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# Reforms and applications of online practice teaching in the field of new engineering

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**Abstract:** Practice teaching is an effective way for students to consolidate their theoretical knowledge and is also a significant module of talent training models used in higher education. Recently, offline practice teaching has faced limitations of space and time, which, online practice teaching, as a supplement to the offline teaching, is an innovative exploration of traditional practice teaching ideas. Such ideas are actively promoted through the extensive integration of information technology and education and a scientific approach using related research results as feedback to create new teaching resources. This simulation platform facilitates the quality and efficiency of the training operations and delineates its applications on machines and engineering equipment. Moreover, students' in-depth knowledge gained through this platform further enhances their ability to practice using innovative ideas. Overall, the study aims to contribute to broadening the horizons for and enhancing the quality of online practice teaching.

**Keywords:** new engineering; mechanical engineering; online practice teaching; teaching reform.

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Tianyu Ren received a BEng in Mechanical Engineering in 2019 from Northeastern University, and currently he is in his 3th year of MSE in the same institution. His research interests include new engineering education reform, practical training.

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## 1 Introduction

There are three stages in the development of higher education: elite, popular and popularisation-based education. Generally, a gross enrolment rate of higher education below 15% indicates the elite education stage; between 15% and 50% indicates the popular education stage; and above 50% indicates the popularisation-based education stage. In 2019, the gross enrolment rate of higher education in China exceeded 50%, implying that higher education in the country has entered the stage of popularisation-based education. While this is the inevitable result of the development of a modern society, the continuous expansion of popularisation-based education exposed certain limitations (Stes et al., 2010). Owing the increase in the number of educated students, there is an increased pressure on the distribution and utilisation of educational resources, particularly for engineering majors in machinery requiring a certain amount of practice teaching. Limitations in offline practice teaching are consequential to site and safety issues. Using online practice teaching methods resolves this issue. Online practice teaching can be integrated into theoretical learning to effectively solve the predicament that appears due to unbalanced distribution of educational resources.

**Figure 1** The characteristics and problems of mechanical undergraduate students


Practical and theoretical teaching supplement and complement each other. However, the former has a positive effect on improving students' practical skills and cultivating sharpness (Van Beveren et al., 2018). The knowledge imparted in classes helps students gain a preliminary understanding of a subject and develop their theoretical knowledge. Next, by combining theory and practice, practice teaching helps students grasp and apply the acquired knowledge in a comprehensive and multi-faceted manner.

In view of this, practice teaching, as an essential part of college curriculum, demands value. However, it is mainly based on offline methods and cannot be flexibly arranged due to its fixed practice time. For large equipment, several limiting factors exist. Ensuring that every student has the opportunity to practically operate the equipment is not an easy task. Additionally, various problems exist in actual applications, such as the inability to apply theories to practical problems and the lack of rich and in-depth practice content. Owing the impact of the COVID-19 pandemic, national colleges and universities implemented 'Delayed return to school without stopping to teach and advised students to begin their semester at home. Offline practice teaching also has its limitations. Therefore, it is necessary to explore a new teaching and learning mode. Online teaching could make up for the delay caused by the pandemic (Ripoll et al., 2021; Shamsir et al., 2021; Shim and Lee, 2020). However, integrating information technology into education and transforming scientific and technological achievements into teaching resources are urgent issues for educators (Scherer et al., 2021; Van Popta et al., 2017).

This paper focuses on majors related to mechanical engineering and explores the reform approaches of online teaching based on online practical methods and real teaching experiences in terms of 'New Engineering'. Web-based teaching platforms, such as Chinese University MOOC, Rain Classroom, BB Platform, Tencent Meeting, and others, can be employed to conduct relevant theoretical teaching (Lapitan et al., 2021). Course resources, such as prepared slides, recorded course video, assignments and others, should be pre-uploaded by instructors. Course requirements like assignment deadlines also need to be clarified (Delnoij et al., 2020; Van Popta et al., 2017). These processes can advance the course and provide students with time to acquire knowledge. Additionally, these steps can help students clarify their doubts when attending a class and improve the efficiency of teaching and learning (Feitosa de Moura et al., 2021; Hew and Cheung, 2014). Simultaneously, online practice teaching based on internet resources and well-combined scientific research and practice teaching may also be implemented. Through the virtual simulation platform provided by the School of Mechanical Engineering and Automation, Northeastern University, China, students can operate online virtual machine tools based on Virtual Reality (VR) technology resulting in increased enjoyment of teaching and learning while practice learning involvement is also improved. Furthermore, the diversified and flexible operation mode aids constant exploration and practice.

