

Exploring the connotation and development of ethical responsibility in engineering practice

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Abstract

With the rapid development of technology, the impact of engineering activities on society is increasingly significant, requiring engineers to consider the overall social interests in their engineering practices. Therefore, the ethical responsibility of engineers has become an important topic. This paper explores the connotation and development of ethical responsibility in engineering practice and analyzes its practical application. Using literature review and case study as research methods, the paper examines the specific connotation and coping strategies of ethical responsibility in engineering practice by reviewing relevant literature and real cases. It concludes that ethical responsibility in engineering practice includes compliance with laws and regulations, respect for human rights and social justice, pursuit of technological and professional excellence, emphasis on sustainable development and environmental protection, as well as enhancing transparency and honesty. The development of ethical responsibility requires strengthening engineering ethics education and focusing on international communication and cooperation under the influence of globalization. By adhering to ethical responsibility, engineering practice can promote harmonious social development, protect the environment, and foster sustainable development, demonstrating the importance of the continuous development of ethical responsibility in engineering practice.

Keywords

Engineering Practice; Engineering Ethics; Ethical Responsibility; Connotation and Development

1. The connotation of ethical responsibility in engineering practice

1.1 Ethical Responsibility for Compliance with Laws and Regulations

In engineering practice, the ethical responsibility for compliance with laws and regulations is an important duty of engineers and also a key factor in ensuring the smooth progress of projects and maintaining corporate reputation. It encompasses various obligations and requirements, mainly including the following aspects:

Understanding and complying with the laws and regulations applicable to engineering practice: Engineers should have an in-depth understanding of the laws and regulations relevant to their work, including the legal system, industry standards, and regulatory documents. They should be aware of the scope of application of relevant laws, specific requirements, and the specific procedures for implementation.

Obligations and responsibilities for compliance with laws and regulations: Engineers have the responsibility to ensure that their work complies with the requirements of laws and regulations. They should adhere to the laws and regulations of their country and region, execute contracts and agreements, and ensure that engineering projects are carried out in compliance with the law. Additionally, they should also comply with industry standards, ethical standards, and company rules and regulations.

Ethical Dilemmas in Handling Legal and Regulatory Conflicts: Sometimes, engineers may face conflicts between their obligations to comply with laws and regulations and other ethical and professional responsibilities. In such situations, they need to make ethical choices, weighing different interests and responsibilities, which requires engineers to maintain professional judgment and moral decision-making in ethical dilemmas, ensuring maximum compliance with laws while minimizing any possible negative impacts.

The ethical responsibility to comply with laws and regulations is very important. In protecting public interests and safety, by adhering to laws and regulations, engineers can ensure that their engineering practices meet requirements for safety, reliability, and sustainability during the design, construction, and operation processes, avoiding engineering accidents and casualties; in upholding business ethics and professional reputation, compliance with laws and regulations is not only an ethical requirement but also the foundation for maintaining the reputation of individual engineers and the industry. Law-abiding and trustworthy engineers can establish good credibility and reputation, gaining trust from clients and partners; in avoiding legal and regulatory risks, violating laws and regulations can lead to legal risks and liabilities, which may result in litigation, economic losses, and reputational damage. Compliance with laws and regulations helps engineers avoid potential risks and issues, maintaining legally compliant engineering practices.

By gaining a deep understanding of applicable laws and regulations, adhering to the requirements of laws and regulations, and making ethical choices in handling legal and regulatory conflicts, engineers can ensure the legality and compliance of their actions and contribute to the sustainable development of engineering practices and the protection of public interests.

