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Engineering Ethics Curriculum Development from an Engineering Philosophy Perspective: Current Challenges and Future Directions in Engineering Ethics Education Against the Backdrop of China's New Engineering Development

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Abstract:

Against the backdrop of advancing new engineering education to address the national strategy of responding to the new wave of technological and industrial transformation, cultivating talents with both outstanding engineering capabilities and noble ethical integrity has become the core mission of higher engineering education. As a crucial component in achieving this goal, the quality of engineering ethics education curriculum development is paramount. However, it currently faces practical challenges such as marginalization and disconnect from engineering practice. Engineering philosophy, as a discipline exploring the fundamental principles and holistic nature of engineering activities, offers profound theoretical perspectives and methodological support for examining and resolving these challenges. Therefore, this study, grounded in the specific context of China's new engineering development, systematically investigates the practical dilemmas in university engineering ethics curriculum development from an engineering philosophy perspective and envisions feasible pathways for its future transformation. The research employs a combined methodology of text analysis and semi-structured interviews. It systematically collects and analyzes national-level policy documents and course materials from representative universities to grasp macro-level requirements and examine the current state of the courses. This is supplemented by semi-structured interviews with frontline instructors and students from different disciplines, aiming to gain a deeper understanding of the challenges and needs of the courses from the dual perspectives of teaching and learning. Building upon a systematic examination of the "new form" challenges in engineering ethics courses—including goal positioning, faculty capabilities, and teaching methodologies—this research draws wisdom from engineering philosophy's holistic engineering perspective and interdisciplinary methodology. It constructs a theoretical framework integrating engineering philosophy concepts and proposes future course development strategies. This work provides theoretical reference and practical guidance for optimizing China's engineering ethics education system and cultivating outstanding engineers capable of shouldering the great responsibility of national rejuvenation.

Keywords: Engineering Ethics; Engineering Philosophy; Ethics Education; New Engineering; Curriculum Development

1. Introduction

The development of the New Engineering disciplines represents a strategic initiative undertaken by China's higher engineering education to address the new wave of scientific and technological revolution and industrial transformation. As an updated iteration of the National Program for Cultivating Outstanding Engineers and a "Chinese solution," the future development of the New Engineering disciplines is crucial to national scientific and technological innovation and the enhancement of international competitiveness. Engineering ethics education is a vital component of engineering education and serves as a form of ideological and political education within the higher engineering education process, playing a significant role in cultivating ethical awareness among engineering students. Engineering philosophy, on the other hand, is an intellectual discipline that studies the essence, fundamental stance, core perspectives, universal laws, and methodology of engineering activities [1]. Therefore, solutions to the challenges faced in the development of engineering ethics curricula may be found within the knowledge system of engineering philosophy.

Based on the above analysis, this study aims to address the following three core questions. First, against the backdrop of the development of new engineering disciplines, what systemic challenges do Chinese universities face in the development of engineering ethics courses, and what are the underlying causes of these challenges? Second, how can the ontological, epistemological, and methodological perspectives of engineering philosophy help us understand and resolve these challenges? Third, based on the holistic view of engineering derived from engineering philosophy, what kind of curriculum development framework should be established to drive the future transformation of engineering ethics education?

2. Literature Review

The core of engineering ethics education lies in guiding engineers to make ethical value judgments and behavioral choices within complex "technology-society" systems [2]. Its theoretical foundations are deeply rooted in classical theories such as deontology, utilitarianism, and virtue ethics, which are used to analyze issues of responsibility, interests, and character in engineering. In the Chinese context, the development of engineering ethics education has been accompanied by the introduction and localization of Western theories. The key challenge of localization lies in overcoming the traditional mindset of "prioritizing technology over ethics" and exploring a path that integrates with Chinese cultural traditions and national strategies [3].In this context, the traditional Chinese wisdom of "the unity of Dao and Qi" provides a crucial interpretive framework, emphasizing that ethical principles (Dao) are inherent in the creation of engineering artifacts (Qi) [4]. This philosophy resonates intrinsically with the core tenet of engineering philosophy, which views engineering as a value-laden creative activity, thereby laying a native philosophical foundation for engineering ethics education [5].

