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Research on Knowledge Management Practices for the Whole Process of Ship Design and Construction

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Abstract

Through the research on knowledge management practices throughout the design and construction process of ships, it is expected to improve design and construction efficiency, stabilize design and construction quality, shorten the training cycle of employees, achieve knowledge inheritance and value-added, promote the activation of enterprise data assets, refine successful experiences in knowledge management, and empower manufacturing enterprises to achieve digital transformation. Using knowledge engineering implementation methodology, construct a full-process knowledge management practice model for ship design and construction, including a multidimensional, multi-layer, multi-modal three-dimensional knowledge system, a knowledge base and knowledge map for the shipbuilding industry, a knowledge management application and service platform, and the integration of knowledge and business systems. On the one hand, it realizes one-stop search, full lifecycle management, and visual operation and maintenance of knowledge in the shipping industry; Automatically identify user identities in business application scenarios and provide accurate knowledge push; On the other hand, it is necessary to refine the successful experience of knowledge management implementation in enterprises: adhere to the "top-level" project, actively take the initiative of the core team, and strengthen project management and execution.

Keywords

Ship Design and Construction; Knowledge Management; Knowledge Map; Digital Transformation.

1. Introduction

1.1 Chinese Manufacturing Enterprises are Facing Digital Transformation and Require Knowledge Management Throughout the Entire Process

In the White Paper on China's Intelligent Manufacturing Capability Maturity Model published by the China Electronics Standardization Institute in 2016, three stages of enterprises moving towards intelligent manufacturing(China Institute of Electronic Technology Standardization, 2016)were proposed: digitalization, networking, and intelligence. Knowledge management is an important driver for the construction of intelligent manufacturing in enterprises, and it is an important foundation for promoting the digitalization, networking, and intelligence of enterprises. In the process of gathering, refining and processing knowledge resources, standardization and digitalization of internal and external structured, semi-structured and unstructured resources are realized; Realize the connection of underlying data in the interconnection of knowledge resources to support the collaboration of upper-level businesses; Based on knowledge extraction, knowledge interconnection, and knowledge

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model mining, it can support business automation and intelligence, and truly realize the leading role of enterprises. Therefore, knowledge management is the only way for enterprises to carry out digital transformation and move towards intelligent manufacturing.

The entire process of manufacturing enterprises requires knowledge management, as shown in Figure 1. There are various types of knowledge flow and application in various stages such as creativity stimulation, technological breakthroughs, molding optimization, production improvement, and marketing. Through the unified and standardized management of knowledge, the combination of knowledge and business scenarios can improve business efficiency and quality, accelerate talent cultivation, and promote the accumulation and inheritance of enterprise experience. Therefore, the "Manufacturing Innovation Method Chain" (Lv Caixia, 2015) considers knowledge management, along with invention problem solving methods, Six Sigma management, and industrial engineering, as methodologies that support innovation throughout the manufacturing process.

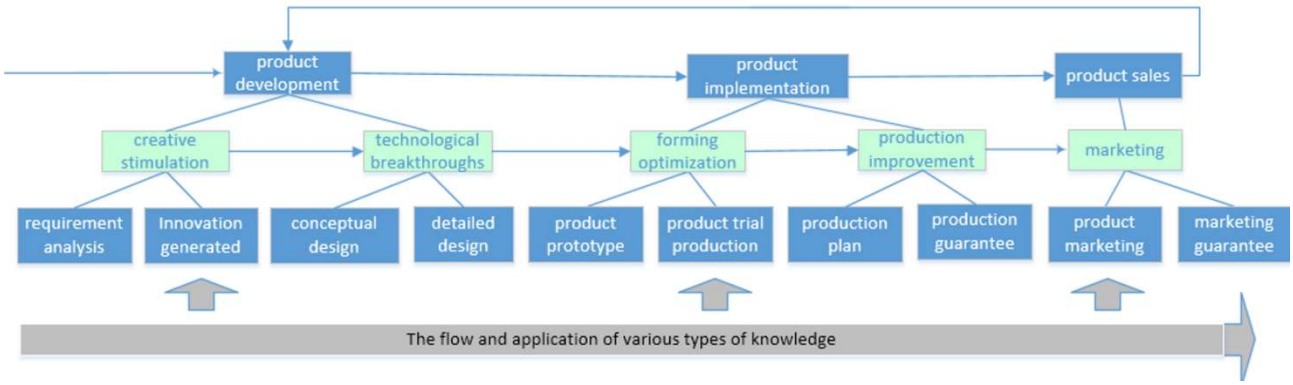

Figure 1. the entire manufacturing process requires knowledge management

1.2 Integrating Knowledge Management with New Technologies to Reshape Data Empowerment and Accelerate the Implementation of Knowledge Management

