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Transformation of Scientific Research Achievements of "Intelligent Early Warning and Prevention of Mine Fire" —Practice of Case Teaching Reform of Mine Fire Prevention Course

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Abstract: Due to the increasing intensity and difficulty of mine fire prevention at present, and the high demand for talents in the field and specialty of coal fire disaster prevention and control, the corresponding course "Mine Fire Prevention and Control" is highly theoretical, covers a wide range of knowledge and complex, and the traditional teaching method is difficult to effectively achieve the teaching purpose. Under the background of OBE teaching theory and new engineering education, the course team transformed the latest scientific research achievements of mine fire intelligent warning and control system into cases introduction of the curriculum, mine fire prevention and control combined with the theory of "case -" teaching method, through the introduction of mine fire intelligent warning system, students develop self-restraint responsibility industry pride, engineers, scientists, overcome the difficult and exploring spirit. After validation of teaching methods on site, the latest technology and techniques for mine fire prevention and control are incorporated into teaching lesson plans and teaching materials in a timely manner to enhance the foresight and practicality of the teaching content, improve the quality of teaching, guide students to use book theories flexibly in practical cases and achieve the purpose of cultivating students' innovative awareness and creative thinking. Providing case-inspired education for future workers in the field of coal fire disaster prevention and control has positive significance for the development of mine fire prevention and control, intelligent monitoring and early warning technology and the training of related talents in China.

1. Introduction

Coal is China's main source of energy and its dominance is difficult to change significantly [1]. As a large producer and consumer of coal, China's coal mines mainly produce bituminous coal and lignite, and more than 90 per cent of the coal seams have a tendency to spontaneous combustion (Type I) or spontaneous combustion (Type II) [2]. With the acceleration of China's industrialization

process, the demand for energy continues to grow, the number and scale of new mines, as well as the intensity and depth of mining are also increasing, but at the same time, the problem of underground fire prevention and extinguishing has always been one of the major difficulties in this field of research. In the event of an underground fire, it can disrupt the mine's production schedule for the current year, disrupt the normal working order of the workers, and in serious cases, ignite the original coal seams underground on a large scale, damaging the production equipment. If the fire is not dealt with in time, it will detonate the gas and coal dust under extreme conditions, resulting in a vicious accident with large-scale casualties and seriously threatening the safe, green and efficient production of coal mines [3]. Therefore, the accurate early warning and prevention and control of mine fire in the early stage has been a worldwide problem, and its intelligent warning and prevention and control is also an important content of the intelligent construction of coal mine safety.

At present, coal spontaneous combustion fire monitoring and early warning mainly take the sign gas analysis method, infrared thermal imaging method, taste detection method, tracer gas method and so on. Among them, the marker gas analysis method and infrared thermography have been widely used and become the main application methods in the study of spontaneous coal combustion, which play an important role in the prevention and control of spontaneous coal combustion fires [4]. However, the scientific basis of the existing coal spontaneous combustion fire monitoring technology indicators is still insufficient, the monitoring indicators are relatively small, and it is difficult to ensure the reliability, stability and comprehensiveness of the monitoring of the initial characteristics of the fire information, and it is only possible to realize the monitoring of a single indicator and the alarm function of exceeding the limit of a single indicator. The risk indicators of coal spontaneous combustion at all stages are missing, the online comprehensive analysis and risk warning function is not perfect, the system has a high rate of false alarms and omissions, and it is impossible to accurately determine the location of coal spontaneous combustion fires, which delays the rapid emergency response and emergency evacuation after the fire, and is very likely to cause heavy casualties and property losses.

Xi'an University of Science and Technology (XUST) has been engaged in the research of mine fire science and its prevention and control theory and technology for many years, and is quite special in mine fire prevention and control and monitoring and early warning. Relevant achievements include: National Science and Technology Research Project "Research on Fire Early Warning System of Multi-source Information Integration for Safe Production in Mines", "Research, Development and Industrialization of Coal Mine Fire Monitoring and Early Warning System Based on Internet of Things Technology", and Science and Technology Special Project of Provincial Department of Education. "Basic Research on Wireless Sensing Network Monitoring and Early Warning of Coal Spontaneous Combustion Hazardous Area Characteristic Information". All of this lays the foundation for training professionals in mine fire prevention and control. The course "Mine Fire Prevention and Control" offered by the school is characterized by its theoretical, practical and pragmatic nature. However, in the actual teaching process, teachers found that due to the influence of various objective factors, students in the entire learning cycle of the book lack of sufficient practice inside and outside the classroom, resulting in a number of students on the classroom of the basic theories of mine fire science is not a thorough understanding, let alone mastery and application. As well as the weak on-site practical ability, it is more difficult to realize the rapid combination of academic knowledge and on-site practice, showing the constraints of the current teaching mode and method on teaching results. Based on this, the members of the teaching and research team combine OBE teaching theory and the concept of new engineering education with the training objectives of our students in the course. The learning objectives for the semester are defined at the beginning of the semester, and the teaching methods are supplemented by the content

