

Construction of Digital Teaching Materials for Equipment Manufacturing Industry Based on Virtual Simulation

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Abstract

Digital textbooks are an important component of China's textbook development, embodying the power to lead educational digital transformation and bearing the mission of talent cultivation in the digital age. Focusing on the talent training system for the equipment manufacturing industry, this paper proposes a construction plan for digital textbooks based on virtual simulation technology. The main contents of the textbook construction include professional qualities with the spirit of craftsmanship as the core, digital cases of single manufacturing equipment, and digital cases of system manufacturing equipment. A project-driven + engineering introduction research method is adopted to elaborate on the process of developing digital textbooks using various virtual reality techniques. Digital textbooks can serve as auxiliary reference books for college students' innovative activities and engineers' product development, and can also provide references and insights for the construction of digital textbooks.

Keywords

Digital Textbooks; Virtual Simulation; Virtual Reality; Manufacturing Equipment; Craftsmanship.

1. Foreword

In 2023, the CPC Central Committee and the State Council issued the "Overall Layout Plan for the Construction of Digital China," which proposed a comprehensive plan for the development of Digital China. In February 2024, the Ministry of Education released the "14th Five-Year Plan for the Construction of National Undergraduate Textbooks in General Higher Education," stating that "exploring the construction of a batch of exemplary new type textbooks is one of the key tasks." Digital textbooks are based on the digital version of paper textbooks, supported by supplementary resources and tools, forming a textbook that is not just a single form but an innovative combination of textbooks and course resources[1].

Digitalization in the equipment manufacturing industry can effectively reduce production costs for enterprises, while also endowing industrial products with strong adaptability. Digitalization is an important enabling means for the transformation from "Made in China" to "Intelligent Manufacturing in China". It deeply implements the strategy of strengthening the manufacturing sector, accelerates the advancement of new industrialization, and further enhances the foundational and supportive role of manufacturing in national economic development and innovation transformation. Among these, digital textbooks are an important means to cultivate high-quality engineers for the new era and lay a crucial groundwork for the future digital transformation of enterprises [2].

Digital textbooks can significantly shorten the development cycle of textbooks, especially in emerging technological fields, ensuring that the content of textbooks can be updated synchronously. This is of great significance for the cultivation of high-quality and high-level talents in the equipment manufacturing industry. This article addresses the issue of digital

textbook construction in the equipment manufacturing industry, utilizes virtual simulation technology, elaborates on the construction process of its digital textbooks, further summarizes the unique advantages of digital textbooks, and hopes to aid in the textbook construction for the equipment manufacturing industry.

2. Research Content of Digital Textbooks

2.1. The Key Issues to be Solved in the Construction of Textbook.

The construction of digital teaching materials in the equipment manufacturing industry mainly solves the following three key problems:

(1) What kind of professionalism should equipment manufacturing practitioners have?

Equipment manufacturing industry is the core of industry, and craftsman spirit is the basic professional quality that practitioners should possess. General Secretary Xi Jinping explained the profound connotation of craftsman spirit at the second session of the 14th National People's Congress: "Persistent focus, striving for excellence, meticulousness, and pursuit of excellence"[3]. The construction of textbooks takes this as a starting point, and elaborates on the spiritual connotation behind the local craftsmen selected in the past five years.

(2) How does virtual simulation serve the equipment manufacturing industry?

Virtual simulation technology, as an advanced computer-aided engineering technology, has brought revolutionary impacts on the field of equipment manufacturing. By accurately simulating the physical processes and behaviors of the real world, this technology can not only effectively optimize product design, improve production processes, but also enhance the efficiency of logistics management.

(3) How to build a digital teaching material for equipment manufacturing industry based on virtual simulation?

Under the construction concept of "project-driven + engineering import", the digital textbook construction is carried out by using the case method, which focuses on the representation form of virtual simulation technology for single manufacturing equipment, that is, the digital characteristics of different manufacturing equipment are displayed through different virtual simulation technology means; For system manufacturing equipment, it focuses on the communication between actual production process and simulation system, that is, the digitalization of industrial scene is realized through the integration of virtual simulation technology and industrial software. Seven engineering examples are introduced in the textbook to drive the whole process of digital equipment manufacturing with specific projects.

2.2. The General Idea of Textbook Construction

(1) The connotation of digital textbook construction that embodies professional quality

For the equipment manufacturing industry, the craftsman spiritFor the equipment manufacturing industry, the craftsman spirit professional quality, but also the The construction of textbooks focuses on the timeliness and regional characteristics of the craftsman spirit in the new era. It constructs a digital case library for local craftsmen selected in the past five years, reflecting that the cultivation of high-quality engineering talents first focuses on integrity and humanities[4].

(2) The principle of "trinity" textbook construction

The "trinity" construction principle of practical reality, combination of virtual and real, and integration of information and physics, adheres to the following guidelines:

Firstly, it steadfastly upholds the principle that engineering practice takes precedence, supplemented by virtual simulation. Secondly, during experimental teaching and technical training activities, it maintains the principle of combining virtual and real elements. This is

especially applied to manufacturing processes that are complex, hazardous, or irreversible, insisting on a blend of virtual and actual methods. Lastly, for manufacturing systems, it adheres to the principle of integrating information with the physical realm, ensuring that the virtual world truly serves the real physical world.