A review of CNKI literature found that as of February 21, 2023, there were a total of 103 articles on knowledge management or knowledge engineering in the shipping industry. The development has been relatively slow in recent years, indicating that the practice and theoretical research of knowledge management in the entire industry are still in the early stages. For example, Zhu (Zhu Zhi-an et al,2020) enterprises believe that knowledge management is urgently needed, but on the other hand, they regard it as an image project, which is difficult to achieve timeliness. Choosing typical literature observation content, it was found that most of the focus was on knowledge management in ship design, and most of the topics in the literature since 2017 were in the design field. For example, Hu and Han (Hu Xiaoping et al,2010 and Han Hairong et al,2016) analyzed that the business characteristics of ship design are mainly large-scale collaboration, including complex collaboration across organizations, regions, disciplines, processes, and systems; The data sources involved are numerous, with different structures, making it difficult to integrate and process them, resulting in inefficient applications and the urgent need to tap the value of digital assets. From these documents, it can be seen that the construction of knowledge management in China's shipbuilding industry is still in its early stages, but the competitive trend, the demand for enterprise strategic development, and the need for business improvement are increasingly urging the development of knowledge management to provide new impetus for the transformation and development of enterprises. The efficient processing of large amounts of heterogeneous data and the collaborative application of knowledge and business are two key issues.

The rapid development of new technologies in the past decade has brought new opportunities for knowledge management, including big data processing and artificial intelligence related technologies. The gradual maturity of multi-source collection, knowledge mining, unified management, and intelligent applications based on big data has provided assistance for integrating various data sources

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from enterprises, ensuring the quality and quantity of data required for complex collaborative business. AI technology, such as natural language processing and image processing, provides a feasible channel for the integration and application of big data by transforming unstructured and semi-structured data into structured data. Knowledge graphs rely on their powerful association and relationship processing capabilities to correlate multimodal data with multiple application scenarios, providing a guarantee for accurate knowledge application. These provide a data and technology foundation for enterprises to achieve digital transformation. Nowadays, the integration of new technologies and knowledge management is increasingly applied and becoming more and more mature. For example, in the book "Knowledge Engineering in the Age of AI", Zhou (Zhou Yuan et al, 2020)fully integrates the knowledge management construction process and AI technology, and proposes a methodology for enterprises to build knowledge engineering. Therefore, new technologies have brought knowledge management to a new stage, enabling ship design and construction companies to accelerate the mining of data value, enabling business and improving quality and efficiency.

2. A Practical Model for the Whole Process Knowledge Management of Ship Design and Construction

Referring to the model of enterprise knowledge engineering implementation methodology in the book "Knowledge Engineering in the Age of AI ", carry out knowledge management practices and provide reference significance for the shipbuilding design and construction industry.

2.1 Knowledge Management Practice Model

The practice of knowledge management includes three parts, as shown in Figure 2: knowledge content construction, knowledge management system construction, and operation guarantee system construction.