1.2 The Ethical Responsibility to Respect Human Rights and Social Justice

Firstly, engineers have an obligation to respect and promote the realization of hu-

man rights, including but not limited to fundamental human rights, labor rights, privacy protection, equal treatment, and freedom from discrimination. They should avoid designing or implementing engineering practices that may infringe on human rights and strive to ensure that projects are fair and just for all stakeholders. Secondly, engineers have a responsibility to consider issues of social justice in engineering decisions and actions. They should endeavor to design and implement fair engineering projects, reducing the occurrence of social inequality and injustice. Finally, engineers should conduct comprehensive social impact assessments to evaluate the impact of their engineering projects on society and human rights. They should also respect and appreciate the existence of different cultures, religions, and perspectives, promote diversity and inclusivity in engineering practices, avoid discrimination and prejudice, and ensure that engineering projects are fair and inclusive for all people.

Engineers' respect for human rights and social justice contributes to the maintenance of social harmony and stability, reduces the risk of social inequality and conflict, and helps build a just and harmonious environment for society. At the same time, it also enhances the professional ethics and reputation of engineers.

1.3 Ethical Responsibility for Pursuing Technological and Professional Excellence

Striving for technological and professional excellence in engineering practice is a complex and multidimensional issue, involving technological innovation, service quality, and learning development at multiple levels. At the technological innovation level, engineers have an ethical responsibility to promote technological innovation and optimization, emphasizing shared responsibility among multiple stakeholders to achieve a virtuous cycle of technological progress and social development. They should actively participate in research and development and innovation projects, seeking more efficient, sustainable, and innovative solutions to drive technological and industry advancement. This means engineers must not only pursue technical excellence but also consider the societal impact of their work, ensuring that technological applications do not have negative consequences. At the service quality level, engineers should strive for excellence in their work and service quality, adhering to industry norms and standards, developing reliable design and engineering solutions, and ensuring project quality and reliability, while taking measures to protect their intellectual property and technical security. At the learning development level, engineers have an obligation to continuously learn and develop their professional skills and knowledge to adapt to evolving technologies and market demands. They should actively participate in training, seminars, and professional exchanges to continuously improve their technical expertise and professional competence.[1], Through continuous learning and professional development, promoting technological innovation and optimization, and providing high-quality work and services, en-

engineers can enhance their own and their industry's competitiveness, and contribute to technological advancement and social development.

1.4 Ethical responsibility for sustainable development and environmental protection

Engineering activities, as a form of modifying nature, fundamentally require respect for and protection of nature, promoting harmonious human-nature relationships[2]. This means engineers must integrate natural ethical responsibility into engineering decision-making, implementation, and management stages to ensure that engineering activities do not harm the natural environment but instead contribute to the restoration and sustainable use of natural resources. During the engineering design phase, it is a critical period that determines the various potential impacts of engineering projects. Therefore, green design and participatory design have become important guiding directions for engineering design. This not only helps reduce the negative environmental impact of engineering activities but also promotes public participation in engineering projects, collectively advancing the development of green engineering.

As direct participants in engineering activities, engineers should take on the ethical responsibility of protecting the natural environment, promoting social well-being, and caring for the well-being of future generations. This requires engineers to continuously improve their ethical awareness and professional capabilities in decision-making, design, implementation, and management processes, to achieve a balance between engineering activities and environmental protection, and to promote harmonious coexistence between human society and the natural environment.

1.5 Enhancing Transparency and Ethical Responsibility for Integrity

As professionals, engineers must adhere to the principles of honesty and loyalty throughout their careers. This is not only a requirement of personal professional ethics but also a demonstration of responsibility to society and the public. Engineering activities directly relate to the safety, health, and welfare of the public, therefore, when making technical decisions and implementing projects, engineers must ensure the transparency and honesty of their actions to protect the public interest. The importance of informed consent in engineering practice cannot be overlooked. Engineering projects often involve broad social impacts, so ensuring that all stakeholders, especially the public most affected by the project, can fully understand the project information and give consent is key to safeguarding public rights. This not only reflects respect for individual freedom and rights but also serves as an important means to advance engineering practice and deepen engineering ethics research. By establishing and improving participation mechanisms that protect the public's right to informed consent and oversight rights, as well as constructing integrated frameworks for engineering decision-making, the dilemma of balancing pub-

lic ethical responsibility can be effectively addressed, promoting the manifestation and behavior of ethical responsibility in engineering practice.[3] This approach not only upholds the freedom and rights of individuals but also facilitates the advancement of engineering practice and the deepening of engineering ethics research. Enhancing transparency and ethical responsibility for integrity requires the collective effort of engineers, the public, and all sectors of society. By upholding professional ethics, respecting informed consent, and establishing sound ethical systems, the ethical standards in engineering practice can be effectively improved, protecting the public interest and promoting overall societal well-being.