The development of the New Engineering discipline is not a simple upgrade of traditional engineering but a fundamental shift in the paradigm of talent cultivation, aimed at fostering innovative, multidisciplinary professionals [6]. The New Engineering discipline reconfigures the competency map for talent, with a broad perspective on engineering, systems thinking, cross-disciplinary integration capabilities, and ethical responsibility becoming the core competencies of future engineers [7]. This signifies that ethical literacy has evolved from an add-on to a key component of core competitiveness. This new paradigm sets forth clear new requirements for engineering ethics education. First, ethical concerns must be brought forward, shifting from a focus on “post-event consequences” to ethical reflection on “pre-event design” in cutting-edge fields such as artificial intelligence. Second, it emphasizes the interdisciplinary and systematic nature of educational content to address ethical issues that intersect across multiple dimensions, including technology, society, and law [8]. However, the project-based learning and rapidly evolving curriculum systems characteristic of the new engineering disciplines have also introduced new challenges, such as ambiguity regarding the primary responsibility for ethics education and the potential dilution of educational content [9].

As the primary vehicle for education, the model and effectiveness of curriculum development are crucial. Mainstream international models include standalone required courses, integration into major-specific courses, and modular teaching, with widespread use of contextualized methods such as case studies and role-playing to enhance students’ ethical decision-making abilities. Although progress has been made in engineering ethics curriculum development at domestic universities, it generally faces the dilemma of marginalization and disconnection [10]. Specifically, this manifests as marginal positioning, with a low proportion of course credits and a weak standing within the educational system; a disconnect between content and practice, featuring outdated textbook case studies and insufficient integration with major Chinese engineering projects and cutting-edge technological ethical challenges [11]; a lack of specialized faculty, with a severe shortage of interdisciplinary instructors possessing both ethical literacy and engineering practical experience; and a one-dimensional evaluation system that struggles to effectively assess core competencies such as ethical sensitivity and judgment [12]. Against the backdrop of the development of new engineering disciplines, these challenges have taken on new characteristics, such as blurred teaching responsibilities resulting from interdisciplinary training and content lag caused by rapid technological iteration.

Engineering philosophy takes “engineering” itself as the object of reflection, viewing engineering as a value-oriented “creative” activity with ontological status that integrates both technical and non-technical elements. The “Five Theories” framework proposed by the Chinese school of engineering philosophy—namely, the Science-Technology-Engineering trinity, engineering ontology, epistemology, methodology, and evolutionary theory—establishes a holistic view of engineering [13]. Engineering philosophy offers a fundamental perspective for resolving curriculum dilemmas. First, engineering ontology reveals that ethics is an essential dimension embedded within the entire engineering lifecycle, rather than an external add-on, thereby critiquing the ontological fallacy that marginalizes ethics education [14]. Second, engineering epistemology posits that engineering knowledge constitutes practical wisdom that incorporates value judgments [15], requiring that ethics education be fully integrated with the transmission of engineering knowledge and the training of engineering thinking, thereby addressing the issue of disconnection. Finally, the methodologies of systems thinking, situational analysis, and value synthesis advocated by engineering philosophy provide direct guidance for bridging the gap between ethical principles and complex engineering practice, as well as for designing interdisciplinary teaching methods.

Existing research has made preliminary explorations using the concepts of engineering philosophy, interpreting core ideas through the principle of "the unity of Dao and Qi," or advocating a shift from a knowledge-centered to a competency-centered approach based on the epistemology of engineering, thereby infusing philosophical depth into engineering ethics education. However, gaps remain in current research. First, there is insufficient integration of perspectives; existing studies have failed to systematically and organically link the requirements of the new engineering disciplines, the perspective of engineering philosophy, and the micro-level challenges of the curriculum. Second, the depth of analysis is insufficient; attributions of these challenges often remain at the operational level, lacking a root-cause analysis grounded in the philosophical essence of engineering activities. Third, there is a lack of a constructive framework; improvement suggestions are relatively scattered, lacking a curriculum reconstruction framework grounded in the core concepts of engineering philosophy and possessing internal logical consistency. Therefore, future research urgently needs to employ the holistic perspective of engineering philosophy to systematically diagnose the root causes of these challenges and construct a framework for curriculum transformation that integrates the wisdom of engineering philosophy.

