

ESTABLISHMENT AND PRACTICE OF UNDERGRADUATE EDUCATION SYSTEM FOR MARINE SURVEYING AND MAPPING IN THE NEW STAGE

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ABSTRACT:

In 2012, China announced its national strategy of building marine power. With the booming of marine development activity, the demand for marine surveying and mapping has increased sharply. However, education for the discipline lagged far behind the growth in demand. For a long time, education in the marine surveying and mapping discipline has faced two problems. First, the education content is mainly for military purposes, and there is little content about civilian use. Second, the education content is outdated and is far from the frontier science and engineering practice. To address these problems, Shandong University of Science and Technology has been working on the education reformation of the marine surveying and mapping discipline for more than a decade. By cooperating with our education partners from the military college, the universities, and the enterprises in maritime industries, we deeply analyzed the booming need in the marine survey and mapping field, and clarified the connotation and characteristics of the discipline in the new era. The discipline roots in the geodesy discipline, but is also deeply connected with oceanography, electromagnetics, and underwater acoustic. Moreover, it serves the national marine strategy and coastal economic development. Thus, it is an interdisciplinary emphasizing practicality and innovation. To this end, under the framework of military-civilian cooperation and industry-education integration, we establish an education alliance with participants from marine institutes, universities, industries, and users. Based on the close collaboration within the alliance, we built a new education model for undergraduate students in the marine surveying and mapping discipline. During the last decade, more than 3000 undergraduate students have been educated to fill the needs of employers relative to the marine economy. Moreover, more than 500 students obtained the qualifications as international hydrographic surveyors and cartographers, and they make worthwhile contributions to the national marine strategy and marine economic development.

1. INTRODUCTION

'The 18th National Congress' of China explicitly proposed its marine power strategy in 2012, and the Chinese ocean industry entered a new development stage. Over the last decade, demands for marine scientific research, engineering applications, and environmental protection have ballooned, which brings unprecedented opportunities for the development of the marine surveying and mapping (MSM) discipline (Guojun Zhai & Motao Huang, 2009; Jiashuang Shen et al., 2018). However, in China mainland, undergraduate education was only carried out in military colleges for a long period, and the graduates mainly served navy. While for the civil MSM region, there was no undergraduate education to cover the talent demand, and the jobs were mainly undertaken by employees from the related regions such as marine investigation (Fanlin Yang & Kai Zhang, 2022). Due to this 'military-civilian separation' problem, there is a big gap between the graduate supply and employing demand. Focusing on the problem, in 2009, Shandong University of Science and Technology (SDUST) set up the first civil MSM undergraduate major in China mainland (Fanlin Yang et al., 2017). Based on the 'military-civilian cooperation, industry-education integration' strategy, a new talent cultivation system for civil MSM has been established. Over the last decade, explorations have been carried out in various aspects of the MSM discipline, including the training objective, the curriculum

system, the practical innovation ability training scheme, etc.

2. TALENT CULTIVATION GOALS BASED ON '13345' TEACHING MODE

Compared with the surveying and mapping in the terrestrial region, MSM discipline has its unique features. Traditionally, the MSM discipline mainly serves navigation purpose, there is little other civilian application for the discipline. Accordingly, the undergraduate education content was mainly about the hydrographic survey. Whilst in the new millennium, the feature of MSM have undergone fundamental changes (Jianhu Zhao, 2007; Xiao Wang et al., 2019; Fanlin Yang & Kai Zhang., 2020). MSM has been commonly involved in various new fields, including marine engineering, environmental protection, fishing, ocean mineral development, etc. Therefore, a critical task for MSM education is to clarify the connotation and characteristics of the discipline. To this end, SDUST cooperated closely with PLA Dalian Naval Academy and Wuhan University, and proposed the connotation of the new MSM: taking surveying and mapping as the main body, and deeply connected with oceanography, underwater acoustics, and remote sensing. Besides, three characteristics of the discipline have been clarified, namely comprehensiveness, practicality, and innovation.

