

The emergency science and engineering discipline in China: Realistic demand, architecture design and safeguard measures

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Abstract

The uncertainty and destructiveness of major emergencies have resulted in China attaching unprecedented importance to emergency management. Ineffective response to emergencies also exposes the shortage of emergency management personnel and professionals, highlighting the necessity and urgency of emergency science education. Based on the actual needs of the state and society for emergency disciplines, this paper analyzes the logical possibilities of the emergency science and engineering discipline system design and gives a design framework. The study also puts forth measures to support implementation, such as conducting interdisciplinary pilot research and exploring the school's tradition of emergency science education. Including emergency science and engineering disciplines in interdisciplinary disciplines is conducive to enhancing resource investment, condensing academic consensus, accurately cultivating emergency personnel, achieving emergency technology breakthroughs, and providing a reference for the development of emergency science education in China.

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INTRODUCTION

In the face of a century of unprecedented change, the frequency of emergencies has become a common problem worldwide. This has enforced changes that have not been seen in a century, China's demand for specialized emergency management talents and professionals has become increasingly necessary and urgent. Whether the development of emergency management and its related education can become a dependable support force for the cultivation and improvement of emergency management talents and professionals is the mission of our emergency management education, and it is also the responsibility of education to serve the country. How to promote China's emergency management higher education to meet the development needs of the new era has become an important question that our emergency teachers must consider and answer. Actively learning from the advanced experience of international emergency management education and promote China's emergency management education is considered to become a feasible path. Internationally, starting with the establishment of the United States Emergency Management Agency, it has successively established a discipline system to support talents related to emergency management, including different disciplines such as homeland security, emergency management, and safety science. China's emergency management has been given more attention since the SARS incident in 2003. As a part of emergency science education, the emergency organization and management talents are the most urgent, and the government's emergency organization and management education has received growing focus^[1]. Time flies, the uncertainty and destructiveness of major emergencies, especially those affected by the impact and influence of COVID-

19, make the country attach unprecedented importance to emergency management, and emergency science education is the first to bear the brunt.

REALISTIC DEMAND

China's natural disasters are characterized by many types, frequency, and distribution. Once they occur, they will have a serious impact on the safety of people's lives and property. According to the Global Disaster Data Platform and the Ministry of Emergency Management, from 2010 to 2021, 2.823 billion people were affected by various natural disasters, and 21,241 people were dead and missing due to disasters (Fig. 1). Natural disasters such as earthquakes, floods, typhoons, landslides, mudslides, and forest fires occur almost every year, testing our ability to cope with disasters repeatedly.

As is well known, the occurrence of a series of emergencies such as SARS in 2003, the Wenchuan earthquake in 2008 and the snow disaster in South China exposed the vulnerability of China to dealing with emergencies. The government and academia have begun to pay attention to research in the field of emergency management^[2]. In the CNKI Chinese database, 'Emergency Management AND China' was used as the subject term, 'Exact' was used as the match type, and 'Academic Journals' was selected as the document type to screen a total of 3,634 articles on emergency management from 2003 to 2021. After analyzing the trend of emergency management publications since 2003, it can be seen that both the number of publications and the number of papers published each year show an increasing trend (Fig. 2). From the distribution of the primary and secondary themes of research in the literature, it covers the research themes of emergency management,

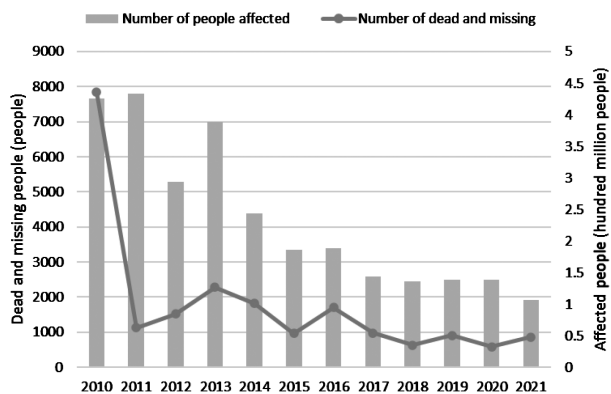


Fig. 1 Number of dead and missing people (left axis) and affected people (right axis) from 2010 to 2021. (Source: The Global Disaster Data Platform and the Ministry of Emergency Management).

emergency management departments, emergency rescue, epidemic prevention and control (Fig. 3). The content is rich and diverse, closely following real-life issues and conveying a strong sense of time and reality.