3. Theoretical Framework

Grounded in the holistic view of engineering inherent in engineering philosophy, this study combines the fundamental principles of engineering ethics with the intrinsic requirements of the "New Engineering" initiative to construct a theoretical framework that integrates the "trinity" of engineering philosophy, engineering ethics, and the New Engineering. This framework aims to provide a solid theoretical foundation for systematically diagnosing current curriculum challenges and exploring future pathways for transformation.

Table 1: Core Concepts of Engineering Philosophy and Their Implications for Curriculum Design

Conceptual Dimension	Philosophical Implications	Implications for Engineering Ethics Curriculum Design	Examples of Analysis and Application
Engineering Ontology	Engineering is the ontological essence of human "creative" activities, and ethics is an intrinsic dimension of engineering	Ethics should not be viewed as an "add-on" to engineering, but rather as a core component of course objectives	Examine whether course objectives treat ethical literacy as a graduation requirement of equal importance to technical innovation
Engineering Epistemology	Engineering knowledge is "practical wisdom" that incorporates value judgments, characterized by	Ethics instruction should go beyond universal norms and focus on ethical decision-making in specific engineering	Analyze whether course content incorporates cutting-edge issues in engineering

	contextuality and integrative nature	contexts	ethics and whether it trains students in ethical decision-making
Engineering Methodology	Engineering activities follow a methodological approach based on systems thinking, situational analysis, and value synthesis	Teaching methods should simulate the complexity of real-world engineering to cultivate students' ability to make trade-offs under uncertainty	Assess whether contextualized teaching methods, such as project-based learning and role-playing, are employed
Holistic View of Engineering	Engineering is a system where multiple elements—including technology, society, ethics, and economics—intertwine	Curriculum implementation requires interdisciplinary faculty and a diverse, collaborative educational ecosystem	Institutional support for faculty composition, interdisciplinary collaboration, and university-industry cooperation
"The Unity of Dao and Qi"	The dialectical unity of "Dao" (ethical principles) and "Qi" (engineered artifacts) in the Chinese philosophical tradition	Engineering ethics education should achieve the organic integration of value-driven guidance and technical training	Examine whether teaching content deeply integrates ethical principles with engineering practice

Engineering philosophy is a comprehensive reflection on human engineering activities—including reliance on, adaptation to, understanding of, and rational transformation of nature—and is a discipline concerned with the fundamental perspectives and universal laws governing such activities [16]. The core of engineering philosophy lies in transcending the specific technical level of engineering to pose fundamental questions about engineering from the perspectives of ontology, epistemology, and methodology. Engineering ethics is the system of moral norms and value standards that engineers should adhere to in their professional activities; its basic principles encompass respect for life and the laws of nature, a people-centered approach, sustainable development, social responsibility, and social justice. Engineering ethics from the perspective of engineering philosophy emphasizes that ethical judgments must be closely integrated with specific engineering contexts, technical approaches, and social consequences. The development of the "New Engineering" represents a strategic paradigm shift in China's higher engineering education in response to the new round of technological revolution and industrial transformation. Its "newness" is reflected not only in emerging technologies and interdisciplinary fields but also in the systematic innovation of educational philosophies, training models, and practical pathways [17].

Based on these three theoretical pillars, this study constructs an integrative theoretical analytical framework. This framework adopts the holistic view of engineering from engineering philosophy as its meta-perspective, the talent development objectives of the New Engineering discipline as its practical orientation, and the value norms and practical wisdom of engineering ethics as its core content, systematically examining the development of engineering ethics courses from four dimensions [18].