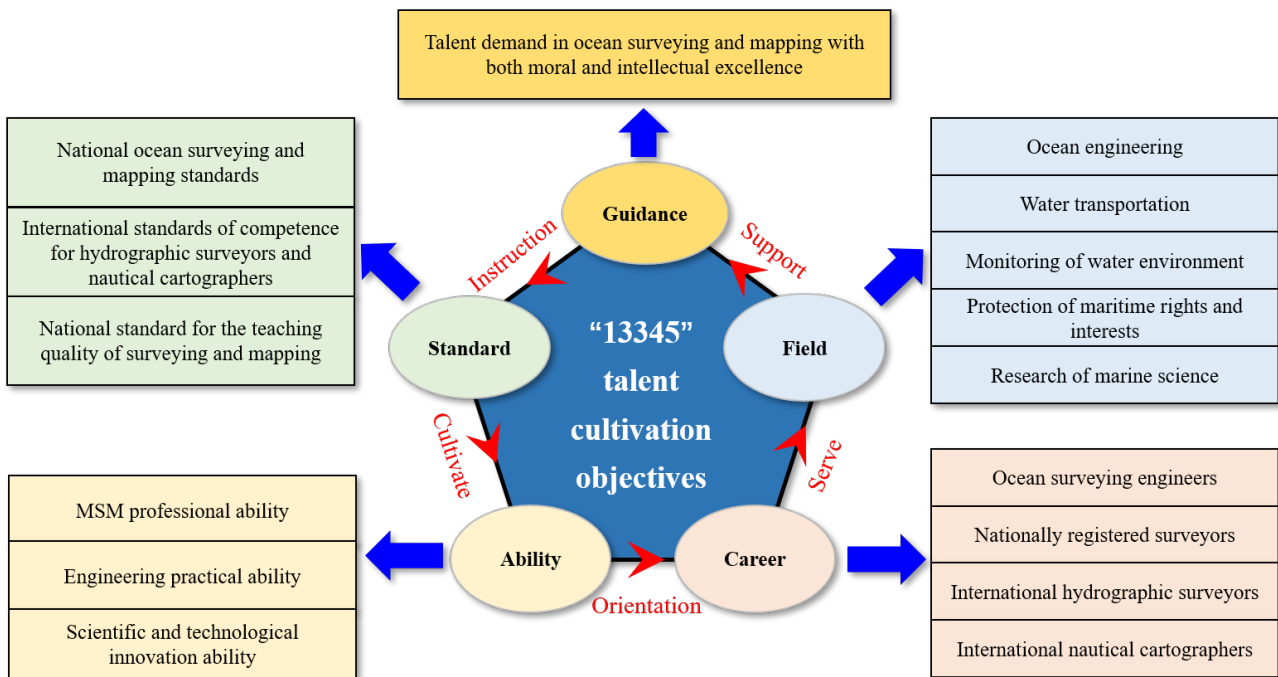


Figure 1. The '13345' talent cultivation objectives

Based on the above concept, we have constructed a new education system for MSM, and formulated the '13345' talent cultivation objectives (Figure 1). Specifically, the objectives serve for one central goal, namely satisfying the demand for MSM talents. Three kinds of standards are used for guidance, namely the national ocean surveying and mapping standards, the international hydrographic organization training standards, and the national standards for teaching quality in surveying and mapping. Three kinds of abilities are focused on, namely the professional competitiveness, the engineering practical ability, and the scientific and technological innovation ability. Four categories of professions are targeted on, namely the ocean surveying engineers, the nationally registered surveyors, the international hydrographic surveyors, and international nautical cartographers. Moreover, the education serves five major fields, including the ocean engineering, the water transportation, the monitoring of water environment, the protection of maritime rights and interests, and the research of marine science.

3. CREATING NEW MSM CURRICULUM SYSTEM WITH MULTIPLE FEATURES

As a new undergraduate discipline which closely links the development of the marine industry, a first problem for the education of MSM is to arrange the appropriate courses to impart the relevant knowledge. Considering the diversity and variability of the MSM knowledge, the course system is arranged by focusing on three aspects of the MSM course system, namely the interdisciplinary, the standardization, and the dynamic updation of the knowledge.

