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A Knowledge Graph-based Study on Online Course Construction and Innovation in Maritime

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Abstract: *Artificial Intelligence (AI) technology, represented by knowledge graph (KG) and large model (LM), has had a profound impact in higher education and maritime fields. Based on the Global Maritime Professional-Body of Knowledge (GMP-BoK) of International Association of Maritime Universities (IAMU), the core BoK of maritime related programs of Dalian Maritime University (DMU) was constructed, by using Outcomes-based Education (OBE) concept, and the BoK of intelligent shipping and low-carbon shipping was especially constructed. Secondly, the construction idea of a KG system that integrates curriculum, program and discipline was put forward innovatively, and four KG-based Massive Open Online Courses (KG-MOOCs) were constructed right now. Thirdly, the idea of building smart teaching system by integrating KG and LM technology was put forward and carried out in DMU. Finally, suggestion of building school-based KG system and exclusive LM was given. The purpose of this study is to improve the rigid knowledge structure and single teaching model of traditional MOOCs, and to serve the education of global maritime professionals through the construction of online courses in the maritime field. This study can provide reference for universities to carry out smart teaching and help digital transformation. It also facilitates the implementation of GMP-BoK of IAMU and helps to build a global maritime education community.*

Keywords: *Body of Knowledge, Knowledge Graph, MOOC, Outcomes-based Education, Maritime*

1. Introduction

As a new form of education, Massive Open Online Course (MOOC) emerged in 2012 and quickly swept the world. By April 2023, there are more than 150,000 MOOCs worldwide[1]. China's MOOC started in 2013. After ten years' exploration and practice, both the course number and application scale rank first in the world. By November 2022, the number of MOOCs in China has reached 62,000, with more than 400 million registered users, and more than 350 million students have received MOOC credit recognition[2]. The large-scale construction and application of MOOCs have played an important role in improving educational equity, learning revolution, the quality of education and international exchanges. At the same time, its limitations have gradually emerged, such as rigid knowledge structure, single teaching mode, slow updating of teaching content and large investment in construction[3].

In recent years, with the continuous deepening of the concept of Outcomes-based Education (OBE), it has become one of the mainstream practices in higher education to construct a body of knowledge (BoK) for professionals training and curriculum construction based on Bloom's Taxonomy. The rapid development of artificial intelligence (AI) technologies, such as knowledge graph (KG) and large model (LM), has enriched the presentation and processing of knowledge, and gradually received the attention of the education industry. Through the construction and innovation of online courses in the maritime field, this study explores the integration of AI technologies such as KG and LM with traditional MOOC, in order to solve some existing problems. Through the construction of online courses in the maritime field, it serves the education of global maritime professionals and helps build a global maritime education community.

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2. International Maritime Education

2.1 Maritime and Maritime Professionals

Maritime transportation is the most important transport mode in international trade, accounting for over 80% of global trade volume[4]. As shown in Figure 1, the maritime industry developed based on the shipping industry and shipbuilding industry. Relying on the ocean, the maritime industry takes maritime transportation as the main chain, and takes two onshore industrial chains (maritime service chain and shipbuilding industry chain) as the auxiliary chains. So, the maritime industry involves a number of economic activities.

As the complexity and intersectionality of maritime industry, the training of maritime professionals is based on navigation technology, closely related to the fields of economics, management, law and other liberal arts, which reflects a strong interdisciplinary and has a distinct international feature.

