Research on Product Design Driven by Big Data and the Cultivation of New Engineering Practice Talents

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Abstract. The construction of new engineering disciplines is an inevitable choice to adapt to the technological revolution and industrial transformation in the new era. Against the backdrop of the rapid development of industrial big data and the industrial Internet, cloud platforms, as key technological support, are gradually becoming important tools for promoting industrial intelligence and efficiency. Combining the educational needs of new engineering disciplines, this paper proposes a construction idea for a big data-driven product design and practical talent training system. Based on industrial big data, industrial Internet, and cloud platforms, this paper studies the application of data mining and collaborative design in industrial product design, and explores how to enhance innovation ability and practical skills through these technologies. This paper aims to provide theoretical basis and practical guidance for talent training in the context of new engineering disciplines, and help promote talent team construction and industrial upgrading in the field of intelligent manufacturing.

Keywords: New engineering; Industrial big data; Industrial internet; Cloud platform; Talent cultivation

1. Introduction

With the rapid development of industrial big data, the digital transformation of manufacturing industry has entered a brand-new stage. Industrial big data not only provides strong support for the production process, supply chain management and other fields, but also brings revolutionary changes for the optimization of industrial product design. Currently, the state attaches great importance to the promotion of digital transformation [1] and intelligent manufacturing, especially in the “14th Five-Year Plan” for the development of the digital economy, clearly put forward to accelerate the promotion of the development and application of industrial big data. In this policy context, industrial big data [2], as the core driving force of industrial Internet, is becoming a key technology to enhance the competitiveness of manufacturing industry. However, compared with the rapid progress of big data technology, the current cultivation of practical talents in new engineering disciplines has an obvious lag, and cannot meet the urgent demand for composite talents in the era of industrial Internet. The traditional engineering education system is difficult to adapt to the new requirements for engineers and technicians in the context of new technologies, especially in the construction of industrial big data platform [3], data analysis, intelligent manufacturing, information management and other aspects of the talent gap is significant. This status quo directly affects the in-depth promotion of the digital transformation of the manufacturing industry, and urgently requires the education system to make innovation and reform.

In this context, it becomes particularly important to explore the new mode of talent cultivation for new engineering disciplines adapted to the industrial Internet era. The concept of new engineering advocates interdisciplinary integration, cross-border cooperation, and strengthening of practical ability to adapt to the development needs of the manufacturing industry in the new era. Therefore, by integrating industrial big data technology, the education system can not only better enhance students' data literacy, but also provide more targeted ability training for engineering practice. At the same time, the use of big data analysis and processing capabilities can significantly improve the efficiency and accuracy of industrial product design. For example, in the management of cutting tool product information and design optimization process, through the cutting tool product information display, intelligent recommendation and product series comparison, for process designers to provide a scientific decision-making basis, design a reasonable tool, formulate the optimal machining program, to ensure machining efficiency and quality. As well as facilitating the user to quickly understand and access to cutting tool products, cutting amount, process environment and other information. Through the integration of industrial big data technology and practical cases, we build a curriculum system that conforms to the concept of new engineering discipline, and cultivate a new generation of engineering talents with innovative consciousness and practical ability.

2. The Analysis of the Current Situation of Higher Mechanical Professional Education and the Lack of Standardization Problems

At present, although the education of higher mechanical majors is constantly innovating and developing under the background of new engineering, there are still some drawbacks that need to be solved, especially in the standardization of personnel training and practical guidance, which is closely related to the lack of uniformity of the standard system at home and abroad. In recent years, the state has put forward a series of policies to support the reform of higher education, but still faces many challenges in the concrete implementation.

