

Research Article

Embedded Education Model for Postgraduate Chemical Engineering Ethics Based on Educational Community

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Abstract

As engineering exerts an increasingly profound impact on human society and the natural world, large scale, comprehensiveness, complexity, and growing engineering influence have become prominent characteristics of modern engineering. Putting the public's safety, health, and well-being first has become a universally observed principle in the international engineering community. Correspondingly, engineering ethics literacy and ethical judgment ability have evolved into core competencies for engineering professionals, and engineering ethics education has thus become an essential component in the cultivation of professional master's degree postgraduates. This paper analyzes the problems existing in engineering ethics education for postgraduates majoring in chemical engineering at local colleges and universities in China. To address these issues, the study proposes establishing an engineering ethics education community in the field of chemical engineering and constructing as well as implementing an embedded engineering ethics education system. Firstly, it proposes establishing a chemical engineering ethics education community to form a joint force for engineering ethics education. Secondly, it suggests building an embedded engineering ethics education system featuring the framework of "course foundation-guidance improvement-practice leap". Finally, it advocates building a composite teaching team and enriching engineering ethics education resources. Through teaching reform and practice, this study aims to address the common difficulties in engineering ethics education for chemical engineering postgraduates and enhance the quality of talent cultivation.

Keywords

Educational Community, Chemical Engineering, Postgraduate Education, Engineering Ethics, Embedded Teaching Model

1. Introduction

The chemical industry occupies an important position in the national economy and is a basic and pillar industry in many countries. The development speed and scale of the chemical industry have an important impact on various fields

of the social economy. At the same time, there are certain potential safety hazards and frequent accidents in the production process of the chemical industry, which have triggered a series of related ethical issues, such as environmental

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ethics issues, interest ethics issues, and responsibility ethics issues. As a moral principle system for engineering practice, engineering ethics is the applied ethics of engineering technology, whose core lies in putting the safety, health, and well-being of the public first [1, 2]. Only chemical engineers with high engineering ethics literacy can consciously apply the ethical principle of "putting the safety, health, and well-being of the public first" throughout the entire cycle of engineering activities, and then make comprehensive and accurate judgments and decisions in chemical production, engineering practice, and scientific research to provide strong support for practical activities [3-5].

In the "Notice on Forwarding the 'Guiding Opinions on Formulating Training Programs for Engineering Master's Degree Postgraduates' and Its Explanation" (Document No. 14 [2018] of the Office of the Academic Degrees Committee of the State Council), "Engineering Ethics" was officially included in the public compulsory courses for engineering master's degree postgraduates. On May 28, 2020, the Ministry of Education issued the "Guidelines for the Construction of Ideological and Political Education in Higher Education Curriculum". The Guidelines mentioned that attention should be paid to strengthening students' engineering ethics education, cultivating their craftsmanship spirit of striving for excellence, and inspiring their feelings of serving the country through science and technology and sense of mission [6]. The postgraduate stage is the final preparation stage for students to gradually shape their spirit, morality, and personality before entering society. Therefore, embedding engineering ethics education into the whole process of postgraduate teaching to realize full-process and all-round education is of great significance for cultivating chemical engineering talents with ethical awareness and a sense of responsibility.

At the 2014 Tsinghua University Engineering Ethics Education Forum, experts called for engineering education to make up for the shortcomings in ethics and put forward the "trinity" educational concept of knowledge transmission, ability cultivation, and value shaping. Tsinghua University has offered "Chemical Engineering Ethics" for postgraduates since 2015, and has successively compiled more than 20 Chinese cases of engineering ethics at different stages (including research and development, planning, design, construction, operation, maintenance, emergency response, and decommissioning) [7, 8]; Guangdong University of Technology has established a "dual-line integration" teaching model for "Engineering Ethics" under the background of new engineering, realizing the organic integration and complementarity of online and offline teaching [9, 10]; Beijing University of Chemical Technology has applied situational drama performances to the teaching of "Engineering Ethics" by guiding students to create scripts and perform on-site [11]. However, the above teaching research and reforms are mostly limited to the construction of the "Engineering Ethics" course, and there is still the problem of an imperfect engineering ethics education system.