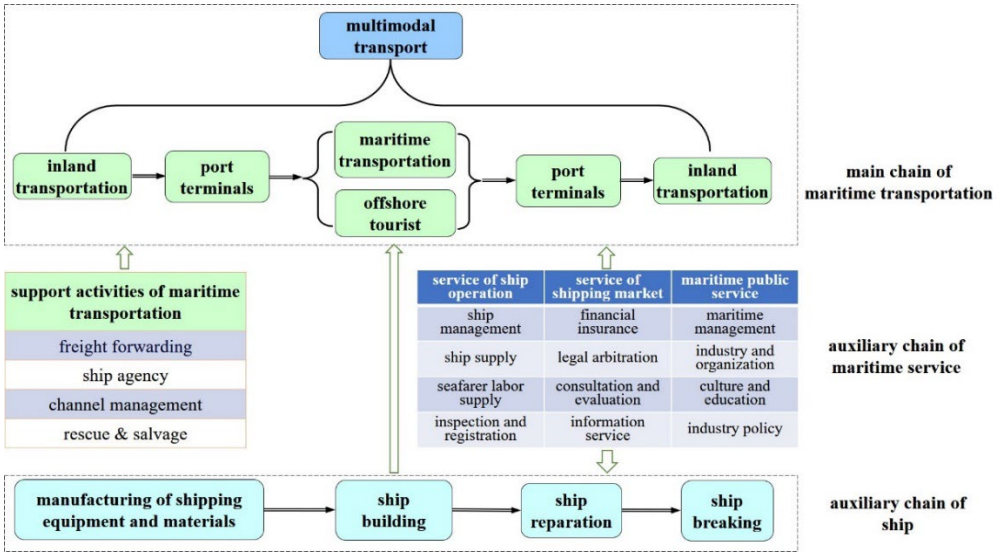

Figure 1: Maritime Industry Chain.

2.2 Global Maritime Professionals Body of Knowledge

International Association of Maritime Universities (IAMU) has sought to formulate a vision for a Global Maritime Professional (GMP) to meet the needs of constantly changing industry, education and employment environment. By organizing member institutions, a GMP-BoK has been released, with reference to which maritime education and training has been carried out.

IAMU officially published the first edition of GMP-BoK in 2019[5]. Based on the minimum requirements of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) [6], GMP-BoK takes into account three factors that affect offshore work: knowledge, skill and attitude (KSA). The relevant factors are summarized into 28 KSAs categorized into 4 sets as shown in Table 1. Based on OBE concept and Bloom's Taxonomy, IAMU describes GMP-BoK according to "learning outcomes", which is divided into three areas: cognition, emotion and psychomotor, and six levels: memory, understanding, application, analysis, evaluation and creation, and then constructs the learning outcomes matrix.

2.3 New Connotations in Maritime Education

With the development of science and technology, intelligence and low carbonization have gradually become a trend of the shipping industry. In shipping industry, intelligence is the need for better development and low carbonization is the need to ensure survival. Intelligence is one of the effective ways to realize low carbonization. Therefore, smart ships, i.e. Maritime Autonomous Surface Ships (MASS), and low carbon technologies for ships are two hot spots in the shipping industry in recent years[7].

Based on the impact of new technologies such as smart and low-carbon technologies and the new

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needs of the industry for maritime education and training, IAMU is organizing the evaluation and revision of GMP-BoK, with a plan to release a new version in 2025. At the same time, in order to facilitate the global implementation of GMP-BoK, IAMU plans to develop corresponding computer applications. As one of the five key members of the IAMU GMP-BoK Revision Committee, DMU sorted out the BoK of maritime related programs, focusing on the BoK construction in the field of smart shipping and low-carbon shipping, and explored the construction of school-based KG system.

Table 1: GMP-BoK.

Sets	KSAs
Foundational knowledge and skills.	Mathematics; Natural (physical) sciences; General humanities and social sciences; English language and maritime communication; Computing and informatics; Physical and mental fitness.
Academic skills.	Problem recognition/solving; Critical thinking; Academic research; Contemporary global issues.
Professional–technical skills.	Technical competencies as per international requirements (STCW); Risk assessment and management; Situational awareness, preparedness and response; Technological awareness (job-specific); Maritime law, policy and governance; Logistics and supply chain; Maritime business.
Professional–soft skills.	Technological awareness (global); Leadership, teamwork and discipline; Effective (interpersonal) communication; Sustainable development; Human resource management; Cultural/diversity awareness and sensitivity; Progressive mindset and lifelong learning; Environmental awareness, sustainability and stewardship; Decision-making and proactivity; Mentorship; Professionalism and ethical responsibility.

3. Application of AI Technology in Education

3.1 Knowledge Graph (KG)

KG is an important branch of artificial intelligence technology, proposed by Google in 2012 to enhance the knowledge base of its search engine. KG is a structured semantic knowledge base used to describe various entities (i.e. knowledge points) and their interrelationships in the real world in symbolic form. It is a subordinate concept of BoK. Its basic blocks are the “entity-relationship-entity” triplet and the attributes used to describe the entity. Entities are connected with each other, forming a relationship network of knowledge structure. These relations are inclusion, above and below, before and after order. Attributes can be understood as the resources associated with each knowledge point, including text, pictures, videos, hyperlinks, etc.

The entities and their attributes in KG can be created artificially or mined technically. In the initial stage, experts’ experience was very important. It was appropriate to combine artificial creation and technical mining. When the technology has developed to a certain extent and the resources are rich enough, KG can be created mainly by technology. At present, KG in the field of education generally involves the aspects of program, discipline and curriculum, among which the construction of curriculum KG is the basic of smart education and the effective way to graph the knowledge system of program and discipline[8].

