Education Reform and Development, 2025, Volume 7, Issue 1
https://ojs.bbwpublisher.com/index.php/ERD
Online ISSN: 2652-5372
Print ISSN: 2652-5364

Teaching Research and Practice of Digital Design and Manufacturing Ability Training

Youliang Tang*, Tao Jiang, Jinhua Zhang

Suqian University, Suqian 223800, Jiangsu Province, China

Corresponding author: Youliang Tang, yltangsqc@126.com

Abstract: The cultivation of digital design and manufacturing ability has become one of the core objectives of the teaching reform of mechanical majors. At the same time, it is also one of the effective measures to solve the disconnection between theoretical education and the practice of mechanical majors. This paper takes the connotation of digital design and manufacturing ability training and effective teaching strategies to carry out in-depth research and discussion on the relevant content, to continuously improve the quality of talent training of mechanical majors, for students to contribute to the career path successfully.

Keywords: Mechanical major; Digital design and manufacturing capability; Teaching strategy

Online publication: February 12, 2025

1. Introduction

Nowadays, the mechanical engineering field is gradually moving towards the era of intelligent manufacturing, and one of the important indicators is the level of digital manufacturing and application ability of the enterprise. In essence, the talents trained by mechanical majors in universities are fundamentally different from those trained by vocational education. The major of machinery in colleges and universities mainly cultivates compound applied talents with solid and sufficient theoretical knowledge of machinery, as well as good humanistic quality and innovative spirit. Starting from practice, mechanical professionals with good digital design and manufacturing ability have gradually become the most needed in the era of intelligent manufacturing. From this point of view, this paper discusses the training goal of digital design and manufacturing ability to deeply explore if the relevant content of mechanical professional teaching has significant theoretical and practical significance.

2. The connotation of digital design and manufacturing ability

2.1. Engineering drawing ability

Engineering drawing ability includes but is not limited to drawing reading ability, spatial thinking ability, modeling ability, drawing ability, and innovation ability. To cultivate students' good engineering drawing ability

not only need traditional engineering drawing courses but also need to rely on advanced 3D modeling software, to achieve the established talent training objectives. According to the classic content of engineering drawing, teachers can guide students to closely combine with computer drawing knowledge and, at the same time, cultivate their ability to skillfully and flexibly use computer-aided spatial thinking, to gradually help students form three-dimensional spatial thinking ability [1]. Given the teaching difficulties, to achieve the expected teaching effect and achieve the goal of training students' digital design and manufacturing ability, teachers can actively bring 3D design software into the classroom in the actual teaching process, such as CAXA, CRO-E, INVENTOR, UGNX, etc. The teaching focuses on the training of students' 3D parts and assembly design skills, to lay a solid foundation for the subsequent courses such as virtual prototype and computer-aided manufacturing [2].

2.2. Computer-aided manufacturing ability

Computer-aided manufacturing capability refers to the ability to automatically generate machining trajectory and program objectives by defining a series of machining elements and parameters based on a two-dimensional or three-dimensional model of a product. Computer-aided manufacturing capability not only improves the efficiency and accuracy of the manufacturing process but also promotes the intelligent and sustainable development of the manufacturing industry [3]. As technology continues to advance, computer-aided manufacturing will continue to evolve and play an increasingly important role in future manufacturing processes, helping companies maintain an edge in global competition. Therefore, computer-aided manufacturing capabilities will become one of the necessary capabilities for those employed in the machining industry. Specific to teaching practice, training students' CAD ability needs to rely on advanced software platforms, such as MasterCAM, UGNX, Powermill and so on [4–5].

2.3. Comprehensive ability of NC machining technology

The comprehensive ability of CNC machining technology is the final link of the training of students' digital design and manufacturing ability, which specifically refers to the training of students' ability to put the preliminary design and process planning into practice. In the early stage, teachers can encourage students to design a virtual prototype of a specific product in the mechanical foundation comprehensive design and virtual prototype application technology, and then carry out activities such as three-dimensional process planning and fixture design of virtual parts [6]. Through the close combination of professional theory and practical training, students can not only master the processing process of common typical parts but also verify the results of digital design in the early stage. In the process of prototype manufacturing, students can not only consolidate theoretical knowledge but also develop the ability to teamwork and problem-solving. By facing challenges in actual manufacturing, they will learn how to optimize the processing process and improve production efficiency [7]. In addition, teachers should encourage students to reflect on and summarize practical experiences to promote a deeper understanding of digital design and manufacturing, thus laying a solid foundation for future engineering practice.

3. Effective teaching strategies for the cultivation of digital design and manufacturing ability

3.1. Establish a systematic curriculum system

In recent years, with the continuous improvement of the intelligence level of enterprises, the market has an

increasing demand for compound talents who master product design modeling and numerical control processing technology. As an important means of talent training in colleges and universities, the curriculum is an important basis for promoting educational reform and improving the overall teaching quality of machinery majors. Building a systematic curriculum system not only helps to improve the training quality of mechanical professionals but also highlights the characteristics of the major. Therefore, colleges and universities should pay more attention to the optimization and reform of the mechanical major curriculum system, to promote the realization of the training goal of outstanding talents [8].

