

Revision Practice of Talent Cultivation Scheme for Materials Science and Engineering Specialty Based on Engineering Education Professional Certification

Jing-jing LIU^{1,a} and Neng-wei WANG¹

¹College of Vanadium and Titanium, Panzhihua University, Panzhihua, Sichuan, China

^ajingjingliu8610@163.com

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Abstract: Engineering education professional certification is a powerful way to improve the engineering education quality of universities in China. Talent cultivation scheme is the “top-level design blueprint” of talent training, and also the fundamental guarantee for the effective implementation of engineering education certification. Based on the engineering education certification practice of materials science and engineering major in our university, the development status of materials science and engineering major is introduced and some experience for the revision of the training objectives, graduation requirements, curriculum system in the talent cultivation scheme and syllabus is summarized so as to provide reference for other universities and other materials majors.

In June 2016, China became the 18th official member of the Washington Agreement, a mutual recognition agreement for undergraduate engineering degrees, marking the realization of international mutual recognition of China's higher engineering education quality certification system^[1]. The three core concepts of engineering education certification are student-centered, outcome-oriented, and continuous improvement, which are the training objectives and graduation requirements-oriented, with enough teachers and adequate support conditions to ensure the effective implementation of the teaching activities, and the improved internal and external monitoring mechanism for continuous improvement, finally ensure the quality of students to meet graduation requirements^[2-3]. Engineering education certification is helpful to improve the international competitiveness and influence of engineering education quality of universities in China^[1]. Talent cultivation scheme is the “top-level design blueprint” of talent training^[4], and also the fundamental guarantee for the effective implementation of engineering education certification. There is a gap between the talent training program formulated by most universities before participating in engineering certification and the standards requirements of engineering certification, so it is necessary to revise the training program according to the standards and core concepts, and form the talent training program that reflects the characteristics of professional training and meets the certification requirements^[5]. Based on the engineering education certification practice of materials science and engineering major in our university, some experience for the revision of the talent cultivation scheme is summarized so as to provide reference for other universities and other materials majors.

1. The Development Status of Material Science and Engineering Major in Our University

The material science and engineering major of our university was enrolled in 2003 and awarded bachelor's degree in 2007. It was approved as a provincial and national distinguished major in 2008 and 2010, respectively. In 2011, it was approved as the pilot program of provincial comprehensive professional reform. In 2012, it was listed as one of the first outstanding engineer training programs of Sichuan Province. In 2017, it was approved as one of the first applied demonstration majors in Sichuan Province. In 2019, it was listed as the first-class major of Sichuan Province and has become the acceptance major of engineering education certification application, the self-evaluation report was submitted in 2020 and the on-site inspection of the experts was completed in June 2021. Based

on the major of materials science and engineering, the College of Materials Engineering was established in 2007, and the College of Vanadium and Titanium was innovatively set up in 2018 based on the College of Materials Engineering. There are currently 495 students in this major with an average annual enrollment of about 120, and the length of schooling is 4 years. It began to jointly train master students in materials with Xihua University in 2007 and has jointly run schools with the Institute of Process of the Chinese Academy of Sciences and Shanghai University, respectively. The scientific research and innovation ability of the students are cultivated by using the platforms of National Key Laboratory of Vanadium and Titanium Testing, Sichuan Key Laboratory of Comprehensive Utilization of Vanadium and Titanium Resources and Sichuan Engineering Technology Research Center of Vanadium and Titanium Materials in the college. The experimental teaching demonstration center of Materials Science in Sichuan province and the practice teaching base inside and outside the college are used to cultivate students' engineering practice ability.

2. Revision of Talent Cultivation Scheme Based on Engineering Education Certification

In 2015, the major of materials science and engineering took the lead in engineering education certification, and revised the talent cultivation scheme based on the requirements of engineering education certification. In order to do a good job in the revision of the talent cultivation scheme, the college has sent backbone teachers to go out for training and learning, organized professional teachers to discuss, and solicited opinions on professional development and talent training quality from the graduates, employers, enterprises/industry experts. Based on the above feedback, combined with the requirements of engineering education certification and the reality of the college, the 2015 version of talent cultivation scheme was formulated, in which the training objectives of professional talents were revised, the graduation requirements and indicators of the major were clarified and the supporting matrix between the graduation requirements indicators and courses was established, and the opinions of engineering certification experts were solicited for improvement. At the stage of submitting application and self-evaluation report, the talent training program is constantly revised based on expert opinions, and the current talent cultivation scheme is the 2019 version.