Based on engineering ontology, this study examines the actual status of engineering ethics within the talent development system and curriculum structure of higher education institutions. It analyzes whether engineering ethics is regarded as an intrinsic component of engineering activities; based on engineering epistemology, it examines whether course content transcends static norms and historical case studies to deeply integrate ethical scenarios derived from cutting-edge technologies and social practices in the new engineering disciplines. We evaluate whether the teaching content is dedicated to cultivating students' practical wisdom—that is, the comprehensive ability to identify, analyze, weigh, and make ethical decisions in specific contexts. Based on engineering philosophical methodology and the practical competency requirements of the New Engineering discipline, we examine whether teaching methods are too narrow, detached from real engineering scenarios, or incorporate case-based teaching and role-playing—methods that simulate engineering complexity and promote the unity of ethical knowledge and action;Based on a holistic view of engineering, examine the interdisciplinary faculty supporting course implementation, the mechanisms for collaborative education both on and off campus, and the institutional safeguards. Analyze whether there is a faculty disconnect where "those who understand ethics do not understand engineering, and those who understand engineering do not deeply grasp ethics," and whether institutional policies, evaluations, and incentives support genuine interdisciplinary teaching innovation.

This framework integrates macro-level engineering philosophy, meso-level engineering ethics norms, and the requirements of new engineering education into the micro-level analysis of curriculum development. It aims to systematically reveal the deep-seated contradictions between the ideal and the reality of current engineering ethics education, and to provide theoretical guidance for constructing a new future curriculum system characterized by clear positioning, cutting-edge content, diverse methods, and ecological synergy.

4. Research Process

4.1 Research Methods

The study primarily employs text analysis, supplemented by interviews, to comprehensively understand the discrepancies between the specific requirements of policy documents and actual practices [19]. Textual materials were sourced from policy documents issued by government agencies such as the Ministry of Education, as well as syllabi and teaching materials for engineering ethics courses at multiple Chinese universities, covering both undergraduate and graduate levels. Interview participants were selected for representativeness: they were required to have a background in new engineering disciplines, to have studied in relevant fields for a certain period, and to have received engineering ethics education. Additionally, participants were chosen to ensure diversity, encompassing different academic stages and disciplinary cultural backgrounds.

The study employed thematic analysis. First, open coding was applied to policy documents, course materials, and interview transcripts to extract initial concepts; then, axial coding was used to cluster concepts into sub-themes; finally, selective coding was used to integrate these into core themes. The author and an industry expert independently coded the first two policy documents and five course materials, achieving 87% coding consistency. After discussing and reaching consensus on areas of disagreement, they proceeded to code the remaining materials. The study ultimately constructed a five-dimensional analytical matrix based on the "Five Theories" framework of engineering philosophy, comprising "Goal Setting—Content Structure—Teaching Methods—Assessment System—Interdisciplinary Integration." Each dimension was pre-set with 2–3 observation indicators, while allowing for the emergence of new themes during the coding process.

4.2 Text Analysis

(1) Policy Guidance Documents

To systematically understand the strategic deployment and directional guidance of engineering ethics education at the national level within the context of the New Engineering Initiative, this study adheres to the following criteria: (1) Authority: All documents are official policy documents issued at the national level; (2) Timeliness: The timeframe spans 2018–2022, covering the critical stages from the launch to the deepened development of the New Engineering Initiative; (3) Relevance: Comprehensive coverage of the policy context for engineering ethics education; (4) Representativeness: Widely cited in academic circles, constituting the core corpus of texts for current research on engineering ethics education policies. Ultimately, four policy documents were selected as core analytical texts, including the "Opinions on Accelerating the Development of New Engineering and Implementing the Excellent Engineer Education and Training Program 2.0" (2018, hereinafter referred to as the "Opinions on New Engineering Development") [20], the "Guidelines for the Construction of Ideological and Political Education in Higher Education Curricula" (2020, hereinafter referred to as the "Curriculum Ideological and Political Education Guidelines") [21], the "Several Opinions on Promoting Disciplinary Integration and Accelerating Graduate Student Training in the Field of Artificial Intelligence at 'Double First-Class' Universities" (2020, hereinafter referred to as the "Graduate Student Training Opinions") [22], and the "Opinions on Strengthening the Governance of Science and Technology Ethics" (2022, hereinafter referred to as the "Science and Technology Ethics Governance Opinions") [23]. These documents collectively form the current top-level policy framework for promoting engineering ethics education in China, addressing four key dimensions: "engineering education reform," "curriculum-based education systems," "interdisciplinary research at the forefront," and "national governance systems" [24]. The selection of these texts aims to provide an in-depth analysis of how national strategy positions and reshapes engineering ethics education from the perspectives of macro-level concepts, educational pathways, disciplinary frontiers, and institutional safeguards. This analysis provides a solid policy context and discursive basis for research that examines the challenges and potential shifts facing engineering ethics courses in higher education institutions from the holistic perspective of engineering philosophy.

