining a competitive edge in the global manufacturing industry.

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