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Ethical Construction and Development of Mining Engineering Based on the Safe, Efficient, Green, and Low-Carbon Concept

Fangtian Wang [1], Hongfei Qu [1,*], Wei Tian [2,*], Shilei Zhai [2] and Liqiang Ma [1]

[1] State Key Laboratory of Coal Resources and Safe Mining, School of Mines, China University of Mining and Technology, Xuzhou 221116, China
[2] State Key Laboratory of Coal Resources and Safe Mining, School of Foreign Studies, China University of Mining and Technology, Xuzhou 221116, China
* Correspondence: ts21020158p21@cumt.edu.com (H.Q.); 5273@cumt.edu.cn (W.T.)

Abstract: Modern mining engineering has become a huge system project with the increased intensification and complexity of mining engineering, which interwinds, involving many factors. Ethical issues in the main body of mining engineering have become more and more prominent. What must complement ongoing discussions is a more professional and systematic analysis that engages with mining engineering on the socio-technical systems. In this paper, first, the connotation and basic principles of mining engineering ethics are put forward. Then, the ethical responsibilities that mining engineers may face are analyzed. It is suggested that the code of mining engineering ethics can, in practice, provide engineers with the necessary guidelines to avoid mine accidents caused by wrong decisions. In addition, a case base is introduced to train students to analyze engineering ethics in practical cases, and four typical case studies are discussed in detail. Then, the implementation paths of mining engineering ethics are studied, which are centered on the concept of safe, efficient, green, and low-carbon development. Finally, we suggest that improving the ethical norms of mining engineering, personnel training system, and moral supervision of mining projects will enable engineers to deal with the ethical issues of mining engineering more effectively, thereby improving the sustainability of mining engineering.

Keywords: development concept; ethical issues; mining engineering; engineering ethics; ethical responsibility; talent training path; ethics construction path

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1. Introduction

China is the world's largest energy consumer and carbon dioxide emitter, and the Chinese economy must turn to high-quality development as soon as possible under the influence of global warming and the COVID-19 pandemic [1,2]. In this context, mining engineering, which is closely related to carbon dioxide emissions, is bound to undergo unprecedented changes. At present, mining engineering has emerged from a safe, efficient, green, and low-carbon road of transformation and upgrading of mining characteristics after initial exploration [3,4]. There is a substantial increase in industry productivity to achieve higher quality, higher efficiency, and more sustainable mining development [5].

The coal industry continues to focus on eliminating backward production capacity and releasing advanced production capacity. As shown in Figure 1, by 2021 the production of raw coal reached a record high of 4.13 billion tons, accounting for 56% of primary energy consumption. At the same time, there were 91 coal mine accidents in 2021, and the fatality rate per one million tons dropped to 0.044, down 92% year-on-year in 10 years [6,7] (the data comes from the National Mine Safety Administration [8] and the National Bureau of Statistics [9]). The coal industry has provided strong support for China's economic development based on ensuring safe production under the concept of people-oriented safety development [5,10].

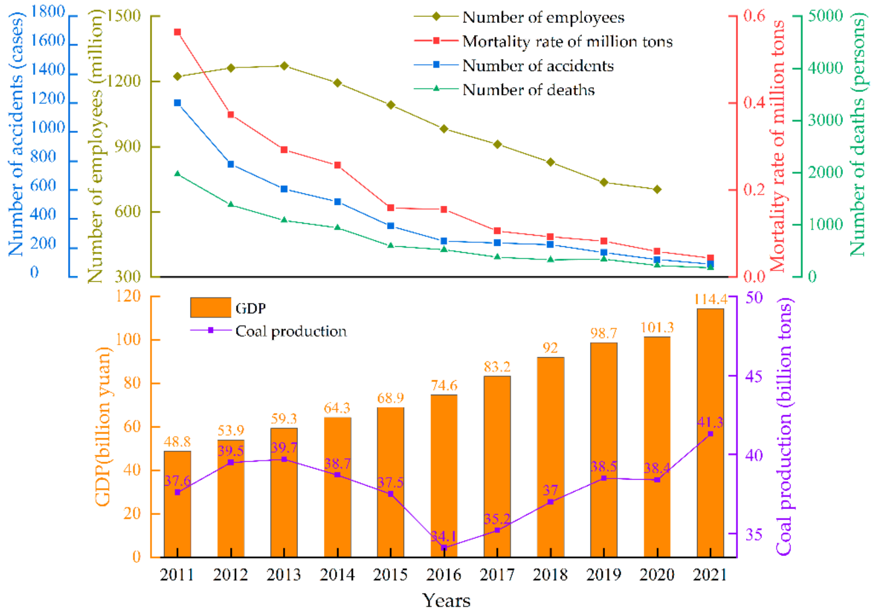

Figure 1. China's coal production-related data from 2011 to 2021.

