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Preliminary Study on the Reform of Mine Gas Control Course based on Hybrid Teaching Method

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Abstract

The coal mine gas management series course is one of the major courses of safety engineering. The primary content of the course includes the state of coalbed methane (CBM) endowment, CBM gush, CBM ejection, coal (rock) and CBM protrusion, CBM explosion, CBM extraction and other risks and management measures. Students who take the CBM management course will be able to understand and master the causes of CBM, CBM disaster accidents, and prevention and control measures and further improve the ability of coal mine safety generation. However, coal mine gas sources are common, disastrous accidents frequently occur, and prevention and control measures are lacking. Using traditional theoretical knowledge teaching method will result in learning and memory difficulties, reduce learning enthusiasm, and a failure to achieve the level of combining theory with practice. Accordingly, the reform of CBM management course based on the hybrid teaching method aims to apply system safety theory to mine gas prevention and control course and practice by combining network teaching platform and research-based teaching mode and theory with practice.The course is based on the philosophical basis of safety science and improves students' understanding of coal mine safety and disaster generation. The reform of this course is proven to be conducive to guiding students' deep learning ability and combining theory and practice, which has certain significance for the curriculum reform of safety engineering in colleges and universities.

Keywords

Hybrid Teaching; CBM Management; Curriculum Reform; Teaching Reform.

1. Introduction

The production technology model has been transformed with the advancement of artificial intelligence, cloud computing, Internet of Things, and 5G technology; howere traditional professional talents are struggling to meet the demands of emerging industrial development, resulting in an urgent need to cultivate excellent talents with innovative and practical abilities [1]. Scholars have widely discussed the concepts, characteristics, and construction goals of new engineering disciplines in response to the Ministry of Educatiion's strategy for the development of new engineering disciplines and modified the talent training mode [2].

Safety System Engineering, Safety Engineering, and Mine Safety Technology are the most important courses in the construction of a safety engineering curriculum. Understanding, mastery, and familiarity with the basic knowledge have become essential skills for safety engineering students and researchers. The concept of new engineering is to lead the diverse cross-disciplinary integration and foster innovative and exceptional engineering skills with strategic and systematic characteristics via the method of inheritance and innovation [3]. Safety engineering is one of the key fields in the construction of new engineering disciplines that requires high professional and technical personnel; effective integration of philosophical thinking is particularly important [4]. The teaching content of the course is primarily focused on the cultivation of fundamental knowledge; it lacks the comprehensive, cutting-edge, and application of professional knowledge and the ability to integrate and apply knowledge; furthermore, the safety problems faced in the practical application process are complex and changeable, and students lack the ability to quickly and accurately analyze and solve problems when dealing with unknown problems [5]. The traditional face-to-face teaching method, which simply transmits information through courseware, cannot sustain students' concentration for a long period of time, and it will reduce their learning motivation and make it difficult to achieve teaching objectives [6]. Therefore, the reform of teaching mode is imperative.

"Hybrid teaching method" refers to the integration of knowledge points, methods, and teaching modes of multiple courses through digital teaching and course teaching combined with teaching design, which facilitates systematic teaching and sublimation of knowledge points, fully mobilizes students' interest in independent learning, and more effectively makes the teaching effect [7]. The adoption of multidisciplinary cross-teaching method in the course of mine gas control has a clearer guiding effect on the course teaching, which is conducive to improving the teaching effect. A new teaching system is constructed in combination with the reform requirements of the teaching mode of the new engineering construction to provide new ideas for the teaching reform of safety engineering courses under the background of new engineering [8].

2. Reform Objectives of the Mine Gas Control Course

2.1. Reform of Teaching Mode

The teaching mode design of the mine gas prevention and control course is shown in Figure 1, which includes the traditional, online, and research-based teaching modes. In combination with the online and offline teaching methods, the research-based mode of "theory-practice-case" is beneficial to improved understanding and application of the course content [9]. Based on the traditional face-to-face teaching mode, online communication platforms, such as Rain Classroom, Ding Talk, and Lexue, can be combined to share classroom courseware, teaching videos, and learning materials in real time, allowing teachers and students to discuss and solve problems anytime and anywhere, especially during the epidemic [10]. The research-based teaching mode can be combined with the accident cases in the project and applied to practice by using the "multidisciplinary interdisciplinary approach", thus improving students' practical ability.