Through systematic interpretation and coding analysis of the four policy documents, it can be observed that a multi-layered, systematic logic for advancing engineering ethics education has been established at the national level, whose core principles align closely with the holism, interdisciplinarity, and value-laden nature advocated by engineering philosophy.

Table 2: Coding for Policy Text Analysis

Selective Coding (Core Themes)	Axial Coding (Subthemes)	Open Coding (Initial Concepts)	Data Source
Top-level Design of the Policy Framework	Strategic Positioning Enhancement	Strengthening Awareness of Engineering Ethics; Integration into All Stages of Teaching; Modern Engineers Dedicated to Serving Humanity	“Opinions on the Development of New Engineering Disciplines” (2018)
	Institutionalizing Value-Driven Leadership	Engineering Ethics as a Priority in Ideological and Political Education; Fostering the Spirit of Master Craftsmen; A Commitment to Serving the Nation Through Science and Technology	“Outline for the Development of Ideological and Political Education in Courses” (2020)
	Integration into Cutting-Edge Fields	Interdisciplinary Training in “AI+X”; Strengthening Education on AI Research Ethics; University-Industry Collaborative Practice Platforms	“Guidelines for Graduate Student Education” (2020)
	Improving the Governance System	Science and Technology Ethics as a Required Course for Students; Integrated Throughout the Entire Research Process; Review and Oversight Systems	“Guidelines on the Governance of Scientific and Technological Ethics” (2022)

The Gap Between Policy Ideals and Reality	Practical Challenges in Policy Implementation	The Conflict Between Integration Requirements and Limited Class Hours; Where Will Interdisciplinary Faculty Come From; How to Effectively Assess Ethical Literacy	Intrinsic Tensions Among Policies

First, the strategic status of engineering ethics education has undergone a fundamental shift, transforming from a marginalized add-on into a core dimension of talent development. The “Opinions on the Development of New Engineering Disciplines” explicitly places “strengthening students’ awareness of engineering ethics and professional ethics” within the framework of innovative engineering education, requiring its integration into all stages of teaching to cultivate “modern engineers guided by the principles of benefiting humanity and sustainable development.” This reflects an ontological perspective in engineering philosophy that views ethics as an intrinsic attribute of engineering activities. The “Outline for the Development of Ideological and Political Education in Curricula” further institutionalizes engineering ethics education as a key focus of ideological and political education within engineering programs, emphasizing its crucial role in shaping the spirit of master craftsmen and a sense of duty to serve the nation through science and technology. This drives the transformation of ethics education from external regulation to intrinsic value guidance within the curriculum.

Second, the educational content and implementation pathways emphasize deep integration with engineering practice and cutting-edge science and technology, as well as interdisciplinary integration, which resonates with the systems thinking and methodology of engineering philosophy. The “Opinions on Graduate Student Training” explicitly proposes “strengthening education on research ethics in artificial intelligence” within the “AI+X” framework for cultivating interdisciplinary talent, and encourages the joint construction of practical platforms by universities and enterprises. This requires engineering ethics education to transcend traditional theory and be embedded in rapidly iterating technology R&D scenarios, reflecting the nature of engineering knowledge as practical wisdom. The “Opinions on the Governance of Science and Technology Ethics,” from the perspective of national governance, establishes science and technology ethics education as a core component for students in relevant disciplines and promotes the establishment of review and oversight systems that span the entire research process.

