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RE-ENGINEERING AND QUALITY ASSURANCE OF MINING PROGRAMS TOWARD THE CHINESE DOUBLE FIRST-CLASS PROJECT GOAL: A CASE STUDY*

As one of the three Double First-Class mining engineering programs to be built in China, the Mining Engineering program at the University of Science and Technology Beijing (USTB) has been actively participated in the process of engineering education accreditation. Through such a process, a student-oriented system for achieving educational objectives has been built to ensure the quality of mining education and for graduates to meet educational requirements and social needs. The system is based on well-structured faculty, broadly designed curriculum and their core competencies. Such a system should also be continuously improved through internal and external reviews and quality assurance mechanisms.

Key words: *Mining engineering, Double First-Class Project, student-oriented system, program review, accreditation of engineering education*
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Introduction

The Mining Engineering program at the University of Science and Technology Beijing (USTB) was comprised of mining engineering and mineral processing when it began to admit students in 1951. And in 2017, it was selected and listed by the Chinese Ministry of Education as one of the Double First-Class mining engineering programs to be built in China. The program and the School are also equipped with the Ministry of Education Key Laboratory of High Efficiency Mining and Safety for Metal Mines. Currently, the program and the Department enroll 197 undergraduate students 200 postgraduate students, with a faculty of 36 full-time members, including 19 full professors. Over the past 66 years, Thousands of mining and mineral processing graduates have completed their education with the program and some of them have become leaders in the related academic fields and industrial and governmental sectors [1]. The program has gained its reputation as the cradle of Chinese hard-rock mining engineering elites.

China has joined the Washington Accord, holding a provisional status in 2013 and becoming a full signatory on June 2, 2016, and now it is the eighteenth full member of the international agreement on mutual recognition of bachelor's degree in Engineering. Such a movement indicates that the quality assurance mechanisms for engineering education in China have been recognized by international engineering education community and its college graduates in engineering fields would be certified a mutual recognition based on international quality standards. It is an important step for Chinese engineering education to become internationalized. It will also promote the Chinese engineering and design fields to go abroad and collaborate with the world.

The Mining Engineering program at USTB was certified by the Chinese Engineering Education Accreditation Association (CEEAA) for 3 years of validity in 2014, and it was certified again for 6 years of validity in 2017. Through such two-stage participation in the process of engineering education accreditation, a student-oriented system for achieving educational objectives has been built to ensure the quality of mining education and for graduates to meet educational requirements and social needs. The system is based on well-structured faculty, broadly designed curriculum and their core competencies. Such a system should also be continuously improved through internal and external reviews and quality assurance mechanisms [2].

Educational objectives

Well-defined objectives are the core of educational programs and professional development. According the history, characteristics, and achievements of program development, the formulation of the educational objectives of Mining Engineering program at USTB is guided by USTB's Thirteenth Five-Year planning, followed a three-step development strategy, and combined with the educational requirements and social needs. The educational objectives are to cultivate wide-caliber talents, high-quality engineering and technical professionals with solid fundamental knowledge, systematic thinking, coordination and innovation, international vision, ability to deal with complex technical problems in mining engineering and related fields. The professionals are able to engage in mineral resource development, utilization and protection at the units related to mine planning and design, production management, investment, education and scientific research. The professionals would up to the challenges of international diversities and rapid changes.

To achieve the educational objectives, the basic requirements for graduates with the USTB Mining Engineering program include:

1. Good humanistic quality, strong sense of social responsibility and engineering ethics, as well as attention to the

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environmental protection, ecological balance and sustainable development in the mining activities.

2. Solid foundation theory and professional knowledge, ability to analyze the complex engineering and technical problems applying various knowledge.

3. Ability to plan and design the exploitation and protection of mineral resources, basic ability to work at the position of mine production and management.

4. Strong thirst for knowledge and innovation, research on the complex engineering problems applying scientific principle and method, master certain modern research methods, ability to forecast and simulation of complex technical and engineering problems, ability to further their studies as Master students;

5. Keep with the modern times, expand knowledge and capabilities through continuous learning, competitive in employment, strong teamwork spirit and cross-cultural communication ability, ability to take primary or intermediate technology jobs in 3 to 5 years.

Curriculum and courses

The rational allocation and optimization of the curriculum system is the key to achieve the educational objectives. The education program of mining Engineering is re-engineered and developed according to professional standards formulated by the Education Committee for Mining Engineering in the Ministry of Education, considering the characteristics and advantages of USTB and the characteristics of employment in the main industry, obeying the requirements of the knowledge system structure and professional training in mining Engineering. It is formed through the discussion led by academic leaders, participated all the faculty and stuff, experts from enterprises and industry, and investigated with senior students, graduates and employers [3, 4].