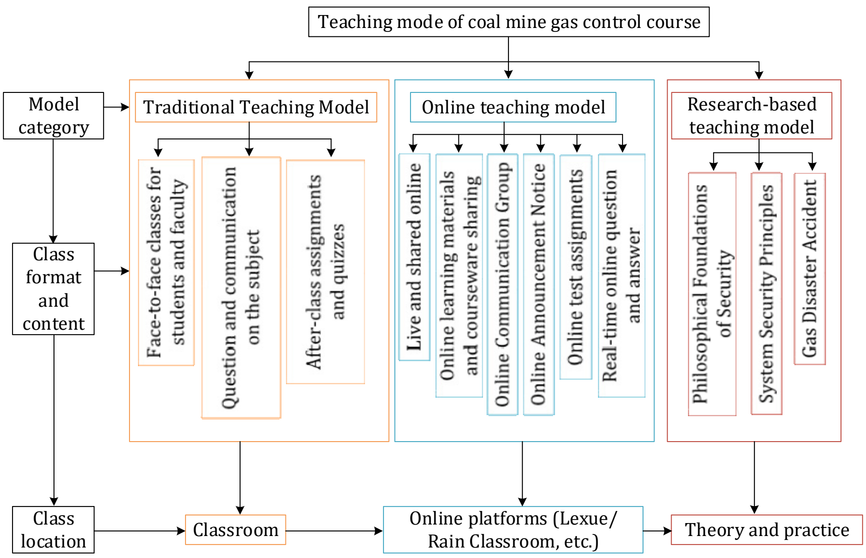

Figure 1. Design of teaching mode for the mine gas control course

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The traditional offline teaching method attaches importance to the teacher's responsibility of "preaching, teaching, and solving doubts" and the student's role as the main subject, with the teacher leading the students to build the knowledge system and find solutions to problems and the students following the course in time under the teacher's guidance. With the introduction of online teaching platform, mobile learning media (such as Rain Classroom, MOOC, and Lexue) can be used as teaching assistants, allowing teachers to notify students of upcoming learning tasks and reference materials; moreover, students can study the important and difficult points of the course in advance and solve problems encountered in the pre-study process and post-class tests anytime and anywhere [11]. The theory and practical experience related to safety science are used to analyze coal mine gas disaster accident cases, forming a series of ability to discover and solve problems; furthermore, students are guided to participate in practice and improve the quality and skills of independent learning through the connection of scientific research projects and courses [12].

The curriculum reform method of combining these three teaching modes is capable of presenting cases of dangerous accident sites, which are difficult to concretely describe in the traditional classroom and in an online technology-based manner, thus enhancing the teaching effect in a vivid way. For example, Ventsim 3D Mine Ventilation Design, Hadoop model building, animation, and VR image making are used to simulate the occurrence, development process, and post-disaster treatment of gas outburst disaster accidents in a coal mine. These tools are used to stimulate students' interest in learning and enable them to have a deeper understanding of what they have learned.

2.2. Reform of Teaching Methods

Mine gas control involves mining, safety, and other disciplines. The related basic theories and practical experience are rich, and the knowledge system is complex. We can resist the occurrence of coal mine disaster accidents if we fully master the theoretical knowledge and apply it in production practice. The goal of this course reform is to transition from theory to practice, summarize experience from practice, and systematically analyze and determine the causes of accidents [13]. The main teaching reform objectives are as follows:

1) Teaching Objectives

The teaching objective is to understand the generation of coal mine gas safety problems in combination the occurrence of coal mine gas disaster accidents through the foundation of safety philosophy. The principles and methods of system engineering are used to analyze and identify the gas hazard sources existing in coal mines, and prevention and control measures are proposed. This teaching method can help students systematically grasp a series of inducing factors and causal relationships caused by gas disaster accidents. Moreover, this method can help in ensuring that students can simply analyze and evaluate gas disaster accident cases.

2) Training Objectives

The training objective is to identify the connections that exist in the coal mine gas system and find the relationship between practice and theory in a systematic analysis of the practical experience of the occurrence of gas disaster accidents. Furthermore, the Marxist view of matter and methodology will be verified, and a forward thinking dialectical approach in preventing the occurrence of gas accidents will be proposed.

3. Research-based Teaching Model Reform

3.1. Philosophical Basis of Mine Gas Control

The Marxist materialistic dialectic believes that everything in the objective world is universally connected. Hence, a relationship exists between safety and danger in a coal mine gas system. The development of coal mine gas is divided into natural flow and artificial flow. The natural

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flow is mainly the gas occurrence form of the adsorption and free states, and it is controlled and regulated by random factors in two different states of safety and danger; the artificial flow is primarily for the safe mining of coal mines, taking measures to reduce the gas concentration to change its natural flow [14].