To improve students' digital design and manufacturing ability, college courses in mechanical majors should cover "Engineering drawing", "AutoCAD", "three-dimensional mechanical software CAD", "Mechanical manufacturing technology", "numerical control technology", "numerical control programming and CAM", "CAD/CAM" and other courses. These courses are not only theoretical, but also closely related to actual production, with significant engineering practicability, and can effectively promote the cultivation of students' digital design and manufacturing ability [9–10].

To ensure the effective implementation and scientificness of the curriculum system, teachers can arrange different courses in different semesters to improve the teaching quality to the greatest extent and promote the organic combination of course content before and after, to gradually cultivate students' ability in digital design and manufacturing. For example, teachers can set up some basic theory courses in the first year of college to help students lay a solid theoretical foundation. If the number of hours is insufficient, some courses can be offered as electives. Subsequently, teachers should guide students to learn the latest technologies, such as digital processes and intelligent manufacturing systems, to ensure that students' knowledge and skills keep up with the time. Finally, teachers cooperate with enterprise mentors to guide students to carry out practical training and practice, and help students accumulate rich experience in practical operation through CAD experiments, factory internships, and project training, to ensure the cutting-edge and practical curriculum system and lay a solid foundation for the cultivation of students' digital design and manufacturing ability [11].

3.2. Building a "double-qualified" teacher team

The construction of a "double-qualified" teacher team is a key measure to improve teaching quality, and also an important support to cultivate students' digital design and manufacturing ability. Colleges and universities should take various ways to improve the theoretical knowledge, practical skills, and comprehensive quality of mechanical teachers, to truly form a high-quality "double-qualified" teacher team. For example, teachers should reasonably arrange the time of winter and summer vacation, and actively participate in the practice of enterprises to accumulate rich practical experience. At the same time, colleges and universities should regularly organize teachers of machinery majors to go to relevant enterprises for research, visit, or temporary training, so that they can understand the latest trends in the industry and the actual requirements of enterprises for machinery talents in the digital age, and have a solid engineering background, to clarify the teaching objectives of machinery majors. Provide typical practical projects for the cultivation of students' digital design and manufacturing ability, and accumulate rich practical experience [12]. In addition, to improve the academic level and practical ability of teachers, schools should actively support teachers to participate in high-level training and continuing education, so that they can timely understand the most cutting-edge mechanical design and manufacturing technology, to provide students with the most professional guidance and help. At the same time, the university may invite outstanding employees of enterprises and engineers in the field of digital design and manufacturing to hold lectures on campus or regularly send teachers to well-known enterprises or universities at home and abroad for exchange and study or encourage

teachers to participate in the training organized by the National Training Center for Manufacturing Information Technology or the human resources and social security department. The teachers can obtain the "three-dimensional CAD training instructor" qualification certificate or "numerical control machine tool operation qualification certificate", which are important to build a "double-qualified" teacher team [13].

3.3. School-enterprise cooperation to build a practical teaching base

School-enterprise cooperation is an important way to improve students' practical ability. Schools should actively establish close cooperative relations with enterprises and jointly build practical teaching bases to provide students with real and abundant internship and practice opportunities. Taking the author's school as an example, the school has always taken the construction of a provincial modern manufacturing technology experimental teaching demonstration center as the core goal and cooperated with local enterprises to create modern manufacturing technology laboratories, CAD/CAM laboratories, and mechanical engineering innovation laboratories, which effectively provide students with a variety of practical opportunities and also provide valuable site support for teachers' teaching activities [14]. The school attaches special importance to the planning and implementation of the practical teaching system of mechanical majors. On the one hand, the school attaches importance to the cultivation of students' basic skills, on the other hand, the school encourages students to explore and innovate. Through the close combination of class and extracurricular, the school has successfully built a multi-level and all-round practical teaching system covering metalworking practice, course experiments, production practice, skills training, and innovative activities. With the help of school-enterprise cooperation, the company provides a variety of comprehensive, research-oriented, innovative, and experimental digital design and manufacturing projects for the school, aiming to help students better understand the digital design and manufacturing process and constantly improve their digital design and manufacturing capabilities [15]. In the process of production practice, the teachers of the school and the "master" of the enterprise actively provide professional guidance and personalized help for the students, guide them to deeply analyze and scientifically and effectively solve the practical process problems on the site, so that the classroom teaching content is closely combined with the actual situation on the site, to better cultivate the students' engineering consciousness and innovative spirit. At the same time, this significantly improves their ability to discover, analyze, and solve problems.