Under the guidance of education program, the overall curriculum is set into two aspects, theoretical courses and practical courses. The theoretical courses include three required courses modules (general courses, discipline platform, and professional core course) and two elective courses modules (professional elective courses and quality expansion). The practical courses have four course modules and include fundamental, professional, experimental and innovational courses. There are four directions in the professional elective courses, include the freshman seminar, professional frontier, professional development, and resource economics and management. Amongst, the professional frontier courses reflect the future direction and development of metal mine and have five courses, include Special Mining Technology, Digital Mine technology, Modern Filling Technology, Deep Mining Technology, and Advanced topics (New Technology and Development Direction of Mining Engineering). Professional development courses add some new courses to expand the students' employment opportunities in cities, for example, Underground Structure Design, Urban Underground Engineering. Resource Economics and Management group include seven courses focusing on resource and environmental issues, such as Resource, Environment and Sustainability, and Recycling of Mine Solid Wastes. **Fig. 1** shows the professional curriculum architecture.

The architecture shows the curriculum in each term each academic year. Different colors present different course modules, include general courses, discipline platform courses, professional core courses, professional elective courses, and quality expansion courses. The architecture also shows the prerequisite of main mining course, and the credit allocation of various courses.

The curriculum system meets the requirement of engineering education accreditation, which is no less than 15% of mathematics and science courses, 30% of Engineering fundamental courses, professional fundamental courses, and professional courses, 20% of engineering practice and graduation design (Thesis), 15% of liberal education of social science courses. The setting of curriculum system is the key factor to achieve the educational objectives.

Quality assurance by teaching

Quality assurance by teaching refers to:

1. Improving faculty structure and teaching effectiveness

USTB stipulates that professional faculties must complete a defined amount of teaching work loads to meet the requirements of their position. The teaching work load is one of the main indicators for the faculty appointment and promotion, which implements one-vote veto system.

All the full professors and associated professors under the age of 60 must teach the undergraduate courses [5].

USTB also provides a series of measures and systems to cultivate the young faculties. For example set up a special development fund for young faculties, appoint responsible mentor, offer chances to assist with the courses and to give trail lectures, provide training opportunities for further studies, and offer credential positions in the enterprises and engineering units. These measures and systems are to improve the new faculties' professional qualities, teaching levels and scientific research abilities.

The Mining Engineering program in USTB pays special attentions to bring in outside intelligence, and establish a sharing mechanism for the excellent human resources. Many notable scholars from famous Universities were hired to teach undergraduate courses and to give academic lectures. For example, those scholars have come from the University of Queensland, Adelaide University, University of New South Wales, University of Tokyo, Tsinghua University and Peking University. At the same time, senior engineers from enterprises and engineering units were appointed to be part-time teachers, who in charge of the guidance in Graduation Design (Thesis) and field practice, and give lectures of case studies in seminar.

The Agreement for the Articulation of Program for undergraduates in mining engineering between the University of New South Wales and the University of Science and Technology Beijing was signed in September 2017. The agreement promotes the international exchange of undergraduate students in the mining engineering program.

2. Enriching the content of practical teaching and cultivate the students' practical and innovation abilities

During the four-year-study, students have to experience the practical trainings, including course experiments, course design, field trip, and Graduation Design (Thesis).

There is a one-to-two weeks' special training or practice in each term, including Engineering Survey Computer Practice, English Training, Entrepreneurship Training, Metalworking Practice, Course Design in Mechanical Drawing, Mine Transportation and Hoist Design, Surface Mining Design, and Underground Mining Design. The field-trip includes Cognition