The development and application of novel technology such as artificial intelligence and virtual simulation break the norms of traditional teaching and drive the reforms in teaching (Cox, 2021; Garzón et al., 2020), making them the future trends of development in education. Thus, online teaching is leading the future of education, and its exploration and application fills the gaps in mechanical practice teaching and promotes the reform and innovation of the teaching system.

## 2 The dynamic integration of online practice teaching and scientific research

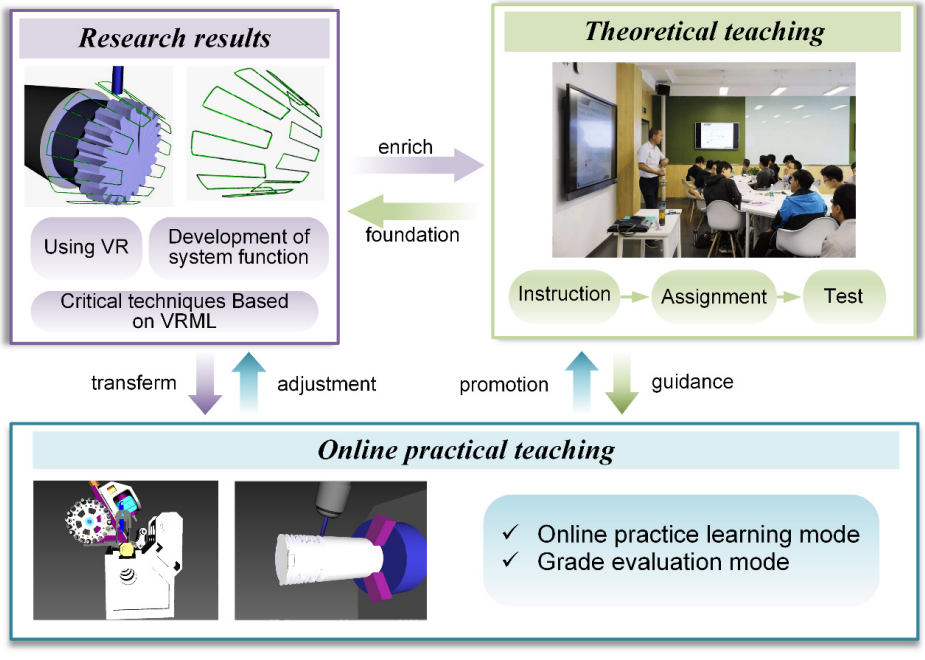
To assist students in stimulating their passion for the curriculum, encourage their initiatives in learning, and implement the teaching mode of 'Dynamic integration of theory, online practice and scientific research', the theories of mechanical manufacturing and virtual simulation can be used as a practice guide. The objective of this process

would be to build a strong foundation for scientific research, enrich the presented theory and improve the quality of teaching.

Regarding traditional experimental courses of a mechanical engineering major, although the instructors explain the principles through videos or animations, the lack of practical experience causes most students attention to wander as they find the subject difficult to understand. For some courses, which need more practical activities (e.g. Fundamental of Mechanical Manufacturing Technology and CNC [Computer Numerical Control] Machining Technology), students have a higher level of corresponding requirements for activities such as operating equipment using their synthetic learning. Thus, the practical course is undoubtedly an essential part of university education.