Establishing an educational community in a region to enable members of the educational community to develop together in mutual cooperation, research, and practice can promote the high-quality and balanced development of educational resources [12, 13]. Engineering ethics is a model of interdisciplinary collaborative research, which can promote interdisciplinary cooperation in education and teaching among various schools in China and drive innovative development [14]. Therefore, it is necessary to mobilize forces and resources from an overall perspective, understand the differences between engineering ethics teachers, professional course teachers, and other types of teachers, as well as between engineering ethics teachers in different universities, advocate in-depth integration and intersection between multiple disciplines and multiple universities, strengthen the collaboration and cooperation among communities, and exert the effect that "integration is greater than the sum of its parts". Based on this, this paper aims to solve the common problems in engineering ethics education for chemical engineering postgraduates and improve the training quality of chemical engineering postgraduates by establishing an engineering ethics education community in the field of chemical engineering and constructing and implementing an embedded engineering ethics education system.

2. Problems in Engineering Ethics Education for Postgraduates Majoring in Colleges and Universities

As the impact of engineering on human society and nature becomes more far-reaching, large-scale, comprehensive, complex, and increasing engineering influence have become important characteristics of modern engineering. Putting the safety, health, and well-being of the public first has become a universally observed principle in the international engineering community. Engineering ethics literacy and ethical judgment ability have become core competencies of engineering professionals, and engineering ethics education has become an important part of the training of professional master's degree postgraduates. However, there are still some problems in engineering ethics education for postgraduates majoring in chemical engineering in local colleges and universities [15, 16].

Problem 1: Stakeholders (social employers, schools, supervisors, and students) have inconsistent understanding of engineering ethics. The training concept of "valuing technical pursuit over value shaping" has not been fundamentally reversed, and a joint force for engineering ethics education has not yet been formed. Engineering ethics awareness is an important quality of modern chemical engineers. Social employers regard engineering ethics as an important criterion for selecting talents but lack channels to participate in engineering ethics education; colleges and universities attach importance to engineering

ethics education and have implemented the teaching of the "Engineering Ethics" course but lack more effective measures; supervisors pay more attention to students' academic output and often ignore engineering ethics education; students only complete the study of the "Engineering Ethics" course and lack more opportunities to research and practice engineering ethics issues.

Problem 2: The credits and class hours of the "Engineering Ethics" course are limited, making it difficult to comprehensively improve students' engineering ethics literacy, and the engineering ethics education system needs to be improved. At present, the "Engineering Ethics" course for professional degree postgraduates is set as a compulsory degree course with 1 credit and 16 class hours. Due to the limited class hours, the "content" is not systematic and in-depth enough; basic theories, basic concepts, and application principles are taught systematically, and relevant cases in the chemical engineering field are used, but there are problems such as insufficient classic cases and a small number of cases in the chemical engineering field, and relatively difficult course construction; there is a problem of "being ineffective", as knowledge and cases are not deeply integrated with chemical engineering professional courses.

Problem 3: There is a contradiction between the complexity of chemical engineering ethics issues, the singularity of teachers' knowledge structures, and the scarcity

of high-quality teaching resources. As a course that studies the moral principles and codes of conduct of engineering and technical personnel in engineering activities, engineering ethics requires teachers to be familiar with the theoretical connotation of engineering ethics, have engineering practice experience, and be able to teach from an ethical perspective, which puts higher requirements on the knowledge structure of engineering ethics teachers; at present, there are relatively few "localized" chemical engineering ethics cases suitable for current engineering education, which need to be improved.

3. Construction and Implementation of Embedded Engineering Ethics Education Model

Colleges and universities work together to establish a chemical engineering ethics education community, focusing on exerting the function of discipline courses. They should also construct and implement an embedded engineering ethics education system to solve the common problems in engineering ethics education for chemical engineering postgraduates, thereby improving the training quality. The specific idea is shown in Figure 1.