In the “14th Five-Year” Education Development Plan, it is clearly proposed to promote the “four new” construction of new engineering, new medicine, new agriculture and new liberal arts, and strengthen the reform of engineering education. However, there is still a lack of national unified educational standards for mechanical education. National standards (GB) and industry standards (IS) in the field of mechanical design and manufacturing mainly focus on product design, manufacturing and testing, but do not regulate for the education system. Although the National Standard for Quality of Undergraduate Education in Colleges and Universities has put forward requirements for undergraduate education, in practical operation, there are still large differences in curriculum and teaching mode among colleges and universities. This lack of unified guidance has led to difficulties in coordinating and harmonizing the quality of education and talent cultivation standards among different institutions, affecting the overall level of engineering talent cultivation.

In the field of international mechanical manufacturing, the mechanical standard system of developed countries has been very mature. For example, the standards issued by industry organizations such as the American Society of Mechanical Engineers (ASME) have wide influence in the world. In contrast, China's industry standard system is still in the process of continuous improvement. Although the strategy of “Made in China 2025” puts forward the goal of promoting the construction of the manufacturing standardization system, there is still a disconnect between the education system and the industry standards in the specific landing process. Domestic colleges and universities often refer to domestic industry standards and enterprise standards in the process of talent training, but these standards are lagging behind in updating in the fast-changing industrial environment, and fail to fully adapt to the development needs of new technologies. Especially in the context of new engineering, the demand for interdisciplinary integration and digital skills has become increasingly prominent, and the current education system fails to respond effectively to these changes, resulting in students facing competency gaps when they enter the workplace.

The Outline of the National Medium- and Long-Term Educational Reform and Development Plan (2010-2020) explicitly proposes to strengthen the practical teaching aspect of higher education, but in actual implementation, there is a lack of unified standards for practical teaching, especially in the context of new engineering disciplines, and guiding regulations for practical education are still scarce. Although cooperation between universities and enterprises has become increasingly frequent in recent years through the promotion of the policy of integration of industry and education, for example, Several Opinions on Deepening the Integration of Industry and Education jointly issued by the Ministry of Education and the Ministry of Industry and Information Technology, which promotes collaboration between universities and enterprises, the mode of cooperation is still not standardized enough due to the lack of nationwide standards for practical teaching. Enterprise standards (enterprise standards) vary according to the needs of enterprises, which makes it difficult for colleges and universities to find a unified teaching practice model, and the quality and effect of practice teaching cannot be fully guaranteed. This not only affects the cultivation of students' practical ability, but also limits the cultivation of innovative talents in the context of the new engineering discipline.

The Opinions on Deepening Educational Reform and Comprehensively Improving the Quality of Compulsory Education issued by the State Council as well as the Action Plan for the Construction of New Engineering disciplines clearly point out that it is necessary to strengthen the cultivation of innovative and composite engineering talents and promote the reform of engineering education. However, in the actual teaching of mechanical specialties, due to the lack of a unified standard system, there are still differences in the cultivation objectives of various universities and colleges, making it difficult to form a consistent orientation of talent cultivation. Some colleges and universities still continue the traditional engineering education model, ignoring the needs of modern industry for emerging technologies such as big data, artificial intelligence and industrial internet. For example, the rapid development of Industry 4.0 and intelligent manufacturing [4] requires students to have interdisciplinary knowledge and data analysis capabilities, but the current curriculum system of many institutions fails to make timely adjustments, resulting in a disconnect between the talent cultivation objectives and industry needs.

At present, higher mechanical professional education in the context of the new engineering disciplines is facing multiple drawbacks, especially in the standardization of talent cultivation and practical teaching guidance regulations, the lack of uniform and standardized standards. Under the vigorous promotion of national policies, the construction of new engineering disciplines has become an important direction of educational reform, but to achieve this goal it is necessary to further improve the docking of the education system and industry standards, and to promote the in-depth integration of the national standards, industry standards, enterprise standards and educational practices. By formulating educational standards for mechanical specialties in line with the context of the new engineering discipline and improving the quality and innovation ability of practical teaching, we can truly cultivate high-quality engineering talents who can adapt to the needs of the industrial Internet era.