3.4. Using modern information technology to build an online teaching platform

The progress of modern information technology provides a brand new opportunity for the education and teaching of mechanical majors. To build a network teaching platform of theory, experiment, and practical training specially designed for digital design and manufacturing, teachers first need to visit enterprises for research. Based on school-enterprise cooperation, teachers should investigate the organization and management mode, product design process, and production and operation mode of the cooperative enterprise in detail, make reasonable simplification according to the actual situation of the major taught, and finally determine the general workflow of a typical manufacturing enterprise. In addition, combined with the existing conditions of the school, work together with professionals to create a special network teaching platform integrating a variety of digital manufacturing, measuring equipment, and various CAD/CAE/CAM unit software. The network teaching platform can truly simulate the digital design and manufacturing process of modern enterprises, and create a close to the real enterprise environment for students, to significantly improve the students' digital design and manufacturing ability [16]. With the help of this platform, teachers can also constantly introduce typical products of enterprises as teaching cases, adopt project-driven teaching methods, divide students into different project teams,

and encourage them to carry out project practice. Teachers can also use the role-playing method to encourage students to choose the role they are most interested in from the design, programming, technology, management, and other related roles to play, to organize students to conduct skills training in a targeted way, and effectively improve their digital design and manufacturing capabilities. In addition, the platform can also be connected with the school's exclusive online teaching platform or app to provide students with rich learning resources and a free learning environment to further meet their personalized learning needs.

4. Conclusion

To sum up, the seamless connection between theory and practice teaching can be effectively realized by building a systematic curriculum system, training a team of "double-qualified" teachers, establishing a practice teaching base in cooperation with enterprises, and relying on modern information technology to build a network teaching platform. At the same time, these measures have also significantly enhanced the students' ability in digital design and manufacturing, as well as their ability to solve complex practical problems, so that they can better meet the high requirements and new expectations of mechanical talents in the age of digital intelligence. This is of great significance in promoting the long-term development of students and schools.

Funding

(1) Jiangsu Province Qinglan Project Excellent Teaching Team Project (Su Jiaoshi Han) [2024] No.14
(2) Special Topic Research on Digital Transformation and Practice of Education Modernization in Jiangsu Province (2024CXJG035)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Cai YF, Yu WQ, 2023, Teaching Research and Exploration of Digital Design Manufacturing Ability Training. Journal of Liaoning Higher Vocational Education, 25(11): 53–57.

[2] Li TG, 2015, Curriculum Group Planning Based on Digital Design and Manufacturing Ability Training. Journal of Jilin Provincial Institute of Education, 2015(4): 54–55.

[3] Tian CY, Jiang H, 2017, Construction of Network Teaching Environment for Training Digital Design and Manufacturing Ability of Mechanical Majors. Equipment Manufacturing Technology, 2017(1): 195–197.

[4] Zhao HX, Wang J, Guo Y, et al., 2023, Analysis on the Cultivation of Innovation Ability of Mechanical Engineering Major — A Case Study of Digital Design and Manufacturing Maker Class in Jinling University of Science and Technology. Science Advisory, 2023(3): 216–218.

[5] Zeng DH, Yang CL, Fan K, et al., 2023, Construction and Practice of Mechanical Digital Design Ability Training System under the Background of New Engineering. Journal of Hubei Minzu University (Natural Science Edition), 41(4): 553–560.

[6] Hao LN, Yang JY, Lin JZ, et al., 2023, Research and Practice of Digital Ability Training in Professional Education

of Intelligent Manufacturing. Education and Teaching Forum, 2023(9): 96–99.

[7] Xu W, 2014, Training Innovative Talents and Exploring the Teaching Reform of "Digital Design and Manufacturing". Laboratory Research and Exploration, 33(7): 218–220 + 235.

[8] Zhou KB, 2020, Construction and Analysis of Innovative Talent Training Model based on Digital Design and Intelligent Manufacturing. Consumer Electronics, 2020(2): 44–45.

[9] Li LC, 2019, Research on Construction of Innovative Talent Training Model based on Digital Design and Intelligent Manufacturing. China Educational Technology Equipment, 2019(4): 132–134.

[10] Kong H, 2024, Application Strategy of Digital Technology in Integrated Teaching of Mechanical Design and Manufacturing. Journal of Jiamusi Vocational College, 40(6): 203–205.

[11] Xu J, 2021, Analysis on Construction Strategy of Digital Design and Manufacturing Teaching Training Platform Based on Work Process. Knowledge Economy, 583(18): 164–165.

[12] Xie F, Feng BH, Li RY, 2024, Exploration on the Integration of Digital Manufacturing and Industrial Design Teaching. World of Toys, 2024(8): 200–202.

[13] Chen Y, Xu FH, Li R, 2023, Application of Digital Technology in Integrated Teaching of Mechanical Design and Manufacturing. Automotive Practical Technology, 48(24): 164–167.

[14] Li XR, Liu MX, 2021, Research on Teaching Model Construction of Digital Product Design and Intelligent Manufacturing based on PLM Platform. Internal Combustion Engine and Accessories, 2021(14): 243–244.

[15] Yao YJ, Wu DX, Bai XL, et al., 2017, Reform and Exploration of Comprehensive Practical Teaching of Digital Design and Manufacturing for Undergraduate Students in Applied Universities. Teaching and Educating People (Higher Education Forum), 2017(3): 92–93.

[16] Li J, Lin HY, Lian BH, 2019, Thinking and Exploration of Typical Parts Digital Design and Manufacturing Teaching. Industry and Technology Forum, 18(23): 190–191.