

## Application analysis of Industrial Software in Training the Engineering Ability of Mechanical Professional Education

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**Keywords:** industrial software, digital tools, engineering ability training, computer software application, practical teaching

**Abstract:** To adapt to China's strategy of strengthening manufacturing power and improving the digitalization of R&D and design tools and key processes, colleges and universities must improve the ability of the students to use digitalized tools comprehensively during the process of personnel training. Qilu University of Technology has played a positive role in promoting the students' understanding and mastery of theoretical knowledge by offering various courses and using engineering software in practical teaching, which has played an important role in cultivating/promoting the engineering abilities of the students.

### 1. Introduction

In recent years, China's manufacturing industry has continued to develop rapidly, which has effectively promoted industrialization and modernization and led to fruitful achievements in various fields. At the same time, China's manufacturing industry has obvious gaps in independent innovation capability, resource utilization efficiency, industrial structure and informatization levels, and quality benefits when compared to the global advancements [1]. In face of the current severe international trade conflicts, transformation, upgradation, and sustainable development of the manufacturing industry are particularly arduous.

For example, consider the two indicators of the two-technology integration mentioned/outlined in the action plan "Made in China 2025" of China's implementation of the strategy of manufacturing a strong country [1]. This requires the digitalization of the R&D tools for enterprises above the designated scale that apply digital R&D design tools, which was 52% in 2013 and is expected to rise to 84% in 2025. The numerical control rate of the key processes of the enterprises above the designated size has been predicted to increase from the current 27% to 64% in 2025. During this period, the growth rate of the two indicators of integration was very high from 2015–2019. This requires the manufacturing industry to achieve rapid growth in the digitization of research and development design tools and numerical control of key processes in the next few years, thus achieving a higher target level in 2025. Engineering colleges that train talent for the manufacturing industry should also consult China's manufacturing development strategy, and rapidly improve the engineering ability of students with respect to the use of digital tools [2].

The engineering team is the largest innovation group in an innovative country, and undergraduate education plays the most important role in cultivating a large number of outstanding engineers. This period of engineering education plays a decisive role in developing a sense of innovation, cultivating innovative ability, and the thrust to achieve innovation in students [3]. Students should be educated and trained to become excellent engineers, and engineering education should be used as an important output target.

To achieve these goals, higher engineering colleges have introduced a variety of engineering software in the basic and practical teaching curriculum to ensure that the improved engineering ability of the teachers and students is accomplished.

## **2. Manuscript Preparation**

The rapid development of modern computer hardware technology and the informatization needs of the machinery industry have led to the rapid development of a large quantity of mechanical software, along with the appearance of numerous typical application software. Professional software can be classified into drawing software, control system and mechanism motion simulation software, mechanics analysis, and numerical control simulation software. There are also integrated CAD/CAE/CAM software such as UG, CATIA, and Pro/Engineer, which provide digital tools for the teaching and practice of mechanical engineering.

The engineering ability development of mechanical majors is a gradual and continuous process. Students first understand and master theoretical knowledge via classroom theory teaching, and subsequently deepen and integrate the theoretical knowledge in practical teaching links/modules. For example, the students can use various simulation analysis software in the practical stage and virtually complete various experiments that can be conducted in the laboratory on a computer platform. Some special experiments that are limited by realistic conditions can also be conducted, which have many advantages such as no time and venue restrictions, reproducibility, and low cost. Such cases have received widespread attention in various institutions in recent years.

When using industrial software to solve a variety of practical problems in computer modeling, teachers can guide students to apply basic theoretical knowledge, and analyze and verify the results to facilitate engineering applications. This theory, combined with the actual teaching process, has promoted the ability of the teachers and students to use industrial software and understand engineering problems. This has also trained students to solve practical problems and achieve autonomy in engineering practice.

## **3. Application of Engineering Software**

### **3.1. Application of the Cad Software**

Drawing software is the most basic digital tool in the mechanical industry. Commonly used mechanical drawing software includes the two-dimensional drawing software AutoCAD, CAXA, three-dimensional drawing software UG, Pro/Engineer, CATIA, SolidWorks, and I-DEAS to name a few. The structural design of direct 3D parts has become the developmental trend in current mechanical design methods due to the popularization of 3D CAD design software. A few companies supporting higher levels of digitization both at home and abroad have even achieved processing without drawings, employing three-dimensional graphics from the design to processing stages [4]. According to the digital development trend of R&D and design tools in “Made in China 2025”, China’s large-scale manufacturing enterprises will all achieve the goal of direct 3D parts design and manufacturing.

