

Specialty Construction of Materials Science and Engineering Based on Physics-Chemistry Interdisciplinary Studies

——A case study at Jilin Institute of Chemical Technology

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Abstract—A case study is conducted at Jilin Institute of Chemical Technology to investigate the development and characteristics of its interdisciplinary specialty construction program in Materials Science and Engineering. It is hoped that our findings will be helpful to other general engineering colleges as education universities in their efforts to develop interdisciplinary programs.

Keywords—general engineering colleges; Materials Science and Engineering; interdisciplinary; specialty construction; higher education

I. INTRODUCTION

Important discoveries in modern science and solution to major problems in national economy often relate to mutual penetration and intersection among different academic disciplines. Inter-discipline has become the characteristics of knowledge innovation and scientific progress. Developing inter-discipline is of strategic importance to cultivation of new discipline and to make universities and colleges more competitive [1–5]. It is generally thought that inter-discipline is one of important goals of strategic plan in Chinese research universities [6]. The position of general engineering colleges is fixed to teaching-oriented universities. Their interdisciplinary construction is often ignored for lack of academic foundation. Inter-discipline gives primary impetus to disciplinary construction and it is an indispensable way to train top-notch innovative talents. In modern China, developing inter-discipline is also necessary means to existence and development of general engineering colleges because of the need of innovative talents characteristic of interdisciplinary compounding type.

Materials science and engineering (MSE) is a new-type inter-discipline consisting of multi-disciplines [7], which covers the basic knowledge of metal materials, inorganic non-metal materials, and polymer materials. The specialties within the discipline of MSE can be divided into eight specialties according to the category of the discipline of MSE. To meet the needs of modern society progress and future orientation,

however, training interdisciplinary compounding talents become the goal of MSE, which makes its specialty construction of this discipline advance according to the direction of comprehensive and integrated specialty of MSE [8].

In this work, a case study is conducted for the specialty of MSE in Jilin Institute of Chemical Technology. The characteristics, achievement, and barrier of this specialty are dissected. This is helpful to casting about for a new branch and to specialty construction in general engineering colleges.

II. POSITION AND FUNCTION OF INTER-DISCIPLINE IN GENERAL ENGINEERING COLLEGES

A. Discipline

A discipline is a branch of knowledge and it is divided into different classes according to academic nature. Branches of science are commonly referred to as the scientific disciplines, e.g. physics, chemistry, mathematics.

B. Inter-discipline

Inter-discipline is referred to as involving two or more academic disciplines [6]. Inter-discipline is a new discipline that is formed by synthesizing different disciplines and blending into each other by the aid of object integration, concept transplantation, theory permeation, complementary method, functional intermingling, etc.

C. Position and Function of Inter-discipline in General Engineering Colleges

General engineering colleges in China show two features of smaller school size and discipline simplification by the end of the twentieth century. China begins to expand its higher education in 1999 and then school size of general engineering colleges expanded rapidly. Interdisciplinary construction becomes a new growing point of disciplinary construction and specialty construction. Chinese traditional administration system and organization system with a unique discipline in research universities are comparatively strict, and therefore the

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disciplinary barrier is easy to be formed. For general engineering colleges, disciplinary integration is sponsored by college administration because of the need of development. Hence, this kind of college is easier to integrate its disciplines and its disciplinary barrier is smaller in comparison with research universities. Since 2000, the proportion of original achievements in the interdisciplinary fields increases year by year, which evaluates interdisciplinary position in general engineering colleges. Thus, interdisciplinary construction can play a bigger role in general engineering colleges than in research universities.

III. PRODUCTION OF DISCIPLINE AND SPECIALTY OF MATERIALS SCIENCE AND ENGINEERING (MSE) IN JILIN INSTITUTE OF CHEMICAL TECHNOLOGY (JLICT)

Since 1960, universities and colleges in the European countries and the United States of America (U.S.A.) renamed their departments associated with materials “department of materials science and engineering”, “department of materials science”, “department of materials engineering” etc. In the late 1980s, most of universities and colleges in these countries have completed this work [9]. With the rapid development of materials science and technology, these developed countries reformed their education system, which results in the formation of the first-order discipline of MSE.