3.2 Large Model (LM)

Since the birth of ChatGPT3.5 in November 2022, LM has drawn wide attention from academia and industry for its excellent performance in language understanding and knowledge answering. LM refers to a machine learning model with large-scale parameters and computing power. Generally speaking, LM is trained by inputting a large amount of corpus, so that the computer can acquire "thinking" ability similar to humans. Thus it can understand text, pictures, speech and other content, and can carry out text generation, image generation, reasoning, question and answer, scientific prediction and other work.

According to the different types of input data, LM can be mainly divided into Natural Language Processing (NLP), Computer Vision (CV), and Multiple-modality(MM). According to the different application fields, LM is mainly divided into general large model (GLM), industry large model (ILM),

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and vertical large model (VLM). GLMs mainly learn from open data and can be trained as general education experts. ILMs mainly learn data related to specific industries (such as maritime industry) and can be trained as industry experts.

3.3 The Fusion of KG and LM

As a means of representing and processing knowledge, KG and LM are highly complementary. KG is structured explicit knowledge with high quality and interpretability, but it is costly to construct and difficult to completely construct. LM is parameterized implicit knowledge which can fully understand and process multiple-modal data such as text, image and audio, but it may fabricate information (create illusion) and be inexplainable. The integrated development of KG and LM can effectively promote the digital and intelligent process in many fields, including education[9].

4. Innovation of Online Courses in Maritime Field

4.1 Status Quo of MOOC Construction of DMU in Maritime Field

At present, DMU has built more than 60 MOOCs in maritime field, serving the global maritime education and training. Among them, 8 courses are in English and have been put into use in France, South Korea, Indonesia and other international platforms, as well as the international version of China MOOC platforms, with a total of more than 1,000 times learning, as shown in Table 2.

Table 2: International Maritime Courses of DMU.

Course	MOOC Platform
Ships	xuetangX, China; FUN, France; K-MOOC, Korea; ICE Institute, Indonesia
An Introduction to Navigation	K-MOOC, Korea; ICE Institute, Indonesia
Introducing Marine Engineering	xuetangX, China; ICE Institute, Indonesia
Maritime English Listening and Speaking	xuetangX, China; iCourse, China
Marine Cargo Operation	xuetangX, China
Astronomical Navigation	xuetangX, China
Marine Engine Room Simulator Training	xuetangX, China; iCourse, China
Marine Engineering Management	xuetangX, China

4.2 KG Based MOOCs (KG-MOOCs)

4.2.1 A Trinity KG System Architecture

To study the construction of KG-MOOC, it is necessary to clarify the logical relationship among discipline, program and curriculum KG. Figure 2 shows the architecture of the trinity KG system.

According to the OBE concept, each program should design the program objectives and graduation requirements (and their index points). And then a curriculum system that can support the graduation requirements is developed. Curriculum objectives should support graduation requirements and be supported by corresponding knowledge points. All these constitute the program KG. Knowledge points included by a knowledge unit, and knowledge units included by a knowledge field. Knowledge field is a concept related to the discipline. Therefore, discipline and program can be integrally developed.

KG-MOOC is a kind of curriculum KG. It not only has the connotation of traditional MOOCs, but also establishes the relationship between various knowledge points in a course. It connects various teaching resources to each knowledge point. In other words, it is a combination of KG and MOOC[10]. MOOC is a tree-like structure, while KG-MOOC becomes a network structure.

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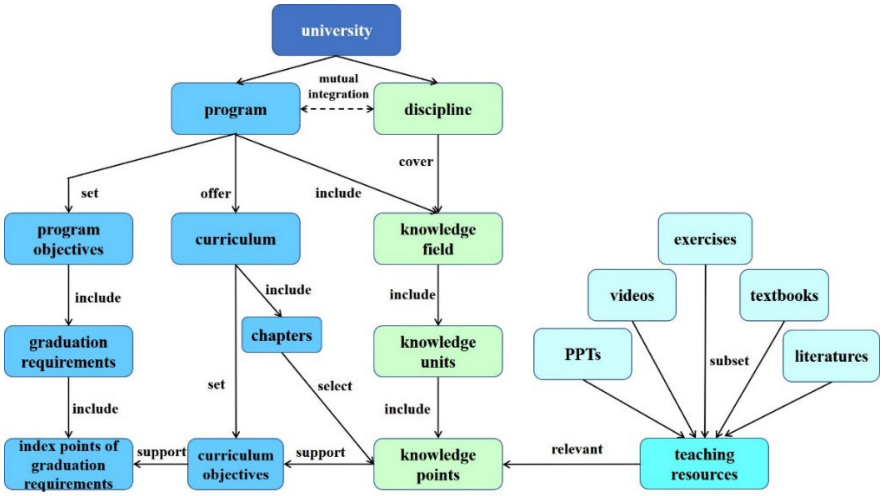

Figure 2: Architecture of the Trinity KG System.