3.1 Interdisciplinary knowledge system

Originating from terrestrial surveying and mapping and being deeply connected with oceanography, MSM naturally has an evident interdisciplinary feature (Fanlin Yang et al., 2020). In theory, the new MSM discipline involves knowledge from multiple disciplines, including surveying and mapping, oceanography, geology, geophysics, hydroacoustics, hydrology, astronomy, geography, and computer technology,

etc. Whilst in practice, the application of the MSM spans the military and civil fields, which are often isolated from each other. Thus, when formulating the professional education scheme, a critical problem is breaking through the barriers between different traditional disciplines and fields when integrating interdisciplinary knowledge systems (Jian Lin, 2017; Yigang Yang, et al., 2018). To this end, we have established a collaborative teaching mechanism based on the 'military-civilian cooperation' strategy. SDUST, together with PLA Dalian Naval Academy and Wuhan University, made great efforts in the construction of the new education system for MSM discipline. Among the three universities, PLA Dalian Naval Academy has a solid foundation in military hydrographic survey education, and Wuhan University has extensive experience in traditional survey and mapping education. By contrast, SDUST, located in the marine economic center city of Qingdao, has close links with many local marine institutes and enterprises, and thus has a deep understanding of the urgent demand of the ocean industry. With their highly complementary foundations, the three universities choose to collaborate on the reform of the teaching mode of the MSM discipline.

Based on a systematic analysis of the internal logical relationship between different related disciplines, a new curriculum system with interdisciplinary characteristics was created. In order to highlight the marine features of the new MSM, the main part of the curriculum system is nearly 70% different from the traditional surveying and mapping engineering major. Specifically, content of a number of courses, including underwater topography mapping, marine engineering survey, marine geophysics, marine geology, marine hydrology, tide and water level control, hydroacoustics, etc., is updated by introducing knowledge points from the related disciplines.

3.2 Standardization

The second consideration when constructing the MSM knowledge system is to make the knowledge compliant with the existing standards in ocean surveying and charting. Specifically, based on the national basic surveying and mapping standard plan project, SDUST developed a series of national-level MSM

standards, which provide useful guidance for the design of the practical training schemes. By contrast, PLA Dalian Naval Academy has been working on the training of international hydrographers and nautical cartographers for years. Accordingly, the valuable experience gained in the training process was applied to the undergraduate education of MSM. Moreover, Wuhan University, as the director of the teaching committee of the surveying and mapping discipline, compiled the national standard for the teaching quality of surveying and mapping, which provides relevant guidelines for controlling the education quality of the MSM education.

Based on the above considerations, we developed a practical ability training courses covering various aspects of MSM applications. On the one hand, experiments were planted into 16 specialized courses to deepen the theoretical knowledge teaching effect. On the other hand, 17 independent experimental courses with a total of 43 credits were set up, covering the core professional content of the discipline, including underwater topography mapping, marine geophysical survey, underwater acoustics design, nautical charting, etc. By organizing the training under the guidance of domestic and international standards, the training content can be closely connected to the application demands of the employing organizations.

3.3 Dynamic updation of the knowledge

Stimulated by the new marine economy, the technologies of MSM are highly dynamic. Thus, a major concern for the knowledge system construction is to track the dynamic

development of MSM. In this respect, apart from the theoretical perspective of the teachers, a second perspective from the industry application is required. This is primarily due to the limited knowledge boundaries of the university teachers, which make them difficult to follow the cutting-edge requirements of emerging industrial applications. Thus, SDUST formed a diverse and complex expert team based on its solid foundation in university-enterprise cooperation. The team consists of acknowledged experts from a number of maritime institutes and enterprises, such as the First Institute of Oceanography of Ministry of Natural Resources, Chinese Academy of Surveying and Mapping, Tianjin Research Institute for Water Transport Engineering, etc. The advantage of introducing scientific and industry experts is that they are closest to cutting-edge ocean engineering practices, and can accurately grasp the development trend of the industry (Qiang Liu et al., 2019). Thus, the knowledge system is ensured to be up-to-date. Moreover, most of these experts understand the requirements of the current marine industry for graduates. Therefore, based on the cooperation of multi-parties, the conceptual boundaries between the textbook and the industry application can be broken through, and the integration of the knowledge system with industry needs can be effectively promoted. When updating the knowledge system, the new practical needs of marine engineering were used as guidance. Specifically, several new popular technologies were focused on, and a series of new courses were created accordingly, including airborne lidar bathymetry (Figure 2), introduction to mobile surveying, and underwater point-cloud data processing.



Figure 2. The lidar bathymetry virtual simulation course

As a new interdisciplinary discipline, the shortage of up-to-date textbooks is a major bottleneck for MSM education. The existing textbooks are mainly concerned with the traditional hydrographic survey, and are generally outdated to cover the new development of the discipline. Thus, based on the ‘military-civilian cooperation’ and ‘industry-education integration’ strategies, an academic committee regarding the

textbook compilation was established. Under the framework, 36 experts from 15 different marine organizations cooperated to compile a dozen of new textbooks. Eleven of the compiled books have been ranked as national-level textbooks. The up-to-date textbooks effectively fill the gap in MSM teaching material. The overview of the course system construction is shown in Figure 3.