In 1999, the enrollment expansion of higher education [10] is one of the most popular education reform measures in China. Industrialization of higher education becomes a good opportunity for universities and colleges, and Chinese school scale associated with economic benefits expanded rapidly. The enrollment expansion had become a top choice of survival and development of universities and colleges in China.

Jilin Institute of Chemical Technology (JLICT) was set up in 1958. After the development history of the 46th anniversary, two specialties of applied physics and applied chemistry were set up simultaneously in 2004. This marks production of two first-order disciplines of physics and chemistry.

Both applied physics and applied chemistry are two undergraduate specialties with the nature of science, and they do not harmonize with the nature of engineering of JLICT. Although the students in these two disciplines have a solid foundation of knowledge, how to apply the professional knowledge in reality and where to work must be confusing for them. The unfavorable employment data in the following years further exposes some problems of talent training dependent on single discipline. These facts reveal that the mono-discipline talent training based on physics or chemistry has unsuited to the current economic society demand for general engineering colleges in China. Under that situation, an interdisciplinary specialty called materials science and engineering (MSE) was born in 2011 based on the inter-discipline between physics and chemistry, as shown in Fig. 1. This specialty with the nature of engineering has been granted directly by the Ministry of Education. It was fully justified by the development trend of “Great Materials” specialty in the future [8, 11]. After 2000, another three specialties of polymer materials and engineering and materials chemistry based on Chemical Engineering and Technology were set up in College of Petrochemicals and of

materials physics was set up in College of Sciences in JLICT. For these achievements, the discipline of MSE was set up in JLICT. This discipline covers 4 undergraduate specialties and a systematized knowledge system consisting of metal materials, inorganic non-metal materials and polymer materials. On the basis of 4 specialties, College of Materials Science and Engineering (CMSE) was set up in JLICT in 2013. It can be seen that interdisciplinary construction expands the school size of JLICT.

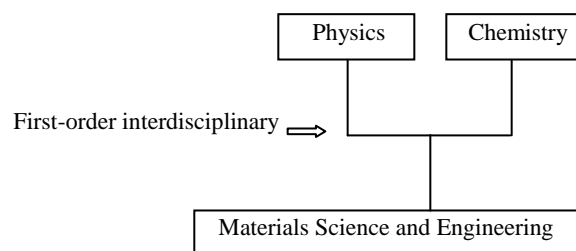


Fig. 1. Illustration of the specialty of Materials Science and Engineering (MSE) in Jilin Institute of Chemical Technology (JLICT).

IV. THINKING AND CHARACTERISTICS OF SPECIALTY CONSTRUCTION OF MSE

Fortunately, 2012 National Degree Commission of the Ministry of Education (4th revision) includes the specialty of MSE [12], which may make this specialty in interdisciplinary construction avoid many problems that arise from disciplinary barrier, such as a lower degree of integration and instability of disciplinary staff, an experimental platform lack of substantial interdisciplinary, a weaker sustainable development capacity of interdisciplinary, etc [2]. In specialty construction of MSE in JLICT, we did not blindly follow the trend, but referred some successful experience and practice in research universities [1-6]. Our concrete measures are as follows:

A. Introducing an Academic Leader of the Discipline and Specialty of MSE

Talents in general engineering colleges are commonly deficient. Academic leader that interdisciplinary construction requires is a scarce resource and it is difficult to produce a high-level disciplinary leader in general engineering colleges. However, in order to survive and develop, JLICT had to introduce physics-chemistry interdisciplinary leader and leader of the specialty of MSE. Academic leader of MSE was required to have the background of interdisciplinary knowledge and higher academic levels. Fortunately, New Century Excellent Talent in University from State Education Ministry—Prof. Da-Yong Lu, as academic leader of MSE, was successfully introduced into JLICT in 2007 and he began to work in department of applied physics, college of sciences. Table I shows his education background with physics-chemistry-materials inter-discipline. His academic achievements show advanced level in the dielectric field [13, 14]. The successful introduction of academic leader lays a solid foundation for the development of the discipline and specialty of MSE.