of the course [5]. It also introduces the case teaching method to create a "live environment" for students and realize scenario-based teaching, with a view to solving the "teaching dilemma". At the end of the semester, students' learning outcomes for the semester are assessed in a variety of ways, and teachers' teaching effectiveness is tested to see if any improvements need to be made to the teaching methods and content.

2. Disadvantages of Traditional Teaching Methods

Mine fire prevention and control are important elements of safe mining and is one of the important guarantees for the development of energy security in China [6]. Its core content is to grasp the signs of spontaneous coal combustion and fire, continuously monitor the underground environment and provide early warning, so as to nip spontaneous coal combustion and fire in the "bud" stage [7].

Mine Fire Prevention and Control is a compulsory, core course for safety engineering students. Because it is characterized by a close combination of theory and practice and is biased towards the field of practical engineering, it is difficult for most students to learn and the knowledge points are not easy to grasp [8]. In the past classroom teaching practice received feedback after class: some students do not have a thorough understanding of the knowledge and theories in the books, and it is more difficult to grasp the key points when reviewing after class, and the phenomenon of forgetting the old knowledge after learning the new knowledge often occurs. This leads to a vicious circle of improvisation only before the examination, and difficulty in getting started when applying on-site afterwards, and an inability to systematically apply the knowledge and theories learnt in practice.

In response to the above situation, teachers now generally adopt the integrated teaching idea that classroom teaching, laboratory teaching, internship teaching and course design teaching are used together [9-10]. Specifically, students are given a basic understanding of the main content and application scenarios of the course, followed by lectures on the basic theories and research methods of mine fire science. And in the process of laboratory teaching, internship teaching and course design teaching, students are guided to analyze professional problems encountered in reality, and apply what they have learnt in the classroom to dismantle and solve the problems. The results that can be brought about are not obvious, and the main reasons are as follows:

(1) Theoretical indoctrination, characterless and fragmented teaching

This course is highly specialized and students need to base their knowledge on a large amount of theory if they are to be able to understand and take in all the content. For students, boring and serious theoretical knowledge is easy to produce a sense of fatigue, and most of the deep abstract, difficult to understand, over time, will lose interest in the course. Although the numerous teaching methods currently employed can to some extent alleviate students' fear, they fail to address the root causes of the problem. And the teaching method of the course is based on traditional classroom lectures, which is difficult to attract students' interest, and the purpose of learning becomes passing the final examination, resulting in poor teaching effect.

(2) Little teacher-student communication and poor student initiative

Because students are already intimidated by the more basic theories of the class, and because of the proliferation of entertainment options on the market today, students with less self-control will use electronic devices for entertainment in class. This not only affects their own learning and gradually forms inertia, but also affects the listening effect of other students around them, and reduces the interaction and communication between students and teachers in and out of class. Teachers are unable to judge the learning status of students in a timely manner, while students' motivation and initiative in learning are getting worse and worse, forming a vicious circle.

(3) Lack of practice and focus on teaching at the expense of learning

In the classroom, teachers are more inclined to the process of imparting knowledge, but pay less attention to whether students can fully understand the content of the class and whether they can use the theory to guide practice, and the test of students' learning outcomes are mainly classroom quizzes and final exams, which are the two traditional ways. On the other hand, the lack of experiments and practice in this course makes it impossible for teachers to accurately assess students' mastery of knowledge, which is the biggest constraint on students' knowledge.