There are currently various 3D design software containing functions that can be continuously enhanced, with the realization of any expression. This can quickly achieve the rapid conversion of 3D models to 2D drawings [5]. The three-dimensional digital model is the basis for any subsequent analysis of mechanical assembly and performance, numerical control machining simulation, and exterior design. In process of teaching engineering practice, the use of 3D design software for modeling requires students to demonstrate their basic engineering abilities. A large number of practices have generally proved that students who are trained based on digital ability requirements of the design tools are more suited to meet the needs/requirements of many enterprises in today’s transformation and upgradation environments.

The application of graphics software is also increasing in the practical teaching curriculum of Qilu University of Technology. In addition to the drawing courses offered by the relevant majors, the school also offers a 3D modeling-based course that can be selected throughout the school. The students undergo extensive 2D and 3D graphics modeling training via relevant courses. Although the students use 3D software to design the initial process, this is more time-consuming as compared to traditional manual drawing methods. However, the later method/option is convenient and fast, with the drawing quality and degree of standardization being higher as compared to manual drawing.

Thus, this provides a good foundation for any subsequent professional course learning and skills improvement.

### **3.2. Application of the CAE Software**

Engineering mechanics, mechanical principles, and mechanical design constitute the core courses of mechanical engineering. The contents of the mechanical principle and mechanical design courses should introduce the principles of each institution in detail. The corresponding practical teaching links mainly cover the course experiment, mechanical principle course design and mechanical design course design, and innovative design and production. These practical teaching contents/topics encourage students to integrate theoretical knowledge and design methods that were learnt based on the requirements, especially in the mechanical innovation design process. It is also necessary to implement new ideas on this basis, leading to the design of a creative and practical mechanism or device.

In engineering mechanics and mechanical design courses, the mechanical analysis of engineering materials and mechanical structures and strength analysis of mechanical components are usually static mechanics problems. Theoretical or material mechanics knowledge can be used to perform simple structural or mechanical component calculations, which generally requires problem simplifications and the obtained results are often used for qualitative analysis. Theoretical analysis and analytical calculations are relatively difficult if the analysis involves a complex mechanical structure composed of a large number of parts and various types of materials, or involves dynamics and nonlinear problems, and usually require professional mechanical analysis software to solve the calculations.

With the continuous development of industrial software, the commonly used mechanical professional CAE analysis software offers a variety of mechanical analysis functions, such as the MSC Software, ANSYS, ABAQUS, HyperWorks, and other software. Furthermore, the main 3D modeling software such as UG, Pro/Engineer, CATIA, SolidWorks, and I-DEAS have also been constantly expanding the CAE analysis functions.

Common CAE problem analysis includes static structural and dynamic analysis, linear and nonlinear problems, and physics or multi-field coupling problems involving solids, fluids, and acoustics. CAE software typically performs the mechanical analysis of mechanical components or assemblies. In addition to meeting the static design criteria, the strength and stiffness of the components are guaranteed. Dynamic analysis, such as modal and frequency response analysis, is required to meet the dynamic performance of the components and assembly as a whole. Additionally, modality planning and adjustment of the natural frequency of the components and assembly as a whole is required, to meet the static and dynamic performance requirements of the mechanical components or whole machine. The above software applications are often used for modeling, analysis, and design in physical experiments, fluid mechanics, material mechanics experiments, and various competitions and graduation designs both within and outside the school. A variety of software must be used to complete the task when tackling complex problems.

Additionally, the pre-processing work/steps in the CAE analysis forms the working basis for any subsequent analysis and involves modeling, gridding, and other related engineering software. Various practices have shown that establishing the model in the CAE analysis, the pre-processing of the input data, and interpretation and evaluation of the analysis results require approximately 50% of the time, while the computer-only analysis operation time only accounts for approximately 5%. Thus, students majoring in mechanical engineering need to be proficient in CAD modeling tools. Additionally, they should have solid theoretical knowledge and accumulated practical experience, otherwise the simulation results cannot be correctly interpreted and evaluated.