3. Based on the Cutting Tool Information Management Platform for Product Design Application Practice

Cutting tool life cycle includes tool design, production, procurement, use, end-of-life and other processes, each process will produce a large amount of cutting tool data information and knowledge, applied to different use scenarios, of which the cutting tool procurement process is particularly important, assuming an important role in the exchange of key information. Accompanied by the continuous growth of cutting tool types and quantities, the traditional knowledge management of cutting tool products has gradually been unable to meet the enterprise's digital manufacturing needs, the relevant resource information cannot be quickly accessed, shared and utilized, affecting the productivity of cutting tool product enterprises and users, so the new period requires manufacturing enterprises to quickly access and utilize the resources to enhance the enterprise's innovation and rapid response capabilities.

Cutting tool products as the object to build information management platform there are the following business pain points:

(1) Data storage environment is not unified

Cutting tool product data includes structured data such as parameter tables; semi-structured data such as XML, JSON; unstructured data such as schematics, text descriptions, models, coding, so it is necessary to provide a unified management, efficient access to multiple sources of heterogeneous data storage support environment.

(2) Difficult to expand the knowledge base

The types and quantities of cutting tools are growing, the product information is discrete and the carriers are diverse, so it is difficult to accurately categorize, integrate and retrieve the newly added knowledge of cutting tools, which makes it difficult to expand and update the knowledge base.

(3) The structure of the knowledge base needs to be continuously adjusted and optimized.

The research object of this paper is oriented to the scene of the whole product life cycle, the operation of each link in order to achieve the interaction and sharing of resources and data, the knowledge has inheritance, so the structure of the knowledge base needs to be continuously adjusted and optimized to ensure the relevance and consistency of the knowledge.

(4) Knowledge base needs to have semantic reasoning function

There are a large number of schematic diagrams, models, parameter lists in the cutting tool product samples, and there are semantic correlations between the knowledge, so the knowledge base needs to be able to carry out semantic understanding and reasoning.

In order to solve the above problems, the graduate students actively combine the theoretical knowledge they have thought about with the industrial Internet platform under the guidance of their supervisors, and construct a knowledge expression model of cutting tool cutting parameters at the theoretical level through the elements, correlations, and structural levels of knowledge in the field of cutting tool cutting parameters, and then finally, use the ontology construction Protégé software to carry out ontology modeling, organize the knowledge of the cutting tool products, and construct a multilevel Cutting tool cutting parameter domain knowledge ontology. The cutting tool product knowledge is expressed and managed in the form of knowledge graph, and the knowledge is stored in a heterogeneous storage system with the coexistence of relational database and Neo4j graph database. Finally, the cutting parameter knowledge is visualized and displayed by establishing the tool cutting parameter knowledge system, as shown in Figure 1. The dispersed and inefficient data resources are managed in a unified way to realize the integration and reuse of cutting tool product knowledge and shorten the tool design and production cycle.

Based on the B/S system architecture and Java language, using Html, Ajax, Spring series framework, Neo4j graph database and other technologies, based on the construction of cutting tool product knowledge map, the cutting tool product knowledge base system is developed, which realizes the functions of intelligent search and recommendation of data information and knowledge.

(1) Knowledge search and display

The bottom of the system uses the Neo4j graph database to store the cutting tool product knowledge map, Neo4j's powerful database graph algorithm can support the user in various forms of advanced search for the required information and knowledge, and can be more than one tool information for detailed comparison and display.

（a）Product range comparison （b）Product details

Figure 1. Cutting tool product information management platform

(2) Knowledge comparison

First of all, through the construction of cutting tool product database, which contains different tool models, specifications of the detailed parameter information, data collection and storage. Secondly, after the comparison algorithm and logic including parameter matching and filtering, weight setting and sorting, difference calculation, to support multiple dimensions of the cutting tool parameter comparison, the user can choose the appropriate cutting tool, to help users intuitively understand the advantages and shortcomings of each tool.