At present, the design of the curriculum system of colleges and universities has not been able to adapt to the requirements of the market for talents, and it must be reformed in order to build a new mechanism for the cultivation of college students from multiple perspectives and in three dimensions [11]. The core of it is to insist on the combination of research teaching and practical teaching, the combination of school-land and school-enterprise, the integration of advantageous resources and conditions both inside and outside the school, the construction of a special platform for talent cultivation, and the formation of a new type of teaching mode for joint cultivation of talents [12]. Through the exploration and practice in recent years, the School of Safety Science and Engineering of Xi'an University of Science and Technology (XUST) has attempted to establish a new teaching mode of talent cultivation practice that is multi-faceted, three-dimensional and platform-based. In the process of building a new model of talent cultivation, two combinations are always emphasized and adhered to: i.e., the combination of research-based teaching and practical teaching, with the aim of strengthening practical guidance for undergraduates and cultivating them to gain rich practical experience. At the same time, integrating the existing internal and external advantageous resources and conditions, constructing the platform of talent cultivation characteristics, according to the transformation of the relevant scientific research results and thus forming the teaching case base. It extends students' knowledge and develops independent thinking to identify and solve problems, as well as active exploration and research on professional knowledge and skills. It cultivates and enhances students' interest in learning, thus effectively improving the professionalism and level of talents in the field of mining safety in China.

3. Introduction to the Case Method

3.1 What is Case-Based Teaching

Case-based teaching, literally, means teaching around cases in the classroom. It is a teaching method, originating from Harvard University in the United States, which involves explaining a targeted case and leading students to discuss and analyze the relevant issues [12]. The core of the case base teaching method lies in the selection and discussion of cases, which is also the key to the difference between the case base teaching method and other teaching methods, which reflects the teaching purpose of letting college students’ focus on theory and practice [13].

Case studies are characterized by the following features:

First, they have a clear purpose. Case teaching is conducted through teachers guiding students to discuss typical cases and analyze relevant case problems, so that students can sort out a set of methods suitable for them to cope with the problems and improve their ability to solve practical problems [14, 15].

Secondly, it is objective and truthful. The so-called objective authenticity means that when the teacher collects and edits the cases, he/she should not add his/her own subjective conclusions in it, and let the students think independently and independently to come up with the conclusions.

Thirdly, it is more comprehensive. Since real cases are richer than typical textbooks and the process of discussing and solving them is more complex.

Therefore, to solve this case well, students need to use all kinds of knowledge they have already learnt, as well as consulting relevant information to explore the case. Therefore, the effective

implementation of case teaching requires students to actively apply the theoretical knowledge and skills they have learnt to deal with the corresponding case problems in a flexible manner.

3.2 Advantages of the Case Method

(1) Improvement of students' ability to solve practical problems

"The survival of the fittest", if people always think in a fixed and unchanging way to think about the ever-changing things, it is not suitable to survive in this ever-changing society. The same applies to education, where the classroom, with the help of case studies, allows students to fully understand how to think and deal with different problems and to develop their own unique ways of solving them. When it comes time to actually go out into the community, these students will be better equipped to solve real-world problems and achieve innovative goals.

(2) Strengthening the link between teaching and learning contexts and real working life

Some students feel that what they learnt in the classroom is not useful to them in their future working life, and there is no difference between learning and not learning. The examples used in case-based teaching are usually closely related to the current content, and students can use what they have learnt in the classroom to solve problems instantly, which greatly increases their interest and motivation. In the short term, this will enable students to cross a new level of knowledge mastery, and in the long term, the knowledge digested and assimilated at this time will lay a solid foundation for them to be able to apply it in real-life scenarios when they go out of the campus and into the workplace later on.

(3) Discussion of cases can lead to a better grasp of theoretical knowledge

Some people think that cases are too specific and specialized to be used to convey relevant theoretical knowledge, but this is not the case. Choosing the right case is more likely to present the theoretical knowledge to be taught [16]. Teachers can select representative cases that address the classroom knowledge points, and then lead to the knowledge points and difficulties to be taught through case discussions. This mode of teaching will be abstract theoretical knowledge into a more easily to understand and absorb the actual case, students are also easier to grasp and digest.

Compared with the traditional teaching method, the case teaching method will be abstract theoretical knowledge materialization, from the perspective of problem solving to make professional knowledge can be applied; prompting professional knowledge tends to systematic. For engineering disciplines, the case teaching method helps to create a "live environment" for students and realize scenario-based teaching, which is expected to solve the teaching problems of the course "Mine Fire Prevention and Control".