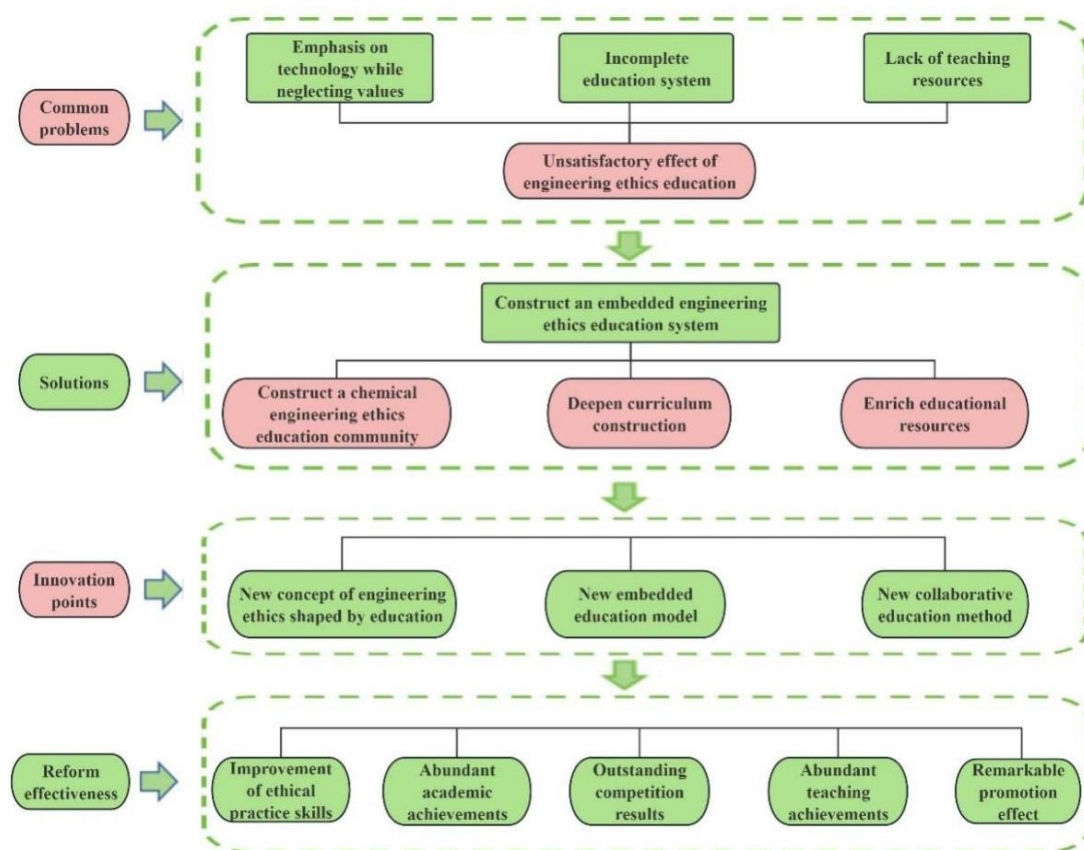


Figure 1. Ideas of Embedded Education Model for Postgraduate Chemical Engineering Ethics Based on Educational Community.

3.1. Establish a Chemical Engineering Ethics Education Community to form a Joint Force for Engineering Ethics Education

Attract the industry to participate in postgraduate engineering ethics education through industry-education integration. Invite experts and scholars from well-known universities and industry experts from leading enterprises to guide curriculum construction; enable enterprise experts to participate in postgraduate engineering ethics education through postgraduate practice education platforms; establish a chemical engineering ethics education community through university cooperation, and clarify the minimum requirements and highest pursuits of postgraduate engineering ethics education.

Enable supervisors to deeply understand the significance of postgraduate engineering ethics education through supervisor training. Strengthen university supervisors' awareness of engineering ethics education, and convey the core ideas of engineering ethics education through expert lectures, engineering ethics seminars, etc., so that supervisors can realize that in addition to professional knowledge learning, there is a course that can better improve the basic literacy of engineering students. Only by fully understanding the significance behind engineering ethics education will supervisors spend more time on postgraduates' thesis topic selection, research, and thesis writing, and improve postgraduates' engineering ethics judgment ability through supervisor guidance. The education community should support each other and adhere to cooperation, sharing, and collaborative linkage.

