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Discussion on the Teaching of "Metallic Mineral Processing" for Mineral Processing Engineering

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Abstract: Social economic growth and the increasing demand for mineral resources have promoted the development of metallic mineral processing technology. Therefore, in order to satisfy the demands for development in mining, cultivating comprehensive mineral processing engineering professionals with strong innovative practical skills has become the top priority in current education. We have established a new course, "Metallic Mineral Processing," for students majoring in mineral processing engineering in universities, with coal and other sources of energy as the main focus. This paper analyzes the purpose and significance of setting up this course and the exploration of the reform of the teaching mode, with the aim of improving the teaching quality and ensuring the cultivation of mineral processing engineering undergraduates.

Keywords: Mining engineering; Mineral processing engineering; Metallic Mineral Processing; Undergraduate students

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1. Introduction

With the rapid development of economy in China, as one of the important industrial countries in the world, the construction of ecological civilization has shown to be successful. Consequently, the construction of a resource-saving and environment-friendly society has put forward higher requirements for the development and utilization of mineral resources. The demand for metallic mineral resources presents an increasing trend. However, the valuable metals derived from China's metal ores are of low grade and are difficult to recover. Therefore, in order to improve the utilization of mineral resources, the development of the entire metallic mineral industry is needed, which in turn requires a large number of professional and technical personnel with good knowledge in "Metallic Mineral Processing" [1]. In addition, coal gangue contains valuable metal elements, such as aluminum, gallium, germanium, indium, *etc*., so improving its comprehensive utilization level is closely related to the knowledge of metal ore beneficiation and metallurgy [2]. Therefore, it is necessary to set up a new "Metallic Mineral Processing" course for students majoring in mineral processing engineering in universities, with coal and other energy sources as the main focus. How to solve the problems, coordinate the teaching of minerals processing involving two different properties (coal and metallic mineral), and stimulate students' interest in learning are all important for improving the teaching quality and ensure the cultivation of mineral processing engineering undergraduates. In this context, the reform and exploration of the teaching of "Metallic Mineral Processing" were carried out.

2. "Metallic Mineral Processing" course for mineral processing engineering majors in universities with energy as their focus

Mineral processing engineering majors in universities, with coal and energy as their focus, emphasize on building an elite education and teaching system for the energy industry. For example, the mineral processing engineering major offered by China University of Mining and Technology (Beijing) (CUMTB), founded in 1952, has a long history of development [3]. The undergraduate education is focused on developing a strong foundation of natural science and professional understanding of mineral processing engineering in the fields of coal processing, comprehensive mineral resource utilization, and deep mineral resource processing. The core courses of the major are "Mineral Processing," "Experimental Design and Research Methods," and "Engineering Design of Mineral Processing Plant." Many undergraduates in similar universities are interested in the field of metallic mineral processing, and there is a certain demand for knowledge related to metal ore beneficiation. Furthermore, coal preparation and metal ore beneficiation belong to the field of mineral processing engineering, and both have common or universal processing and separation methods, such as crushing, gravity separation, magnetic separation, flotation, solid-liquid separation, *etc*.

However, these two directions have differences. Metallic mineral processing generally involves grinding, while it is less involved in coal preparation. Besides, in reality, metallic mineral processing is often the separation of polymetallic minerals. It often involves the coexistence of copper, lead, zinc, gold, silver, tin, and other metals, requiring a complex separation process, which is more complicated than the coal preparation process. It is difficult to adapt coal preparation knowledge alone to the knowledge and skill needs of the metal ore beneficiation industry [4]. Therefore, it is necessary for universities that focus on coal or energy to offer this special course, which is conducive to the expansion of students' knowledge and the improvement of undergraduate employment rate.

We have established the "Metallic Mineral Processing" course and set a systematic syllabus for undergraduate students majoring in mineral processing engineering in CUMTB.

This course, on the basis of introducing the basic theory of mineral processing and the common processing technology of metallic minerals, systematically introduces the mineral resource status, ore types, mineral composition, mineral processing methods, technological processes, production practices of mineral processing plants, *etc*.

Through these teaching contents, students would be able to master basic theoretical knowledge, the basic methods, and the development trend of metallic mineral processing. Moreover, the reform and practice of the teaching mode in terms of teaching methods and assessment forms have been carried out.

3. Innovation in teaching measures

3.1. Expansion of course objectives

Compared with the traditional course objectives, the new course objectives should not only focus on the learning of professional knowledge and the cultivation of professional skills, but also familiarizing students with the cutting-edge science and technology of the major and field by presenting them in a vivid and intuitive manner, so that students would be able to correct their previous misconceptions about the major. In addition, the course objectives should also be based on the national conditions and professional status, promoting the cultivation of students' ideological ethics and professional quality, and invoking students' sense of mission, responsibility, and struggle spirit to further venture into the grassroots, nurture a devotion for mining, and take root in frontline work.

3.2. Teaching methods and means

In the "Metallic Mineral Processing" course, offline teaching is assumed as the main teaching mode, while

online interaction is taken as the auxiliary. This teaching mode combines theoretical teaching by teachers with independent discussions among students. Besides, it is a student-centered teaching mode that encourages students to communicate and share, with constructive feedback given based on their sharing. At the same time, with the help of modern teaching resources, this teaching mode provides students a platform for independent learning with the addition of micro-lesson videos and other online learning resources. The diversified teaching methods and rich teaching resources would enhance students' recognition of the curriculum and enrich the professional knowledge content and system for students' learning.