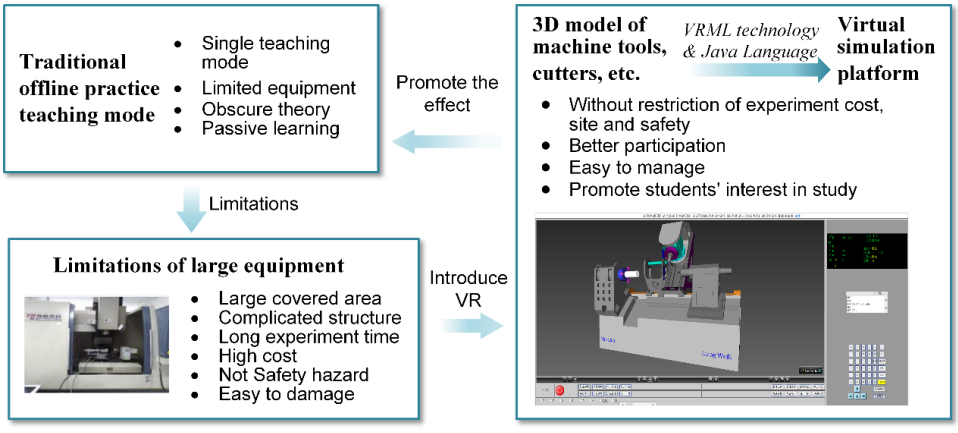
However, a few practical activities which employ large mechanical equipment (like CNC machining centre) usually suffer from some disadvantages. For instance, the activities occupy a large area and they are complex in structure and time-consuming.

**Figure 2** Schematic presentation of the teaching mode – the 'Trinity of Theory, Practice, Scientific Research'




Given the above circumstances, it is necessary to explore the approaches of introducing VR technology in teaching production practices and innovation training courses. By adopting these advanced technologies to reform the mode of teaching mechanical courses, combining the scientific research results and teaching content and using online virtual simulation experiments, the limitations of the teaching process can be overcome, including the number of equipment sets, processing costs, safety and other factors. Additionally, students may develop an interest and become actively involved in learning the contents of the course.

**Figure 3** The necessity of online practice teaching




VR technology provides a good visual and aural experience. Based on its characteristics, students can complete the practical training online with almost realistic scenarios. Thus, the traditional face-to-face, live teaching of training activity becomes a touchable and interactive distance-learning experience. Inspired by this, with an interaction of Java language and Virtual Reality Modelling Language (VRML) technology, a virtual machining simulation system with independent intellectual property was developed by the School of Mechanical Engineering and Automation, Northeastern University. It integrates scientific research results and teaching content and supports online model previews of machining tools, motion presentations, and simulation experiments.

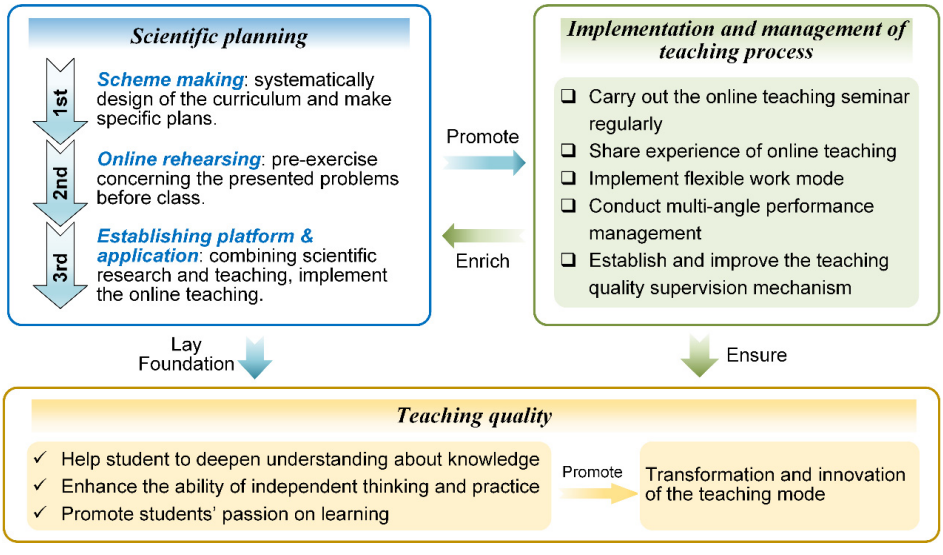
This platform can also support online virtual pre-assembly. Consequently, students will have a deeper understanding of the machine structure in 3D vision and virtual machining can also be realised by entering the correct CNC machining programmes on the corresponding panel. Such novel teaching and learning modes using rich teaching content will encourage students to increase their passion for learning and motivate them to acquire more professional knowledge. Moreover, this system is easy to understand and convenient to access. Students can directly complete their learning on the webpage by signing-in from their own accounts on system platform. Such an approach overcomes the restrictions of time and space.