Since emergency management became a prominent subject in 2003, it has experienced rapid development for over a decade and achieved many research results. However, it has also fallen into the predicament of inadequate foreign experience and insufficient original results, which is embodied in a series of problems such as how to further seek breakthroughs in the theoretical level of emergency discipline, where to go, and so on, which pose great challenges to academic circles. The increasing frequency of emergencies has exposed the lack of established scientific emergency theories and methods, such as the lack of on-site command personnel and the lack of implementation of grassroots emergency work, which confirms the urgency of carrying out scientific emergency work. In our country, safety science, disaster science, fire fighting engineering, safety engineering, and other disciplines all involve the analysis of emergency discipline problems, but more attention is paid to the study of one aspect of emergency, which has local characteristics and lacks the discussion of its holistic perspective. In addition, different disciplines at home and abroad have interpreted their views on emergency from their own experiences, especially at present, the phenomenon that emergency management covers emergency engineering and technology

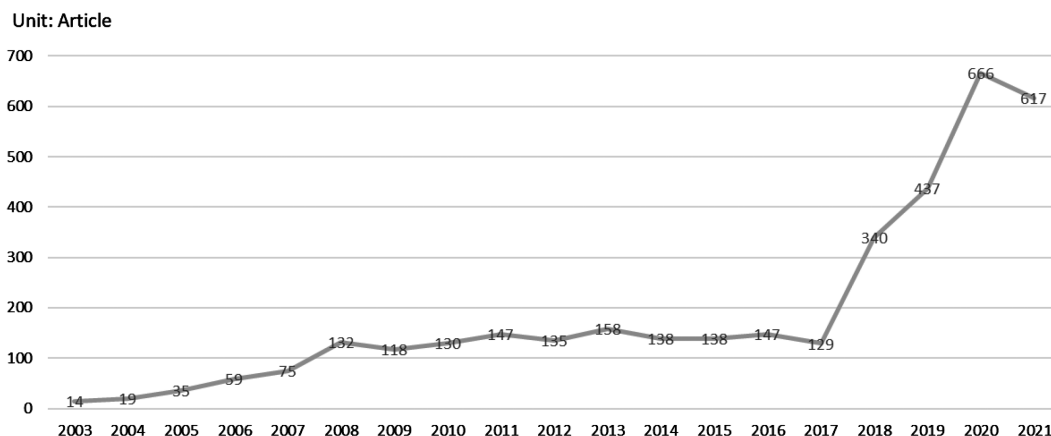


Fig. 2 Trends in emergency management research in China. (Source: CNKI).