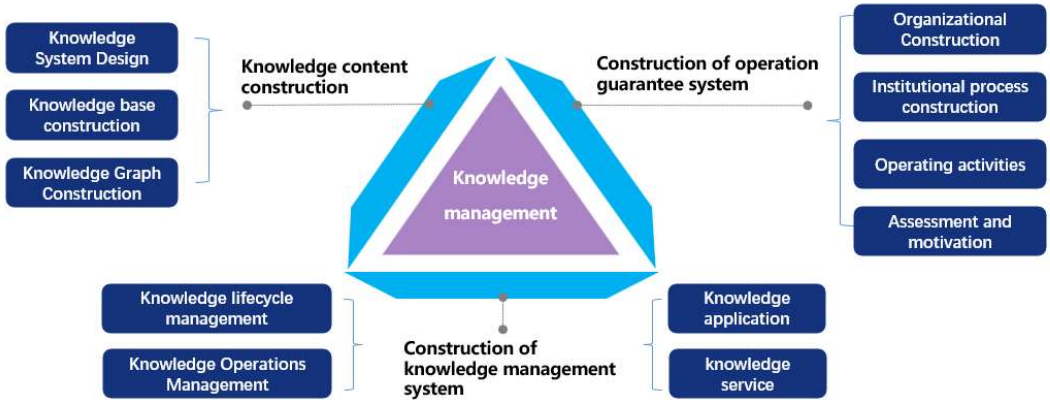

Figure 2. Construction Content Model

Referring to GB/T23703.1-2009 "Knowledge Management Part 1 Framework", it can be seen that knowledge content is the core of knowledge management. Knowledge content construction usually includes the design of a knowledge system and the construction of a knowledge base. In order to support intelligent applications, the knowledge base needs to establish corresponding relationships with business scenarios through a knowledge graph. Therefore, knowledge graph construction is also known as a part of knowledge content construction. A knowledge management system is built for the full lifecycle management, application, and service of knowledge, including support for operations. Knowledge operation is crucial for ensuring the consolidation and continuous optimization of construction achievements, including organizational, institutional, process, assessment and incentive measures, as well as various operational activities.

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Just as the digital transformation of enterprises cannot be achieved overnight, the practice of knowledge management in enterprises is also a continuous process. Most enterprises start with pilot projects, and after achieving success and demonstration effects, they advance to larger business and organizational scope until the entire enterprise becomes a knowledge-based organization, as shown in Figure 3. The implementation of each stage is based on the GB/T 37097-2018 "Enterprise Innovation Method Work Specification", following the concept of the Deming Cycle PDCA, and is constantly summarized and optimized through planning, execution, inspection, and action.

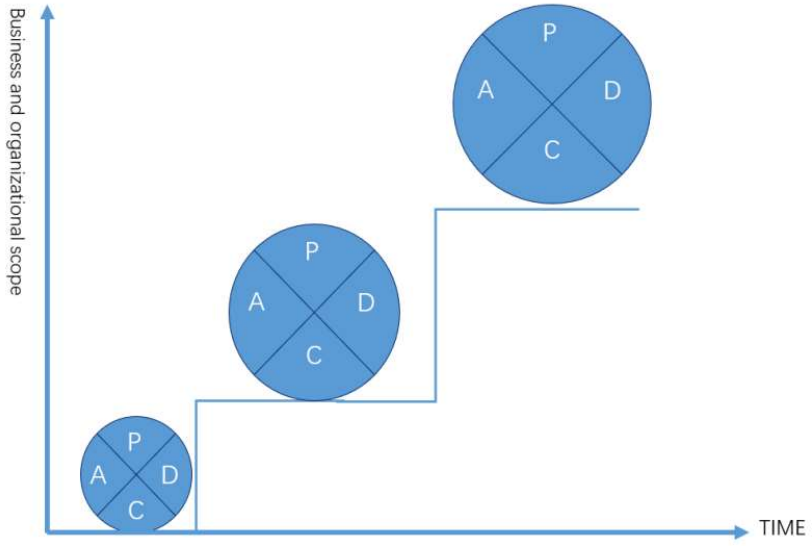

Figure 3. Phased Implementation Model

2.2 Knowledge System Model

The long-term practice of knowledge management places high demands on the organizational structure of knowledge. It requires stability to maintain long-term construction, as well as flexibility to accommodate the needs of different business segments, application scenarios, and different periods. The knowledge organization model designed for this purpose is shown in Figure 4, including object design, classification design, association design, and template design, collectively known as knowledge system design. Objects are abstract representations of various entities in business scenarios, and classification is a way of organizing each object, expressing the generalization and specialization relationships between classification dimensions, hierarchies, and classification items. Associations are used to express other relationships between objects, and templates are used to carry the characteristics of each object, including content attributes, classification attributes, association attributes, management attributes, and so on. The construction of knowledge bases mainly refers to the classification and template of each type of knowledge, while the design of knowledge graphs mainly stems from the design of objects, classification, and association.

