

Construction of the Practical Teaching System for the Mineral Processing Specialty Under the New Engineering Talent Cultivation Model

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Abstract: *Focusing on the transformation and upgrade of industries, New Engineering construction stresses the hands-on competence and industry adaptability of engineering talents' training. The practical teaching needs to be realized by the Mineral Processing specialty to achieve the transition from mineral processing theory to on-site production. Some colleges and universities find that the long-term practical teaching framework does not fit the current development pace of the intelligent and green mining industry regarding its course contents, practical training support, faculty reserves, and assessment rules. This paper analyzes all kinds of practical problems occurred when the traditional practical teaching operates; clarifies the new educational orientation brought about by New Engineering construction to the practical teaching of the specialty; sorts out based on the existing teaching resources of colleges and universities the basic conditions for system construction; conducts a design focused on a complete framework for practical education. To promote simultaneously improve both the basic operational skills and ability to deal with complex engineering problems, it can provide an available reference for resource-oriented engineering colleges and universities adjust their practical teaching work.*

Keywords: *New Engineering; Mineral Processing; Practical Teaching; Engineering Ability; Industry-Education Integration*

Introduction

Mineral resources are the basic raw material for the stable operation of industry, an important driving force for the national industrialization. Ore sorting and purification, separation and enrichment as well as comprehensive resource utilization carried out by the Specialty of Mineral Processing Engineering play an irreplaceable role in converting mineral resources into smelting materials. It has always needed engineering and technical personnel that can do production organization, process adjustment, technical transformation, equipment renewal, and operation and maintenance. Gradually, with the development of China's industrial production system, the upgrade and replacement of production methods, some new technologies, new processes, new management methods and intelligent control technologies have been fully implemented in mines, and enterprises raise higher demands on the comprehensive engineering literacy of graduates. Changes in the situation requires colleges and universities to adjust their talent cultivation plan, strive to solve the problem of disconnecting theory teaching from industrial practice, to meet the new requirements of production enterprise talent cultivation. The Mineral Processing specialty covers wide range of theoretical knowledge, but it has strong practicality. Practical teaching is a key link between schools and factories. The teaching effect determines how fast students adapt to their position after being employed. Some colleges and universities limit the teaching content to traditional mineral processing technology, so the cultivation target of interdisciplinary engineering talents cannot be achieved. We combined professional teaching with actual mine production and studied a practical teaching system oriented to New Engineering in this paper.

1. Existing Problems in Practical Teaching of the Mineral Processing Specialty Under the Traditional Teaching Model

The majority of practical teaching of the Mineral Processing specialty is done by segments attached

to original theoretical courses. The practical teaching of the Mineral Processing specialty at the University of Science and Technology Liaoning includes: Mineral Processing Experiments based on four core specialized courses – Crushing and Grinding, Magnetic Separation, Gravity Separation, and Flotation; Virtual simulation training in Mineral Processing Engineering based on individual specialized courses; Introductory internship, production internship, and graduation internship established in combination with specialized courses and the whole teaching system. There is no comprehensive coordination designed throughout this teaching plan. Different practical links have independence from each other without forming an ability training progression. Contents of theory of experiments, internships, and practical training are basically at the primary level of simple understanding, basic operations, and low-level imitation. Some actual separation training projects only involve simple operation of basic equipment. Cutting-edge industrial technologies like actual separation tests for lean, fine, complex, and refractory metallic ores, small-scale semi-continuous tests, and comprehensive resource utilization rarely appear in practical training content. So, there exists a rather big gap between what students see at school and the real working conditions of modern mines.

Most on-campus laboratory has small and simple mineral processing test device without hands-on training using large-scale complete set of separation equipment and semi-industrial combined magnetic-gravity-flotation separation. Students could only separate tests on basic samples but couldn't get complete linked debugging training for a mineral processing production line. Duration of internship at off-campus enterprises is very short because of prioritizing production tasks; it's impossible for technical personnel to give systematic teaching guidance. Most of them just do independent visit accompanied by explanation given by instructors and answer provided by on-site technical personnel, lack opportunities to deeply participate in core works such as process optimization, flowsheet inspection, hazard identification, and fault handling. Most of those teachers who are engaged in practical teaching spend most of their time doing theoretical research on campus, rarely go to the front line of mining enterprises for long-term production practice. Don't have a comprehensive understanding about key points including operating modes of new on-site equipment and process adjustment. In hands-on teaching, they can only explain the basic theoretical operating specifications, cannot explain the process adjustment ideas based on complex working condition coupled with real production cases, let alone solving problems that arise in production. Assessment of teaching mostly focused on the writing of internship reports and experiment reports or the recitation of basic equipment operating steps. Lack of standards for quantitatively assessing students' ability to independently analyze process anomaly and designing an optimized separation scheme results in inability to reflect the educational effect of practical teaching.