Mining engineering has made great progress under the new conditions, but there are still many problems and challenges [11–13]. In particular, research conducted on mining engineering ethics is almost nil. International research on engineering ethics began in the 1960s [14]. Through the practice and continuous improvement of ethical norms and rules, "limited ethical goals" can be achieved, providing guidance for the ethical problems in practical engineering [15]. Most engineering ethics research focuses on, for example, clinical treatment [16] in medicine, the Space Shuttle Challenger disaster [17] in mechanical engineering, and autonomous driving [18] and artificial intelligence [19] in computer engineering. Regarding the study of general engineering ethics, Mike W. Martin and Roland Schinzinger discussed engineering risks, ethical guidelines, and other aspects in *Ethics in Engineering*, providing a code of conduct for engineers [20]. In *Engineering Ethics: Concepts and Cases*, Charles E. Harris, Michael S. Pritchard, and Michael J. Rabins provide a detailed analysis of the ethical issues in many engineering cases [21].

However, no systematic research on engineering ethics has been conducted in mining engineering, and there is a lack of ethical guidance for mining engineering and ethical education for mining engineers. The ethical issues of mining engineering can be interpersonal, involving people and society, and people and nature, and have extreme, complex, and cross-cutting characteristics in the mining field compared with general engineering practice [22]. Therefore, it is not possible to use general engineering ethics theory directly, and there is an urgent need to generate engineering ethics with mining characteristics and have theoretical and practical engineering guidance for the implementation of mining engineering and professional and systematic ethics education for the cultivation of mining engineers [23,24].

Based on the above, it can be noted that there is no perfect code of mining engineering ethics to guide the practice of mining engineering. The aim of the current paper is to discuss how to further improve the system of mining engineering ethics, specifically focusing on the mining engineer's moral responsibility and their training, one of the central concepts of engineering ethics [25].

Therefore, this paper analyzes the connotation and basic principles of mining engineering ethics and makes clear the ethical responsibility and cultivation of mining engineers. Then, the ethical issues of mining engineering were analyzed from the perspective of safe, efficient, green, and low-carbon development to propose corresponding countermeasures and construction paths. This can provide a reference for the development and utilization of mining resources as well as the high-quality development of mining engineering in China.

2. Connotation and Basic Principles of Mining Engineering Ethics

Many complex ethical issues exist in mining engineering, from design and decision-making to implementation, some of the main factors to be considered before the construction and production of mining engineering. Mining engineering ethics consider the safety and interests of people and the interests of the natural environment. They include interpersonal ethics and environmental ethics and need to be evaluated and guided from a broad engineering perspective. Mining engineering ethics is an ethical code that adjusts ethics among relevant personnel, enterprises, and departments in mining engineering. In addition, it is an ethical principle that all personnel must abide by in mining engineering practice [26]. Its basic principles should be clarified to solve ethical problems in mining engineering activities (see Figure 2).

