Exploration and Practice of the Undergraduate Training Mode in Electronic and Information Engineering with Marine Characteristics

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***Abstract*—Marine higher education plays an important role in ocean countries in the world. Interdisciplinary integration of ocean and other disciplines has been the development trend and characteristics since the 21st century. In this paper, some explorations and practices have been carried out about the talents cultivation in Electronic Information Engineering with marine characteristics in Ocean University of China. This is a practical choice based on the national marine strategy and regional development demand for marine talents, and also benefiting the discipline intersection of information and ocean in College of Information Science and Engineering. We develop the professional training program with marine characteristics, including curriculum system and course syllabus. In order to strengthen the students' engineering practice, we construct multi-level, multi-stage and diversified practical teaching system; offer students various innovative practice out of class; open advanced experimental platform. As a result, the specialty construction in Electronic Information Engineering based on all of these measures is feasible and effective in improving the engineering ability of students, especially the application ability of electronic information in the ocean.**

***Index Terms*—undergraduate training mode, Electronic Information Engineering, marine characteristics, interdisciplinary integration, engineering practice**

I. Introduction

Ocean area accounts for 71 percent of the total area of the earth, and there are abundant resources in the ocean. Many countries in the world have made a great effort in understanding the ocean, exploiting the ocean, utilizing the ocean, developing the marine economy, protecting the marine ecological environment and so on. Some ocean countries, such as the United States, Canada, Russia, Japan, and so on, have realized the important strategic role of ocean in the national development earlier [1], and these countries have developed into world-class maritime powers for many years. To build a maritime power requires strong talent, intelligence and technology support, and marine education is the key in this respect. All of these countries have promoted the continuous development of ocean higher education. Many colleges and universities in the United States offer marine related majors, and some of them are accelerating the integration of marine disciplines with geosciences, atmospheric sciences, space, geology, and the environment, etc. This fully reflects the development trend and characteristics of marine science and technology since the 21st century. Other maritime powers also have a large number of marine universities and research institutes, which attach great importance to the cultivation of marine talents. The implementation of Marine Spatial Planning (MSP) in some developed marine countries prompted the construction of higher education curricula with multi-disciplinary that can support the newly-forming MSP [2], [3].

In China marine undertaking started relatively late, and there is a gap with the developed country, especially in marine monitoring technology, exploration technology, deep-sea equipment engineering technology, etc. In 2012, China put forward to the strategy to build a strong maritime country. There is no doubt that the key to implementing the strategy lies in talents and education. Thus, we should vigorously develop marine education, especially higher education, in order to meet the needs of the marine undertaking development. In 2019, the International Symposium on Marine Education was held in Qingdao. The theme of this conference is "the concept and action of marine education". China should be dedicated to strengthen international cooperation and vigorously develop marine education in order to provide talents, science and technology, cultural support for the marine exploitation and protection.

II. The Current Situation of Ocean Higher Education in China

A. Existing Problems

In the 21st century, marine higher education in China has developed rapidly, which provides a certain basis for the sustainable development of marine undertakings and industries, but there are still several outstanding problems [4]-[7].

2) Insufficient number of trained marine talents

At present, there are nearly 200 colleges and universities carrying out marine education in China, which can be divided into two categories: Ocean

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Universities and universities with majors in ocean filed. There are totally seven Ocean Universities in China, including Ocean University of China, Dalian Ocean University, Shanghai Ocean University, Guangdong Ocean University, and so on. In addition, many other universities also have ocean-related majors or disciplines, aiming to cultivate high-level marine talents. For example, Xiamen University, Tongji University, Harbin Engineering University, etc. all have their own advantages in marine disciplines [8]. According to the National Marine Talents Development of Long Term Planning Program (2010-2020) [9], the total amount of marine human resources in need should be 4 million by 2020, and 30% of them have a bachelor's degree or above. But the marine talents, not reaching the planned population number, have been still insufficient so far. Therefore, more young men are expected to enroll in the ocean-related majors in colleges and universities with the implementation of marine power strategy in China.

3) Unreasonable discipline structure

In China, there are three disciplines related to the ocean, namely, Science, Engineering and Agriculture. There are 5 primary disciplines, including Marine Science, Hydraulic Engineering, Naval Architecture and Ocean Engineering, Food Science and Engineering, and Fishery Sciences. According to the China Marine Statistical Yearbook in 2017 [10], there are 275 undergraduate professional points involving marine majors in all colleges and universities in China. However, most of the marine talents are concentrated in "fishery" and "ships", and the student number accounts for more than 60 percent of the total undergraduates of all marine majors. This is mainly due to the historical reasons that some ocean universities are formerly known as "College of Fisheries" or "College of Shipbuilding Engineering".