2. New Requirements Proposed by New Engineering Construction for Practical Teaching of the Mineral Processing Specialty

2.1 Teaching Content Needs to Accommodate Both Traditional Processes and Modern Industrial Technologies

New Engineering's talent cultivation keeps the teaching content of traditional mineral processing technology: Crushing, Grinding, Gravity Separation, Magnetic Separation, Flotation are the basic technologies in the mineral processing industry; Students need to proficiently master the principle of these processes and operate on conventional equipment^[1]. Meanwhile, with the development trend towards large-scale equipment and automated operation in the mineral industry, Technologies like online grade analysis, Automatic adjustment of equipment operating parameters, Efficient combined separation of polymetallic ores have been widely used in production. Practical teaching must add relevant hands-on training modules. It is necessary for there to be a natural link between old and new technologies. We should consolidate traditional mineral processing test training and add practical training contents (such as intelligent mineral processing control systems and solid waste treatment simulation), so that students can master both conventional mineral processing operations and at the same time operating logic of digital production lines. Teaching process cannot disconnect traditional processes from emerging technologies. Using mine production examples to explain how new technologies optimize separation processes helps students build a complete and coherent knowledge system and adapt to changes in job competence due to industry technological updates. Besides ensuring that students mastering basic knowledge and basic skills, we set up case-based teaching methods as much as possible to cultivate students' ability to master knowledge and improve their competence when solving problems. If the faculty strength of experimental positions allow us to consider reconstructing comprehensive professional experiments, integrate the experimental links of each unit in Mineral

Processing Engineering, conduct research-oriented experiments with an engineering background or strong comprehensiveness to improve students' practical ability and comprehensive quality.

2.2 Teaching Organization Needs to Connect Campus Classrooms with Enterprise Production Sites

The New Engineering construction advocate school-enterprise collaboration education. Besides on-campus laboratories, practical teaching of the Mineral Processing specialty should establish a normalized linked teaching mode between on-campus practical training site and production workshop of mineral processing enterprises^[2]. After completing basic practical training on campus, students will go into complete production line of enterprises step-by-step for on-site learning. Industrial complete set of equipment make up for shortage of small-scale on-campus practical training and single training content. Joint practical guidance from both on-campus teachers and enterprise on-post technical personnel give theoretical explanation and on-site hands-on teaching respectively, keep students in the real production environment, shorten the post-employment adaptation period. Quite easily to say, it is still very difficult to truly implement. It mainly reflects that there are still some difficulties faced by cooperation enterprises and off-campus internship bases in carrying out large-scale internship training for undergraduate students. Basically oriented towards production, enterprises cannot spare a lot of manpower to help schools cultivate undergraduate students; on the other side, due to concern for production safety, production mines and plants cannot let internship students truly carry out actual production operations. We can think of adding a transitional link: A comprehensive semi-industrial experimental base connecting school teaching and actual production sites of enterprises under school-enterprise integration. University of Science and Technology Liaoning and the Anshan Municipal Government jointly established the Qianshan Bay Mining Laboratory. The Qianshan Bay Mining Laboratory takes advantage of Anshan City's advantages in mineral resources and its foundation for mining development, researches and develops key technologies for large-scale green and efficient development of lean ore resources, develop key technologies for smart mines, promoting high-quality development of the industry, helping mining enterprises transform and upgrade. On the one hand, this laboratory undertakes research and experimental work for major provincial and municipal projects, at the same time provide a relatively good platform for undergraduate students of the Mineral Processing specialty to carry out actual professional training and professional practice as early as possible. When undergraduate students go to the laboratory for hands-on training, not only exercises their own professional ability, but also undertaking some simple professional work actually achieve a win-win result.