In practice, students can first complete the machine model of their own design using CAD modeling tools, simulate the pre-designed motion trajectory, realize the expected function, achieve the desired performance, and realize/develop the digital mechanism model design. In the CAE method, the design of the drawing plan is simulated and analyzed before subsequently returning to the real training on the experimental bench. This plays an important role in promoting the

consolidation of theoretical knowledge and cultivation of experimental skills.

### **3.3. Application of the CAM Software**

In addition to completing the basic performance analysis requirements in the CAE phase, the existing component structure is further statically and dynamically optimized and advanced to the manufacturing process analysis stage. In this stage, it is necessary to analyze the design life of the product and corresponding mold development process to meet the multi-faceted analysis requirements of the mechanical product design, manufacturing, and assembly. These processes can use the corresponding digital simulation tools to guide the actual product design process via simulation analysis and verification of the digital prototypes. In addition to the UG, Pro/Engineer, CATIA, SolidWorks, I-DEAS and other CAD/CAE/CAM integrated software, common CAM analysis software includes the MasterCAM, SurfCAM, HyperMILL, and Cimatron software. The virtual manufacture of the products on a computer using simulation software would greatly facilitate the teaching practice activities in mechanical engineering.

The numerical control technology course is a professional course that is closely related to product manufacturing. In practice, the CNC simulation software is generally required to train the numerical control programming ability of the students. The accuracy and processing efficiency of the NC code could be improved via the simulation process of simple parts. Finally, the optimized code is input to the CNC machine tool to realize fast and efficient part processing. Students' understanding and mastery of the manufacturing process and process flow can be deepened using CAM simulation analysis.

### **3.4. Application of the Control System Simulation Software**

Mechatronics system design, microcomputer principles, and computer and process equipment control are important mechanical and electrical control related courses for mechanical majors. They mainly describe the working principle of the computer and control system of the process equipment. The practical teaching links corresponding to this course mainly involve various experiments and course design. In the course design of the control system, students are required to use the relevant sensor detection technology, software and hardware interface technology, system modeling, control system design, and other related knowledge based on the control indicators to design practical mechanical and electrical products or achieve process control.

There are currently various software that can be used to control system simulation, such as MATLAB, Simulationx, LabVIEW, Siemens LMS Imagine.Lab, and other professional software, along with simulation software corresponding to the PLC, DCS, and FCS systems. The professional course on electromechanical control can estimate the control objectives and tasks, build software and hardware systems, establish signal acquisition and detection systems with the help of related software. The control strategy can be selected for different complexity control objects, and the simulation software of the control system can be used for modeling and processing simulation calculations to obtain a control scheme with excellent performance.

In the practical process, students can select the appropriate simulation module and adjust the simple parameters, and conduct a large number of repeatability tests on the control process. This offers a flexible, convenient, and low cost solution and promotes the students' practical ability and comprehensive application of multidisciplinary knowledge. Additionally, teachers and students can combine various electronic extracurricular competition activities with the practical training of control system simulation, actively train the ability of the student to solve engineering problems and foster teamwork, form various innovative and entrepreneurial teams, and activate the learning enthusiasm of the students.

## **4. Conclusion**

In the process of talent cultivation, colleges and universities must focus on developing the ability of the students to use digital tools comprehensively. This is necessary to achieve the digitization of the manufacturing R&D design tools and numerical control of key processes outlined in the "Made

in China 2025” action plan, and to realize the demand for the comprehensive quality of mechanical engineering professional abilities in manufacturing.

Qilu University of Technology has set up various courses and competitions in recent years, to guide the students in the practical use of various industrial software, train them to combine the practical observations of production and life, and accumulate different levels of engineering experience. Additionally, students learn to use a variety of engineering software and positively promote the understanding and mastery of theoretical knowledge. This enables the students to realize that solid theoretical knowledge accumulation is a prerequisite for the skilled use of tools and correct evaluation of analytical conclusions, and is necessary to promote ones professional knowledge. This demonstrates that learning has played a good positive feedback role.

Industrial software is varied in application and is still evolving after nearly half a century of development. Students at the university level can learn the most common mechanical engineering software via various practical teaching links. They can master one CAD\CAE\CAM integrated software and be familiar with 2~3 professional domain analysis software. This has far-reaching implications for improving the’ professional quality/ability of the students and accelerating the development of the manufacturing industry in China.

### **Acknowledgements**

This work is supported by Project of Shandong Province Higher Educational Science and Technology Program (J17KA029) and Key Research and Development Plan of Shandong Province (2018GGX103006).

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