2. Development of Ethical Responsibility in Engineering Practice

2.1 Historical Evolution and Context of Ethical Responsibility

The historical evolution and context of ethical responsibility in engineering practice is a complex and multidimensional topic, involving technology, society, culture, and more. From the early days of absolute obedience to military commands to modern engineers taking responsibility for human health, safety, and welfare, this process not only reflects the enhancement of technological power and changes in societal needs but also demonstrates the deepening and expansion of human understanding of ethical responsibility.

In the early 20th century, the ethical responsibility of engineers was primarily focused on absolute obedience to the military. With the development of society and technological progress, engineers began to take on broader responsibilities, expanding from initial loyalty obligations to universal responsibilities[4]. This transformation marked the rise of the technocracy movement, as the role of engineers gradually shifted from technical implementers to drivers of social development.

Entering the mid-20th century, with the emergence of global ecological crises, engineers' ethical responsibility further expanded to include responsibility for nature. During this period, the systematic conduct of engineering activities and the rapid spread of technological innovation led to the creation of a "second nature" by engineering products. Engineers needed to ensure technological progress while also considering the impact on the ecological environment.

In China, the development of engineering ethics norms has gone through three periods: incubation and creation, reconstruction and stagnation, and recovery and development. This developmental path not only reflects the gradual improvement of China's engineering ethics norms but also Reflects the enhancement of Chinese society's emphasis on the professional integrity of engineers and the concept of saving the nation through industrialization[5].

In recent years, with the development of new technologies such as artificial intelligence, engineering ethics norms are also evolving in new directions, such as promoting the internationalization of engineering ethics norms and moving towards artificial intelligence. These changes indicate that engineering ethics norms will con-

tinue to adapt to new technological and social environments to better guide the professional activities of engineers.

Overall, the historical evolution and context of ethical responsibility in engineering practice is a process of continuous adaptation to technological advancements and changes in social needs. This process involves not only changes at the technological and social levels but also a deepening and expansion of human understanding of ethical responsibility. Through continuous reflection and adjustment, engineering ethics norms aim to better guide the professional activities of engineers, ensuring that engineering practices can promote the sustainable development of human society.

2.2 The Impact of Globalization on Ethical Responsibility

Under the backdrop of globalization, the ethical responsibilities in engineering practice are facing unprecedented challenges. Globalization has not only promoted the exchange of technology and knowledge but also brought diversity and complexity in culture, values, and work ethics. Globalization has made engineering projects no longer confined to a single region but rather span across different countries and cultures, introducing a dual characteristic of local and global. The conflict and coordination of this characteristic have become one of the main challenges in engineering practice.

Globalization has intensified cross-cultural communication, requiring engineers to consider ethical standards and values in different cultural contexts. For example, in the United States, professional autonomy is regarded as an important component of engineering ethics, but in some other cultures, individual autonomy is not considered a virtue[6]. This indicates that in globalized engineering practices, engineers need to possess cross-cultural understanding capabilities to maintain their professional autonomy while respecting different cultural values.

To address the challenges of globalization, engineering ethics education is particularly important. Globalization may require engineers to consider broader social, economic, and environmental factors when making ethical decisions, placing higher demands on their ethical judgment capabilities. For instance, in international engineering projects, engineers may need to find a balance between adhering to the requirements of funders and meeting environmental conditions in the host country. This may lead to compromises in the engineering design and implementation process, thereby affecting the ethical nature of the project[7]. Engineering ethics education can cultivate engineers' global perspectives, help them identify ethical issues related to engineering practices, and master appropriate ethical standards for engineering evaluation. This enables engineers to handle ethical understanding and integration issues in cross-cultural engineering collaborations.