(3) The textbook construction idea of "project-driven + project introduction".

The textbook is introduced with specific project cases, selecting seven typical equipment manufacturing cases, elaborating in detail the construction process of digital textbooks based on virtual simulation, which reflects the digitization of textbook content and the digitization of the textbook itself.

3. The Process of Building Digital Teaching Materials

3.1. Textbook Construction Framework

The overall framework for the construction of digital textbooks in equipment manufacturing is as follows: with typical manufacturing equipment cases as the core content, supported by virtual simulation and industrial software and hardware devices, we construct digital textbooks with multiple application scenarios and application fields. As a digital textbook for manufacturing equipment, the primary audience is front-line engineers from enterprises. The construction of textbooks firstly mentions professional quality, cultivates craftsman spirit, and uses case studies for ideological connotation construction; secondly, for single manufacturing equipment, four cases are used to explain the construction method of digital textbooks; finally, for system manufacturing equipment, three cases are used to explain the construction method of digital textbooks.

3.2. Engineer Professionalism

Professionalism focuses on the spirit of craftsmen, and the construction of teaching materials includes the following four points:

(1) The theoretical connotation of the craftsman spirit

In China's traditional culture, there has always been a pursuit of "ingenuity" and a cultural lineage of "technique advancing towards the Dao (way)". The professional ethics demonstrated by the ancient Chinese and the humanistic qualities behind them have infused the spirit of craftsmanship, characterized by striving through hardship, perseverance, continuous improvement, and pursuit of excellence, into the cultural DNA of the Chinese nation. This spirit is not only about the constant pursuit and perfection of skills but also about the elevation of morality and character.

Modern craftsman spirit belongs to the category of professional spirit and is a kind of professional value orientation behavior of practitioners. The core of craftsman spirit is the pursuit of quality, and the goal of craftsman spirit is to create high-quality products in the industry. The basic connotation can be summarized as follows: dedication with whole heart, lean spirit of pursuing excellence, persistent focus spirit, and innovative spirit of pursuing breakthroughs.

(2) The specific characteristics of the modern craftsman spirit in different countries

The core of Japan's modern craftsman spirit can be summarized as "(protect), (break), and (leave)". German modern craftsman spirit primarily stems from the stringent product quality requirements of German companies, valuing high-quality products and services over speculative gains, focusing on long-term benefits rather than short-term profits, and placing great emphasis on product quality. The essence of American craftsman spirit is innovation, with pragmatism and standardization being additional defining characteristics of American artisans. Italian craftsman spirit is reflected throughout the entire process from design to manufacturing,

with its core elements encapsulated as "striving for excellence in quality", "ingenious and novel design", and "integration of tradition and modernity".

(3) The main way to cultivate the spirit of craftsmen in China

Establishing a craftsman academy, the purpose of running a school is to improve the education level and ability level of craftsmen, highly skilled talents and the majority of workers, and to cultivate great national craftsmen with persistent focus, striving for excellence, meticulousness and pursuit of excellent professional quality. Generally, non-degree training is the main part, while credits are provided for craftsmen with academic needs.

(4) Exploration of the cultivation of craftsman spirit in the new era

Research and interview Shanghai craftsmen and model workers selected in the past five years, refine the characteristics of the characters, and summarize the craftsman spirit contained in them. The construction of digital textbooks includes the digitization of character cases, accessing the character case website by scanning the QR code in the textbook for online learning of character spirit.

3.3. Cases of Digitalization of Monomer Manufacturing Equipment

The digital case of single manufacturing equipment adopts the method of "project drive + engineering import". Four typical cases are constructed in the textbook, with the main focus on different presentation methods of digitization. Different cases adopt different combinations of software and hardware, and the construction ideas are shown in Figure 1. The technical route and implementation steps are as follows: The motor exhibition system in the textbook is made by virtual reality + holographic projection; The reducer digital design system realizes the data transfer between virtual scene and three-dimensional model and the interference judgment function of model sub-parts by using virtual reality + three-dimensional modeling; The milling machine training digital courseware realizes the virtual teaching classroom demonstration and screen sharing function by using virtual reality + naked eye stereo; The digital courseware of water pump teaching realizes the three-dimensional model exhibition function by using virtual reality + augmented reality.