3.3. Teaching content

The course "Metallic Mineral Processing" is an innovative course for the mineral processing engineering major in CUMTB. This course aims to stimulate students' sense of mission and responsibility to further venture into the grassroots, nurture their devotion for mining, encourage students to take root in frontline work, and cultivate more high-quality professionals for the development and progress of an efficient and comprehensive utilization of mineral resource technology along with economic and social development. Therefore, it is particularly important to reform and innovate the teaching content of the course. Guided by the course objectives that are aimed at talent training, the teaching contents of each chapter (or theme) of the course include specific modules.

(1) Module 1

Module 1 includes cutting to the chase in the introduction of basic courses and professional knowledge learning by using the deeds of the older generation of beneficiation personnel or real-life cases. By using real-life cases, students would be able to understand the development history of mineral processing engineering and "metallic mineral processing" as well as the problems faced, thus stimulating their patriotism, enhancing their enthusiasm, confidence, and sense of mission for professional course learning, and improving the status of mineral processing engineering in their hearts. According to the main topic, students should be encouraged to consult materials or discuss in groups the basic knowledge required to solve technical problems in the major. In this way, students would be inspired to learn independently about the relevant professional background and professional knowledge.

(2) Module 2

In this module, frontier science and technology would be introduced, sharing the fun of scientific research, stimulating the enthusiasm of students for science and technology, illustrating the latest fields and advancements of "Metallic Mineral Processing" technology, and introducing the development process of these cutting-edge theories. Through this process, students would come to acknowledge the difficulty in scientific research and experience the fun in the process. This would also help cultivate students' professional confidence and stimulate their scientific research enthusiasm and professional pride. At the same time, the seminar contents or topics should be arranged according to relevant cutting-edge technologies and topics, so as to encourage students to consult materials independently and explore unknown areas, thus expanding their professional knowledge, continuously improving their professional cognition and professional skills, and cultivating an innovative spirit.

(3) Module 3

In this module, theoretical and seminar teaching are combined to advocate "flipped classroom," which would help promote active interaction and collision of ideas. The following model is applied in the "Metallic Mineral Processing" course: independent discussion and learning, theoretical teaching with independent discussion, and discussion in groups. This model encourages students to exchange and share ideas as well as allows constructive feedback to be given to students based on their sharing, so as to promote the internalization of what they have learned, felt, and understood.

(4) Module 4

This module focuses on literature research reports and case analysis as well as solving practical problems with professional knowledge. After students are taught on the significance and methods of literature research, they are required to collect literature data based on specific topics and keywords. During this process, students would not only understand the industry dynamics and expand their professional knowledge, but also cultivate their skills in information search, problem analysis, and idea summary. Through the analysis of professional examples, such as copper mineral processing plant, iron mineral processing plant, *etc.*, students would be able to sort out what they have learned in classroom, transform this classroom knowledge into tools to solve practical production problems, and gain a deeper understanding of the industry dynamics. Through the introduction of actual production cases, targeted discussions can also be carried out to help students improve their ability to solve on-site problems.

4. Course assessment and evaluation system reform

4.1. Enrichment of score structure

The traditional course assessment method is mainly based on the sum of scores from the attendance and the final examination [5]. A diversified assessment system has been proposed in the "Metallic Mineral Processing" course. The overall course assessment score consists of four parts: assessment of attendance, class participation, research reports, and final examination. The primary purpose of changing the assessment method is to encourage students to participate more in classroom, think and learn actively, fully understand what they have learned, and eventually master the basic knowledge.

4.2. Combination of theoretical assessment and achievement assessment

Theoretical assessment mainly assesses students' ability to understand and apply metallic mineral processing professional knowledge. On the other hand, achievement assessment, such as literature research reports, examples of mineral processing, and classroom seminars, can better stimulate students' interest in learning and cultivate their cooperative ability and problem-solving skill.

4.3. New assessment methods

In terms of the final examination assessment content, educators should focus on skill development and the combination of basic knowledge, innovation, and practice. Assessments that emphasize on memorized contents should be reduced, while subjective, comprehensive, and practical assessment contents should be increased. It is also important to assess students' ability to comprehensively and flexibly use the knowledge they have learned to deal with problems. Based on the characteristics of this course, practical propositions are included as part of the assessment to evaluate students' ability to solve practical engineering problems, so as to foster independent thinking and flexibility among students and ensure that the professional and technical knowledge and skills they acquire in class are closely related to the needs of social and enterprise economic development.

5. Conclusion

The "Metallic Mineral Processing" course serves as an important part of the systematic professional knowledge of undergraduate students majoring in mineral processing engineering. This course is also an innovative course for mineral processing engineering majors in universities that focus on coal or energy. This course aims to improve the teaching quality and ensure the cultivation of mineral processing engineering undergraduates, while focusing on the reform and exploration of the teaching mode from the aspects of innovation of teaching measures and curriculum assessment and evaluation system reform. This course also employs the student-centered teaching model and adopts the small private online course (SPOC)

mode [6]. With the help of modern teaching resources, this course would be able to renew students' understanding of the major and its courses, enrich their professional knowledge, expand their horizons, and cultivate patriotism and an innovative spirit in students.

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Disclosure statement

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