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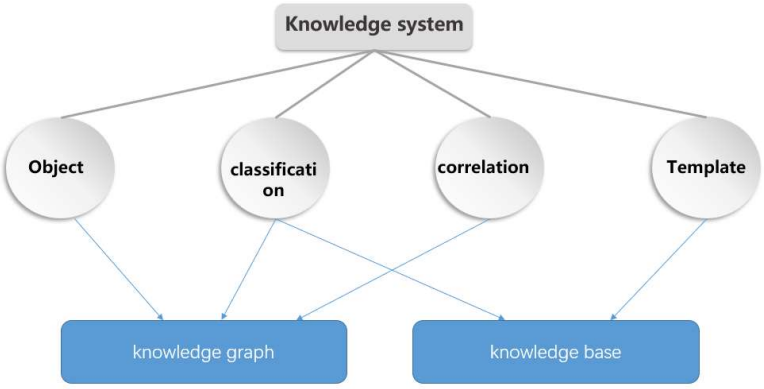

Figure 4. Knowledge Organization Model

2.3 Business Application Knowledge Service Model

For employees, the most desirable way of applying knowledge is to seamlessly acquire knowledge and achieve knowledge accumulation in the original business scenario. Therefore, knowledge services need to be integrated into the original business system, and their application modeling is shown in Figure 5. At the data layer, knowledge graphs are used to connect knowledge repositories and databases of enterprises, supporting graph-based search services and push services for the service layer. Each business scenario interacts with the data of the knowledge management system through the invocation of these two types of services by the business layer.

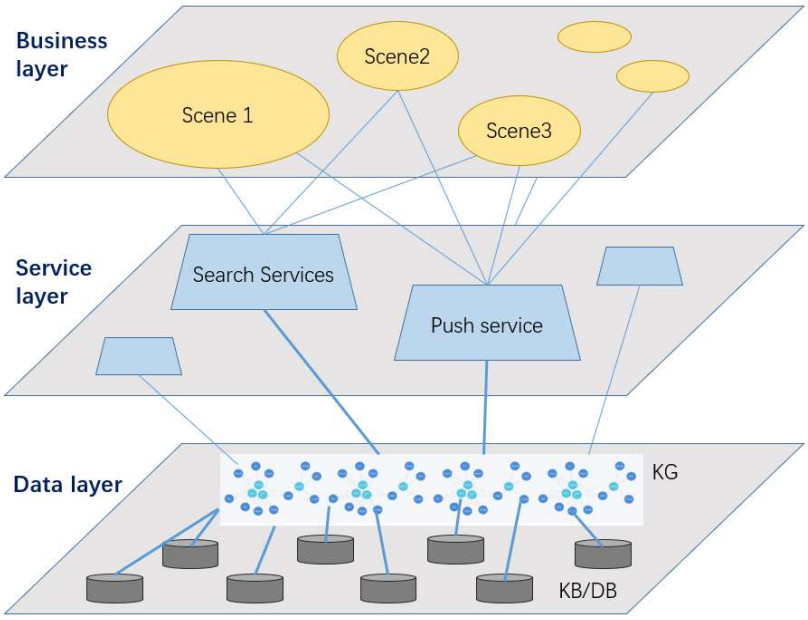

Figure 5. Knowledge Service Model for Business Scenarios

To this end, it is necessary to model the scenario and refine the knowledge requirements. As shown in Figure 6, the business scenario model includes three types of elements: people, activities, and resources. The characterization of people includes departments, positions, majors, job levels, etc., clarifying who needs knowledge, what majors are needed, and what level of knowledge is required. The characterization of activities includes multiple dimensions, such as the activity itself, which may stem from a specific operation of a business system; For example, the active objects may include the ship type and number, deck number, section, minor discipline, pipeline number, etc. The description of resources mainly refers to the types of knowledge or data required for this scenario, including drawings, conventions, standards, equipment information, supplier data, and so on. Through these

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depictions, the digitization of business scenarios is realized, and more accurate requirements for knowledge content are also proposed. Conversely, when the multi-dimensional fine-grained description of knowledge content is realized, it can be mapped to business scenarios one by one to provide accurate services.