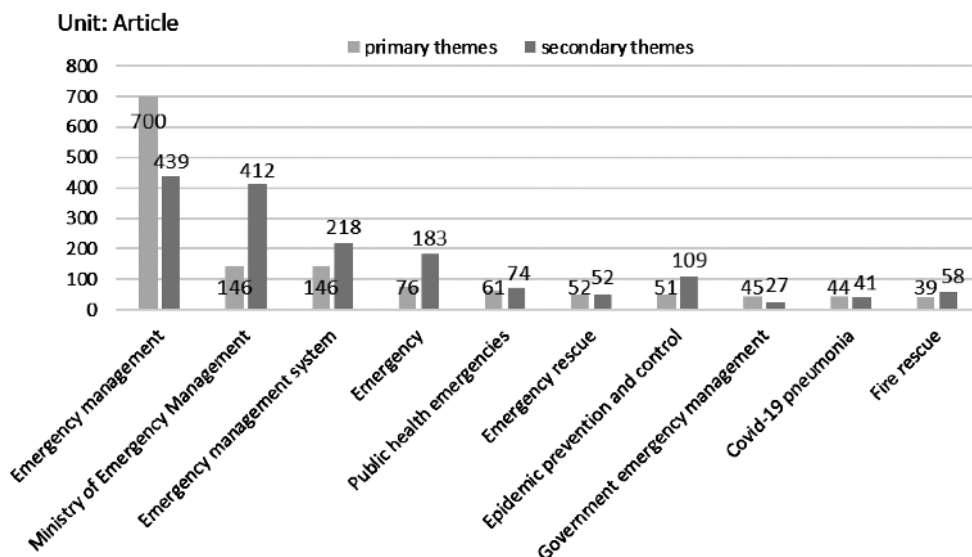


Fig. 3 Thematic distribution of emergency management research literature in China. (Source: CNKI).

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industries. According to scientific theories and methods, management and the engineering technology industry cannot cover each other, and the reality is that the former's research results cover the latter but cannot be recognized by the latter, which leads to a contradiction between emergency hard science (engineering, technology, industry) and soft science (emergency management, policy, culture, behavior) and it is difficult for them to be compatible. European and American countries have carried out lots of relevant research on the emergency discipline system, such as the formation of a master's degree and doctoral discipline system for homeland security and emergency management in the US based on the functions of facing the public and serving national security. In accordance with the emergency response functions and mechanisms at the management level, the UK has designed emergency early warning, recovery management, media communication, holiday emergency management, from the most basic emergency introduction education to a Master's course in emergency management, with rich and thorough content^[3]. In 2005, China clearly proposed carrying out emergency discipline education. Zhao^[4], Xia^[5], Xue^[6], Tong^[7], Qian & Yin^[8], Zhang^[9] and other early explorations of emergency management professional disciplines, began research around emergency management, crisis management, interdisciplinary and skills to carry out discipline professional training research. In order to promote emergency discipline and personnel training, since 2005, China has launched the undergraduate higher education of emergency management at Henan Polytechnic University (Jiaozou, China) and other universities. For various reasons, the development of undergraduate education in China is struggling. However, although today's emergency management discipline has not yet become an independent established discipline in the discipline catalogue of the Ministry of Education, in China, emergency management has been set up under the professional or direction names of emergency management, emergency technology and management, and other majors, relying on different first-level disciplines to hatch and grow, showing a blooming trend^[10].

In recent years however, many problems have been exposed in China's emergency management, such as those who study emergency management do not understand engineering technology; the exhibitions with the names of the emergency industry, safety industry, and fire protection industry have appeared one after another. Although the names of the terms are different, there is no essential difference, which is not conducive to the comprehensive utilization of emergency resources and requires integration. Although the Ministry of Education has approved scattered emergency majors, the systematic emergency discipline system is still imperfect. Under this situation, it is urgent to establish an organized discipline system that can coordinate emergency management, policy, culture, emergency engineering, technology, and industry, and it is urgent to extract a set of emergency theory systems for emergency practice from theory to practice. Therefore, based on the actual needs of society for specific emergency business, the discipline of emergency management needs to be urgently reconstructed. Some scholars began to pay attention to the discipline construction of the comprehensive integration of emergency management and emergency technology and carried out research on the discipline system of emergency science and engineering. For example, Qian^[10] explored the

discipline direction of emergency science and engineering and analyzed its feasibility and practical significance. Ma & Zhang^[11] pointed out that the construction of emergency science and engineering can include the advantages of safety engineering, fire engineering, emergency industry, and other professional fields, making disaster research localized and specialized. The research of this discipline system has just begun, both home and abroad, and it is basically in an isolated research state. In the face of the demand for theoretical systems in the field of emergency management, it is necessary and urgent to explore the construction of a complete emergency discipline system.