TABLE I. EDUCATIONANAL BACKGROUND OF ACADEMIC LEADER OF THE DISCIPLINE OF MSE

Academic Degree	Bachelor	Master	Doctor	Postdoctor
Specialty	Solid state physics	Condensed state physics	Materials science and energy engineering	Chemistry and chemical engineering

B. Construction of Research Platform with Interdisciplinary Nature ahead of Specialty construction

In 2007, the enrollment expansion was encouraged by national policy [10]. The application and approval of a new specialty was easier and pupils were comparatively adequate at that time. After introducing an academic leader, JLICT did not immediately apply for the specialty of MSE with physics-chemistry interdisciplinary nature, but created a research platform with interdisciplinary nature—Research Center for Materials Science and Engineering (RCMSE), with four laboratories: Ceramic Engineering Lab, Thin Film Engineering Lab, Materials Processing Lab, and Test & Measurement Lab. Until now, RCMSE has developed to 13 research labs and can do research work covering metal materials, inorganic non-metal materials and polymer materials. The creation and development of the research platform RCMSE lays a solid foundation for the creation and development of the specialty of MSE and talent introduction in the future.

C. Research Innovation Team Construction with lofty goals

1) Creation and development of provincial research team

For general engineering colleges, the construction target of research team based on newly emerging discipline should not be over-ambitious but should emphasize college's reality, and gradually accumulates and develops. In 2007, Prof. Lu created a research team whose main research direction is inorganic dielectric materials. The initial team consisted of eight teachers who were from physics and chemistry. Because this team was not formed spontaneously by means of long-term research cooperation, it was still a loose team lack of substantial cooperation. This immature research team is the prototype of physics-chemistry interdisciplinary team in JLICT. With the development of team construction and specialty construction, the team members were gradually eliminated and reorganized, optimized and developed. This team was awarded Outstanding Innovation Team by JLICT in 2010 and by Jilin city in 2011, and Jilin Provincial Inorganic Materials Physics Research Innovation Team in 2012.

2) Jointly training postgraduate students and training trans-disciplinary undergraduate students

Cultivation of students' ability is primary task of universities and colleges. The ultimate aim of research platform construction and scientific research is connected with talent training of postgraduate. However, JLICT was a general engineering college without a charter to confer master's degree before 2014. Only training of undergraduate students is incompatible with our provincial team. We had to cooperate with Jilin University and Northeast Normal University from 2008 to train postgraduate students. The cooperation provided abundant human resources for our research projects and also offered great help for constructions of research platform and

team. Double harvest of research achievements and talent training were realized in RCMSE.

With the help of high-level research subjects and "Top-notch talents plan", Prof. Lu in RCMSE directed 100 undergraduate students and transmitted 16 postgraduate students to 985-level universities. These achievements built reputation and influence of JLICT in China, and lays a solid foundation for development of the specialty of MSE.

D. Creation of the Specialty of MSE and Its Characteristics

After introducing an academic leader of MSE and creating research platform and team, JLICT applied for and set up the specialty of MSE in 2011 and began to admit students.

The first task is to build characteristics of the specialty of MSE. The key educational directions must be founded upon our main research directions and development directions of the specialty in the future. Initially, the characteristics of the specialty of MSE were two educational directions: (1) inorganic solid functional materials and (2) Metal surface science and technology. They belong to physics-chemistry interdisciplinary field, as shown in Fig. 2. With the rapid development of research platform construction and scientific research, two additional educational directions, inorganic-organic complex materials and pharmaceutical science, were expanded (Fig. 2). The former belongs to physics-chemistry-materials interdisciplinary field, and the latter four interdisciplinary fields. The specialty of MSE becomes a "great discipline" specialty covering three kinds of materials.

