The reform of informatization of college curriculum teaching based on the integration of science and education

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Abstract. Aiming at the phenomenon of the students' education of science universities in our country attaching more importance to scientific research than teaching in the aspects of scientific research and teaching, scientific research and talents cultivation, the transformation of scientific research achievements rather than talent cultivation, centering on the fundamental task of "establishing morality and educating people" and based on the integration concept of science and education, this paper analyzes the problems existing in the students' theory and technology course teaching on mine fire prevention. From the aspects of "optimizing curriculum system to stimulate scientific research thinking", "scientific research platform to serve practical teaching", "knowledge sharing to deepen understanding and application", "innovation competition to integrate knowledge learning and practical innovation" and "university-enterprise joint cultivation of comprehensive ability", we explored the first-class talent training mode, and explored a set of crisscrossing curriculum training mode of science and education integration and collaborative education. It provides reference and reference ideas for personnel training in relevant colleges and universities.

Keywords: Integration of science and education; Mine fire; Curriculum construction; Collaborative education.

1. Introduction

Higher education is an important pathway for a nation to cultivate advanced specialized talents and professionals[1-2]. General Secretary Xi Jinping emphasized during the National Education Conference that education is a matter of great importance for the country and the Party, exerting influence over and even determining the long-term stability of the nation, as well as the rejuvenation and rise of the nation. Premier Li Keqiang pointed out during a symposium on higher education reform and innovation that education forms the foundation of national development and shapes the future of the nation, with high-level education serving as a crucial manifestation of the nation's overall competitiveness.

In the context of the new technological revolution, the advancement of the integration of science and education in higher education institutions has become a common trend in the development of world higher education. The Massachusetts Institute of Technology (MIT) in the United States has combined theoretical research and teaching with industry, developing along a nonlinear interactive innovation model and establishing a three-way collaborative training model involving "university-industry-government"[3]. In order to support the development of science-education integration, Germany has innovatively introduced and implemented a variety of corresponding systems, leading to the development of two forms of science-education integration: teaching-research laboratories and teaching-research seminars[4]. During the process of exploring reforms in the education system integrating science and education, Japan has uniquely established graduate schools within universities, creating a novel model for training postgraduate students[5].

Meanwhile, in China, action plans and strategies for collaborative education integrating science and education have been gradually implemented in the three stages of higher education: undergraduate education, master's graduate education, and doctoral graduate education. Various universities have actively responded to the national call and begun to explore and implement these initiatives.Peking University, Tsinghua University, and the Beijing Institute of Life Sciences jointly launched a doctoral student collaborative training program, fostering innovative talents for industries through collaborative efforts between universities and enterprises based on research practices[6-7]. The University of Chinese Academy of Sciences (UCAS) has leveraged the science-education integration platform of the Chinese Academy of Sciences (CAS) to utilize the strengths of research institutes, academies, and educational institutions, creating a two-stage "undergraduate-graduate" science-education integration training model[8]. North China Electric Power University has integrated research projects into teaching activities, established research interest groups, and nurtured students' abilities for technological innovation within the context of the power industry[9].China University of Geosciences (Beijing), through its School of Earth Sciences, has practiced an innovative talent cultivation model for world-class universities by focusing on curriculum development, mentor team cultivation, concurrent laboratory work and practice, and international exchanges[10]. Beijing University of Posts and Telecommunications has proposed an engineering-oriented research-based teaching model tailored to the characteristics of engineering research courses, integrating theoretical teaching with independent practical learning and applying these practices to the core teaching model, yielding effective teaching outcomes[11].Taiyuan University of Science and Technology's College of Environmental Science and Engineering has approached science-education integration from a student perspective, extracting key elements and conducting differential analysis. Their research explores the impact of practical teaching, science-education papers and projects, research atmosphere, and political orientation on science-education integration[12].

Amidst the overarching trend of integrating science and education, the construction of university curriculum and education systems places demands on transforming research outcomes into teaching materials[13-14]. By leveraging the construction of science-education integration platforms and drawing upon the rich educational and research resources within universities, an exploration of comprehensive talent development models through multi-party collaboration is underway. This effort holds significant importance in enhancing students' abilities in understanding knowledge, fostering innovative research skills, and cultivating practical production capabilities.

2. Current situation and course nature of coal mine fire in China

Coal mine fires are one of the five major hazards in the process of coal resource extraction and production, and the occurrence of coal mine fire accidents often accompanies the generation of a large amount of toxic and harmful gases, resulting in very serious accident consequences[15-16]. In recent years, there have been several major coal mine fire accidents that have had a significant impact. For instance, the "9.27" major underground inclined coal conveyor fire accident at the Songzao Coal Mine in Chongqing in 2020 resulted in 16 deaths and 42 injuries. On December 4th of the same year, a major fire accident occurred at the Diaoshuidong Coal Mine in Chongqing. In 2021, an explosion accident took place at the "1.10" return air shaft of the Husan Gold Mine in Qixia, Shandong, resulting in 10 deaths and 1 person missing. The frequent occurrence of mine fire accidents has prompted increased attention and emphasis on the education and teaching of theories and technologies related to mine fire prevention and control.