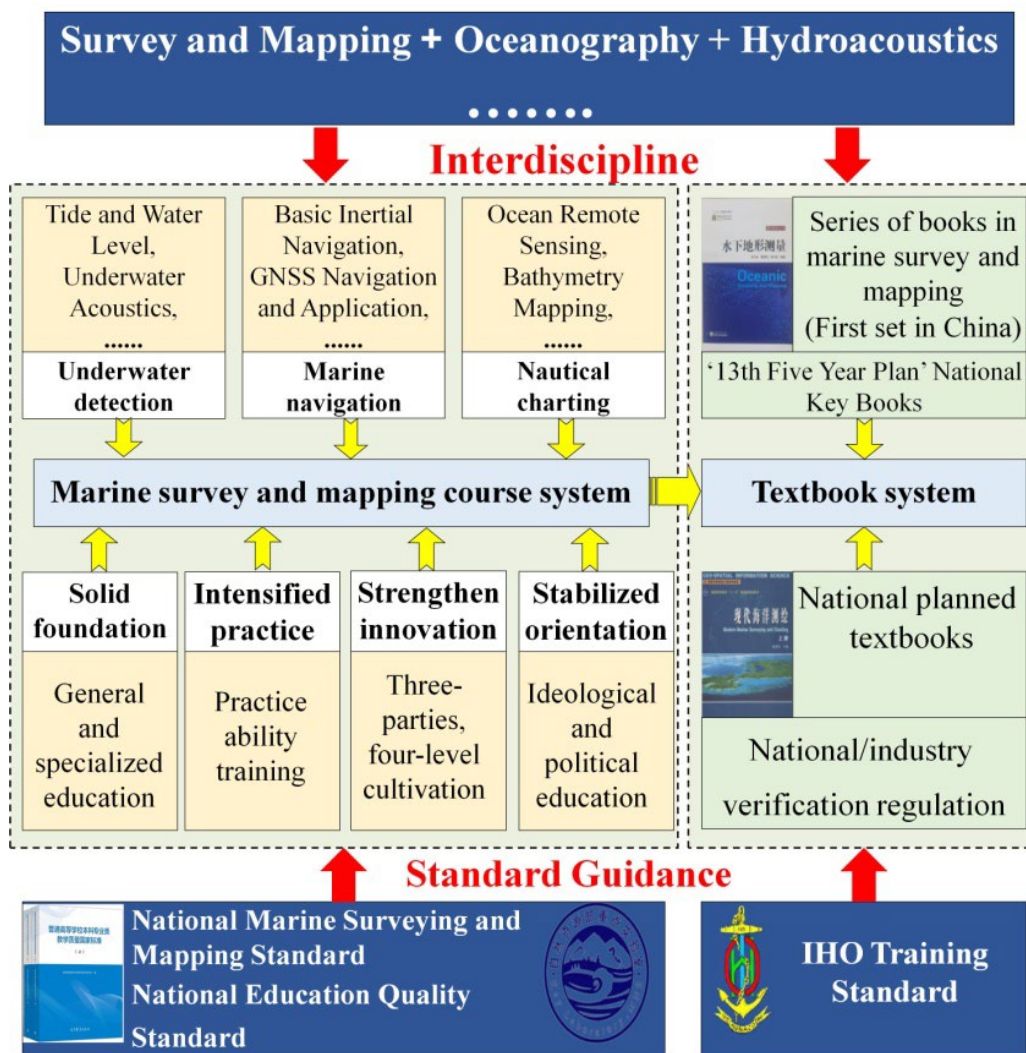


Figure 3. The logical relationship diagram of the developed course system

4. CREATING A NEW TRAINING MODEL WITH EMPHASIS ON PRACTICAL APPLICATION AND INNOVATION

As a new practical discipline, The MSM has evident practical and innovative features (Chunhui Li et al., 2009; Qiang Liu et al., 2019). Thus, to strengthen the practical ability of students, we set up a number of experimental classes in both indoor and real sea settings. However, the expenditure for marine experiments is very expensive. To address the problem, we built a comprehensive MSM laboratory to simulate the real ocean setting (Zhiyong Wang et al., 2018). Moreover, to enhance the practical training effect, we built a real-sea experiment base in Jiaozhou Bay, Qingdao. To overcome the expenditure bottleneck, we closely cooperated with marine institutes and industries based on the ‘industry-education integration’ strategy. By borrowing the instruments and ships from the institutes and

industries, the cost of the experiments can be well controlled. Meanwhile, by experiencing experiments simulating real marine applications, the students can master cutting-edge MSM technologies, which is beneficial for their future careers in institutes and industries (Figure 4).