4. Practice of the "Case-Theory" Teaching Methodology

4.1 Introduction and Application of the "Case-Theory" Teaching Methodology

In order to improve the effectiveness of course teaching, the teaching and research group of Emergency Response Technology and Management Department, School of Safety Science and Engineering, Xi'an University of Science and Technology (XUST), combining the application of case study teaching method at home and abroad, as well as the characteristics of the school discipline, has integrated the "Case-Theory" teaching method, OBE teaching theory and the concept of new engineering education into the undergraduate course of "Mine Fire Prevention and Control". The "Case-Theory" teaching method, OBE teaching theory and the concept of new engineering education have been integrated into the undergraduate course "Mine Fire Prevention and Control". The method requires the lecturer to select teaching cases that are suitable for the students of the program and objectives of the program. Firstly, the theory to be learnt in this class is introduced

from the selected case, then the teacher puts forward guiding questions, and the basic theory is summarized through the students' discussion of the questions, and finally the summarized theory is used to guide the practice. The flow of practice is shown in Fig.1.

Figure 1: Flowchart of the "Case-Theory" teaching method in practice

The "Case-Theory" teaching method is that the teacher will take the case as the starting point of the lecture, in the lecture of mine fire prevention and control of a certain knowledge point in the textbook, the teacher first selects the case related to the content of this class in advance, and puts forward to the students the inspiring questions related to the study of this class. The students are led to discuss and analyze each other with the questions. After students have reached their own conclusions, the teacher will finally conduct a guided summary of this discussion to check for gaps. In this way, it deepens students' understanding of and interest in the profession and the course, and achieves the outcome orientation emphasized in the OBE teaching theory. Teachers can also improve their own teaching plans and methods in this process based on students' immediate feedback, realizing the concept of new engineering education and innovating the existing education methods and tools. The specific procedures are as follows:

First, case presentations. First, the instructor will select appropriate cases to present to the students for the mine fire prevention and control points learned in this lesson. The use of cases as an entry point for lectures enables students to become curious and interested in what they are learning in this section as they learn about real-life cases. Even if the students forget the points afterwards, they will retain an impression of the cases, which will help them to review and apply them after the lesson.

Secondly, questions are asked. The instructor will ask questions that are illuminating to the content of the lesson around the case presented, leading the students to think and discuss the case around the questions.

Thirdly, analyse the problem. The analysis of the problem is divided into two parts. In the first session, students will first think independently, based on the information they have accessed, and explore the case with the rest of the class to draw preliminary conclusions around the questions posed. In the second session, students will present the results of their thinking and discussion in the first session, and other students may add and improve. At the end of the session, the teacher will summarize the results of the discussion, pointing out any shortcomings and providing heuristic guidance.

Finally, problem solving. Again there are two links in this phase. The first session consists of students proposing solutions based on their analyses of independent thinking. The second link is that after the students have finished their own conclusions, the teacher will first make a unified summary of the students' conclusions, further supplement and explain the loopholes and

deficiencies in the process of students' analyses and discussions, and finally show the correct conclusions for the knowledge points involved in the case.

The "Case-Theory" teaching method uses cases as an entry point to make students interested in knowledge and stimulate their curiosity. Psychological research has found that when abstract and concrete things are present at the same time, people are more likely to choose the latter. More than abstract and boring academic theories, a concrete case can attract students and mobilize their desire to explore and analyze. This is why the "Case-Theory" teaching method of delivery maximizes students' motivation and contributes to their ability to think and analyze problems. The characteristics of the "Case-Theory" teaching method is to leave enough time for students to think independently, change the previous passive acceptance to active thinking, focusing on cultivating students' independent thinking and problem-solving learning habits, and improve the ability to analyze the problem. The role played by the teacher in this process changes from that of a transmitter to that of a guide, simply providing the general direction for the students' independent analyses. Finally, the teacher will summarize and test the results of the students' analyses to further analyze where the gaps are and what the problems are. All of these "self-summaries" can help students deepen their understanding and application of knowledge, and make their grasp of mine fire science more solid.

4.2 Validation of the "Case-Theory" Teaching Methodology

In order to verify the teaching effect of the "Case-Theory" teaching method adopted in the course of mine fire prevention and control, the teaching and research group takes the mines in which the self-developed mine fire intelligent early warning and control system has been successfully applied as cases. The system device mainly consists of four parts: mining GD7 intrinsically safe multi-parameter wireless sensor terminal, ZDC7-Z mining intrinsically safe wireless monitoring host, MHJC-V2.0 intelligent monitoring and early warning service software (including mobile phone APP) and ground server. The ZDC7 mine fire intelligent monitoring and warning system is designed to real-time monitor the coal spontaneous combustion characteristic information in the key areas such as underground working face hollow area, old hollow area, roadway high-rise area, neighboring hollow side, etc. The application scenario is shown in Fig.2.