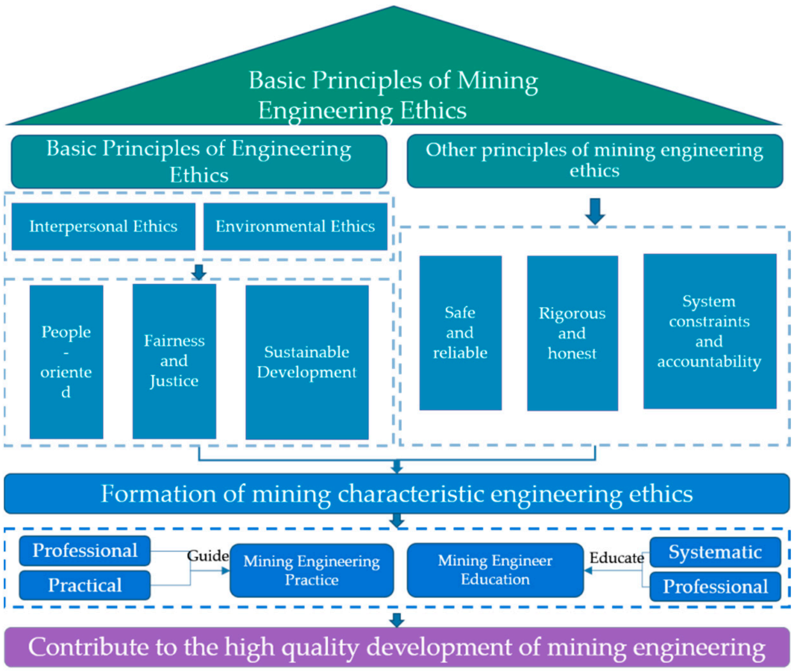

Figure 2. Basic principles of mining engineering ethics.

The basic principles of mining engineering ethics include the following six aspects:

(1) Human-centered principle [27]

They should comply with the people-oriented principle and respect the safety, needs, and values of others from design to the implementation of mining projects, in order to improve the quality of human life.

(2) Fairness and justice principle

Equity and justice are the most basic principles of ethics [20]. Mining engineering involves a wide range of stakeholders, and it inevitably causes benefits and other harm to some groups while contributing to individuals, society, and the country. Therefore, it is necessary to ensure the interests of all parties in the decision-making and implementation process of mining engineering while creating more material wealth for human beings.

(3) Sustainable development principle

The principle of sustainable development is an inevitable requirement for building a resource-saving and environmentally friendly society. The following aspects should be focused on in mining engineering activities: respecting nature; improving the sustainable design, implementation, and maintenance of mining engineering; protecting the ecological environment; establishing a friendly partnership between humans and nature; and realizing ecologically sustainable development [28].

(4) Safety and reliability principle

The mining engineering system works with a wide range of projects, which are huge and subject to certain risks of natural factors. There are many uncertain risks, especially in the production of underground mines, compared to the general engineering activities that require a higher level of safety and reliability [29]. This requires strengthening the cultivation of safety and quality awareness among mining engineering practitioners, reinforcing the awareness of ensuring safe and reliable quality, and correctly handling the relationship between production and safety.

(5) Rigor and honesty principle

Mining engineers and related technical personnel often play a guiding, leading, or practical role in mining engineering activities, which requires practitioners to possess the principle of rigorous integrity [30]. Engineers need to complete the following items: (1) Engage only in professional work for which they are professionally qualified or have relevant professional competence, maintain professional rigor in their work, and be responsible for their professional conduct. (2) Maintain objectivity, sincerity, integrity, and mutual respect in the professional work they carry out, and create a satisfactory working environment.

(6) System constraints and accountability principle

Mining engineering is a typical high-risk occupation. Practicing engineering ethics is often coordinated with related institutions. Therefore, study of mining engineering ethics should present the system as a positive factor and enhance mining engineers' awareness of responsibility and ethics as well as their institutional and legal awareness. It is necessary to establish and improve relevant national laws, local administrative measures, and enterprise management systems to ensure production safety, prevent mine accidents, and further promote the industry. The principle of "there are laws to follow and laws to be followed" should be seriously implemented [7].

3. Ethical Responsibility and Training of Mining Engineers

Compared with the general public, engineers have strong abilities of professional analysis, independently solving more complex technical problems [31]. When facing ethical dilemmas, they must possess high ethical value standards and professional quality, make moral choices, and clarify the ethical responsibilities of all parties (see Figure 3).

Figure 3. Ethical responsibilities of mining engineers.

3.1. Ethical Responsibilities of Mining Engineers

3.1.1. Technical Ethical Responsibilities of Mining Engineers

Mining engineering activities are technical. The technical design of mining engineers runs through all aspects of decision-making, implementation, and application of engineering activities and has a close relationship with the production of engineering activities and industry development [32]. Mining engineering activities involve two major engineering contexts, surface and underground, with poor engineering environmental conditions, difficult construction, and high safety requirements. They should pay attention to mining engineering construction technology. This requires mining engineers to consider technical feasibility and economic rationality in engineering design, demonstration, construction, management, and maintenance as well as to respect and maintain public health and safety to ensure that the project benefits mankind.

3.1.2. Environmental Ethical Responsibilities of Mining Engineers

Mining production causes much more direct and serious damage to the environment and ecology than other activities due to its high dependence on the mining environment. Over-exploitation of mining resources and unreasonable development planning can easily lead to ground subsidence, a sharp reduction of water resources, and the destruction of soil vegetation, which seriously damage the surrounding environment of the mining area. Therefore, mining engineers need to bear in mind the responsibility of environmental ethics in engineering design, decision making, and implementation, and use rational thinking to reasonably balance nature and human society under the premise of respecting the laws of nature [33].