DISCIPLINE DESIGN

Accordingly, how to realize the transition from scientific emergency to emergency science is increasingly critical, and scientific emergency needs a set of interdisciplinary systems supporting integrated natural science and social science. Henan Polytechnic University (Jiaozou, China) has made a positive response to the above-mentioned problems, and since 2005 the university has launched an undergraduate higher education program in organization and management in the field of emergency response. Together with domestic colleagues, Henan Polytechnic University (Jiaozou, China) has promoted this direction to become the mainstream of domestic universities and has accumulated vast experience in the field of emergency response organization and management. Since 2015, Henan Polytechnic University (Jiaozou, China) has also began a new discipline layout in the field of emergency organization and management, established the Emergency Science and Engineering Research Center of Henan Polytechnic University, and is making great efforts to explore the discipline system construction with the cross characteristics of organization and management and engineering technology, that is, the discipline system of emergency science and engineering. Since the founding of 'New China', emergency management education in China has gone through four main stages of development (Fig. 4):

(1) 1949–1978. Emergency technology system formation phase: the government attaches importance to the prevention and response to emergencies such as earthquakes and floods, and at this stage, disaster management in China is mainly carried out by specialized departments for single-hazard response;

(2) 1978–2003. The initial exploration phase of emergency science, technology, and engineering systems: emergency response has gradually emerged as a disaster management feature that puts economic development first, with fewer research results addressing the basic laws of education in the disciplines of emergency science systems;

(3) 2003–2017. High-speed development phase of emergency management systems: during this period, an emergency management system with 'one case and three systems' as the core was built, and emergency management documents and laws and regulations, including emergency education, were devised and implemented one after another. At the same time, China's undergraduate education in emergency management was developed;

(4) 2017–present. The proposal of an emergency science and engineering education system and the initial exploration stage: the system provides a more complete framework for thinking

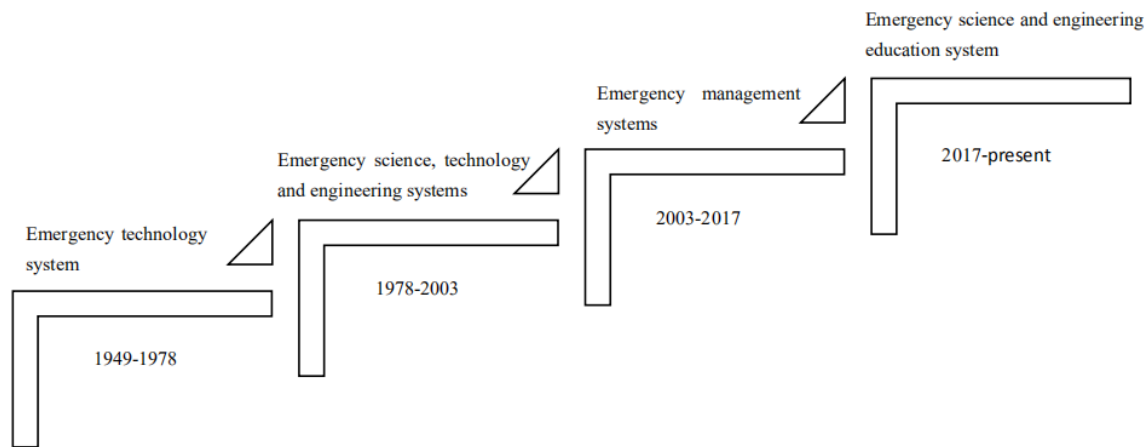


Fig. 4 The four main stages of the development of education in the discipline of emergency management.

about disaster management and response and offers room for innovation in the in-depth study of emergency response theory and events.

The Emergency Science and Engineering Discipline System includes six branches of emergency science: emergency technology; emergency engineering; emergency industry; emergency management; and emergency culture; and has published the exploratory achievements of this discipline system. That is, the '*Knowledge System of Emergency Science and Engineering-New Progress of Modern Emergency Management Theory and Methods*' among others, and promoted the establishment of relevant domestic entity teaching and research institutions and social organizations. A series of work shows that the basic academic ideas of the discipline system of emergency science and engineering have been initially formed^[12-14].