4.2.2 Advantages of KG-MOOC

KG-MOOC has significant advantages over traditional MOOC. KG-MOOC can improve the inflexible knowledge structure of MOOC with the help of KG. It can present a variety of teaching resources and create learning maps for different learners to enrich the MOOC teaching mode. It can realize knowledge extraction through technological mining, automatically create knowledge points and related resources, to update MOOC teaching content timely and lower the construction investment.

4.2.3 Achievements of DMU KG Construction

At present, DMU has built 44 core BoKs of maritime related programs, 2 discipline BoKs of smart shipping and low-carbon shipping, and 4 KG-MOOCs including Ship Statics, Computer Networks, Innovative Thinking and Innovative Methods, and Dangerous Goods Transportation.

5. A Smart Teaching System Integrating KG and LM

The knowledge provided by KG is boundary, depth and relatively accurate, which can be directly used for planned teaching activities. The knowledge provided by LM is general, generalized, and occasionally inaccurate, which is suitable for extra-curricular questions and answers. By combining the above two, it is expected to promote the content combination of depth and breadth, and the formal combination of standardized learning and autonomous learning in higher education, as shown in Figure 3.

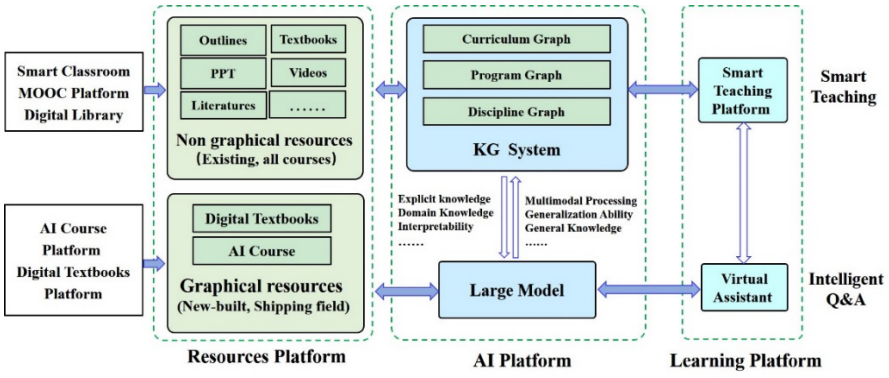

Figure 3: Architecture of Smart Teaching System.

KG is mainly applied in the construction of new teaching resources such as MOOCs and textbooks. This application is relatively easy and requires a lot of artificial participation in order to construct the BoK first. In China, many universities have adopted KG technology: DMU promoted KG-based courses and textbooks construction in smart shipping, low-carbon shipping and other emerging fields. Another application of KG is relatively complex--some universities are building school-based KG system. In the system, the building of BoK is very important, and it's generally built from the curriculum (i.e. bottom

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up). KG system automatically mines the existing teaching resources and generates a curriculum BoK initially (manually correcting are needed), and relates teaching resources to knowledge points, then a curriculum KG is created. A number of curriculum KGs constitutes a program (or discipline) KG. In this process, a program BoK generated by technical mining can be corrected by a program BoK generated artificially, and continuously iterates.

In order to introduce LM from the general domain into education and teaching, universities need to introduce an exclusive (industry or vertical) large model. DMU is planning to train a maritime large model (MLM) by inputting DMU's institutional documents, teaching resources, scientific research resources and other resources, so that it can become an expert who knows all the circumstances of DMU and has a large amount of maritime knowledge. The MLM can answer various questions raised by DMU teachers and students, including teaching, scientific research, daily management and so on. It can help to truly realize “student-centered development".

6. Conclusion

KG-MOOCs not only have the features of traditional MOOCs, but also establish the relationship between curriculum knowledge points. It can effectively solve traditional MOOCs’ problems, such as rigid knowledge structure, single teaching mode, slow updating of teaching content, and mass construction investment. At present, the construction of KG still mainly relied on expert experience instead of technical mining, thus developed slowly in application. But with the rapid development of technology and the gradually reduced artificial operation, universities should take the initiative to master technology. They should positively layout school-based KG system and exclusive large model construction at the same time of KG-MOOCs’ construction. And universities should realize "student-centered development" with the help of digital and intelligent means.

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