"Mine Fire Prevention and Control Theory and Technology" is a foundational theoretical course offered by China University of Mining and Technology (Beijing), suitable for undergraduate, master's, and doctoral students majoring in Safety Science and Engineering, as well as Resource and Environment (Safety Engineering). This course primarily focuses on the research of coal spontaneous combustion mechanisms related to mine fire prevention and control, determination methods for coal spontaneous combustion indicator gases and critical values, new technologies and methods for mine fire prevention and control, and research on fire prevention and extinguishing materials and equipment. The educational objectives of this course are to enable students to grasp the mechanisms of coal spontaneous combustion and the identification of indicator gases, as well as to understand new technologies, methods, materials, and equipment for preventing and controlling intrinsic fires.

3. The problems existing in college curriculum teaching and their causes

Energy serves as a vital foundation for the development of the national economy, and societal progress has brought forth new aspirations and demands for higher education in energy, particularly in the cultivation of high-level talents. However, regarding the current state of teaching mine fire prevention and control theory and technology, the translation of our country's research achievements into practical applications within education or practice does not present an optimistic picture.

3.1 The teaching content is lagging behind

The lagging teaching content mainly refers to the disconnect between the foundational theory and technical methods taught in the course "Mine Fire Prevention and Control Theory and Technology" and the current advanced level of the industry. This lag prevents timely integration of the latest scientific research outcomes. The lagging teaching content is primarily attributed to two reasons:

1.Outdated Teaching Materials: The selection of teaching materials for course instruction is subjected to rigorous principles and thorough review. The adoption of new editions of teaching materials requires re-evaluation, and priority is given to nationally and provincially planned textbooks that align with the curriculum of the university, ensuring their quality and applicability for classroom teaching. While the selected textbooks are undoubtedly of high quality, the complexity of the selection process can lead to delays in updating materials, resulting in outdated content.

2.Limited Class Hours: The design of the course allows for only 16 teaching hours. However, the scope of foundational theories and advanced technical methods related to mine fire prevention and control is extensive. With limited hours, it becomes challenging to comprehensively cover both basic knowledge and advanced research in the field.

These factors contribute to the discrepancy between the content taught in the course and the current industry practices and research, leading to a lag in the teaching content.

3.2 Teaching practice deviates from production practice

The practical components of this course largely involve studying, analyzing, and applying documents related to coal mine fires, such as the "Coal Mine Safety Regulations" and "Coal Mine Fire Prevention and Control Guidelines." It also encompasses the analysis of coal mine fire accidents. During the teaching practice, the practical direction and content are less integrated with actual enterprise production practices. This lack of integration results in students having insufficient ability to apply theoretical knowledge to real-world situations.

3.3 Teaching activities lack the integration of science and education

Teaching activities lack the integration of students' academic inquiry and knowledge learning. Graduate education differs from undergraduate education; the former is primarily oriented towards research, while the latter focuses on learning. In the teaching process of this course, students are less inclined to engage in classroom thinking and discussions, showing a preference for passive listening. This deficiency reflects a lack of desire for academic exploration.

4. College curriculum teaching construction plan

4.1 The main ideas of curriculum teaching construction in universities

4.1.1 To investigate the quality requirements of first-class professionals

In accordance with the requirements of the nation, society, and industry for the comprehensive competencies of Double First-Class disciplines in the field of safety, a targeted approach has been undertaken to develop new models for cultivating Double First-Class talents. By adjusting the goals and orientations of talent cultivation, the innovation abilities and research thinking of students in higher education are regarded as important assessment criteria for educational instruction. This approach facilitates the organic integration of knowledge systems and research outcomes in classroom education and talent development processes, enabling teachers to help students construct their own knowledge structures and foster their innovative awareness.

4.1.2 Build an education model that integrates science and education and educates people cooperatively

Teachers introduce students to the latest advancements and challenges in scientific research during classroom instruction, broadening their knowledge perspectives, inspiring deeper thinking, and nurturing students' research competence. A comprehensive and systematic classroom teaching system is established. This involves refining classroom teaching objectives, designing specific teaching content, proposing teaching methods and approaches aligned with the course objectives, and devising systematic course assessment and evaluation methods. A teaching and learning application model for synergizing science and education is designed, contributing to the construction of an integrated and systematic curriculum teaching system.