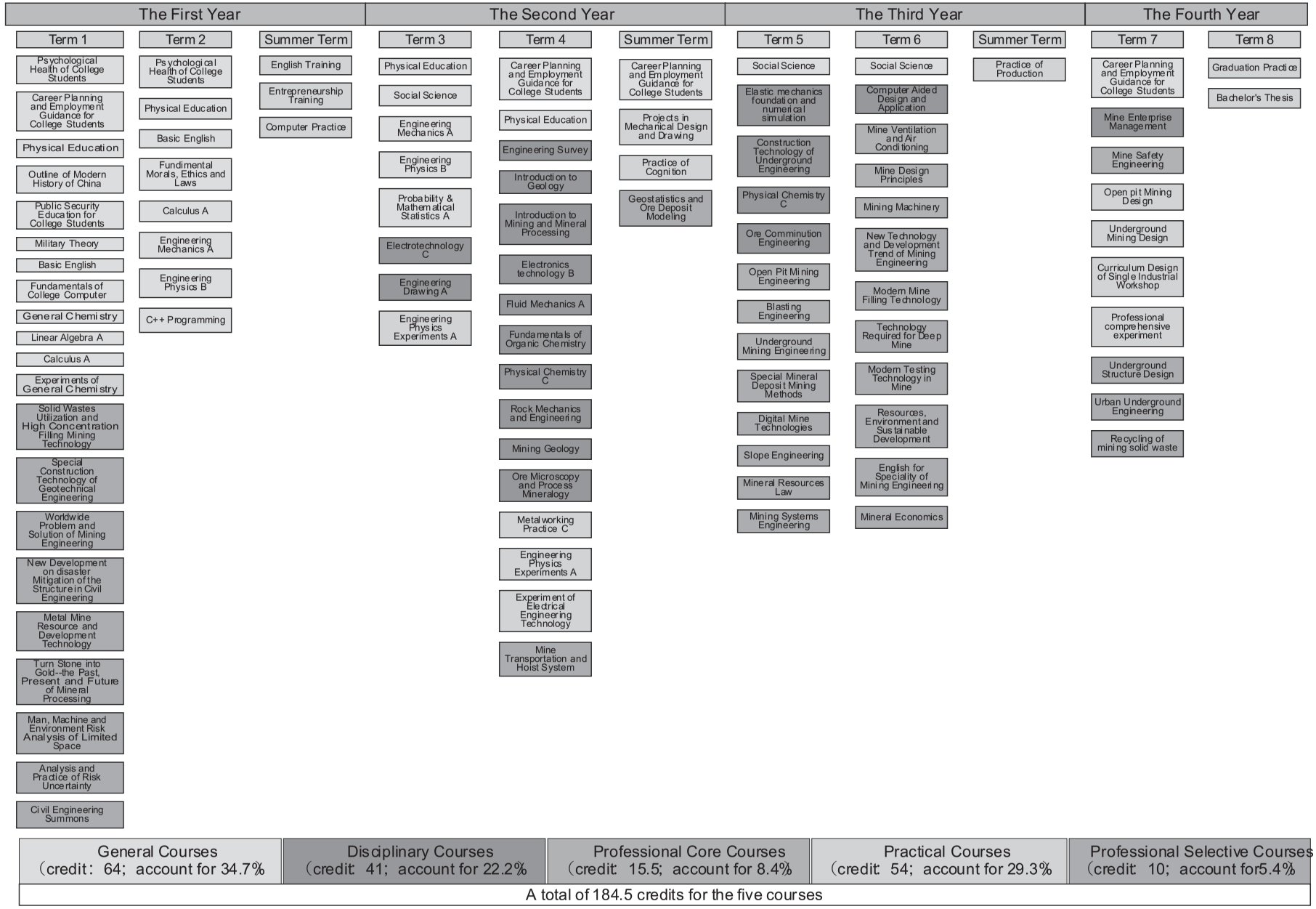

Fig. 1. The professional curriculum architecture

Practice and Production Practice. The Cognition Practice is divided into Geological Cognition Practice and Mining Cognition Practice. The Production Practice is divided into Production Practice in Underground Mine and Production Practice in Open Pit Mine.

Graduation Design (Thesis) is a comprehensive training for all the knowledge in mining engineering obtained in four years. The practical subjects require that students take two to four weeks' Graduation Practice at the proposal stage. Graduation Design (Thesis) has three steps: proposal report submission (including Graduation Practice), mid-term review and thesis defense.

At the same time, students must complete practical activities, such as Volunteering, Military Training, Social Practice, and Innovation in Scientific and Technological during the terms [6–11]. The practical activities in science and technology follow the principle of full mobilization, extensive participation, and major support and they are based on theoretical activities in science and technology, closely connected to the first class, such as academic forums, science and technology lectures, and knowledge contests.

On the platform of Undergraduate Research Training Program (SRTP), we establish the Science and Technology Innovation Fund for undergraduate students. The mining students were actively organized to participate in the technological innovation activities, such as "Challenge Cup" extracurricular academic science and technology works competition for students in Chinese, practice work contest for mining engineering students in Chinese universities, social practice and technology innovation competition of energy-saving and emission reduction.

Program reviews

The establishment of internal and external review mechanism is to promote the accomplishment of educational objectives and the continuous improvement of the educational qualities.

According to the requirements of teaching quality assurance, the mining engineering program at USTB canonically and systematically evaluates the achievements of educational objectives to each course. The internal review mechanism periodically evaluates the curriculum systems and teaching qualities, which include faculties review mechanism and students review mechanism. Meanwhile, the external review mechanism evaluates the quality of professional training, including social reviews and graduate tracking feedback. The external review mechanism is undertaken by the associate dean in teaching, the Deputy Secretary of the school (responsible for student work), student affairs office, and the Department.