2.3 Teaching Evaluation Needs to Focus on Students' Engineering Hands-On Practice and Comprehensive Problem-Solving Ability

Traditional practical teaching evaluation is written materials and standard operating procedures with theoretical memorization as an evaluation standard which can't truly evaluate their ability to solve real engineering problems. Change the main assessment direction of the evaluation system under the New Engineering orientation, take hands-on operation, process scheme design, on-site fault handling as a key point for assessment, reduce the percentage of paper-based assessment standards such as internship reports, internship diaries, experiment reports, final course examination in the grade. Encourage students' initiative during internships and practical training, use the guidance of examinations and assessments in students' learning priorities, expand assessments focusing on problem solving and ability cultivation, weaken knowledge assessments dominated by memorization. Covering all kinds of practical links including on-campus practical training, on-site hands-on operation, flowsheet inspection experiments, analyzing actual production problems, set up multidimensional evaluation standards: Basic level assessment: standardized equipment operation and experimental data recording; Improvement level assessment: adjust reagents, grinding parameters, equipment operation according to ore properties; Comprehensive level assessment: flowsheet troubleshooting and designing production problem handling schemes. The evaluation subjects include on-campus teachers and on-site on-post enterprise personnel. Scores given by enterprise technical personnel based on on-post hands-on performance, scores from multiple parties are included in the total grade, objectively reflect students' true level of engineering practice.

3. Construction Foundation of the Practical Teaching System Under the Background of New Engineering

Slowly build up a complete practical teaching system for the Mineral Processing specialty based upon four types of core foundational conditions: existing faculty; practical training sites; school-enterprise cooperation resources; large-scale semi-industrial experimental bases. As regards faculty, our full-time teachers in this specialty hold master's degree or above in disciplines related to mineral processing, they can fully teach theoretical classes such as mineral separation, mineral materials, and mineral processing machinery. Some teachers have been working for a long time in scientific researches relating to mineral processing technology, comprehensive resource utilization, and solid waste treatment, possessing theoretical research and experimental design capabilities that constitute basic faculty reserves for integrated theory-practice teaching. As regards practical training sites, we established a basic mineral processing laboratory equipped with conventional small-scale test equipment (crushers, ball mills, flotation equipment, magnetic separation equipment, and gravity separation equipment) capable of carrying out basic ore separation test training. Our large-scale semi-industrial experimental base possesses complete industrialized mineral processing production equipment and a semi-industrial combined separation platform, which can provide senior students an on-site hands-on learning site, complementing each other between small-scale experimental training and industrialized production training. As regards school-enterprise cooperation, The University of Science and Technology Liaoning is backed by Ansteel, a large central state-owned enterprise, thus having very abundant resources which can be fully utilized. Single magnetite concentrators of Ansteel Mining Company and Benxi Steel Mining Company include Dagushan Concentrator, Waitoushan Mine, and Nanfen Concentrator. All these concentrators are large single magnetite concentrators with highly typical separation processes and applications of various advanced equipment, being the best internship bases for single magnetite separation. Mixed ore concentrators of Ansteel Mining Company and Benxi Steel Mining Company include Qidashan Iron Mine, Anqian Mining Company, Gongchangling Concentrator, and Guanbaoshan Concentrator. They possess advanced equipment, typical process flow sheets, and stable separation indices, being ideal sites for mixed ore separation internships.

4. Implementation Path for Constructing the Practical Teaching System Adapted to New Engineering Cultivation Requirements

4.1 Optimizing the Course Teaching Arrangement That Integrates Theory and Practice

Break the original separate teaching mode of theoretical courses and practical courses being taught in segments. Choose another teaching mode of theoretical instruction and synchronized practical training is carried out. One core specialized course has one practical training project. Explain process principles in class, then go straight to the lab to perform small-scale experimental operations while digesting theoretical knowledge points^[3] According to the graded practical course modules for students' learning stages, The university provides cognitive practical training (Process Mineralogy Experiments, Basic Ore Testing) in the sophomore year to make students familiar with the basic characteristics of mineral raw materials; Provide basic operation practical training (crushing and grinding, gravity separation, magnetic separation, and flotation), which makes students master the operating specifications of conventional separation equipment in the junior year; Add comprehensive practical training (ore beneficiability research, actual separation training for single magnetite and mixed iron ore) in the senior year, so as to allow students to fully utilize laboratory equipment to design actual separation flowsheets and carry out actual separation. Cooperate with technical personnel from cooperative enterprises to revise the practical course syllabus, Turn the frequent process adjustment and equipment fault occurring in daily enterprise production into practical training topics and replace the standard and patterned test projects. Adjust the proportion of credits: Increase the proportion of credits for comprehensive practical training and enterprise on-site internships, Reduce the class hours for simple practical training just for theory verification. Meanwhile, Offer a series of special practical lectures, Invite enterprise technical personnel to come to campus to introduce operation cases of modern mineral processing production lines, Carry out process analysis teaching based on real production data, Ensure that theoretical knowledge always fit the actual production logic of the industry, Theoretical knowledge and practical training move forward and support each other.