Taking coal mine gas as a research system, the following laws in the system are not difficult to find (Figure 2): unity and contradiction, connection and system views, qualitative and quantitative changes, simplicity and complexity, precision and ambiguity, and inevitability and chance [15]. Specifically, the dangerous state of gas persists. When the concentration is below the standard value, gas is in a relatively safe state, and its degree of safety depends on the size of the danger potential, that is, the danger remains. When the dangerous potential accumulates to a certain degree, it will be quickly unleased, causing serious impact and damage. The quantitative change of the safe state results in a qualitative change of the dangerous state, which has the characteristics of relativity, hierarchy, and mutual transformation. The dangerous state of gas is inevitable, and the elimination of any risk factors will reduce this danger to a level of contingent relative safety.

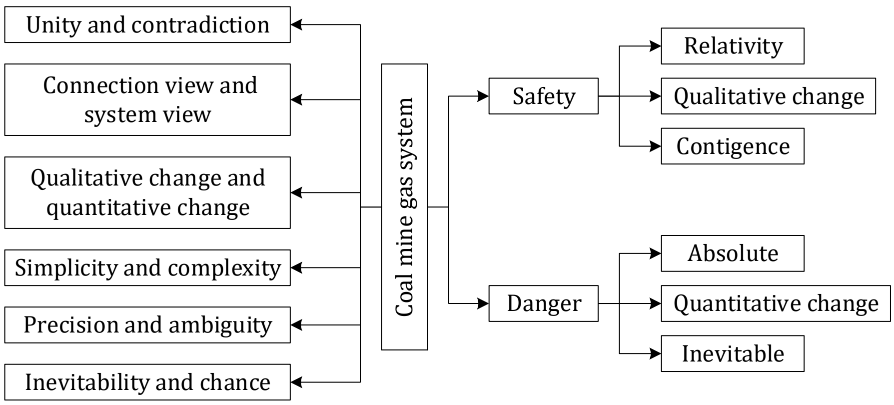

Figure 2. Philosophical basis of the coal mine gas system

Various safety and hazard factors are interconnected in the coal mine gas system, resulting in accidents with intricate cause-and-effect relationships, identifying the primary and secondary causes of occurrence, internal and external causes, direct and indirect causes, and objective and subjective causes and comprehensively analyzing the impact of the interacting and interconnected elements on the study system as a whole to produce synergistic effects. The complex system is divided into basic aggregates, and the fuzzy concepts of safety and danger are described with precise figures; a qualitative and quantitative analysis is carried out according to different practical situations to eliminate the danger of the unit, thus improving the system safety [16].

Applying Marxist philosophy to the field of coal mine gas research allows for the use of a scientific world view to understand the state of safety and danger and utilization of a systematic methodology to analyze and adopt transformative measures. The relationship between risk factors should be understood to deal with the risk state in the production process combined with the actual geological conditions of the mine. Finally, dialectical thinking should be used to treat and deal with risk and safety factors, and various factors should be correctly solved to promote the safe production of the coal mine [17].

3.2. System Theory of Mine Gas Control

The generation of safety problems has contributed to the continuous development of safety science. The development of safety science theory has gone through three stages: empirical (post hoc feedback decision), post hoc predictive (anticipatory control), and integrated systems theory (comprehensive countermeasure) [18]. The consequences of coal mine gas accidents are serious. Accordingly, comprehensive system theory must be adopted to predict and prepare measures in advance. Moreover, the principles and methods of systems engineering must be used to identify, analyze, and evaluate the hazards in coal mine gas system. These mechanisms are necessary to provide basis for adjusting gas extraction technology, coal seam mining methods, and safe use of gas and other factors. Thus, the gas hazard factors in the system can be eliminated and controlled and the loss of gas disaster accident is reduced to the lowest degree to achieve the best safety condition of the system.