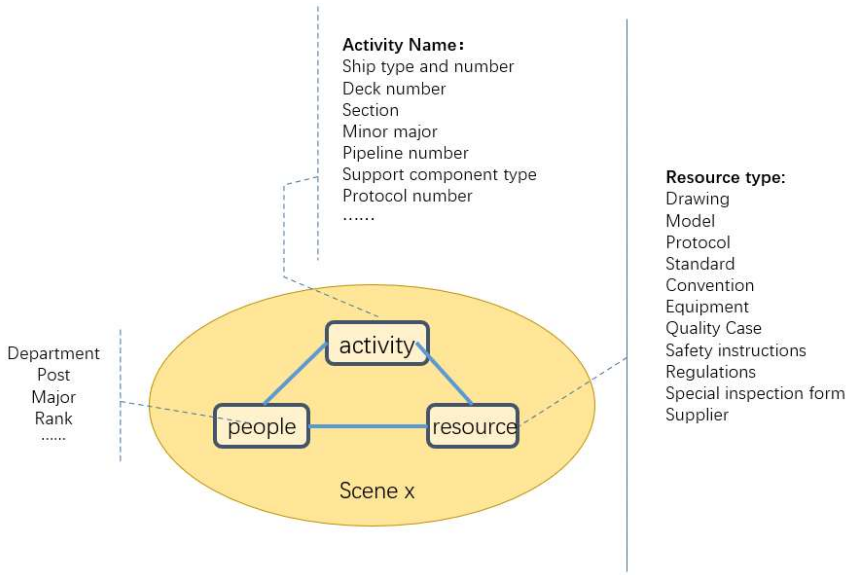

Figure 6. Business Scenario Model

3. Practice of Knowledge Management Throughout the Entire Process of Ship Design and Construction

Since 2020, Shanghai Waigaoqiao Shipbuilding Co., Ltd. has launched knowledge management construction, taking the lead in carrying out pilot construction and application in the design domain, and then promoting it to the production domain and management guarantee domain. It has covered 8 business departments related to development, design, production, ship delivery, and after-sales operation and maintenance, with a business coverage rate of over 80% and an organizational coverage rate of 50%, as shown in Figure 7.

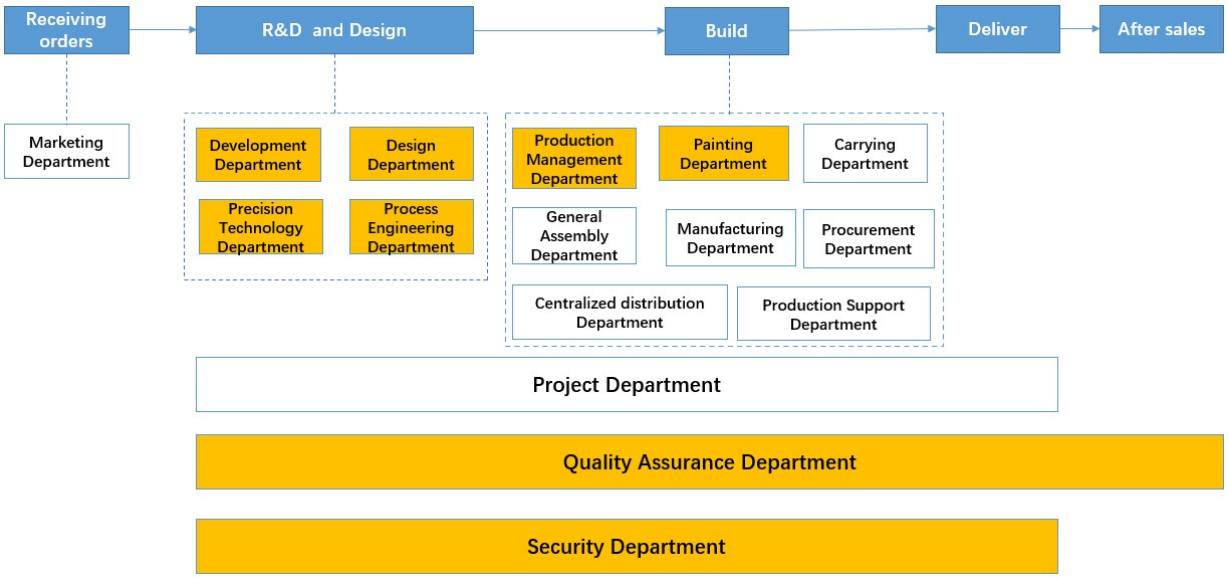

Figure 7. Scope of Knowledge Management Practice at Shanghai Waigaoqiao Shipbuilding Co., Ltd