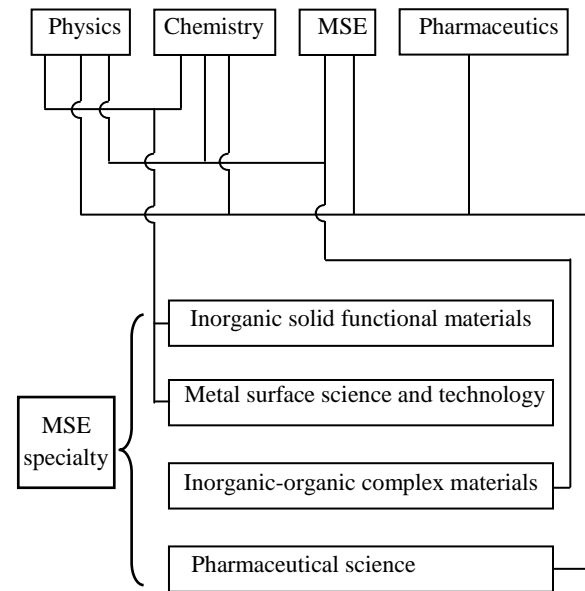


Fig. 2. Illustration of talent training directions of the specialty of MSE.

E. Construction of Teaching team with Interdisciplinary Nature

The specialty of MSE began to enroll new students in 2011. We set up department of MSE and then introduced talents step by step. The members from the initial research team and temporary teaching team derived from Department of Physics

and Department of Chemistry. Apart from a skeleton staff of several teachers, other members still stayed at their departments with single discipline due to disciplinary barrier. This can provide adequate positions and talent introducing space for optimization of both research team and teaching one, and ensure creation of teaching team with interdisciplinary nature. The second-order disciplines of our teaching team are shown in Table II. The features are as follows: the team teachers have their education backgrounds of physics, chemistry, and materials, and simultaneously of metal materials, inorganic non-metal materials, and polymer materials. Thus, our teaching team is interdisciplinary optimization of organization based on the requirement of specialized characteristics. After a young teacher was introduced into our teaching team, he or she will be required to learn three to four courses of the discipline of MSE.

TABLE II. EDUCATIONANAL BACKGROUND OF TEACHING TEAM OF THE SPECIALTY OF MSE

<i>Teacher No.</i>	<i>Professional title</i>	<i>Specialty</i>
1	Professor	Physics Chemistry
2	Professor	Materials Science and Engineering (Metal Materials direction)
3	Associate Prof.	Applied physics
4	Associate Prof.	Inorganic Chemistry
5	Lecturer	Materials Science (Polymer Materials direction)
6	Lecturer	Materials Physics and Chemistry (Inorganic Materials direction)
7	Teaching Assistant	Materials Science and Engineering (Metal Materials direction)
8	Teaching Assistant	Inorganic Chemistry
9	Teaching Assistant	Inorganic Chemistry

F. Construction of curriculum system and Practical Teaching Base

Our curriculum system was constructed according to characteristics of the specialty of MSE [8], and this system emphasized our key educational directions: (1) inorganic solid functional materials and (2) Metal surface science and technology. Five professional labs were set up, including materials science foundation, inorganic chemistry, XRD calculation and structural analysis, modern test and analysis, metallographic, metal surface treatment labs. We cooperated with enterprise and research institutes to form four practice bases, covering inorganic ceramic materials, metal materials, polymer materials, and materials testing.

V. EXPERIENCE AND PERSPECTIVE

This article sums up the construction experience of a new interdisciplinary specialty of materials science and engineering (MSE) in Jilin Institute of Chemical Technology (JLICT). The

employment rate of our first graduates of the specialty of MSE was 94% in 2015. One of our first graduates succeeded in postgraduate examination of Tsinghua University. These facts testify to a relatively successful construction of the specialty of MSE in JLICT. Our experience will be helpful to other general engineering colleges in their efforts to develop interdisciplinary programs. With the development of the age and local economics, our talent training directions will expand into composite materials and R & D of pharmaceuticals in the future.

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