With the goal of party building leading scientific research for the country, strive to build a "double-strong" party branch with "strong party building and strong development" around party building leadership, sense of mission, and role models, so as to fully integrate party building with academic research and student development. In organizational activities, continuously awaken postgraduates' awareness of engineering ethics and strengthen their ideal and belief in striving for the great rejuvenation of the Chinese nation. Ultimately, industry, universities, supervisors, and students reach a shared understanding of engineering ethics, build a chemical engineering ethics education community, and form a cohesive force for engineering ethics education.

3.2. Build an Embedded Engineering Ethics Education System

Revise the postgraduate training program, regard engineering ethics literacy as a core competency for outstanding engineers in the new era, and position engineering ethics education as an important component of professional degree postgraduate training. Embed engineering ethics education into all aspects of postgraduate training, and construct an embedded engineering ethics education system featuring "curriculum-based foundation,

guidance-driven improvement, and practice-oriented leap".

- 1) Update teaching content, reform teaching methods, and innovate course assessment methods. First and foremost, explore the elements of "curriculum ideological and political education" and integrate the "salt" of "ideological and political education" into the "soup" of "Engineering Ethics" to cultivate postgraduates' scientific research literacy and professional quality. Integrate the spirit of craftsmanship, independent innovation, pursuit of excellence, red line awareness, sense of responsibility, doing a good job in mass work, carrying forward the fine traditional Chinese cultural spirit, courage to take responsibility and mission, and responsible professional virtues into each chapter of the teaching content. Furthermore, adopt case teaching, seminar teaching, mixed teaching, etc., to bring students into the situation and generate emotional resonance. Moreover, in terms of course assessment methods, a diversified assessment approach should be adopted to enable timely summary and feedback as well as in-depth exploration.
- 2) Integrate engineering ethics education into the curriculum system of chemical engineering professional education. Sort out the chapters in the courses for chemical engineering professional degree postgraduates that involve engineering ethics issues. Teachers from the engineering ethics teaching team provide "engineering ethics" related knowledge points that need to be introduced to other professional course teachers; the college and discipline organize the revision of the syllabi of relevant professional courses, and clarify the "legitimacy" of relevant content in the syllabi. Some relevant content and more cases of engineering ethics are scattered in multiple professional courses and organically integrated into classroom teaching, just like salt dissolving in water, achieving the educational effect of "moistening things silently", so that students can have a better experience, accept the concepts more easily, and be more conducive to applying them in the future. In the introduction of corresponding courses and certain chapters and sections, relevant engineering ethics knowledge is introduced as "cases" according to content needs to demonstrate the application of engineering ethics.
- 3) Integrate engineering ethics judgment into thesis topic selection, research, and writing, and improve postgraduates' engineering ethics judgment ability through supervisor guidance. Postgraduates' graduation thesis is an important task in the postgraduate stage. It is a comprehensive assessment of postgraduates' knowledge and abilities in their professional fields and an important part of the postgraduate training plan. The topic selection, research, and writing of the thesis are inseparable from the careful guidance of supervisors, and they are also important carriers for improving postgraduates' engi-

neering ethics judgment ability. Guide postgraduates to think about the sustainability of chemical engineering practice from the perspective of environmental and social sustainable development, and evaluate the possible harm and hidden dangers to humans and the environment during the product cycle. Abide by engineering ethics, understand and abide by engineering professional ethics and norms, and respect the laws and regulations of relevant countries and international peers. Establish postgraduates' concepts of noble morality, scientific spirit, engineering awareness, innovative ability, and green development, and consciously practice socialist core values. Combine moral education with professional course learning, pay attention to the important role of the chemical industry in national strategic needs, industrial chains, and the main economic battlefield, so that students can become socialist builders and successors with all-round development of morality, intelligence, physical fitness, aesthetics, and labor. Especially under the background of "double carbon", integrating engineering ethics education into thesis topic selection, research, and writing plays an important role in improving postgraduates' engineering ethics judgment ability through supervisor guidance.