## 3 Exploring online practice teaching

The implementation of online teaching and learning requires systematic planning to facilitate the educational process for maintaining the quality of teaching.

During the online teaching process, the implementation, management, and emergency handling of teaching and learning requires systematic planning to fully utilise the various management functions provided by the e-learning platform. This also establishes a sound management system for the implementation of online teaching and learning and ensures quality control. Finally, a smooth implementation of the online process can also be achieved to create the online assessment model (Scherer et al., 2021).

**Figure 4** Exploring the online teaching mode



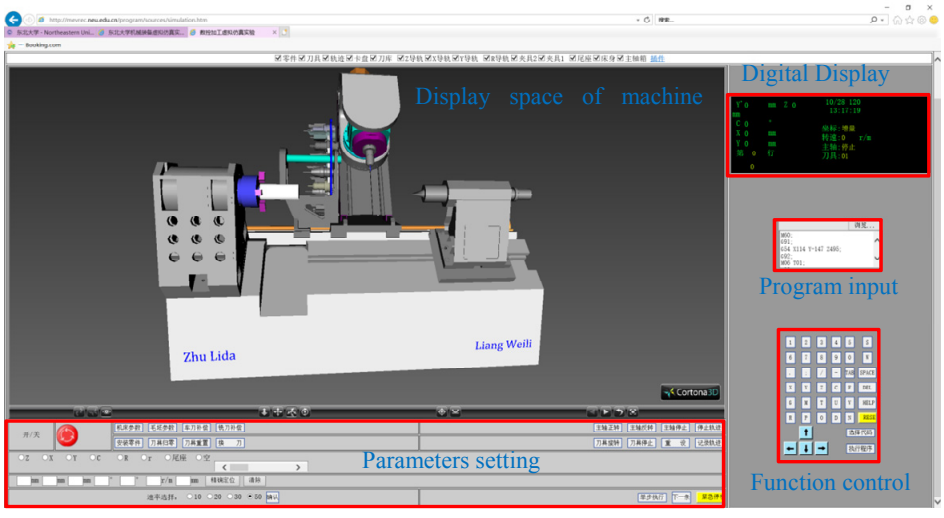

By introducing VR, virtual manufacturing technology, and simulation processing technology to the mechanical engineering innovation training, the machine model – assembly process and working state of the five-axis linked, combined turning and milling machining centre – can be presented to students in a virtual environment. This serves as a 'transfer station' between theoretical studies and engineering practice, allowing students to understand the CNC machining in a close but contactless manner.

## *3.1 The implementation process of online practice teaching*

Students can personalise their learning based on the theoretical online instruction of CNC machine tool technology, virtual simulation machining technology and the relevant uploaded digital learning material (e.g. micro-lessons, videos, knowledge points and course exercises). Meanwhile, teachers have the right to supervise the students. For example, students can access further learning material only after they have cleared a certain period of learning and qualified in the current theory examination.

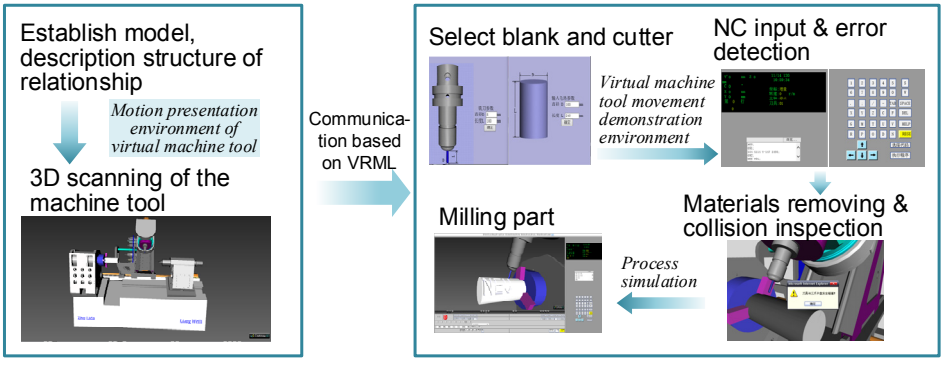
Modelling software can be utilised to establish the turning and milling virtual simulation model – consisting of the machine tool, fixture, cutter and workpiece – and describe their structural relationship. The motion simulation environment built under the network enables students to preview the virtual prototype model via a browser. According to the interactivity of the VRML technology, the given relationship among workpiece, fixture and tool holder provides the students with an opportunity to choose the cutter and bulk material per their requirements.