Six branches of the discipline system of emergency science and engineering, namely:

- (1) Attaching importance to basic research in emergency science, including basic theory and basic experiment;
- (2) Attaching importance to the research and development of emergency common technology of 'stuck neck';
- (3) Paying attention to emergency system engineering construction;
- (4) Paying attention to the initial mission of the emergency industry and the dialectical unity of regional economic development;
- (5) Paying attention to the effective allocation of comprehensive emergency management and special management;
- (6) Paying close attention to the administration of emergency culture, team unity, and the multidimensional culture of popular science, among other things.

Taking the six branches as the key elements, it can be expanded into 14 aspects of knowledge system content (Table 1), namely:

- (1) The emergency concept is the soul: life first, service, prevention first, a combination of prevention and rescue, system, etc;
- (2) Emergency philosophy is guidance: emergency epistemology, emergency ontology, emergency value theory, emergency methodology, and emergency practice theory;
- (3) Emergency culture is leading: emergency science culture, emergency technology culture, emergency engineering culture, emergency industry culture, and emergency management culture;

(4) Emergency education is fundamental: basic education, training education, academic education, knowledge-updating education, and emergency popular science education;

(5) The emergency team is the core: emergency team, rescue team, and three-dimensional emergency (rescue) team of land, sea, and air;

(6) Emergency capability is the means: emergency scientific capability, emergency technical capability, emergency engineering capability, emergency industry capability, and emergency management capability;

(7) Emergency science is the foundation: basic theoretical system, basic experimental system, etc;

(8) Emergency technology is the key: general technology, professional technology, etc;

(9) Emergency engineering is a system that includes both physical engineering and virtual engineering;

(10) Emergency industries are landing: the equipment industry, support materials industry, service industry, and biological search and rescue industry;

(11) Emergency management is the guarantee: natural disaster emergency management, production accident emergency management, etc;

(12) Life safety is the goal: foreign-related security interests, people's security interests, the Community of Shared Future for Mankind, etc;

(13) Emergency regulations are guidelines: '1+4' emergency management laws and regulations system, etc;

(14) The disposable objects are disaster risks: natural disasters, production accidents, etc.

Emergency science needs to explain how to understand nature and discover its objective laws; emergency technology addresses the task of how to transform nature to make it work for humanity; emergency engineering is the creation of emergency man-made objects that do not exist in nature, mainly in terms of engineering integration; the emergency industry is the endpoint of emergency science, technology, and engineering on the ground, the emergency management business needs to form a market and the emergency industry needs to mature in order for emergency management to achieve effective protection; emergency management is an integrated embodiment of emergency science, industry, engineering, and technology, so emergency management is integrated and coordinated management; emergency culture is embodied in all aspects of emergency work, and the essence of culture is to realize seamless

Table 1. Overall design of the emergency science and engineering knowledge system.

Number	Name	Branch contents
1	The emergency concept is the soul	Life first, service, prevention first, combination of prevention, resistance and rescue, system, etc
2	Emergency philosophy is the guidance	Emergency epistemology, emergency ontology, emergency value theory, emergency methodology and emergency practice theory
3	Emergency culture is leading	Emergency science culture, emergency technology culture, emergency engineering culture, emergency industry culture, emergency management culture
4	Emergency education is fundamental	Basic education, training education, academic education, knowledge renewal education, emergency science education
5	The emergency team is the core	Emergency team, rescue team, sea, land and air three-dimensional emergency (rescue) team
6	Emergency response capability is the means	Emergency scientific capability, emergency technical capability, emergency engineering capability, emergency industrial capability, emergency management capability
7	Emergency science is the basics	basic theoretical system, basic experimental system, etc
8	Emergency technology is the key	General technology, professional technology, etc
9	Emergency engineering is a system	physical engineering and virtual engineering
10	The emergency industry is the landing	Equipment industry, support material industry, service industry, biological search and rescue industry
11	Emergency management is the guarantee	natural disaster emergency management, production accident emergency management, etc
12	Life safety is the goal	Foreign-related security interests, people's security interests, and a community with a shared future for mankind
13	Emergency regulations are the guidelines	"1+4" emergency management legal and regulatory system, etc
14	The disposal object is disaster risk	Natural disaster, production accident, Health emergencies, Social security incidents