3.1.3. Social Ethical Responsibilities of Mining Engineers

Mining production is an activity that involves nature and human society and is a huge pillar of human social development [34,35]. Therefore, we should comply with relevant national or industry regulations in mining engineering activities and consider taking responsibility for human society in production activities, by implementing the following directives: (1) use advanced technological means in production, continuously improve the utilization rate of resource development, and contribute to the technological progress of society; (2) pay attention to the employment and development of employees and social residents in the mining area and social sphere of influence and strive to improve their safety, health, and happiness; (3) consider the consequences of production activities in the present and the future impact on future generations, and respect the equal rights of individuals to enjoy resources; (4) improve and supervise the industrial chain, value chain, and supply chain involved in production, and actively respond to relevant policies. To summarize, mining engineers should consider people, resources, and the environment comprehensively and assume social responsibility for them to develop society.

3.2. Cultivation of Ethical Responsibility of Mining Engineers

The cultivation of ethical responsibility for mining engineers has been focused on by the teaching and research personnel in related engineering fields and by general engineering science and technology personnel and engineering management personnel [36]. It is conducive to improving engineering ethics, the social responsibility awareness of mining practitioners, energy resources, the ecological environment, and coordinating the interests of various social groups.

Focusing on the ethical elements of mining engineering that are safe, green, efficient, and low-carbon, the work collects typical ethical cases and materials of mining engineering and analyzes the ethical responsibilities of mining engineering. The technical plans for project damage reduction and restoration are considered, combined with the simulation design and implementation of excavation, support, and production plans under the actual background. Engineers are cultivated with professional knowledge and ability in engineering practice as well as a basic quality of engineering ethics and a sense of ethical responsibility from the aspects of professional ethics, responsibility, risk, etc. in mining engineering (see Figure 4 for the training path).

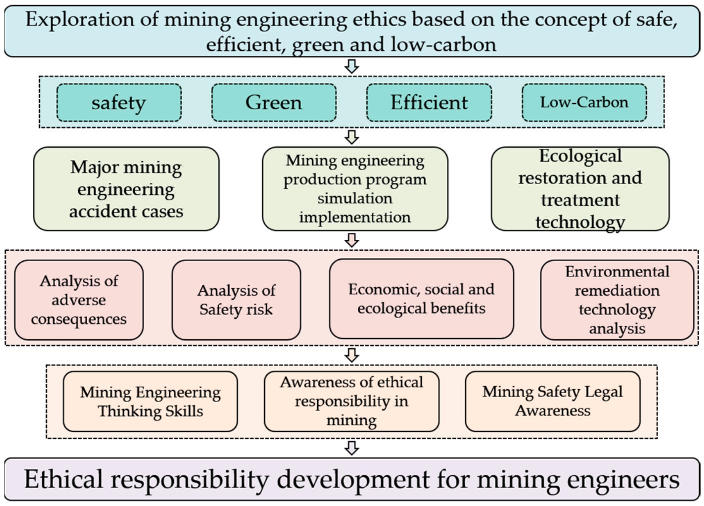

Figure 4. Path to develop the ethical responsibility of mining engineers.

3.2.1. Analysis of Ethical Responsibility in Mining Engineering in Major Accident Cases

Combined to cultivate mining engineering ethics, the work collects and organizes typical accident cases (see Table 1) through a large number of mine-related accident investigation reports, academic papers, and monographs—(1) in line with the interpretation and judgment of national safety, economic, and development policies; (2) belonging to the field of mining engineering, especially on cases focused on interpretation by relevant departments; and (3) correlated with accident cases in recent years as much as possible, and attempting to correlate with recent accident cases and converge with the frontier hotspots and focus of mining disciplines. Characterized by case teaching and focusing on mining engineering ethics education, the work analyzes the ethical issues of mining engineering in safety production, environmental protection, social stability, conflict of interest, etc. Mining engineers' ability to analyze ethical issues and overall thinking ability, in addition to considering safety risks and adverse consequences, are cultivated [37] (Table 2).

Table 1. Mining engineering major accident cases in recent years.