(3) Intelligent Recommendation

On the basis of the processing parameters provided by the user, such as machining materials, cutting speed, accuracy requirements, etc., the cutting tool products are intelligently recommended with the help of a rule engine or machine learning algorithms, such as recommendation algorithms based on historical data.

Research on cutting tool product information is conducive to helping tool manufacturers and user companies to manage cutting tool product knowledge, tool manufacturers can unify and comprehensively display and sell their tool product information to promote innovation and R & D enthusiasm of tool companies, users can quickly access the required tools and put them into production, improve the industry's production efficiency, reduce costs, and achieve a win-win situation for both the tool manufacturer and the tool user, and promote the knowledge of the tool industry. A win-win situation for both tool manufacturers and tool users, promoting the standardization of knowledge in the cutting tool industry. The modernization and upgrading of cutting tool product knowledge management, to a certain extent, to promote the pace of manufacturing information, digitalization and intelligence, which is conducive to the transformation and development of the manufacturing industry.

4. Practical Talent Cultivation in the Context of New Engineering Science

4.1 Opportunities and Challenges Facing the Development of Industrial Big Data. With the rapid development of information technology, industrial big data, as one of the core technologies of Industry 4.0, has become an important driving force for the transformation of the manufacturing industry. Through the collection, analysis and application of large-scale industrial data, enterprises can optimize the production process, improve efficiency, reduce costs, and thus enhance competitiveness. However, despite the huge development potential of industrial big data, its application in practice still faces many challenges.

Industrial big data is the key to realizing smart manufacturing. By monitoring and analyzing production data in real time, enterprises can make accurate decisions to improve the flexibility and responsiveness of production. At the same time, industrial big data provides a new way for innovation, not only to help enterprises find potential problems, but also to provide support for product development and process improvement. Secondly with the help of big data analytics, industrial enterprises are able to extract valuable information from a large amount of data to assist in the decision-making process. Achieve optimized production scheduling, reduce energy consumption and improve productivity. As the development of industrial big data applications continues to accelerate, there are still some problems and deficiencies.

(1) Multi-source heterogeneous massive data

Industrial data is characterized by massive, heterogeneous and multi-source, which makes data collection and processing complex. Among them, the amount of cutting tool product data information is complicated, the tool information carrier provided by tool manufacturers has not achieved formal unity, and cutting tool products do not have uniform and detailed information display standards, resulting in tool information retrieval and comparison difficulties, while the inconsistency of different data formats and standards increases the difficulty of data integration.

(2) Insufficient data analysis and processing capabilities

Although industrial big data has great potential, but to transform it into actual productivity, still face the problem of insufficient data analysis and processing capabilities. The complexity of industrial data requires enterprises to have strong computing power and efficient data analysis algorithms, however, many traditional manufacturing enterprises lack the corresponding technical accumulation, making it difficult to effectively utilize big data for decision-making support. In addition, big data analysis often requires the integration of technologies from multiple disciplinary fields, including data science, industrial engineering, etc. How to cultivate and introduce composite talents is also a problem for enterprises.

(3) Data silos and standardization issues

In most industrial enterprises, data still exists in silos in different departments, resulting in data that cannot be fully shared and utilized. In addition, the lack of unified standardized management of industrial data, it is difficult to interoperate data between different systems within the enterprise, resulting in increased difficulty in data integration. Without a perfect standardization mechanism, synergistic optimization between different systems is difficult to achieve, thus limiting the breadth and depth of industrial big data applications.

4.2 Optimization and Prospect of Industrial Talent Cultivation Mode. With the rapid development of industrial Internet, big data, artificial intelligence and other emerging technologies, the traditional engineering education model has been difficult to adapt to the rapidly changing technology and industrial demand. The core of New Engineering [5] is in the integration with industry and education, interdisciplinary synergy, emphasizing the cross-fertilization of disciplines and technologies, and the introduction of emerging technologies and industrial needs. At the same time, New Engineering advocates the modernization of engineering education, focuses on students' innovation ability, practical application ability and social responsibility, and cultivates composite talents who can solve complex engineering problems.