2.1. Revise Talent Training Objectives Based on Social Needs and University Orientation, and Highlight the Specialty Features of Vanadium and Titanium

According to economic development and social needs, combined with the university's educational orientation, professional characteristics and development direction, on the basis of the 2015 version of talent cultivation scheme and the rationality evaluation results of the training objectives, the training objectives in the 2019 version of talent cultivation scheme are revised and formed, including the overall objective and 5 sub-objectives. The overall objective is: Based on Panxi national strategic resources development, this major is committed to promoting vanadium and titanium technology progress and the development of vanadium and titanium industry, and training application-oriented senior specialized talents who could adapt to the needs of socialist modernization and are well-developed in moral, intellectual, physical, aesthetics and labour education, with the down-to-earth, persistent faith, good quality, advocating science and strong practice ability, and who are able to master basic knowledge of natural science, humanities and social science and material science and engineering, who has strong practical ability, knowledge acquisition ability, social intercourse ability, organization and management ability and innovation consciousness, has the knowledge, skills and ability of material composition and structure, synthesis and production process, properties and use, who can be engaged in applied basic research of materials science and engineering, development of new materials and new technology, enterprise management, production technology management, production quality management, technical maintenance and transformation with innovative spirit, entrepreneurial consciousness and professional ability, especially in the related field of vanadium and titanium material in the scientific research institutes or enterprises.

The 5 sub-objectives are: (1) Have healthy body and mind, good humanities and science literacy,

have effective communication skills and good teamwork skills, and be able to play an effective role as a backbone or leader in a technology research and development team. (2) Be able to adapt to the development of modern inorganic non-metallic materials and metal materials engineering technology, and can understand, analyze and solve complex engineering problems in the field of materials, especially vanadium-titanium metal materials and inorganic non-metallic materials. (3) Have engineering innovation ability, and be able to use modern tools to engage in related scientific research, production, technology research and development and transformation, process and equipment design, production organization and technology management in this field. (4) Have good senses of social responsibility, understand and adhere to professional ethics, and be able to comprehensively consider the impact factors of economic, legal, environmental and sustainable development. (5) Have international vision, be able to adapt to career development through lifelong learning, and be willing and able to serve the society.

The revised training objectives are closely focused on the development of Panxi's national strategic resources, and are committed to promoting vanadium and titanium technological progress, and the transformation and extension of vanadium and titanium industry, has formed distinctive vanadium and titanium characteristics in the field of materials engineering, and more highlight the cultivation and promotion of the students' comprehensive literacy. The training objectives are in line with the university's orientation, meet the needs of social and economic development, and are based on the needs of regional economic development for talents.

2.2. Revise Graduation Requirements Based on Training Objectives to Highlight Professional Characteristics

The training goal is the basis for formulating graduation requirements and the graduation requirements supply important support for achieving the training goals. The training goals focus on "what can the students do", while the graduation requirements highlight "what can the students have", "what can the students do" originates from "what can the students have"^[6]. Based on the general standards of engineering education certification and the training objectives, combined with the university's educational orientation, economic and social development needs and professional characteristics, the 12 graduation requirements have been revised and improved after full investigation and discussion (seen in Table 1), with clear connotation, fully covered content and the ability level not lower than the 12 general standards, demonstrating the specialty features for talent training. Through the supporting analysis of the graduation requirements for the training goals, it can be seen that each training goal has several graduation requirements to serve and support it, and the graduation requirements can supply better support for the achievement of the training goals.

In order to make the connotation of graduation requirements clear, the 12 graduation requirements have been reasonably decomposed and formed 31 graduation requirements index points that are measurable, evaluable, logical and professional. During the decomposition process, the college has organized teachers to conduct multiple seminars, solicited opinions from employers, outstanding alumni, and industry/enterprise experts. The decomposition of graduation requirements pays attention to the logical relationship between the sub-index points. The non-technical graduation requirement index points are decomposed according to "ability elements", and the technical ones are "vertically" decomposed based on the ability formation logic, which fully reflects the logical relationship in the progressive aspects of knowledge and ability for students.

Table 1 Graduation requirements for materials science and engineering.

Graduation Requirements	Specific Description
1. engineering knowledge	Be able to solve complex engineering problems in the field of materials science and engineering by using mathematics, natural science, engineering technology foundations and materials engineering expertise.
2. problem analysis	Be able to apply the basic principles of mathematics, natural science and engineering disciplines, combined with literature research, to identify, express, study and analyze complex engineering issues such as preparation, processing and properties control in the fields of materials science and engineering to obtain effective conclusions.
3. design/develop solutions	Be able to design materials (especially vanadium-titanium metal and inorganic non-metallic materials) composition, production process and equipment selection to meet specific needs with innovative consciousness in the design process, taking social, health, safety, legal, cultural and environmental factors into consideration, for the solutions to complex engineering problems such as material preparation, processing and performance control in the field of materials science and engineering.
4. research	Be able to study complex engineering issues such as preparation, processing and performance control in the field of materials science and engineering (especially in the field of vanadium-titanium metal and inorganic non-metallic materials) by using the principles of material science and effective methods, including experimental design, data interpretation and results analysis, and obtain reasonable and effective conclusions through information integration.
5. use modern tools	Be able to develop, select and use appropriate technologies, resources, modern engineering tools and information technology tools, including the prediction and simulation of complex engineering problems, and understand their limitations, for complex engineering issues such as preparation, processing and performance control in the fields of materials science and engineering (especially in the fields of vanadium-titanium metal and inorganic non-metallic materials),
6. engineering and society	Be able to conduct reasonable analysis and evaluate the impact of materials professional engineering practices and complex engineering problem solutions on society, health, environment, safety, law, and culture, based on relevant background knowledge of materials science and engineering, and understand the responsibilities that should be undertaken.
7. environment and sustainable development	Be able to understand and evaluate the impact of material science and engineering professional engineering practices for complex engineering issues such as material design, preparation and processing on the sustainable development of society, resources and the ecological environment.
8. professional norms	Possess humanities and social science literacy, social responsibility, be able to understand and abide by engineering professional ethics and norms in material science and engineering professional practice, and fulfil social responsibilities.
9. individuals and teams	Be able to undertake the roles of individuals, team members and leaders in a team with a multi-disciplinary background.
10. communication	Be able to effectively communicate with colleagues and the public on complex engineering issues in the field of materials science and engineering, including writing reports and design manuscripts, making statements, expressing clearly or responding to instructions, etc, have international perspective and be able to communicate in a cross-cultural context.
11. project management	Understand and master engineering management principles and economic decision-making methods, and be able to apply them in a multi-disciplinary environment.
12. lifelong learning	Have the consciousness of self-learning and lifelong learning, master the correct learning methods, have the ability to self-learn and adapt to development.