Date	Accident Name	Casualty Count	Direct Economic Loss/Million Yuan
10 April 2021	"4·10" major water seepage accident in Fengyuan Coal Mine, Xinjiang, China	21 dead	7067.2
4 December 2020	"12·4" major fire accident in Diaoshuidong Coal Mine, Chongqing, China	23 dead and 1 injured	2632
14 August 2021	"8·14" serious sand and mud collapse accident in Qaidar Coal Mine, Qinghai Province, China	20 dead	5391.02
27 September 2020	"9·27" major fire accident in Songzao Coal Mine, Chongqing, China	16 dead and 42 injured	2501
29 November 2020	"11·29" major water seepage accident in Yuanjiangshan Coal Mine, Hunan Province, China	13 dead	3484.03
10 June 2021	"6 10" major water seepage accident in Dahongcai Iron Mine, Shanxi Province, China	13 dead	3935.95
10 January 2021	"1 10" major explosion accident in Hushan gold mine, Shandong Province, China	10 dead and 1 missing	6847.33
9 April 2021	"4·9" large coal and gas outburst accident in Dongfeng Coal Mine, Guizhou Province, China	8 dead and 1 injured	1238.22

Table 1. *Cont.*

Date	Accident Name	Casualty Count	Direct Economic Loss/Million Yuan
4 June 2021	"6·4" large coal and gas outburst accident in the Sixth Coal Mine, Henan Province, China	8 dead and 1 injured	892.39
24 February 2021	"2·24" large collapse accident in Tuanchengdong Iron Mine, Hebei Province, China	6 dead	1345
15 July 2021	"7 15" serious flood accident in Haojialiang Coal Mine, Shaanxi Province, China	5 dead	1382.8
10 November 2021	"11·10" large roof accident in Monkey Field Coal Mine, Guizhou Province, China	4 dead	744.4
25 March 2021	"3·25" large coal and gas outburst accident in Shigang Coal Mine, Shanxi Province, China	4 dead	1300

Table 2. Analysis of engineering ethics issues in typical mining engineering accidents.

Serial Number:	Accident Name	Existing Engineering Ethics Problems
1	"4·10" major water seepage accident in Fengyuan Coal Mine, Xinjiang, China [38]	(1) The legal awareness of the production unit is indifferent and refuses to execute the order to stop production. The major risk of water penetration is ignored and risky operations are demanded, in violation of regulations. Technical work is lagging, with the weak foundation of water control. The main responsibility is not implemented, and the safety management is lax. (2) Enterprise security management is not in place. The higher-level company does not attach importance to coal mine safety work and has not equipped safety-management functional departments and personnel. A safety production responsibility system has not been stablished. There are many management levels, and the security management is weakened. (3) The relevant units undertaking the technical service business of Fengyuan Coal Mine fail to perform their duties conscientiously: the technical information is inaccurate; the examination and approval of technical documents are not strictly checked; the report issued is inconsistent with the actual situation. (4) The local government and related departments of the enterprise are not strict in performing their duties of coal mine safety supervision and inspection, and do not seriously supervise the rectification of hidden coal mine safety problems.
2	"12·4" major fire accident in Diaoshuidong Coal Mine, Chongqing, China [39]	(1) The production unit contracts out the underground equipment retraction to an unqualified commissioning unit in violation of the law and does not carry out the equipment retraction according to the retraction plan and measures. The safety management of the equipment retraction is not in place, and there is a situation of receiving financing from the commissioning unit. (2) The entrusted unit does not possess the conditions for underground retraction operations and does not establish a sound production safety responsibility system and production safety rules and regulations. It is not equipped with production safety management personnel and violates the law to start fire operations underground. The site management of underground equipment retraction operations is chaotic. (3) The local government and related departments of the enterprise are not in place during the closure of the mine safety supervision. The management of the resident mine safety supervisor is not in place, and the performance of local supervision of coal mines is not conducive.
3	"8·14" serious sand and mud collapse accident in Qaidar Coal Mine, Qinghai Province, China [40]	(1) The inspection and management of safety hazards in production units are not in place, and the safety management is chaotic. The mine refuses to implement the supervision order to stop production for rectification and organizes production operations in violation of regulations. (2) The parent company does not seriously fulfill its safety management responsibilities and fails to manage and monitor the loopholes and blind areas in safety management. (3) The local government and relevant departments are not effective in implementing safety supervision responsibility and do not seriously study and solve the weakness of the emergency management department. Coal mine supervision is insufficient.