**Figure 5** Interface of the online practice teaching and learning system




This teaching and learning platform also support the virtual pre-assembly of a 3D model of machine tools, interactive viewing of parts and free loading and unloading operations, thereby enhancing their understanding of the machine tool structure. Moreover, the input, error detection and other functions of the Numerical Control (NC) machining programme can be realised in the virtual machining environment. Further, parameterised modelling, material removal and collision detection can also be performed during the virtual simulation process.

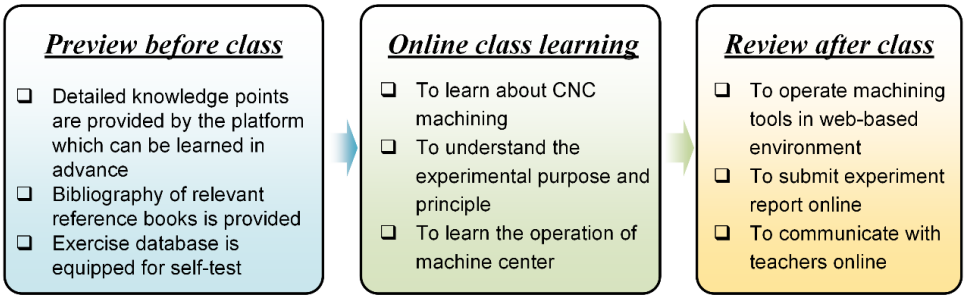
**Figure 6** Virtual reality technology-based operation process of online practice teaching system




Students can access the virtual simulation classroom by making an advance appointment. First, the experiment purpose, principles, operation method of the software platform should be clarified. The VR system introduces an almost real experimental environment, procedures, tasks, equipment performance with high-fidelity to the learner, allowing them to develop an initial understanding of the CNC machine tool digital parameter modelling, virtual simulation of the assembly and processing with human-machine

interaction mode. Additionally, the system has an animation module producing relevant animations for realistically reproducing the working process.

**Figure 7** Implementation of online practice teaching




## *3.2 The effect of implementing online practice teaching*

During online practice teaching, machine movement demonstrations, virtual assembly and machining simulations would be provided so that students can comprehensively apply their knowledge and develop a broader understanding of mechanical equipment.

The teaching mode that combines the virtual simulation experiment and theoretical learning reduces the restrictions of field operation. It provides students with a faster, clearer and a more convenient way to develop deeper perceptual cognition of the operation process of a machine tool. The rational cognition of students is enhanced through the process of setting the machine tool parameter and its virtual operation. Such a learning process significantly improves the effects of theoretical and experimental teaching. This further enhances students' knowledge of CNC machine tools and machining technology and consolidates the acquired knowledge of mechanical engineering. Through accurate learning and interpretation of complex experimental processes, the outcome of practice teaching could be remarkably improved and the shortcomings of insufficient experimental teaching resources, high cost, long learning cycle, security risks and others could be avoided.

Students' learning curiosity can be boosted through innovative teaching approaches primarily used to help them explore suitable learning methods. Students can match their specific problems to the methods and find a suitable resolution. Online practice is useful for learning subjects when the traditional teaching methods are deemed insufficient.

### *3.2.1 Stimulating interest: 'I have the passion to learn'*

The new teaching mode helps students change their mindset from 'passive learning' to 'active learning'. Taking the course 'CNC Machine Tools Technology' as an example, when an instructor asks the students to discuss and analyse the principles of different combinations of structural materials, connection states, force characteristics, as well as the correlations and differences between them, relatively more students show a keen interest.