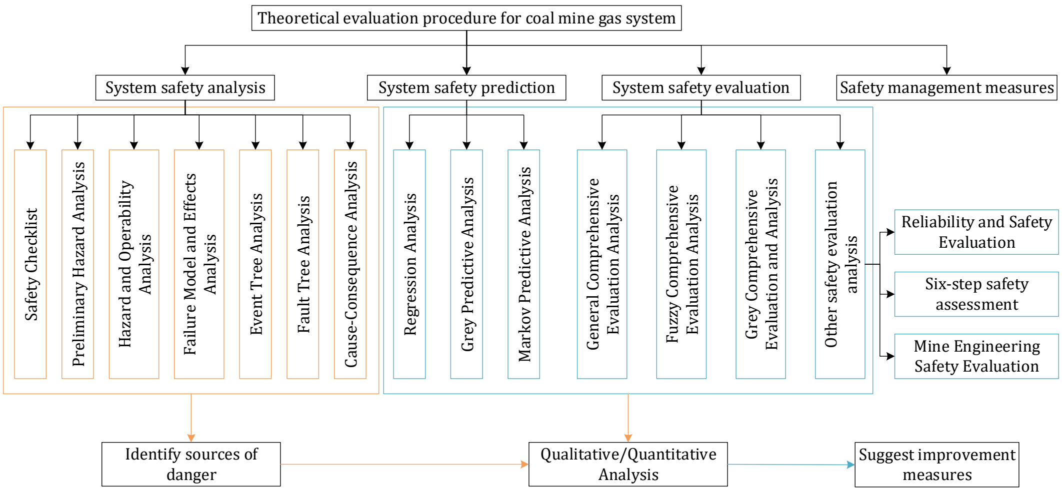

Figure 3. Procedures for the theoretical evaluation of the coal mine gas system

Figure 3 depicts the procedure for evaluating the coal mine gas system, which includes dissecting the various sources of gas in the coal mine gas system, recording the cause, passage, and consequences of each risk factor affecting the accident, judging the impact of its occurrence or non-occurrence on causing the accident, and proposing mining methods and pre-pumping measures to prevent gas accidents [19]. For example, different gas extraction methods are used: (by gas source) extraction from this coal seam, extraction from adjacent seam, extraction from the mining area (legacy coal/adjacent seam/perimeter rock gas), and extraction from the perimeter rock; (by mining time) coal seam gas extraction, extraction while mining, and post-mining extraction; (by whether the coal seam is depressurized or not) unpressed, depressurized seam extraction, and enhanced extraction; (by extraction process) borehole extraction, roadway extraction, and mixed extraction of drilling and roadway to extract gas. Improving the balance of mining, reforming the drilling process, improving the quality of sealing holes, optimizing the extraction system, and strengthening the extraction management are beneficial to improve the gas extraction rate.

3.3. Gas Disaster Accident Sources

Coal mine gas mainly comes from coal seams and coal formation process of coal strata, and gas hazard sources exist in the form shown in Figure 4, which are assigned to coal seams in adsorption and free state; moreover, gas transport occurs under certain conditions, resulting in uneven distribution of gas content, which leads to accidents, such as mine gas gush, coal and gas protrusion, and gas ejection [20]. The mining balance of gas pressure in the coal seam is destroyed in the process of mining, digging, and drilling. The amount of mine gas emission is predicted through statistical prediction and source calculation, and the measures of source treatment, hierarchical treatment by classification, and comprehensive control are adopted.