However, while these policy documents outline a grand vision, they also imply several inherent tensions and practical challenges. These are precisely the key issues that engineering ethics curriculum development must confront and resolve as it transitions from theoretical ideals to practical reality, viewed through the lens of engineering philosophy. For example, while the policy repeatedly emphasizes integration and pervasiveness, how can ethical elements be organically—rather than piecemeal—incorporated into a highly specialized and technical curriculum without exacerbating academic burdens [25]? The policy encourages cross-disciplinary collaboration and multi-stakeholder governance, but where will interdisciplinary faculty members with both deep philosophical and ethical literacy and cutting-edge engineering experience come from, and how should their evaluation and incentive mechanisms be constructed [26]? Furthermore, while policies emphasize a practice-oriented approach, how can the evaluation of ethical literacy move beyond traditional paper-and-pencil tests to effectively assess complex dimensions such as ethical sensitivity and decision-making ability?

(2) University Courses and Teaching Materials

To thoroughly examine the actual development of engineering ethics courses in the context of the New Engineering discipline and systematically verify whether they embody the holistic, interdisciplinary, and practice-integrated nature advocated by engineering philosophy, this study will conduct a systematic review and thematic analysis of representative university courses and teaching materials. In selecting materials, the study considers the following factors: (1) Institution type: top-tier comprehensive universities, industry-specialized “Double First-Class” universities, and regionally key universities; (2) Geographic distribution: covering North, East, South, and Southwest China; (3) New Engineering disciplines: ensuring coverage of core fields such as artificial intelligence, big data, intelligent manufacturing, and bioengineering; (4) Educational level: encompassing both undergraduate and graduate education. The final selection comprises 34 syllabi for “Engineering Ethics” and related courses from 12 universities, along with corresponding courseware, textbooks, and student assignments. All materials were compiled in 2025 (“related courses” refer to those whose course titles include the keyword “engineering ethics” or explicitly list engineering ethics literacy as a learning outcome in their course objectives;2025 marks a critical juncture for the interim assessment of the New Engineering Initiative; selecting materials from this year best reflects the current state of engineering ethics curriculum development). The aim is to objectively present the current implementation of engineering ethics education through authentic, structured course materials, thereby providing a solid empirical basis for subsequently diagnosing the practical challenges of these courses from a philosophy of engineering perspective and revealing the gaps between them and the requirements of the New Engineering Initiative.

Based on the holistic view of engineering in engineering philosophy and its fundamental assertion that ethics is embedded in engineering practice, this study constructed a five-dimensional analytical framework comprising “objective positioning, content structure, teaching methods, evaluation system, and interdisciplinary integration” to code and extract themes from the aforementioned texts. The main findings are as follows:

Table 3: Coding of University Course Materials Analysis

Selective Coding (Core Themes)	Axial Coding (Subthemes)	Open Coding (Initial Concepts)	Data Source

Course Focus: Ethics as an External Add-on	The focus is on the transmission of norms	Learning objectives are framed as “mastering ethical norms”; Emphasis on fostering a sense of responsibility; Lacks reflection on the integration of ethics into engineering	34 syllabi for “Engineering Ethics” and related courses, along with corresponding course materials, textbooks, and student assignments
	Lack of a holistic view of engineering	Failure to clarify the role of ethics throughout the entire engineering lifecycle; Lack of requirements for cultivating systems thinking	
Content Structure: Overreliance on classics; insufficient coverage of cutting-edge topics	Case studies are outdated and out of step with current developments	Classic cases such as the Challenger disaster are repeatedly featured; Limited coverage of cutting-edge topics such as artificial intelligence and gene editing; Domestic cases, such as the South-to-North Water Diversion Project, remain at the level of descriptive analysis	
	Lack of integration with local culture	Lack of cultural interpretations that integrate “Dao and Qi”; Insufficient analysis of the interplay between technology, society, and ethics	
Teaching Implementation: Lecture-dominated, with a lack of practical application	Monotonous teaching methods	Teacher-led; Case discussions follow a linear format; Low proportion of group discussions and scenario simulations	
	Lack of hands-on learning experiences	Project-based learning and interdisciplinary collaboration are rare; Lack of practical teaching methods such as field research	
Assessment System: Primarily knowledge-based assessment	Limited assessment methods	Primarily exams and course papers; Emphasis on conceptual memorization and understanding; Lack of assessment tools for ethical sensitivity and decision-making skills	