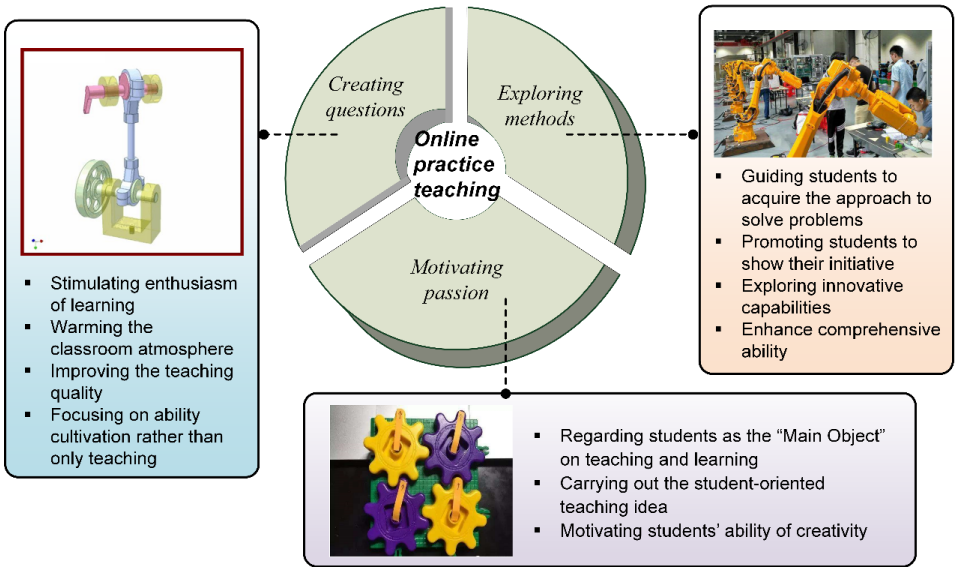
### 3.2.2 Teaching method: 'To explore'

The progressive approach is advocated to help students analyse and solve problems. Students are naturally involved in exploring the teaching and learning process. In this case, their enthusiasm and motivation might be promoted, and their creative skills could be developed. Additionally, students could experience a sense of pride in their learning and participation.

### 3.2.3 Creating questions: 'Thinking hard'

In the experimental course, questions are valuable to nurture students' curiosity. This procedure can fully stimulate their interest in learning and positively affect the class environment, leading to a qualitative leap in the teaching outcome. For instance, in a gear processing experiment, it is possible to set the module parameter with abnormal data. Thus, students can continue the experiment until they find the solution. Finally, they can conclude the experiment and analyse the results with their teacher.

**Figure 8** A closed-loop teaching model based on online practice




Web-based practical activities are beneficial for students to enhance their practical ability and cultivate innovative thinking. Consequently, it is necessary to establish such web-based numerical control virtual simulation practice platforms. Currently, several batches of online practice teaching classes have been conducted (mechanical engineering innovation training) and numerous students have completed the course. The online practise teaching classes provide a good external condition for students to strengthen their ability of solving complex engineering problems. Through the assessment of assignments, students can access the practical exercises and submit reports online. Figure 9 gives an example of the submission status of assignments on the web-based platform. The screenshot shows that the practice reports have been submitted and the

grades given in conjunction with the quality of the reports. Figure 10 depicts the online operation of work samples machining by a student.