Colleges and universities need to pay attention to changing the traditional manufacturing model with the concept of industrial Internet. School-enterprise cooperation and learning, on the enterprise side, enterprises through the industrial Internet platform to organize production and business activities, manufacturing enterprises can realize the rapid integration and utilization of resources, low-cost and rapid response to the hourly demand, giving rise to personalized customization, networked collaboration, and other new modes of new business. On the university side, graduate students, under the teaching guidance of their supervisors, actively participate in major research projects, and through the acts of participating in the development and design of building mechanism models, optimizing processes, calibrating and checking, writing reports, etc., they exercise the multifaceted academic abilities of graduate students in the manner of learning, practicing, re-learning, and re-practicing, cultivate the comprehensiveness of the students, and enhance the comprehensive quality of the composite talents of the industrial Internet.

Improve the cultivation of students' innovation ability in project research. In the process of digital collaborative design and manufacturing, students lack sufficient training of collaborative ability, so there will be many problems when dealing with projects collaboratively, such as the selection of the project topic, the feasibility criteria of the project, and the project evaluation, which will affect the successful completion of the project to a certain extent. The application of industrial Internet platform, through the application of data collection and big data cloud workshop analysis, can provide the required information to students in the project engineering, through the digital collaborative approach, students can choose to cross-discipline and cross-school to seek students, teachers, social and technical personnel to help and cooperate; based on the platform for design collaboration, process collaboration, production collaboration, manufacturing collaboration to develop the product full life cycle design; the platform for design collaboration, process collaboration, production collaboration, manufacturing collaboration; the platform can be used for the design of the whole life cycle of the product. Through the discrete industrial production management application platform, we can evaluate the production resources and energy allocation, mobilize resources across industries, regions and fields to complete the whole project, which has a very good promotion effect on improving students' information acquisition ability and collaborative innovation ability.

5. Summary and Prospect

The rapid development of big data technology provides a new driving mechanism for industrial product design, making the design process more refined, intelligent and efficient. Based on the analysis and decision-making ability of big data, product design can achieve accurate prediction and optimization at an early stage, improve product performance while shortening the development cycle and reducing development costs. Through the deep mining of massive data, enterprises can better understand market demand and user preferences, and then promote the development of customized design and personalized manufacturing. This change puts higher demands on the cultivation of practical talents in new engineering disciplines, requiring students to master interdisciplinary knowledge, have the ability to process and analyze big data, and be able to flexibly apply these skills in complex industrial design environments.

Looking to the future, the role of big data in industrial product design will be further deepened and become one of the core driving forces of intelligent manufacturing. In order to cope with the challenges brought by this technological development, the new engineering talent cultivation model needs to be further revolutionized. First, colleges and universities should strengthen the penetration of cutting-edge technologies such as big data and artificial intelligence in engineering education, and promote the updating of the curriculum system so that students can master more diverse tools and methods. Second, the process of industry-teaching integration should be accelerated, with the help of enterprise resources and practical projects, so that students can apply what they have learned in real industrial environments and develop their ability to solve practical problems. In addition, the education model needs to pay more attention to the cultivation of innovative thinking and practical ability, promote the close integration of theoretical learning and practical application, and ensure that graduates have the comprehensive quality to deal with complex engineering problems.

In the future, with the continuous evolution of big data technology, the integration of new engineering education and industrial product design will be further deepened. This will not only help promote the digital transformation of China's manufacturing industry, but also provide a valuable opportunity to cultivate high-quality engineering talents adapted to the era of intelligent manufacturing. Only through the multi-party synergy of technological innovation, standardization construction and talent cultivation can industrial big data truly exert its potential and promote the full realization of industrial intelligence.

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