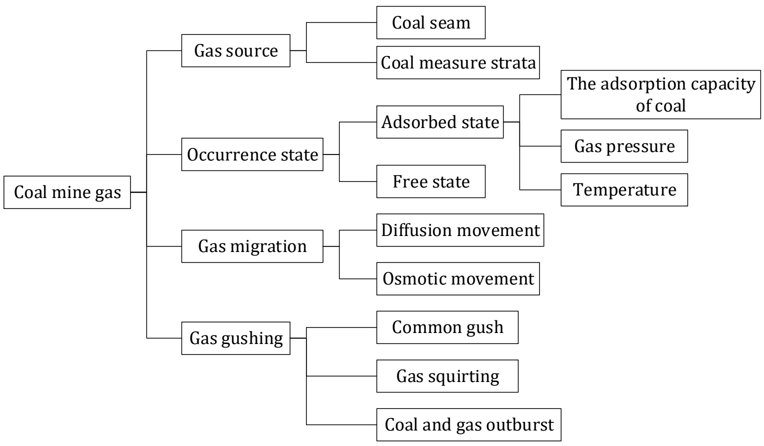

Figure 4. Coal mine gas hazard sources

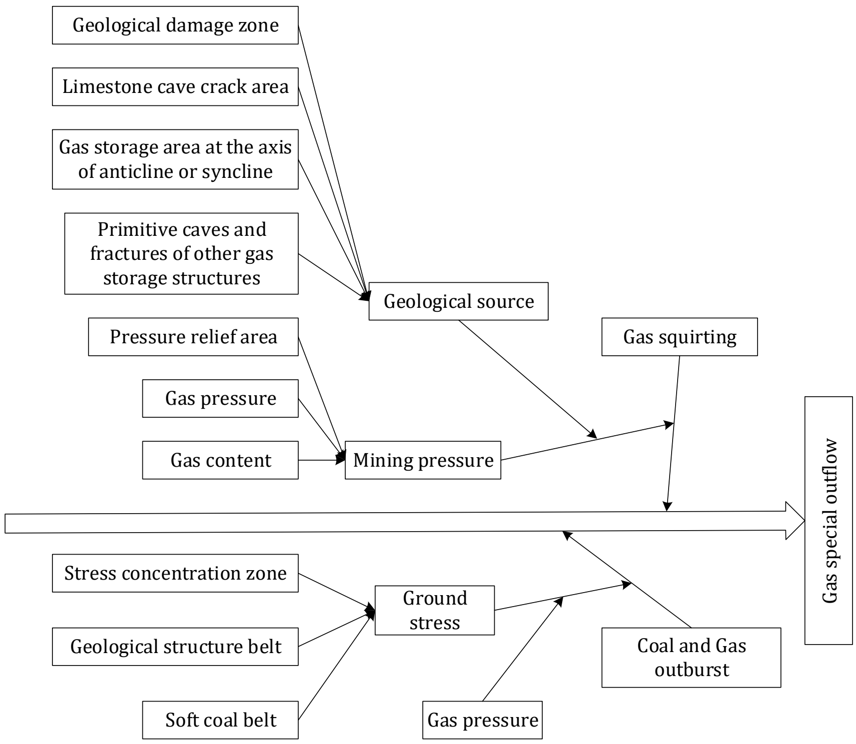

Figure 5. Cause-and-effect analysis diagram of gas gushing out

The mining operation changes the gas occurrence balance condition of the coal seam and surrounding rock in the process of coal mining, causing gas into the tunnel from the mined coal seam, surrounding rock, adjacent layer, and goaf, resulting in the gas gushing accident. The cause and effect analysis of gas special gushing is shown in Figure 5 [21]. The mining ground pressure is primarily affected by gas pressure, gas content, and extent of the pressure relief zone, and the ground stress caused by the geological structure zone leads to gas gushing and coal and gas protrusion accidents. Therefore, the release of gas sources from the root must be controlled, and the influence of ground stress on coal seams must be reduced to prevent the occurrence of gas special gushing accidents.

4. Discussion

This research is a preliminary study on the reform of a mine gas control course based on a hybrid teaching method. The combination of traditional course lectures, digital online teaching, and research-based teaching mode can fully mobilize students' learning enthusiasm, facilitate teachers' teaching at anytime and anywhere, and increase the interaction between teachers and students in the classroom, information transfer, and question and answer session after class. This teaching mode has become a new trend in the global epidemic situation.

The research-based teaching mode combines the knowledge points of multiple courses and the analysis methods of different problems, which is conducive to teaching systematically and sublimating the knowledge points, enhancing students' cognition of the courses, and cultivating the scientific thinking of teachers and students. For example, the course of mine gas prevention and control is combined with the teaching mode of Safety Engineering, System Safety Principle, and Mine Safety Technology. Only by dialectically understanding the relationship between safety and danger of coal mine gas and systematically identifying and analyzing the hazard sources of mine gas can we grasp the causality of gas gushing and fundamentally reduce the probability or severity of accidents.

The use of multidisciplinary cross-teaching method in mine gas control course has a clearer orientation to the course teaching, which is conducive to improving the traditional teaching effect. The reform of hybrid teaching method fully mobilizes students' interest in independent learning and makes the teaching effect more effective. In combination with the reform requirements of the teaching mode of the new engineering construction, the construction of this new teaching system provides new ideas for the teaching reform of safety engineering courses under the background of new engineering.

5. Conclusion

(1) In response to the requirements of the new engineering teaching reform, a new teaching system for the reform of mine gas prevention and control courses based on the blended teaching method is established to provide new ideas for the teaching reform of safety engineering courses under the background of new engineering.

(2) Integrating traditional course lectures, online teaching, and research-based modules will help teachers and students teach and learn the course anytime and anywhere in the general environment of the epidemic, mobilize students' learning enthusiasm, establish a diversified new teaching system and improve learning quality and effectiveness.

(3) The research-based teaching module is a systematic knowledge system from engineering and technology cases and a systematic theoretical analysis to philosophical cognition of accidents in a large safety teaching method. The implementation of hybrid teaching method helps cultivating students' scientific thinking and cognitive ability.

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