According to the situation that coal spontaneous combustion hazards exist in the mining air zone, old air zone and other hazardous areas of Daliuta Coal Mine's Live Chicken Rabbit Shaft, in order to achieve real-time accurate identification of multi-area fires in the underground, based on the real-time online monitoring and early-warning technology of networked real-time monitoring of multi-source information about fires in the mines, the mining multi-parameter monitoring system hardware is researched and developed, so as to achieve the networked full coverage of the key areas of spontaneous combustion of coal in the underground. At the same time, it adopts IoT communication, near-field data acquisition and other technologies to develop monitoring hardware equipment integrating coal spontaneous combustion indicator gases, temperature and humidity, differential pressure and other multi-source heterogeneous data, as shown in Fig. 3(a), which can realize the three-dimensional networked full coverage of coal spontaneous combustion key areas such as the old underground airtight confinement, the working face and the mining area, and the connection mode of the underground is shown in Fig. 3(b).

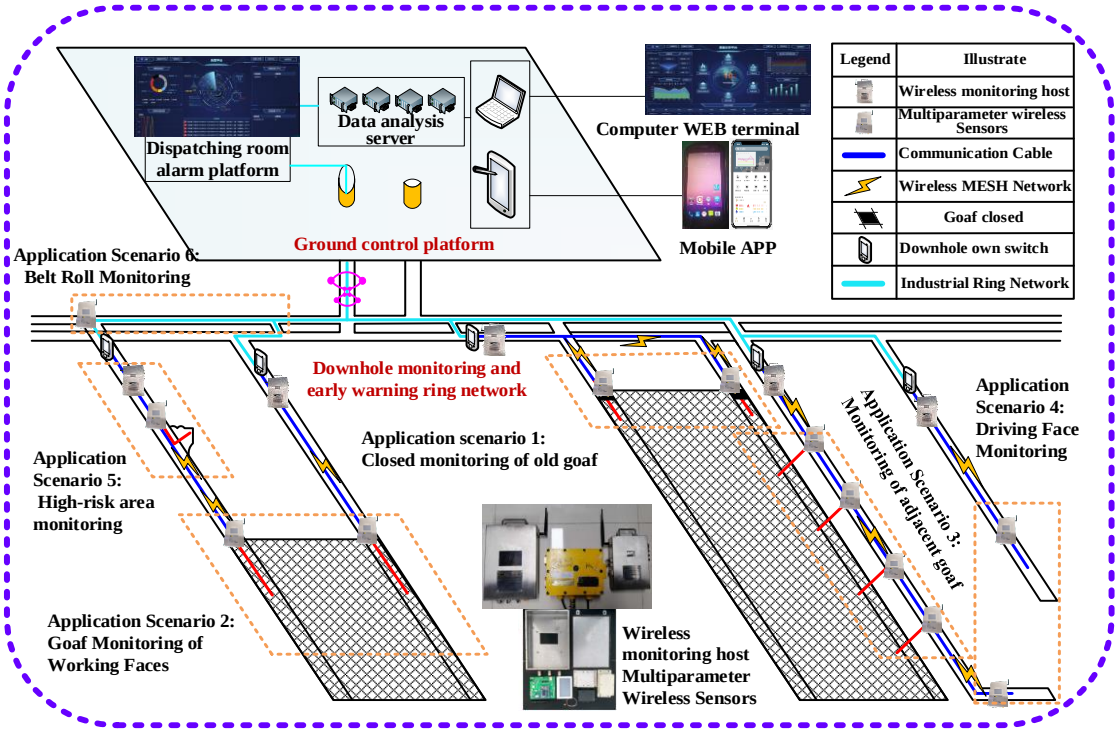

Figure 2: Application Scenario of Mine Fire Intelligent Early Warning and Control System

(a) Monitoring of physical hardware equipment

(b) Schematic of down hole connection

Figure 3: Monitoring hardware equipment

At the same time supporting the development of intelligent monitoring and early warning software, the classification of mine fires early warning and spontaneous combustion anomalous areas to determine, and based on the analysis of monitoring information to give recommendations to deal with the fire of the technical solutions. Therefore, the software interface is dominated by the

display of trend curves, data lists and other forms of indicator parameters such as the ratio of characteristic gases of spontaneous combustion of coal, as shown in Fig.4.