4.1.3 Promote the learning mode of mutual promotion between theory and practice

By providing students with research and innovation platforms, they are enabled to apply theoretical knowledge to innovative projects. Subsequently, they absorb the knowledge gained from these projects and integrate it back into their studies, filling gaps in theoretical understanding. Teachers assign relevant and appropriate research projects or topics to students, creating an environment conducive to research. Encouraging students to transform their achievements, actively participate in competitions, and address challenges through practical experience is also a key aspect of this approach.

4.1.4 Build a reasonable curriculum teaching team

Accelerate the construction of the teaching team, cultivate and foster middle-aged and young academic leaders in course instruction, establish a teaching team with high-level teaching capabilities, and develop a well-structured course teaching group.

4.2 Concrete measures for curriculum teaching construction in colleges and universities

In response to the issues in course instruction, based on the fundamental principles of higher education curriculum teaching, we propose a synergistic science and education collaborative model that involves both horizontal and vertical interdisciplinary cultivation, as illustrated in Fig. 1.

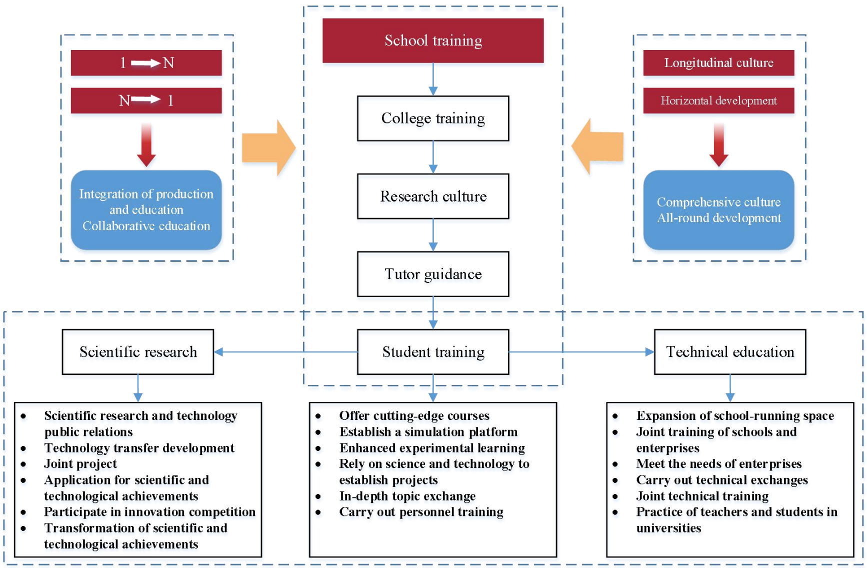

Fig. 1 Model of science and education integration and collaborative education

4.2.1 Optimize curriculum system to stimulate scientific research thinking

China University of Mining and Technology (Beijing) has established a four-level student development responsibility system, comprising "University-Department-Institute-Instructor." The "Mine Fire Prevention and Control Theory and Technology" course, offered for a total of 16 class hours, covers a range of topics including coal spontaneous combustion theory, prevention and control techniques, and materials, as depicted in Fig. 2. Specifically, the course consists of four main modules: research on coal spontaneous combustion mechanisms, determination methods for coal spontaneous combustion indicator gases and critical values, new technologies and methods for mine fire prevention and control, and research on fire prevention and extinguishing materials and equipment.