Source: Qian H, Guo J, Yin X. 2021. Traceability, conception and prospect of construction of modern emergency discipline system in China. *China Safety Science Journal* 31:77-82.

connection. The design of the knowledge system of emergency science and engineering is a prerequisite for the development of the education system of the discipline of emergency science and engineering. The in-depth study of this knowledge system helps to explore academic theoretical and practical propositions such as core emergency science issues, key common emergency technologies, integrated emergency engineering, emergency industrial transformation system, integrated emergency management, and emergency cultural values touched by the branches of emergency science, emergency technology, emergency engineering, emergency industry, emergency management, and emergency culture. By strengthening the discipline system and supporting knowledge system construction, we can effectively coordinate the discipline resources related to emergencies, which is an advanced discipline strategic layout. Since the establishment of the Ministry of Emergency Management in March 2018, emergency work has received widespread attention. Liaoning Technical University and Taiyuan University of Technology were the first to apply to the national education department for an undergraduate major in emergency technology and management, which was approved in March 2019, heralding a new beginning for education in the field of emergency response. In 2020, there are five universities, such as Henan Polytechnic University (Jiaozou, China) and Xi'an University of Science and Technology (Xi'an, China), that have been approved to add this undergraduate major in emergency (emergency technology and management, emergency management). In 2021, more than 30 universities, such as China University of Mining and Technology (Beijing, China) and China University of Geosciences (Wuhan, China), added such majors. So far, more than 60 universities have set up emergency undergraduate majors. The significant addition of emergency specialties is driven not only by the urgent need for an emergency cause but also by the unavoidable trend of emergency discipline development^[12,15].

IMPLEMENTATION SAFEGUARDS

At present, the State Council has set up an interdisciplinary category, which will become the 14th discipline category in China, with a technology branch specialty under it. Under the current background of industry and technology, most of the high-level talent urgently needed by our country are distributed in the interdisciplinary fields. Accelerating the training of interdisciplinary talents is essential for national governance and coping with the complicated international situation. Major disasters occur frequently, and how to effectively prevent and deal with them poses a great challenge to the emergency discipline on how to comprehensively consider them. Scientific and efficient prevention and response to major disasters requires scientific response. The discipline system of emergency science and engineering comprehensively coordinates the discipline elements of organization management and engineering technology in the emergency field, which can make a positive and effective response to the current domestic and international emergency response problems. At present, related majors around emergency disciplines, such as emergency technology and management, emergency management, all rely on other first-level disciplines to run schools. Under the existing system, interdisciplinary development needs more resources to remove the shortage of individual combat in colleges and universities, and the discipline setting directly determines the amount and direction of resources. The emergency discipline involves natural science, social science, and other disciplines, and its concern is far beyond the scope of the existing major in two disciplines. Setting up the first-level discipline of emergency science and engineering, and including it in the newly-established interdisciplinary category, will help to further enhance resource input, condense academic consensus, accurately train emergency talents, and solve the technical 'neck-stuck' professional series problems in the

process of major disaster prevention and response, such as major emergency science and key emergency technology breakthroughs such as major disaster scenario deduction and big data transmission channel of major disaster emergency science. How to implement the 'six elements' of emergency science, emergency technology, emergency engineering, emergency industry, emergency management, and emergency culture, and improve national emergency scientific literacy are necessary and urgent and of great practical value for promoting the modernization of the national emergency management system and capacity. It is suggested, that while setting up the discipline of emergency science and engineering as an interdisciplinary subject, we should break the thinking concept of 'heroes don't ask their origins' and support colleges and universities with rich experience in running schools, such as Henan Polytechnic University (Jiaozou, China), to carry out the pilot work of undergraduate, master's, and doctoral degrees in emergency science and engineering on the basis of organizing and managing undergraduate courses in emergency fields^[16]. Practice the overall concept of national security, focus on the awareness of theoretical problems and realistic proposition ideas of emergency science, dig deep into the basic theory of emergency science and explore practical problems, cultivate compound emergency management talents who are 'skilled, capable of management and command', serve the emergencies of large countries, and provide intellectual guarantee for the modernization of national emergency management systems and capabilities.