To reinforce the innovation ability of students, we developed a dozen of scientific research teams. The research scope for the teams spans different aspects of MSM, including submarine detection, marine navigation and positioning, ocean remote sensing, etc. In the research process, we developed a multiparty-participate mechanism. Specifically, under the guidance of teachers, Ph.D. students lead the research. Meanwhile, the postgraduate and undergraduate students cooperate to participate in the research jobs. Based on this ‘teacher + Ph.D. students + postgraduate students + undergraduate students’ four-level mechanism, students' innovative ability and scientific quality can be strengthened.

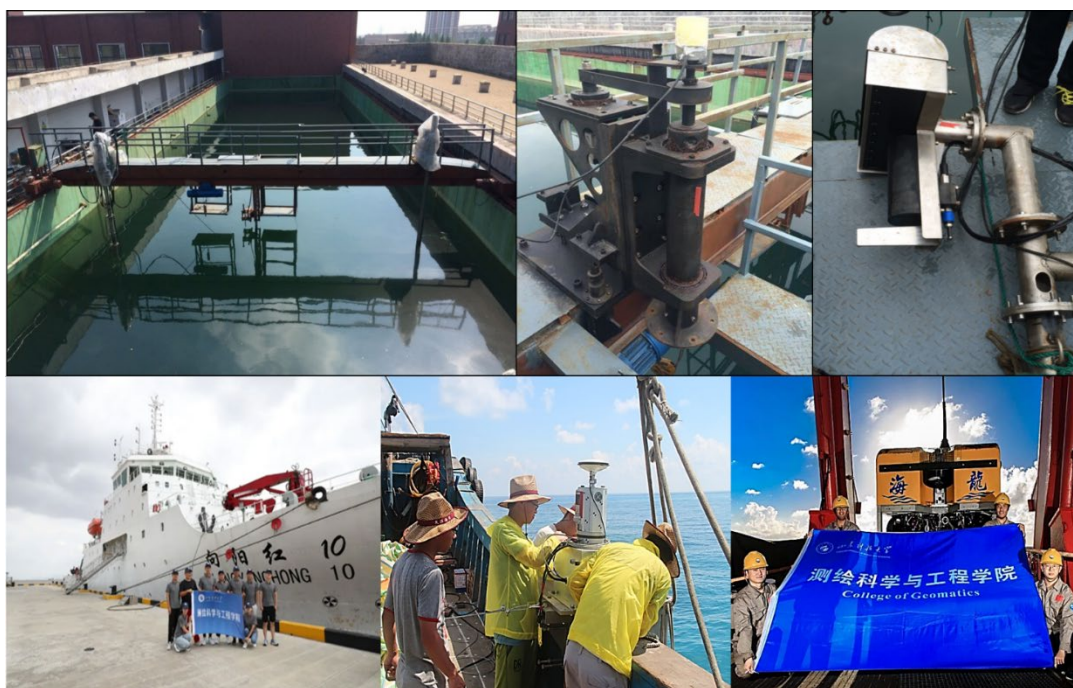


Figure 4. Practical ability training based on real-sea experiments

5. CONCLUSIONS

By integrating civilian and military MSM educational resources, we developed a new undergraduate education mode system for MSM discipline. By continuously adapting the education mode to the dynamic industrial demands, the education effect has been gradually improved. Over the past decade, SDUST, Wuhan University, and the PLA Dalian Naval Academy have trained more than 3,750 undergraduate graduates in MSM. The graduates serve in various marine-related regions such as marine route measurement, ocean surveying and mapping, hydrological monitoring, etc. Among them, more than 510 graduates gain the quality of international hydrographic surveyor and international nautical cartographer. The education effect of the new MSM discipline has received wide coverage in the press (People's Daily, 2021; Guangming Daily, 2021; Dazhong Daily, 2020; Science and Technology Daily, 2020). Generally, the developed education mode should be relevant under the background of China's national maritime development strategy and the 'Belt and Road' initiative.

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