1. Teaching quality assurance mechanism

Faculties review is achieved by a teaching supervision group. The group is mainly composed of retired faculties, who in charge of the inspection, supervision and consultation in the undergraduate tutorial. They place an important role in consulting and advising on the decision of teaching. They inspect the lecture tutorial according to the plan, hold regular seminars for teaching management personnel and faculties, and timely give the feedback of the problems in teaching.

Students review is to evaluate the teaching quality of the lecturer through the teaching quality evaluation system on campus network. The evaluation results is an important indicator for the faculties' year-end assessment scores. The academic affair office opens the website for the students' evaluation the teaching quality of the faculties. The students could evaluate each courses in each term, and faculties could inquiry the results of evaluation. In addition, the school regularly hosts student forum every term. The student representatives, who are selected randomly from each class, evaluate the teaching effect of each course. The faculties get the feedback through the academic affairs office.

2. Feedback from graduate tracking and social review

To track the implementation of education objectives of undergraduate student in Mining Engineering, feedback mechanism from graduates' tracking and social review mechanism were established [12]. The aim of the mechanism is to comprehensively understand the employment situation and occupation development, and to clear grape the expectations of graduates and employers for the professional education in the new period. The feedback is obtained by the means of regularly network questionnaire, holding forum, student reunion, visiting the employers, professional chart group, and alumni dinner.

The review on the educational quality of mining graduates from all sectors of the community is important to the Mining Engineering program. MyCOS provides the feedback to the educational quality of the Mining Engineering professional graduated from USTB in multi-faces, include employment competitiveness, alumni evaluations, employment characteristics and advantages, postgraduate study analysis, studying aboard analysis, and cultivate process analysis [13]. Among them, the Mining Engineering alumni have 58% of recommendation degree and 91% of satisfaction degree.

Chinese economy has shifted from a high-speed growth stage to a high-quality development stage, which is a rare strategic opportunity and also the most severe challenge to the mining industry. Take the advantages of engineering education accreditation, the Mining Engineering program in USTB improved the quality assurance system to ensure the achievement of educational objectives. Meanwhile, they continuously enhanced the educational qualities and promoted the continuous improvements of educational objectives to adapt to the new stage of economy. The cultivated mining undergraduate students are new engineering talents, who have both professional accomplishment and the spirit of time, will promote the mining industry to achieve a significant transformation and benign development.

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INTERNATIONALISATION OF MINING EDUCATION AND RESEARCH – A RECURRING PROCESS RUNNING THROUGH THE CENTURIES

International cooperation and mobility are buzzwords of today's research and innovation clusters all over the world. These are however not new concepts. The understanding that research and innovation can only thrive in an international and open environment has been in place for at least 300 years in Sweden. All interested and knowledgeable scientists and business developers have been welcomed to push the front of knowledge and the industry forward. The international contacts of Swedish mining education, research and innovation prove that with an open mind and a persistent, long term effort results will come.

The roots of mining education and research in Sweden dates back to the 17th century. Initially the focus was on applied research rather than education, but the early efforts also slowly led to important purely scientific results. Swedish metallurgists/chemists have discovered more elements than scientists from any other nation. Over 150 years, from the early 18th century to the end of the 19th century, 20 elements - and among them many industrially important metals — were isolated and described.

The ancient Falu copper mine was the logical choice for location of one of the first technical schools in Sweden: "Falu Bergskola" (Falu Mining School), which was set up in 1822. Its first director was precisely one of the chemical scientists engaged in the discovery of new elements. This Mining school was later merged with other existing institutions offering some technical training into "Tekniska Institutet" (the Technical Insitute). This was in 1876 transformed into a technical high school along German models. The Association of Swedish Iron and Steel industry (Jernkontoret in Swedish) was a key supporter and funder of these developments. The new school was called Kungliga Tekniska Högskolan (KTH) in translation Royal Institute of Technology. KTH had 5 departments, including a school of mining science.

In 1972 the education of mining engineers was transferred to the newly established Luleå Technical College close to the Arctic Circle. The College was later expanded and in 1997 renamed Luleå University of Technology (LTU).

LTU has become one of the leading mining universities in Europe, to a large extent due to the fact that it is situated in the centre of one of Europe's remaining mining regions. Around 2/3 of all university trained staff employed by Swedish mining has been trained at LTU. But LTU has also had its focus on the mining sector for a long time and in its internal program Mines of the Future it has relentlessly pushed the importance of mining and minerals and demonstrated its ambition to be a leading actor in this area. LTU has been appointed by Swedish government to lead the national education and research in mining. The recent decision by the EU to locate one EIT Raw Materials CLC (Co-location Centre) to Luleå means that the university has been given a similar role also on the EU level. LTU has actively built international links and supported cooperation with other universities within Europe and around the world. The bold and officially stated aim is to become one of the globally leading mining universities.

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