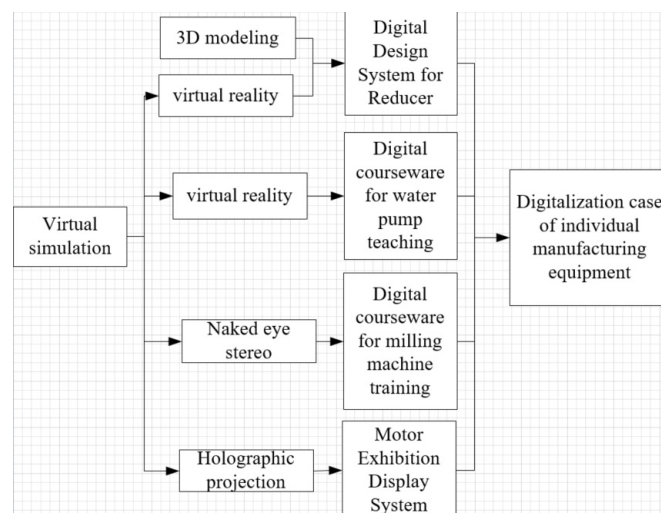


Figure 1. Ideas for the construction of digital cases of monomer manufacturing equipment

3.4. Cases Study of the Digitalization of System Manufacturing Equipment

The digital case of system manufacturing equipment adopts the method of "project drive + engineering import". Three typical cases are constructed in the textbook, with the main focus on the data communication between virtual system and industrial production process. The construction ideas are shown in Figure 2, and the technical route and implementation steps are

as follows: The digital teaching platform of industrial robot adopts the research method of OPC UA industrial communication standard + digital twinning + mixed reality; It realizes the synchronization between industrial production process and virtual simulation system; CNC AnDeng manufacturing production line adopts the research method of virtual reality + WebGL technology to realize the communication between industrial production data and virtual simulation system; The circular water saving demonstration system adopts the research method of virtual reality technology to realize the exhibition function of energy saving data and energy saving scene integration.

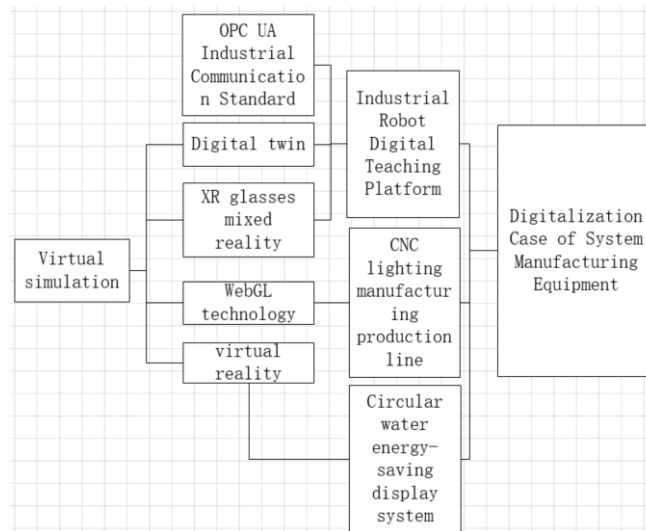


Figure 2. Ideas for the construction of digital cases of system manufacturing equipment

4. Innovations in Digital Teaching Materials

Based on virtual simulation, the construction of digital textbooks has the following innovations:

(1) Model innovation: Digital textbooks can integrate virtual simulation experiments into equipment manufacturing, forming three modes of combination, alternation, and integration of virtuality and reality, realizing the seamless connection of "trinity" of virtual simulation, equipment manufacturing, and information-physics integration.

(2) Technical innovation: Digital textbooks combine modern information technology with traditional manufacturing, integrate craftsman spirit, and take engineering literacy and engineering capability as the core to construct intelligent collaborative scenes for virtual engineering training, intelligent interactive guidance teaching, and intelligent evaluation. In addition, on the basis of virtual simulation technology, further research on digital twin industrial application scenarios is conducted. Through the further integration and innovation of information-physics technology, an engineering training collaborative environment that combines virtuality and reality is innovatively created. This also reflects the craftsman spirit and the spirit of innovation in upholding tradition and embracing new ideas in the new era.

(3) Means of innovation: Digital textbooks can use the Internet plus virtual simulation technology to integrate virtual simulation into online teaching classrooms, forming a hybrid teaching model of online and offline. This effectively solves the problem that practical teaching cannot be taught online. Virtual simulation experiments can also open up online teaching resources for sharing and serving the society.

(4) Content innovation: Digital textbooks are suitable for teaching content in the context of large projects. They change the traditional single equipment operation practice-based learning

and add manufacturing system engineering practice learning, which is more conducive to cultivating the ability to analyze and solve engineering problems.

5. Conclusion

The construction of digital textbooks is an important part of the textbook system with Chinese characteristics in the new era. Firstly, the construction of textbooks should fully reflect the national will. Secondly, it should highlight the value logic of educating people and building morality and ethics. Lastly, attention should be paid to technology empowerment, reflecting the tool logic of the digital attributes of textbooks. This article takes the national strategy of intelligent transformation of equipment manufacturing industry as the background, highlights the spirit of craftsmanship in textbook construction, supports virtual simulation technology, and tries to create a characteristic digital textbook that adapts to the development of the times.

Acknowledgments

Funding Projects: China Machinery Industry Education Association 2024 Annual Industry-Education-Science Integration Project "Construction of Digital Teaching Materials for Equipment Manufacturing Industry Based on Virtual Simulation" (ZJX24CY013); Shanghai Polytechnic University's 2024 Research Project on Ideological and Political Work, "Cultivation of Craftsman Spirit in the Perspective of Higher Engineering Practical Teaching" (EGD24SYH07).

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