Table 2. *Cont.*

Serial Number:	Accident Name	Existing Engineering Ethics Problems
4	"9·27" major fire accident in Songzao Coal Mine, Chongqing, China [41]	(1) The production unit lacks awareness of the red line and emphasizes production over safety. Failure to implement shutdown and rectification results in the failure to eliminate hidden dangers in the belt conveyor lane as well as accidents. (2) The higher-level company's coal mine safety production management responsibility is not fully implemented. It has not learned any lessons from frequent accidents in recent years and has not taken effective measures to improve the safety production of coal mines. (3) The relevant departments of the company have unsound material procurement systems, procurement inquiries, and delivery acceptance violations. The tape used in the purchased belt conveyor is a counterfeit and shoddy product. (4) The management and supervision of local governments and relevant departments are not efficient. Supervising and guiding coal mining enterprises' safety risk research and judgment, and hidden danger investigation and management is not comprehensive enough, and it is not strong enough to promote coal mining enterprises to implement the main responsibility for safety production.

In addition to the accidents that occurred above, we also collected classic projects for students to learn about promoting ethical behavior in practice. In China, in order to promote the intelligent construction of coal, the coal industry introduced Harmony OS. The application process showed that Mine Harmony OS could make the equipment more intelligent, quickly find problems and provide an early warning, and effectively improve the safety production efficiency of coal mine and equipment operation and maintenance efficiency [42]. In other regions, such as Poland, we have also learned how former post-mining waste dumps are handled locally, and analyzing the handling of stored coal mine waste in this region can help students better understand the ethical responsibilities of mining engineers [43]. The Technical University of Ostrava (Czech Republic) presented research on the safe exploitation of coal tailings after land reclamation in abandoned mining areas [44].

Mining engineers can not only cause serious engineering accidents but can also carry out actions that are conducive to the development of the industry. For this reason, it is necessary to permit them to understand the implementation of specific cases, which can also point out the direction of their future behavior.

3.2.2. Simulation Analysis of Mining Engineering Risks in Production Scenarios and Scenario Optimization

Mining engineering focuses on practicality, and engineers should learn professional and technical skills, and pay attention to the impact of mining engineering implementation on people, society, and environments. Engineers must design and implement reasonable engineering technology solutions under certain external constraints (hydrogeological conditions, natural disasters, and actual conditions of mining) in the practice of simulated mining engineering cases. This can improve the overall thinking ability of engineers on the scheme design, permitting them to obtain practical experience and understanding of the ethical dilemmas and contradictions in the above cases. The legal awareness and ethical responsibility awareness of mining safety can be improved by including the roles of designers, decision-makers, and responsible persons, which lays the foundation for solving the complex ethical issues in practical mining engineering.

3.2.3. Learning the Idea of Sustainable Development of Mining Engineering in Ecological Restoration and Management

Mining production inevitably causes a certain impact on the environment. The continuous large-scale development of mining operations generates climate change, environmental damage, ecological disturbance, and other problems. Mining engineers should be capable of ecological restoration and governance, and be fundamentally aware of the adverse impacts of engineering on the environment. Based on the idea of sustainable development, we should reduce the damage of engineering activities on the environment, from program design to decision making, and change the passive repair of environmental damage into active damage reduction before implementing the program.

4. Exploring the Path to Solve the Ethical Problems of Mining Engineering

Promoting high-quality development of the mining industry is an inherent requirement and a real need for the current development of China. China's mining engineering development is facing the contradiction between the aggravation of disaster threats and ensuring safety during production, the contradiction between mining overcapacity and the lack of advanced and efficient productivity, the contradiction between mineral resources development and green development, and the contradiction between the high proportion of fossil energy and the carbon-neutral target. Therefore, mining engineering must be led by the new development concept and actively adapt to the development trend of the new round of scientific and technological revolution and industrial changes. The construction of a modern, safe, efficient, low-carbon, and green coal-utilization technology system should be accelerated to lead the coal industry to a high-quality development path with high-tech characteristics (see Figure 5).