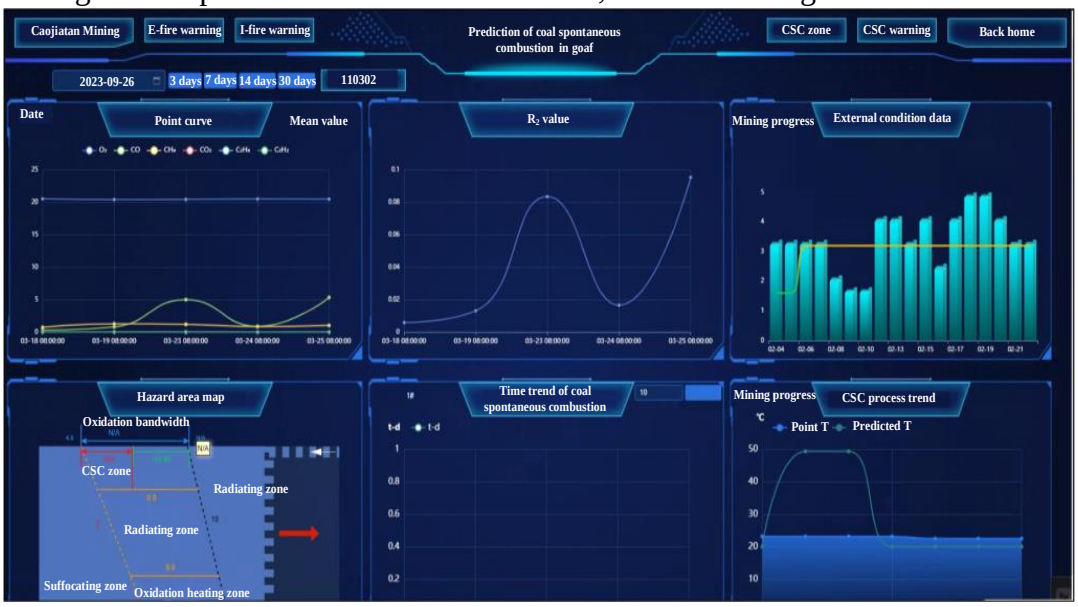

Figure 4: Coal Spontaneous Combustion Early Warning Software Interface

Applying the "case-theory" method of teaching by presenting cases and raising questions in the classroom. For example, what are the components of a mine fire intelligent monitoring and early warning system? What are the functions of each part? Where are the application scenarios? What other features can be added to intelligent monitoring and warning software? How can these functions be realized? And so on. Analyzing and solving problems requires the use of OBE pedagogical theories with the outcome-oriented thinking in new engineering education with the professional knowledge learnt in the course, as well as the theories learnt in the classroom, and ultimately returning to the case to guide practice.

The key to the success of the application of the "case-theory" pedagogy, the OBE teaching theory and the integration of the new engineering education concept lies in the organization of classroom discussions. In order to be able to achieve good teaching results and meet the teaching objectives, the teachers of this program will plan every aspect of classroom teaching before the class. Considering the various problems that may arise during the classroom discussion and preventing the classroom from getting out of control, the teaching and research department organizes special teachers to follow up the practice of the three pedagogical methods and teaching concepts in the classroom to understand the whole teaching process. Discussions are organized at the end of the course to discuss and propose effective solutions to problems related to the Case-Theory teaching method, the OBE teaching theory and the new engineering education concept, so as to improve the teaching methods and processes of the course.

5. Conclusion

Xi'an University of Science and Technology, Department of Emergency Response Teaching and Research Group will be the latest mine fire intelligent early warning and control system of scientific research results into cases introduced into the "mine fire prevention and control" course, and the "Case-Theory" teaching method combined. By introducing the design of an intelligent early warning system for mine fires, on the one hand, students will develop a sense of pride in the industry, the duties of engineers, and the scientist's spirit of tackling problems and exploration on

the other. On the other hand, the latest technologies and techniques will be timely integrated into the teaching plans and teaching materials, so as to enhance the academic and cutting-edge nature of the teaching content, improve the academic taste of teaching, stimulate students' enthusiasm for learning, and cultivate students' sense of innovation and creative thinking. It allows students to understand and master the design ideas of mine fire intelligent early warning from the technical and technological level, forming a good atmosphere of mutual drive and integration of teaching and scientific research, and enhancing students' innovative imagination, judgement, thinking ability and practical ability.

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