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3.1 Construction Achievements

The knowledge system for ship design and construction has been established, including more than 10 dimensions of knowledge classification, more than 200 types of relationships, and more than 40 templates; Gathering more than 10 information sources, integrating data volume of tens of millions, forming a knowledge graph of ship design and construction with more than one million nodes and tens of millions of relationships; Dozens of business standard packages for design, production management, quality management, precision management, safety management, etc. have been established. A unified knowledge management platform has been established, providing a variety of typical applications such as one-stop search, collaborative space, business standard package, daily learning, thematic space, expert think tank, personal space, as well as knowledge search and knowledge push based on the graph, realizing the full life cycle management and visual operation and maintenance of knowledge. Realize integrated applications with multiple business systems, including 3D design software for ships, dispatching systems, quality inspection systems, accuracy inspection systems, and unified portals, and be able to automatically identify user identities in hundreds of business application scenarios, providing accurate knowledge push.

3.2 Typical Business Applications

3.2.1 Intelligent Design

The goal of applying knowledge in the design domain is to deeply integrate knowledge with design activities and designers in the process of ship development design, detailed design, and production design, create new design models, and promote the automation of design activities and the digitization of design results. With the help of knowledge push service, the scenes in the design tool are associated with the knowledge base. In the design software, the background and design tasks of each user are automatically identified, and the matching design points, review checkpoints, standards and specifications to be followed, design conventions, processes and related drawings that can be referenced, the opinions of shipowners and ship inspectors related to or similar to ship design, quality cases that have appeared here, and other content are pushed. This reduces cross-system queries and cross-business domain application and review processes, simplifies business processes, and increases design management effectiveness: providing guidance before design, reminding during design, Post-design verification.

3.2.2 Safety Management

In terms of production management, safety management has always been a top priority, and it can be described as "one line above and one needle below". How to help front-line workers receive management requirements in a simple and understandable way is the key to knowledge integration and application. In the practice of knowledge management, safety instructions are integrated into the production dispatching scenario, and accurate safety instructions related to the daily dispatching content are obtained through mobile terminals, enabling the responsibility for safety management to be decentralized to the front line and promoting the safe performance of managers. At the same time, managers can focus on high-risk tasks according to the risk level, promoting the fine management and efficiency improvement of safety management work.

3.2.3 Quality Management

In terms of quality management, knowledge application can also promote the efficiency and effectiveness of quality management. In the quality inspection system, quality cases, inspection standards, and special inspection forms are actively pushed to front-line inspectors, enabling inspection orders to be formative, characterized, and correlated. It supports front-line applications to quickly initiate and form new inspection orders, and provides a basis for on-site inspection and rapid confirmation.

3.2.4 Knowledge Learning Management

Business standard packages are important applications for the explicit, standardized, and organizational inheritance of expert experience. It is built around the supporting materials required

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for business activities, including management processes, training materials, tool templates, design guidelines, design conventions, review points, quality cases, standards and specifications, with a basic package and an advanced package designed for employees of different years of experience. It has greatly promoted the standardization of business and the organization of expert knowledge, improved the consistency and efficiency of new employee training, and significantly shortened the training period for suitable positions.

Through the daily learning setup, employees can obtain learning content through knowledge management systems, enterprise WeChat and other channels. Each business department can customize their own learning content, push rules and timing, and administrators can understand the learning status of all department members through automatic statistical analysis, achieving paperless learning and closed-loop management.