FUTURE OUTLOOK

Strengthen emergency popular science education

In the process of promoting the construction of an emergency cultural system, the popularization of emergency science plays an important role as a starting point. What content does the emergency science popularization work include? How to do a good job in emergency science popularization work and other issues that urgently need our research? The basic feature of emergency popularization science education is that it is 'on top of the sky and on the ground'. 'On top of the sky' means attaching importance to the basic research of emergency science; 'on the ground' means attaching importance to the work of rooting emergency culture. For the former, based on the STS (Science, Technology, and Society) education concept, it is important to promote the construction of the emergency science and engineering education system, to study in depth the history of emergency culture and thought, and to trace the emergency culture education system; for the latter, it is important to strengthen the work of emergency popularization science education on the ground, insist on the people's sense of access above all else, let the work of emergency culture take root, rely on grassroots communities, fully integrate the concept of universal emergency science education, and promote the system of disaster survival education.

Gather consensus on emergency science and engineering ideas

As mentioned above, emergency science as a new discipline plays an important role in responding at the national social security level. Its significance is self-evident, so experts and scholars in different disciplines have to use their own voices or

more familiar disciplines to carry out the discussion of emergency science problems, which is a typical discipline. In the 'path dependence' thinking of experts and scholars, in the short term, various disciplines are competing, which is conducive to promoting the development of disciplines. For a long time, there will be confusion in the attributes of the disciplines, each speaking in its own words and lacking standardized and unified professional terms. This has two consequences: on the one hand, it generates a lot of duplication of work and wastes many social resources. On the other hand, it also results in a lot of work that does not match up. According to this, the academic community of emergency science and engineering disciplines is established, and everyone's consensus point on the discipline is found, so as to standardize the professional terminology of the discipline and establish a theoretical foundation for the docking of emergency theory and practice.

Explore the theoretical development law of the emergency science and engineering disciplines

The development of disciplines has a certain regularity, which needs to be understood and grasped from the inner, inevitable connection of disciplines, mainly manifested in the knowledge system. The construction of the knowledge system of emergency science and engineering provides the educational starting point for the training of emergency talents. For emergency rescue teams (including professional emergency rescue teams and civilian rescue teams), professional emergency rescue teams have their own subordinate management departments, training and learning by their respective departments for targeted education and training, but mainly short-term training, and professional rescue teams also have different sources, but one thing is that they are not simply from universities or research institutes that have received four years of university or similar collegiate education. When faced with the constraints of theoretical knowledge that is not solid, systematic, and other issues, training emergency rescue command personnel poses a big challenge. Most of the civil rescue teams belong to part-time public welfare rescue; full-time personnel are few. The question of how to carry out comprehensive and systematic emergency knowledge and skills training for civil rescue teams has resulted in problems for relevant departments. It is of great significance to establish a body of knowledge in the discipline of emergency science and engineering to systematically teach rescue teams from basic scientific theory to practical skills.

Deepening systematic application research

The discipline of emergency science and engineering integrates the professional components of several disciplines involved in emergency and has a strong integration and systematization. At the doctrinal level, the intersection and unification of multiple disciplines in the understanding of emergency has been achieved, but at the applied level, systematic and systemic research only partially exist. There are many types of disasters in China and many areas involved in safe production, but the frequency of their occurrence and the potential loss of life and property vary greatly. The market for low-frequency emergency products is unstable^[17]. The real market space for the emergency industry is in emergency preparedness, i.e., monitoring and early warning, security monitoring, and other daily safety products, but most of the emergency products in many industries are foreign products. For these phenomena, the reason is the lack of systematic

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research on emergency product research and development, overcoming the two skins of emergency talents and emergency markets. It is therefore necessary to establish a system of emergency science and engineering disciplines and to carry out basic research work related to emergency products in universities, such as the basic theoretical and experimental exploration of physics, chemistry, biology, and machinery, and other basic theories involved in emergency products, which at present in China is rare in^[10].

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Conflict of interest

The authors declare that they have no conflict of interest.

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