In summary, globalization has presented new challenges to the ethical responsibilities in engineering practice, including conflicts between local and global, ethical un-

derstanding and integration issues across different cultures, and an increase in engineering ethics risks. Addressing these challenges requires strengthening engineering ethics education and cultivating engineers with a global vision and sense of responsibility to ensure the smooth implementation and sustainable development of engineering projects.

2.3 Education and Cultivation of Ethical Responsibility

The importance of engineering ethics education is self-evident. Engineers not only need solid professional knowledge and skills but must also possess good moral character and social responsibility, including basic qualities such as adherence to laws and regulations and honesty. Engineering ethics education can help students understand and comply with engineering professional ethics and norms, fulfilling their professional responsibilities.

The objectives of engineering ethics education should be clearly defined, namely to enhance students' ethical awareness, mastery of ethical norms, and ethical decision-making abilities. This requires educational content not only to cover ethical issues, conflicts, and influencing factors in engineering decision-making processes but also to emphasize the principles of "using technology to carry values" and "using values to guide technology," i.e., by adjusting the curriculum system and teaching content, to promote the integration of engineering technology education and engineering ethics education.[8]. The goal of engineering ethics education is comprehensive, aiming not only to enhance students' ethical consciousness and humanistic awareness but also to cultivate their correct values and sense of responsibility. For example, Tsinghua University emphasizes that engineering education should not only prioritize knowledge and skills but also focus on the cultivation of values and integrity.

Engineering ethics education requires continuous innovation and improvement in its content and methods. Comparative analysis can be conducted on the development history of engineering ethics education both domestically and internationally, its educational characteristics, teaching methods, and content innovation, to optimize curriculum content, build case libraries, implement blended teaching reforms, and strengthen faculty development. Additionally, teaching models that integrate engineering ethics education into engineering training and practical training can be adopted to enhance students' ethical awareness and effectively improve their engineering literacy. Furthermore, future-oriented engineering ethics education should be emphasized, focusing on future ethical issues in engineering, their characteristics, and the scope and emphasis of future engineering ethics.[9].

Building the teacher team, especially in terms of professional ethics and ethics education, is crucial for the success of engineering ethics education. This not only requires the personal efforts of teachers but also systematic training and support, as well as emphasis and investment at the school and societal levels, to improve the

engineering ethics quality of teachers, strengthen relevant curriculum development, and integrate teaching elements. Therefore, strengthening the teacher team, especially enhancing its professional ethics and ethics education, is the key to ensuring the success of engineering ethics education.

In summary, the education and cultivation of ethical responsibility in engineering practice is a systematic project that requires comprehensive consideration and design from multiple aspects such as educational objectives, teaching methods, and teacher team building, to cultivate engineering and technical talents with high ethical responsibility.

2.4 Ethical Challenges and Countermeasures in Engineering Practice

(1) The challenge of balancing technological innovation and ethical responsibility: With the rapid development of technology, engineers face the issue of how to promote technological innovation while ensuring that technological progress interacts positively with social development. The concept of responsible innovation emphasizes shared responsibility among multiple stakeholders, which requires engineers not only to focus on technological development but also to consider its impact on society, the environment, and other aspects.

(2) Addressing the relationship between engineering projects and society and the environment: Engineering activities must not only consider their own interests but also the overall interests of society, and sometimes even sacrifice personal interests for the public good. This involves issues of safety ethical responsibility, environmental ethical responsibility, and social ethical responsibility. To resolve these issues, it is first necessary to strengthen engineering ethics development, improve the ethical standards of engineering practitioners, and better fulfill ethical responsibilities; second, to enhance ethical education centered on "responsibility," with planned, organized, and purposeful cultivation of engineers' sense of responsibility toward others, society, and the environment; and finally, to establish and refine punitive systems for violating ethical responsibilities.