B. References Problem-solving Strategies

With the development of marine industry in China, more abundant and diversified marine talents are looking forward to be trained. In 2018, China proposed the program of Emerging Engineering Education, through the penetration of information and intelligence into other disciplines, to cultivate and provide new types composite engineering talents for the industry development. As a result, some new marine engineering majors then emerge based on the social demands. For example, Harbin Engineering University took the lead in setting up the first undergraduate major of Marine Robot in 2019 and Ocean Information Engineering in 2020 in China. Ocean College, Zhejiang University was established in 2015 to train advanced talents in marine science and marine engineering. These new majors involve the interdisciplinary inevitably. For example, the marine robot is the comprehensive application of high-tech means such as hydrodynamic analysis, control technology, sensor technology, artificial intelligence, computer simulation and so on in the marine field.

At the same time, some colleges and universities in China are trying to develop the marine characteristics in some traditional engineering specialties with extremely wide application, such as Mechatronics Engineering, Electronic Information Engineering, Computing Engineering, Automation and Control Engineering, etc. These majors are the most popular in higher education and the undergraduates account for about 50% of the total engineering ones in China. Based on the wide application of these traditional engineering techniques in the ocean, some marine colleges and universities make full use of the existing resources and advantages, combine marine characteristics education with professional engineering education to cultivate composite talents [11], [12].

Cultivating interdisciplinary marine talents will be one of directions for colleges and universities related to marine higher education in order to meet the needs of social and economic development.

III. Speciality Construction in Electronic Information Engineerng with Marine Characteristics in Ocean University of China

Ocean University of China (OUC) is located in Qingdao, which is one of the 20 coastal cities to be focused on according to the National Marine Talents Development of Long Term Planning Program (2010-2020) [9]. OUC is a comprehensive university with particular strengths in oceanography and fisheries science. And it has a wide range of disciplines and many majors are related to ocean. College of Information Science and Engineering has the research advantages in marine exploration technology and information engineering technology, which is supported by information and marine interdisciplinary disciplines. Moreover, the construction and development of Blue Economic Zone in Shandong Peninsula also needs a large number of marine engineering talents [13]. Specialty construction in Electronic Information Engineering with marine characteristics is a practical choice, also based on the college's own marine advantages.

A. Construct the Curriculum System with Marine Characteristics

1) Training objectives

As an engineering major, enabling students to solve practical problems in related fields with professional knowledge and skills is one of the most important training objectives. Based on the principle of "strengthening the professional connotation and highlighting the marine characteristics", this major focuses on the theory and application of electronic information. We will cultivate the compound engineering talents who can develop in a coordinated way in quality, knowledge and ability and can engage in research, design and technical management in the fields of electronic technology, information technology and marine electronic information technology.

2) Curriculum system

In the construction of curriculum system, we change the traditional training mode, integrate and optimize the traditional training content, and build a multi-level and multi-module curriculum system aiming at capacity training and practical application. The curriculum system is divided into three levels, including Public Foundation,

General Education and Professional Education (Table I). Professional core courses and characteristic courses are the main body in the Professional Education Level. All the professional core courses, such as Circuit Analysis, Advanced Programming Language, Signal & System, etc. are exactly the same as that in traditional Electronic Information Engineering major. Professional characteristic modules, as "non-core" modules, include three elective packages about Underwater Detection, Underwater Monitoring and Underwater Perception, set up for junior and senior undergraduates. Each package consists of 4 courses related to the application of electronic information technology in the ocean (Table II). Students are required to choose any one of course packages according to their interests. This offers specialization or option in addition to traditional content. Moreover, other courses have been added in General Education Level, such as Oceanography, Marine Environment and Ecological Civilization and so on. This is identical with the undergraduate education concept of "GENERAL KNOWLEDGE AS THE BODY AND SPECIALTY AS THE USE" IN OUC.

TABLE I. CURRICULUM SYSTEM

Public Foundation Level	Ideological and political category
	College foreign languages
	Advanced mathematics
	College physics
	Sports
General Education Level	General education curriculum
Professional Education Level	Disciplinary basic courses
	Professional knowledge courses
	Work skills courses

TABLE II. PROFESSIONAL CHARACTERISTIC COURSE PACKAGE

Underwater detection	Principles of automatic control
	Embedded system
	Measurement & control technology and instrumentations
	Underwater robotics technology
Underwater Monitoring	Communication theory
	Computer network and communication
	Underwater communication
	Ocean observing system
Underwater Perception	Foundation of information theory
	Digital image processing
	Subsea optics and imaging
	Underwater near-field data analysis

B. *Reflect Marine Characteristics in Course Content and Course Syllabus*

Apart from the three elective course packages mentioned above, some other courses, mainly reflecting the basic knowledge of electronic information specialty, embed some application of theory knowledge in the ocean appropriately. For example, Signal and System, Digital Signal Processing, Digital Image Processing and so on, take the real ocean data and signals as the analysis object. Sea clutters, seaweed micro images are analyzed based on MATLAB software to interpret the signal processing methods more intuitively. DSP Technology and Application tends to introduce some DSP technologies and special DSP chips applied in the ocean. Marine characteristics are required to be reflected in the syllabus. All of these come from the teachers' research projects and achievements, most of which focus on ocean information and system.