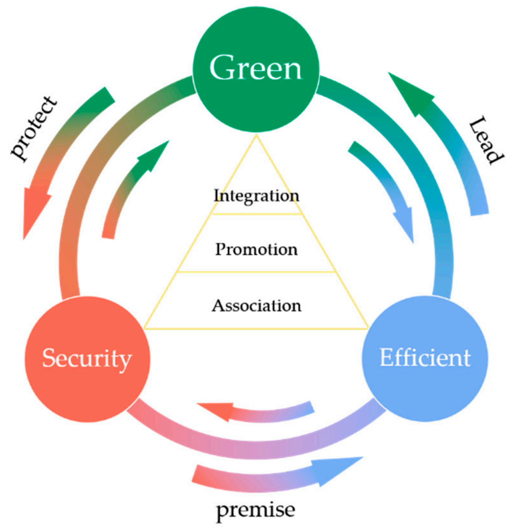

Figure 5. High-quality development of mining engineering based on the safe, efficient, and green concept.

4.1. Exploring the Ethical Issues of Mining Engineering under the Concept of Safety Development

4.1.1. Mine Production Safety

The awareness of safety ethics in mining engineering is continuously deepening with the continuous advancement of mine safety governance, the update of mining technology and equipment, as well as the system of national supervision, local supervision, and enterprise responsibility. However, the current energy transition and development pose greater challenges to mine safety. The safety situation of coal mines is still severe, and the above-mentioned accidents occur from time to time. Accidents caused by hydrological and geological conditions only account for a small part of the accidents. Analysis shows that most of the accidents are mainly due to the poor establishment of the concept of safe development and the lack of implementation of the primary responsibility of enterprises, which results in improper deployment of workers, unfavorable company and local supervision, and other human ethical elements. Some enterprises and engineers are driven by improper interests and ignore laws and regulations, which leads to illegal behaviors such as over-strength mining, coal mine over-layer and over-boundary mining, and "multiple mining with one permit" in non-coal mines [45]. This breaks the safety bottom line and increases the risk of mine accidents.

Mine safety construction is a key factor for safe mining and a comprehensive reflection of many factors such as government participation, public participation, and enterprise management. Safety risks can be reduced and mine safety accidents can be curbed by using professional ethical knowledge to analyze possible safety and ethical problems in the process of mine production, establishing responsibility and legal awareness, and completing engineering risk management programs.

4.1.2. Energy Supply Security

Energy security is an important part of national security and is related to future peaceful development. Currently, there is a risk of supply imbalance in the world energy system as well as country-specific trade risks due to the international situation and emergencies such as the novel coronavirus pandemic, which will increase the risk of energy security in China. China's economy has been recovering steadily from the domestic situation in 2021, under the normalized prevention and control of the pandemic, and the rising energy demand has led to tight coal supply and demand. Some places have experienced power rationing.

Current new energy safety and reliability are low and ensuring the safety of the coal supply is the key work of the government. Mining engineers and technicians should complete the following aspects: abiding by professional ethics and norms of the overall situation, providing a useful decision basis for the healthy and stable operation of the domestic energy system and orderly adjustment of the energy structure, ensuring the stable release of coal production capacity, and strengthening coal safety support and protection.

4.2. Exploring the Ethical Issues of Mining Engineering under the Concept of Efficient Development

The development of coal mine intelligence is still at the primary stage, and there are certain shortcomings, or even gaps, in the basic theory of intelligent mining, equipment linkage, intelligent sensing, and decision making [46,47]. Integration with a new generation of information technology must also be strengthened. Efficient innovative technologies that enhance the economic benefits of the mining industry also bring certain ethical dilemmas: intelligent technologies encounter difficulty when dealing with complex ethical dilemmas of human beings; intensive production generates fewer people with greater ethical responsibilities; the engineering risks of innovative science and technology applications; and digital technology abuse.

Mining companies should accelerate the construction of intelligent decision-making, production, and operation systems, and improve digital governance capabilities, the technological innovation system of industry, academia, and research. The key lies in clarifying ethical responsibilities and observing ethical principles, establishing scientific and technological innovation, efficient production based on the ethical concept of putting people first and promoting human welfare, and implementing the ethical responsibilities of actors in production activities. This requires (1) more proactive participation of efficient-production mining subjects in science and technology innovation and taking into full consideration factors such as interdisciplinary intersection, and complex and uncertain environments; (2) attaching great importance to human–human and human–institution systems and fully implementing the undertaking of ultimate ethical responsibility; and (3) cultivating ethical awareness of innovative researchers and strengthening their ability to deal with ethical issues.