(3) Traditional theoretical frameworks for engineering ethics norms have limitations: These traditional frameworks are increasingly inadequate in providing concrete methodological guidance for real-world engineering practices. This necessitates theoretical innovation by engineers, such as integrating ecological integration engineering with ethics and carefully considering the priority of ethical behavior in engineering activities, to overcome the limitations of traditional theoretical frameworks and connect them with the diversity of modern society and the complexity of engineering practices.

3. Practical Cases of Ethical Responsibility in Engineering Practice

3.1 Analysis of Cases Involving Violations of Ethical Responsibility in

Engineering Practice

The Xiangshui 3.21 major explosion accident occurred in 2019, involving a chemical plant in the Xiangshui Economic and Technological Development Zone in Jiangsu Province. This accident resulted in 78 deaths, 640 injuries, the collapse of multiple buildings, and brought significant losses to the surrounding environment and society. An analysis of this accident reveals the following unethical behaviors:

Insufficient safety risk assessment: It was reported that the chemical plant had serious safety hazards in its production process, including improper material storage, failures in the automatic control system, and hazardous chemical leaks. Engineers failed to fully assess and address these safety risks, leading to the accident.

Improper construction and operational management: After the accident, investigations revealed violations by engineers and relevant management in construction and operational management. For example, excessive use of flammable materials, failure to conduct inspections and maintenance on tanks according to regulations, and illegal operations during emissions. These violations exposed the dishonesty and illegal practices of engineers and management in engineering practice, and also reflected the failure of engineers to fulfill their ethical responsibilities to comply with laws and regulations.

Ineffective supervision: The obvious safety hazards at the plant should have been identified and rectified under the supervision of regulatory authorities. However, investigations later found that regulatory authorities were negligent in their oversight of the plant's safety, failing to promptly identify and address issues, allowing the accident to occur.

The above cases indicate that the breach of engineering ethical responsibilities led to the occurrence of the Xiangshui 3.21 major explosion accident. The responsible parties failed to fully fulfill their engineering duties, ignored safety risks, operated in violation of regulations, lacked appropriate supervision, and ultimately caused an accident with severe consequences. This case reminds us that engineers must always keep in mind their ethical responsibilities in engineering practice, prioritize the safety and interests of the public, adhere to relevant laws, regulations, and industry standards, and ensure the safety, reliability, and sustainable development of engineering projects.

3.2 Case Studies of Adhering to Ethical Responsibilities in Engineering Practice

China's Three Gorges Project is one of the world's largest hydropower projects, involving the development of hydropower in the Three Gorges region of the Yangtze River. Engineers in this project have focused on ethical responsibilities in terms of environmental protection, resettlement, and ecological restoration.

Environmental Protection: Before the construction of the Three Gorges Project, engineers conducted extensive environmental impact assessments and implemented a

series of measures to mitigate the impact on the ecological environment. For example, during the construction, they protected wildlife and plants, preserved valuable natural landscapes and historical sites, demonstrating the ethical responsibility of engineers for sustainable development and environmental protection.

Resettlement of Immigrants: Due to the construction of the Three Gorges Project, many residents need to be relocated. In this process, engineers actively participate in and promote the resettlement work, striving to minimize adverse impacts on local residents. They work to provide good living conditions, employment opportunities, and community service facilities, ensuring that immigrants are properly settled in their new homes, reflecting the ethical responsibility of engineers to respect human rights and social justice.

Emergency Rescue: The construction of the Three Gorges Project involves complex hydrological conditions and geological situations, posing certain disaster risks. During the planning and construction process, engineers have fully considered disaster prevention and emergency rescue measures to ensure timely and effective actions can be taken in the event of emergencies, protecting people's lives and property. This also reflects the ethical responsibility of engineers to respect human rights.