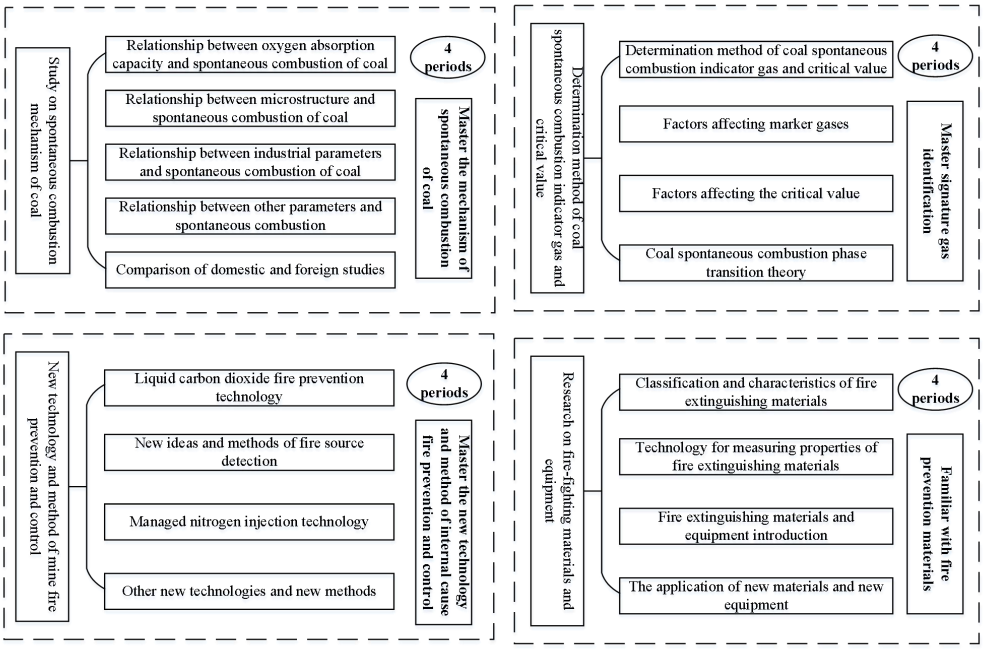

Fig. 2 Teaching planning of mine fire prevention theory and technology course

The first module pertains to fundamental theoretical research and primarily covers coal spontaneous combustion theory, the mechanism of spontaneous combustion processes, and the relationship between grid parameters and spontaneous combustion. The use of programmed temperature rise experiments and thermal gravimetric experiments, along with explanations and demonstrations of the results, helps students swiftly grasp the fundamental theory of coal spontaneous combustion and draw inspiration from the experimental process.

The second module covers the fundamentals of coal spontaneous combustion identification and early warning. The key topics encompass methods for determining coal spontaneous combustion indicator gases and critical values, factors influencing indicator gases, factors affecting critical values, and the theory of stage transitions in coal spontaneous combustion. The module delves into the selection of coal spontaneous combustion indicator gases, determination of critical values, and classification of coal spontaneous combustion stages. Practical research projects are integrated into the teaching process, with examples provided to facilitate deeper comprehension.

The third module focuses on new technologies and methods for mine fire prevention and control. It includes topics such as liquid carbon dioxide fire prevention and extinguishing technology, novel approaches and methods for fire source detection, nitrogen injection through drag-reducing pipes, spectrum-based beam tube monitoring technology, distributed optical fiber temperature measurement technology, and microelectromechanical systems (MEMS) fire monitoring technology. The module elaborates on the technical principles, characteristics, pros and cons, as well as future development directions of these new methods and technologies.

The fourth module primarily covers research on fire prevention and extinguishing materials and equipment. It introduces the latest research achievements, principles, and characteristics of efficient flame-retardant foam and other fire prevention and extinguishing materials and equipment. The main objective is to familiarize students with the application status of fire prevention and extinguishing materials and equipment in coal mines.

4.2.2 Research platform service practice teaching

Utilizing virtual simulation technology, the "Virtual 20L Ball Explosion Test System" has been developed, encompassing features such as virtual simulation teaching, smart classrooms, dynamic interactive sessions, playback recordings, and classroom teaching management[17]. This virtual simulation platform facilitates understanding of incident progression, offering a dual benefit of reducing experimental hazards and enhancing learning engagement, while providing students with a more profound comprehension of fire and explosion events.

4.2.3 Knowledge sharing deepens understanding and application

Establishing the "DaoBenAn" WeChat official account, student organizations gather, organize, and publish knowledge points, questions, articles, and more related to mine fire prevention and control theory and technology. Leveraging the "explanation effect," this platform encourages better understanding and deeper insights as knowledge is shared. Additionally, incentive strategies are devised to stimulate students' enthusiasm for sharing.

4.2.4 Innovation competition combines knowledge learning with practical innovation

Encourage and guide students to convert the knowledge and relevant research outcomes of this course into applications for university-sponsored student innovation training projects, safety discipline competitions, as well as regional innovation and entrepreneurship projects. This approach enables students to utilize their professional knowledge to address real-world issues in project research, translate project outcomes into new technological achievements, and engage in learning discussions with teachers and peers in the classroom. Through this approach, hands-on practical skills and knowledge comprehension reinforce each other. As a result of this training model, students have achieved impressive results in multiple competition projects.

4.2.5 Schools and enterprises jointly cultivate comprehensive ability

Establishing a university-enterprise joint cultivation model leverages the distinctive educational environments and resources of both institutions, along with the unique practical production demands of enterprises. Through the seamless integration of real-world production practices and classroom teaching, this approach enhances students' professional competence, boosts their capacity to apply theoretical knowledge in real production scenarios, and fosters their innovative thinking in science and technology.

5. Summary

Based on the core concept of synergizing science and education in collaborative student development, an instructional model is implemented in students' specialized courses, combining heuristic, discussion-based, case-based, virtual simulation, and practical training approaches. This model emphasizes both tradition and innovation, blending theoretical and practical elements, aiming to cultivate students' innovative practical capabilities. Anchored in fundamental scientific theory and inspired by cutting-edge technological achievements, it sparks students' interest in scientific research, encouraging them to convert scientific achievements into practical applications and deeply engage in innovative competitions.

Simultaneously, driven by real-world production demands, a collaborative educational approach involving universities and enterprises is adopted. This approach hones students' ability to integrate theory and practice, thereby fulfilling the goal of synergistic science and education in fostering students' development.

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