**Figure 9** Submission status of practice report

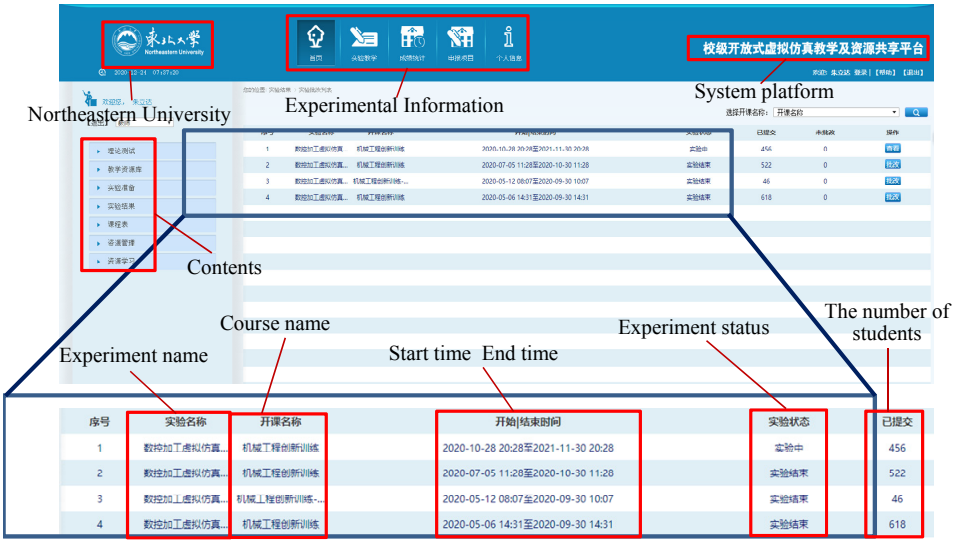
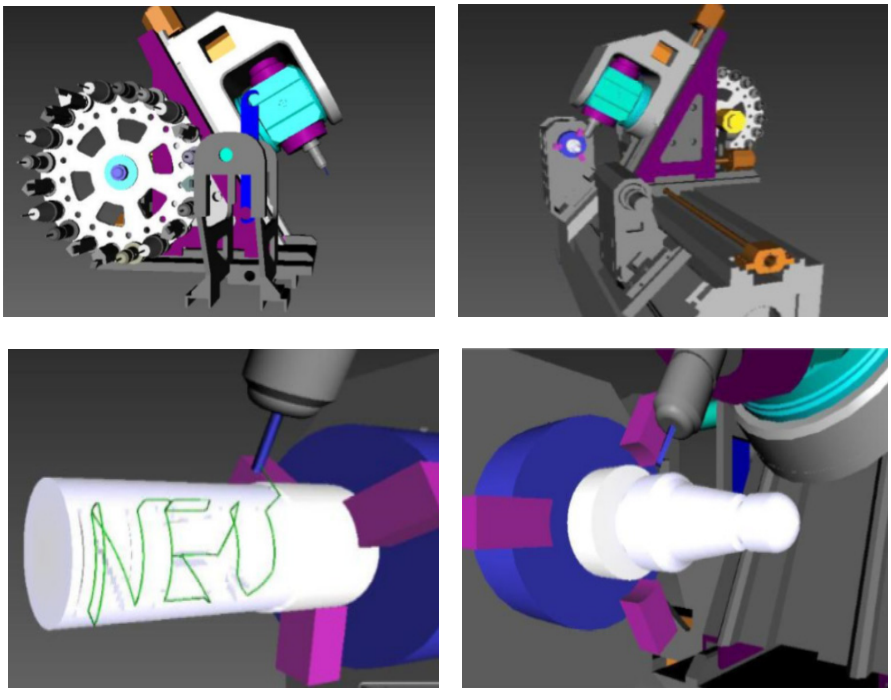



**Figure 10** Online operating process of the sample drawing completed by students



## 4 Concluding remarks

Practice course – the supplement and transformation of theoretical knowledge acquired from face-to-face classes and books – is a crucial aspect of university education. Applying scientific research results into practice teaching, dynamically integrating research and teaching, and employing web-based practice methods can improve the efficiency and effectiveness of experimental practical operation of engineering equipment in the mechanical field and optimise the learning experience for students. Additionally, for students, their professional experience could be consolidated by learning the typical cases from the virtual platform. For the teaching process, the instruction approaches can be enriched. Online practice teaching modes have established a 'closed-loop feedback' evaluation mechanism between the teaching process and quality, including the online courses, practice training and assessments, and online submission of assignments. This process adds to the novelty of the teaching content and makes teaching activities more interesting, management more effective, and evaluation more accurate. Furthermore, it introduces a heuristic experience to the innovation and reform of the teaching mode in New Engineering.

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