3.3 Knowledge Operation

The value of knowledge lies in its use. In order to promote the use of more employees, identify problems and new needs, and promote the continuous optimization of the knowledge management system, it is necessary to set up a dedicated operation system for promoting knowledge management throughout the entire process. The knowledge operation system includes organizational construction, system process and standard construction, assessment and incentive construction, and operation activity design. The publishing of a series of measures for knowledge management standardizes and actively promotes knowledge management work, facilitates the virtuous cycle of knowledge acquisition, storage, sharing, application, and innovation, and promotes the four modernizations (i.e., tacit knowledge explicitation, explicit knowledge systematization, knowledge application scenario, knowledge reuse and value-added). The framework of the operating system is shown in Figure 8. A number of knowledge operation activities have been carried out, such as learning competitions for business standard packages, selection of outstanding proposals in the community, and awards for outstanding teams and individuals at all levels, effectively promoting employees' enthusiasm for learning and using knowledge.

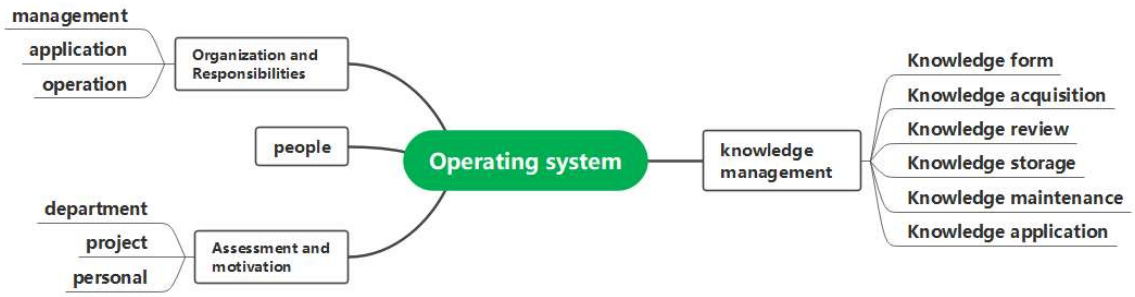

Figure 8. Framework of Knowledge Management Operation System

4. Conclusion

In the process of knowledge management construction, the main team has communicated and studied with multiple enterprises such as Sinopec, PetroChina, COMAC,, Huawei Technology, Chang an Automobile, etc. In practice, they have continuously explored and summarized suitable operating modes for their own enterprise, positioned the goals of each phase of construction with a pragmatic attitude, and controlled the construction process and costs in a lean manner, effectively completing each phase of construction tasks. There are three key elements to success:

One,it is to adhere to the "top notch" project. Knowledge management is not only about building an information system, but more importantly, it is about building a learning organization, transforming the thinking and behavior patterns of the entire organization, continuously learning and optimizing

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with a mindset of mutual assistance, sharing, and win-win, and promoting the digital transformation and intelligent manufacturing of the entire construction process. It must be unified in thought, consistent in action, and persistent from top to bottom, making it a typical "top leader project".

Second, the core team should take the initiative. The scope of business for each phase of knowledge management construction is different, so it is necessary to clarify the value objectives of the project, conduct demand research, analysis, and design work around the business value objectives, and ensure that the project deliverables achieve core business value; At the same time, the business team needs to be deeply involved in the design of the knowledge system, the sorting of business requirements, the confirmation of prototypes, and the verification of system applications, ensuring the accurate correlation between knowledge and business.

Third, strengthen project management and execution. Knowledge management involves a large number of teams and personnel, including internal business teams, management teams, leaders at all levels, and external suppliers. How to coordinate all parties to effectively carry out work and complete tasks as planned is also a key factor in the successful implementation of the project. Take standardized and strict project management measures, establish joint working groups, and promote timely communication and effective collaboration among resources in various aspects of the project; Standardize the project management process, strengthen planning and execution, and adhere to the management closed loop to ensure the achievement of project progress and quality goals.

As an important foundation for digital transformation, knowledge management is a highly innovative, complex, and continuously improving systems engineering that is an inevitable choice for the long-term sustainable development of enterprises. The research on knowledge management practices in the field of ship design and construction in this article is of strong cutting-edge nature and has excellent iterative development capabilities, which can provide valuable experience that can be replicated and used for reference in the domestic shipbuilding industry and even other manufacturing industries.

Acknowledgments

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