These cases demonstrate that the engineers in the Three Gorges Project have made efforts to uphold ethical responsibilities. They focus on ecological environmental protection, the resettlement of immigrants, and disaster prevention, actively considering the interests of society, the environment, and the people in the planning, design, and construction of the project. This ethical practice not only helps protect the ecological environment and the well-being of the people but also, to some extent, enhances the sustainability and social acceptability of the engineering project. Similarly, this also reminds other engineers to always keep in mind their ethical responsibilities, focusing on social responsibility and sustainable development goals in similar large-scale engineering projects.

4. Conclusion

4.1 Summary of Ethical Responsibilities in Engineering Practice

Ethical responsibilities in engineering practice include adhering to laws and regulations, respecting human rights and social justice, pursuing technological and professional excellence, focusing on sustainable development and environmental protection, and enhancing transparency and integrity. Engineers should ensure compliance with applicable laws and regulations in projects, while respecting and promoting the realization of human rights and considering issues of social justice. They must also strive to improve their technical and professional standards, driving technological innovation and optimization. Additionally, engineers must focus on sustainable development and environmental protection, reducing the consumption of natural resources and pollution through environmentally friendly engineering solutions. Finally, they should conduct engineering practice in a transparent and

honest manner, engaging in effective communication with project stakeholders to build trust relationships.

These ethical responsibilities are interconnected and mutually supportive, ensuring that engineering practice maintains a good state in terms of legal compliance, public interest, technical standards, sustainable development, and trust-building. Engineers should actively pursue these ethical responsibilities, striving to fulfill their responsibilities to society, the environment, and project stakeholders, and promoting the comprehensive development of the engineering industry and the realization of public interests.

4.2 The Importance of the Continuous Development of Ethical Responsibilities in Engineering Practice

The continuous development of ethical responsibility in engineering practice is crucial for ensuring the safety, sustainability, and social responsibility of engineering activities. With the rapid advancement of technology and the increasing social impact of engineering activities, the strengthening of engineers' ethical responsibility, as core participants in engineering activities, has become particularly important[10]. Ethical responsibility is not only related to the success of engineering projects but also directly affects social well-being and environmental sustainability.

Firstly, ethical responsibility is one of the fundamental principles that engineers must consider when practicing engineering. This includes, but is not limited to, protecting human health, safety, and welfare, as well as protecting the environment and making reasonable use of resources[11]. With the development of science and technology, the risks and challenges brought by engineering activities are also increasing, which requires engineers to have a high sense of ethical responsibility to ensure that engineering activities do not have a negative impact on society and the environment.

Secondly, the continuous development of ethical responsibility helps to enhance the professional ethics of engineers and promote the healthy development of engineering practices. By strengthening engineering ethics education, engineers can be cultivated to develop a sense of ethical responsibility, enabling them to make decisions that meet ethical standards when facing complex engineering issues. Additionally, the continuous development of ethical responsibility can foster better interaction among engineers and between engineers and the public, enhancing the social acceptance and support for engineering projects.

However, there are still some issues in China regarding the education of engineers' ethical responsibility, such as the disconnect between educational content and actual engineering needs, and the singularity of educational methods. The existence of these problems severely restricts the enhancement of engineers' awareness of ethical responsibility and the healthy development of engineering practice. Therefore, it is necessary to work together at multiple levels, including national policies, univer-

sity education, and social practice, to strengthen the education of engineers' ethical responsibility, improve their sense of ethical responsibility, and thus promote the sustainable and healthy development of engineering practice[12].

Overall, the continuous development of ethical responsibility in engineering practice is of great significance for ensuring the safety, sustainability, and social responsibility of engineering activities. By strengthening the education of engineers' ethical responsibility, it can effectively enhance their sense of ethical responsibility, promote the healthy development of engineering practice, and bring more well-being and progress to society. development, to bring more well-being and progress to society.

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