4.2 Improving On-Campus Practical Training Sites That Integrate Virtual and Physical Elements

Upgrade the present on-campus physical mineral processing laboratory. Upgrade some traditional experimental equipment such as crushers, ball mills, magnetic separation tubes, magnetic separation columns, shaking tables, spiral chutes, flotation machines, flotation columns etc., add some new emerging equipment (tower mills, high-pressure grinding rolls, IsaMills, vertical ring high-intensity magnetic separators, vertical centrifuge, suspended vibrating separator) to upgrade students' basic experiments; Add some high-end experimental projects: X-ray diffractometers, infrared spectrometers, X-ray fluorescence spectrometers, atomic force microscopes, Zeta potential analyzers, surface tension measurement experiments, and other modern mineral processing testing technology.

Besides the traditional iron ore separation practical training test, we should also add magnesite separation tests and pelletizing and sintering experimental projects which can expand our students' horizon and improve their ability. Set up a digital virtual simulation practical training platform. According to the three dimensional simulation software used by mineral processing production lines, create a virtual operation scene including the whole process production line from crushing, grinding, separation, and tailings disposal. Students are able to adjust process parameters or simulate equipment faults, deduce process optimization scheme under virtual system without losing raw materials and damaging equipment existing in operating physical equipment, overcome the deficiency that physical laboratories cannot build large-scale industrial production lines. Two kinds of practical training site have complementary functions; hands-on operations with basic equipment rely on physical sites whereas linked debugging for complete production lines and simulation of complex faults relies on the virtual system.

4.3 Enhancing Teachers' Comprehensive Teaching Ability in Practical Teaching

Standardize enterprise practice systems for on-campus professional teachers. In our university's personnel assessment system we require that those who hold teaching and research position should have on-post enterprise practice experience (six months to one year) or research experience which is actually engaged in projects from high-level universities or research institutes. We encourage some incentives for young teachers to work temporarily at enterprises for training. Aims to let professional teachers get on-site production experiences and upgrade their reserves of industry technical knowledge^[5]; Establish special funds by secondary college to enhance practical teaching ability: Support participating in industry conferences, relevant industry training and academic exchange activities; Learn the operating methods of new industry technologies and new equipment; Transform it as the teaching content of practical training courses. Building channels between on-campus teachers' scientific research and enterprise production. Encourage teachers undertaking vertical and horizontal research projects; Encouragement undergraduate and graduate students to take part in teachers' research projects. Developing synchronous supporting practical training topics based on research projects, transform the research process into practical teaching resources. Improving the standard for assessing teachers' practical teaching ability. Enterprise practice time, school-enterprise joint teaching results, and the effectiveness of practical training course development shall be an important indicator of teachers' annual teaching assessment, motivate teachers to actively improve their hands-on teaching and industry alignment abilities.

Conclusion

With the continuous advancement of digital and green transformation of the mineral processing industry, there are increasing demands on mineral processing talents who have interdisciplinary engineering practice capability. New Engineering construction put forward the reform direction for colleges and universities to optimize the practical education model. Traditional practical teaching system for mineral processing has been limited by many conditions which cannot well cultivate the ability of solving complex mineral processing engineering problems. Through coordination of course arrangement, upgrade virtual and physical practical training site, improvement teacher's factory based practice mechanism, optimization multi-dimensional assessment standard, we can build up a new practical teaching system meeting the need of industrial development. Follow the development trend of industry technology in our teaching work, timely update the practical training teaching content and practical training carrier, strengthen the cooperation between schools and enterprises in teaching, clarify the operation detail of each link in practical teaching, gradually improve the quality of engineering talent cultivation in the Mineral Processing specialty.

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