- 4) Integrate engineering ethics into professional degree postgraduates' internship practice and extracurricular scientific and technological activities, so that students can achieve a leap in engineering ethics ability in practice. For outstanding engineers in the new era, since they will be engaged in chemical engineering construction projects in the future, which have complex social attributes, the cultivation of socialist core values for outstanding engineers in the new era should pay attention to both the cultivation of personal values and social values, and neither can be ignored. Otherwise, when they enter the workplace in the future, they may make decisions and take actions that violate social value requirements due to the lack of social values. Therefore, integrate engineering ethics into postgraduates' activities such as the "Internet +" College Students' Innovation and Entrepreneurship Competition, the "Challenge Cup" China College Students' Entrepreneurship Plan Competition, and the College Students' Energy Conservation and Emission Reduction Social Practice and Science and Technology Competition, so that students can achieve a leap in engineering ethics ability in practice.

3.3. Build a Composite Teaching Team and Enrich Engineering Ethics Education Resources

Through university-university cooperation and university-enterprise collaboration, establish a postgraduate engineering ethics education community, form an inter-campus teaching team. The teaching team shall strengthen the construction of the

teaching staff through measures such as "introduction and training combination, and combination of full-time and part-time teachers", support teachers to take temporary posts in enterprises, and encourage teachers to participate in innovation and entrepreneurship practices in social industries. Actively invite entrepreneurs from all walks of life, successful entrepreneurs, experts and scholars from well-known universities, and industry experts from leading enterprises to guide curriculum construction, organize teacher training, practical training, and exchanges, such as guiding curriculum construction. Introduce high-quality "Engineering Ethics" courses from Xuetang Online and implement online-offline mixed teaching; rely on the National Virtual Simulation Experimental Teaching Center to build virtual simulation teaching resources and provide postgraduates with engineering ethics practice scenarios.

Build a chemical engineering professional engineering ethics case database, select appropriate localized engineering ethics cases according to the actual situation of chemical engineering majors, and let students face the "Chinese problems" in "Chinese practice" of engineering. From cases in real research projects or chemical production, bring students into real complex situations, guide them to analyze and think from the aspects of health, safety, and environmental protection, so that they can establish the concept of abiding by engineering ethics before taking up engineering practice positions.

4. Conclusion

This paper deeply analyzes the practical problems existing in engineering ethics education for postgraduates majoring in chemical engineering in local colleges and universities, puts forward the reform ideas of the embedded engineering ethics education model, forms a joint force for engineering ethics education in the chemical engineering field by establishing an educational community, constructs an embedded engineering ethics education system of "course foundation-guidance improvement-practice leap", and forms a new concept of shaping modern chemical engineers through engineering ethics education.

After years of exploration in teaching practice, the teaching reform has achieved remarkable results. According to the follow-up feedback from graduates and the evaluation feedback from employers, the engineering ethics awareness and ethical judgment ability of postgraduates majoring in chemical engineering in relevant universities have been significantly improved: Graduates can apply engineering ethics principles and handle complex social issues in accordance with the law; the postgraduate training effect of relevant degree programs is remarkable, and the postgraduates have outstanding professional abilities, which have been unanimously recognized by employers, with many graduates growing into backbones of the industry; the number of provincial and university-level excellent dissertations, papers published in authoritative journals, and postgraduates participating in extracurricular science and technology competitions has increased year by year.

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Author Contributions

Lu Meizhen: Conceptualization, Data curation, Formal Analysis, Writing – original draft, Writing – review & editing
Yu Fengwen: Formal Analysis, Investigation, Resources
Lu Xianghong: Investigation, Resources
Liu Xuejun: Data curation, Resources
Wang Guangquan: Formal Analysis, Software
Zhang Zhiliang: Data curation, Investigation
Ai Ning: Conceptualization, Methodology, Supervision

Conflicts of Interest

The authors declare no conflicts of interest.

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