2.3. Optimize the Curriculum System Based on Graduation Requirements and Index Points, and Establish a Reasonable Curriculum Support Matrix

Graduation requirements are the basis for the construction of the curriculum system, and the curriculum system is an important support for achieving the graduation requirements^[3]. In accordance with the requirements of engineering education professional certification, the professional curriculum system includes four classes of mathematics and natural science; engineering basics, professional basics and professional; engineering practice and graduation design (thesis); humanities and social science, with the total credits of 26, 56, 42, 46 in sequence, and the proportions of 15.29%, 32.94%, 24.71% and 27.06%. The curriculum system is in line with the requirements of engineering certification standards, focusing on the solution of complex engineering problems for students, and can effectively support for the achievement of the graduation requirements. The college has formulated the "Implementation Measures for the Rationality Evaluation of the Curriculum System of college of Vanadium and Titanium", and the rationality of the curriculum system is evaluated and revised once every 4 years, and industry/enterprise experts are invited to participate in the design and revision process. A relatively complete practice teaching system has been set up, with the documents such as the "Interim Regulations on the Management of Off-campus Practice Teaching of Panzhihua University" and "Interim Management Measures for the Construction of Teaching Practice Bases of Panzhihua University". The practice teaching process fully cooperates with enterprises and makes use of multiple practice bases off campus to carry out internships, practical training and teaching to cultivate students' practical and innovative abilities. The topic selection of graduation design (thesis) is combined with practical engineering applications. The types of topic selection mainly include engineering design and engineering research, to fully cultivate students' engineering awareness, collaboration spirit and the ability of solving practical and complex engineering problems. Enterprise or industry experts participate in the guidance and assessment of graduation design (thesis), which is guaranteed by related systems.

In order to serve the regional economic development and connect with the innovative development of vanadium and titanium resources in Panxi, highlight the specialty characteristics of vanadium and titanium of the college, coupled with the opinion solicitation on former graduates, current students, professional teachers, employers and industry/enterprise experts, the materials science and engineering major is divided into two directions, metallic materials and inorganic non-metallic materials, and the curriculum system of the 2019 version of talent cultivation scheme was adjusted in the terms of the settings and credits of some courses. The optimized curriculum system effectively supports the achievement of graduation requirements and meets the needs of students' individual growth.

2.4. Revise the Syllabus Based on the Curriculum Support Matrix to Promote the Achievement of Curriculum Goals and Graduation Requirements

The curriculum syllabus is a programmatic document for guiding teaching and is also the fundamental guarantee for the implementation of the curriculum goals and the achievement of graduation requirements. The formulation of the syllabus in this major is led by a course group leader with an associate professor or professor title. The course group leader organizes course-related teachers to conduct discussions. The course goal is determined according to the graduation requirement index points supported by the course, and the teaching contents, teaching methods, assessment methods and scoring standards are determined based on the course goal. For each course, a teacher is responsible for writing the syllabus, which is jointly reviewed by the course group leader and a professor of the major, and submitted to the college's undergraduate teaching steering committee for approval before implementation. The revised course syllabus of this major mainly includes basic course information, course nature, course goals, correspondence between course goals and graduation requirements, course content and class hours allocation, correspondence between course assessment methods and course goals, grading standards, and comprehensive assessment methods of scores, recommended teaching materials and reference

materials, the revised syllabus plays a better guiding role for teachers to carry out teaching based on the curriculum goals and graduation requirements, makes the teachers more clear about why they teach, and makes the students get a better understanding of why they learn^[6].

3. Conclusion

The talent cultivation scheme is the top-level design document for the engineering education certification of engineering majors that needs to be revised timely. In the course of revision, all majors should implement "reverse design principle" of the outcome-oriented, that is, from training goals→graduation requirements→curriculum system→syllabus→teaching process in order and integrate the three core concepts of engineering education certification into the design process, truly realize high-quality talents cultivation for economic and social development with the application of the student-centered, outcome-oriented and continuous improvement into the teaching practice.

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