C. *Strengthen Engineering Practice*

1) *Construct multi-level, multi-stage and diversified practical teaching system*

For engineering talents, the key point is to cultivate their practice ability, innovation spirit and application ability. The practice teaching system plays an important role in the cultivation of engineering abilities. Three practice stages have been set up to train and improve students' abilities step by steps (Table III). From the first grade to the fourth grade, different training contents are set at each stage, so as to achieve the training objectives.

TABLE III. PRACTICE TEACHING SYSTEM

Step	Training content	Ability aim
Basic practice	Basic experiment	Engineering consciousness and basic research methods
	Metalworking practice	
	Cognitive practice	
	Electronic technology practice	
Comprehensive practice	Comprehensive design experiment	Initial problem-solving ability
	Production practice	
	Professional practice	
	Curriculum design	
Research and innovation practice	Discipline competition	Analyze and solve problems, research and innovation
	Innovation practice program	
	Scientific research project	
	Graduation project	

2) *Offer various innovative practice out of class*

Student Research and Development Program in Ocean University of China (SRDP-OUC) and National Undergraduate Innovation Training Program have been carried out and funded by OUC for nearly 15 years. Most programs come from teachers' research projects, naturally relating to ocean information engineering in the majority. In addition, students are encouraged and instructed to participate in multiple competitions, including the National Undergraduate Electronic Design Contest, National College Students Intelligent Car Race, National Marine Vehicle Design and Manufacture Competition and National Underwater Robot Competition. In summer holidays, many students are attracted to stay in the labs and make preparations for these competitions. Four or five students form a team spontaneously and complete a practical project under the guidance of teachers. For example, the project of Micro Underwater Glider and Integrated Underwater Thruster once won the first prize in China. All of these activities improve the students' ability of practical operation, problem analysis, problem-solving and team cooperation, which is extremely essential for an engineer. In the last semester of senior year, about 50% students tend to

choose graduation project topics relating to ocean information engineering because of their interests.

3) Open advanced experimental platform

Advanced research labs have been open to senior undergraduates in order to help them participate in research work of teachers or complete innovative design projects. These labs have supported a wide range of marine research projects and directions, such as remote operated vehicle (ROV), autonomous underwater vehicle (AUV), underwater vision and image processing, underwater communication, etc. Also, research results based on teachers' projects have been transformed into undergraduate experiments. Innovative, integrated, systematic and marine projects have been especially added to the specialty experiment.

D. Build a Distinctive Teaching Staff

The research directions and projects of teachers include information field and ocean field in College of Information Science and Engineering. In essence, specialized knowledge about electronic information engineering is applied to solve practical problems in the ocean. Some representative and typical research directions of teachers is illustrated in Table IV. Based on the research advantages of information and ocean intersection, it is possible to achieve the talent education target.

TABLE IV. EXAMPLES OF RESEARCH DIRECTIONS

Lab	Research direction
Underwater vehicle	Research and development of system platform and key technologies for advanced marine robot
	Autonomous navigation and control technology of underwater vehicle
Ocean optics	Research on underwater target optical detection
	Underwater visual information processing
	Atmospheric ocean laser detection technology and application
	Underwater communication and signal processing
Underwater acoustics	Underwater positioning and sensing network technology research
	Development of ocean sensor and observation instrument
Intelligent perception and signal processing	Intelligent recognition and prediction of marine and atmospheric environment targets based on deep learning
	Method and application of intelligent perception and machine learning
	Research direction

IV. SUMMARY AND DISCUSSIONS

Electronic Information Engineering is one of the most common and important majors in higher education in China. Facing the national marine strategy and the local economic development, this major in OUC has been constructed continuously, combining the connotation of electronic information engineering with marine characteristics. It provides a way to realize the characteristic construction, combining the advantages of disciplines with the development of specialties. Moreover, a lot of professional engineering talents with significant marine information characteristics have been cultivated to serve the national and regional development. However, there are several issues to note.

Firstly, most undergraduates prefer to traditional careers related to electronic engineering because of higher wages and welfare with more employment opportunities. By comparison, the application of electronic information engineering in ocean fields remains a relatively small professional option. Carrying out the collaboration between enterprises and universities maybe a strategy for solving the problem. Seek more cooperation with excellent marine enterprises and provide more internship opportunities for students, which attracts graduates into this industry. Also, a smaller number of students continue to pursue post-graduate degree maybe choose direction of marine research. So the specialization or option modules should be combined with Masters-level education.

Secondly, marine higher education should promote integration and development of more disciplines. In addition to the traditional sciences and technologies, humanities education is increasingly important. High-quality complex marine talents with engineering background and also knowledge of economics, management, culture, law, etc. is in great demand with the rapid development of marine undertakings.

The marine higher engineering education reform and talents cultivation involves many aspects, such as marine engineering education courses and actions, marine engineering education comparison and reference among countries or regions, the integration and development of marine humanities and social science, etc. All of these should be considered with the carrying out of Emerging Engineering Education in China.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Both Xinmin Ren and Haiyong Zheng participated in the professional reform and construction. Xinmin Ren is in charge of the construction and implementation of curriculum system. Haiyong Zheng focused on the design of three elective course packages with marine characteristics and Lab construction. Xinmin Ren wrote the paper. All authors had approved the final version.

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