4.3. Exploring the Ethical Issues of Mining Engineering under the Concept of Green Development

Mining engineering is gradually moving towards a green development route with the increased intensity and scale of mineral resource development [48]. The brutal development of the mining industry has become a thing of the past, and green transformation has become one of the important responsibilities of the mining industry with the participation of the government and the public. The practice of green mining technologies such as water conservation mining [49], pillarless coal mining [50], backfill mining [51–53], utilization of abandoned mines [54,55], and mine ecological restoration technology [56] is beneficial to the green development of coal. The current practice of mining engineering ethics under the concept of green development still exists against the path of green development and professional ethics, due to the intersectionality and complexity of mining engineering, the stage of professional ethics cultivation of relevant personnel, and other practical factors.

In addition to establishing correct green ethical values for engineers and technicians under green development, the following goals must be achieved: (1) Strengthen engineering supervision and strictly implement supervision and monitoring responsibilities in three places (the state, local, and enterprises), and strengthen third-party supervision (e.g., media). (2) Promote environmental and ethical assessment of the mining engineering industry and disclose supervision information during construction to better help the public understand the impact of mining projects around them. This can raise their ethical awareness to protect their interests and environmental interests. The driving force and binding force of engineering ethics in the green transformation of the mining industry are reinforced through the above measures to provide basic support for the green development of mining engineering in China.

4.4. Exploring the Ethical Issues of Mining Engineering under the Concept of Low-Carbon Development

The concept of low-carbon development is mainly practiced from two perspectives. One is to improve mineral resources and reduce carbon emissions in the process of mining and for low-carbon mining production [57,58]. The second is to strengthen innovation, research, and development of new carbon capture, storage, and utilization technologies. A gap still exists between the current situation of the coal industry and the vision of carbon neutrality; this gap is constituted by a mismatch of standards and norms, imperfect regulatory policies, and technology development in its infancy, which poses a greater challenge to the clean and low-carbon transformation of China's coal industry.

On the one hand, achieving sustainable development and utilization is an inevitable path for China's mining industry. Engineers, being alert to development traps, should adhere to ethical and moral principles and make careful decisions on low-carbon transition technologies and programs. On the other hand, the ethical evaluation of low-carbon measures should be carried out to strengthen the division of ethical responsibilities and supervise the research and development of low-carbon mining technologies in the coal sector.

5. Mining Engineering Ethics Construction Path

5.1. Establishing a Sound Ethical Framework for Mining Engineering

A perfect mining engineering ethical system should be established to ensure that mining engineers have better consistency and operability when dealing with ethical issues. New analytical ideas are provided to solve ethical dilemmas in mining engineering from the perspective of ethics and morality.

5.2. Establishing an Engineering Code of Ethics with Mining Characteristics

The American Society of Civil Engineers (ASCE) and the Institution of Civil Engineers (ICE) in the UK possess sound professional ethics charters for engineers [20]. Fewer domestic codes of ethics have been developed, and more general and subdivided codes are still at the compilation stage [14]. It is necessary to deeply explore Chinese philosophical thoughts [59] and ethical codes, combine the similarities and differences in decision making and practice between mining engineering and other engineering fields, and form engineering ethical codes with mining characteristics, according to the characteristics of mining engineering.

5.3. Establishing a New Era of an Ethics Talent Training Program in Mining

It is necessary to strengthen the training of mining talents and provide effective and continuous training on different ethical issues for key personnel, such as mine supervisory department personnel, enterprise leaders, operation personnel, and scientific researchers. In addition, an ethical talent training system for mining in the new era must be established—one that keeps pace with the times.

5.4. Establishing a Perfect Ethical Supervision System for Mining Projects

It is necessary to strengthen the supervision of mining engineering and establish a perfect ethical supervision and management system of mining engineering [60]. The supervision responsibilities of engineers, enterprises, government, etc., must be strictly implemented, and third-party supervision, such as that of the media, must be introduced when necessary. The formation of community of interests in mining resources must be promoted, and responsibility and legal awareness must be raised in all sectors of mining engineering.

6. Conclusions

Ethics is crucial to mining engineering, but the empirical study of ethics has revealed shortcomings in the education of mining engineering ethics and ways to increase mining engineering ethics under the new development concept.

On the one hand, this work respects the law of natural economic development and combines the characteristics of mining engineering, offering an initial exploration of mining engineering ethics with mining characteristics and Chinese features. On the other hand, it advocated amendments to the code of ethics for mining engineering and provided professional and systematic guidance for mining engineers and mining engineering practice. Thereby, the work promotes engineering ethics in the mining industry and cultivates more professionals with a consciousness of ethical responsibilities, which is beneficial to the high-quality development of mining engineering in China.

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