	Lack of a comprehensive evaluation mechanism	No performance-based assessment integrated throughout the learning process; Discrepancy with the “practical wisdom” assessment philosophy	
Level of integration: More form than substance	Interdisciplinary integration is superficial	Perspectives on engineering, society, and law remain at the level of conceptual introduction; Ethical content and engineering knowledge remain disconnected	
	Lack of a structured integration pathway	Philosophical and sociological knowledge has not been organically integrated	

Objectives remain skewed toward the transmission of norms, failing to fully reflect the intrinsic nature and holistic nature of engineering ethics. Most course syllabi state objectives as mastering ethical norms and fostering a sense of responsibility, emphasizing students' understanding of and adherence to ethical principles, while rarely clarifying, from an engineering ontological perspective, that ethics constitutes an intrinsic value attribute of engineering activities [27].For example, the syllabus at University Z proposes “enabling students to understand the basic principles and professional norms of engineering ethics.” While such phrasing addresses ethical awareness and decision-making ability, it fails to situate ethics holistically within the full lifecycle of the engineering system [28] and does not fully embody the interdisciplinary collaboration and systems thinking required by a broad engineering perspective. This reflects that ethics education remains at a stage of being perceived as an external add-on rather than an intrinsic component within the curriculum.

In terms of content structure, the curriculum is dominated by classic case studies, with insufficient integration of cutting-edge issues and local practices. Teaching content generally adopts a three-tiered framework of “theory—principles—case studies,” with classic cases such as the Challenger disaster recurring frequently. While these cases serve as cautionary tales, they are updated slowly and lack sufficient connection to the ethical practices of emerging technologies such as artificial intelligence, gene editing, and data governance. Furthermore, although some courses incorporate local issues such as the South-to-North Water Diversion Project, they often remain at the level of descriptive analysis, lacking cultural interpretation and value integration from the perspective of the engineering philosophy of “the unity of Dao and Qi.” Consequently, they fail to deeply illustrate the interactive coordination of technical, social, and ethical factors in engineering practice.

Teaching methods are primarily lecture-based, with a lack of contextualized and hands-on learning experiences. While case discussions serve as the main teaching method, they largely follow a linear pattern of “factual description—attribution of responsibility—normative comparison,” lacking in-depth design to guide students in ethical risk assessment and decision-making simulations. While interactive formats such as group discussions and scenario simulations do occur, the proportion of practical teaching methods—including project-based learning, interdisciplinary collaboration, and field research—remains low. Teaching methods are still dominated by instructor-led lectures, making it difficult to embody the unity of knowledge and action emphasized by engineering philosophy, as well as the cultivation of ethical character "through the act of creation".

The evaluation system focuses on knowledge assessment, and there is a lack of a comprehensive evaluation mechanism for ethical literacy. Course evaluations primarily take the form of exams and term papers, focusing on the memorization and understanding of ethical concepts and principles, while evaluation tools for core competencies, such as ethical sensitivity and the ability to weigh values, remain relatively limited. Although some courses require ethical analysis reports, a systematic, performance-based evaluation mechanism that spans the entire learning process has not yet been established, indicating a significant gap from the "practical wisdom" evaluation philosophy advocated by engineering philosophy.

Interdisciplinary integration remains superficial, with no structured pathway for convergence. While courses mention multiple perspectives—such as engineering and society, or engineering and law—these are largely limited to conceptual introductions and fail to construct interdisciplinary ethical analysis pathways based on the framework of engineering philosophy. Ethical content and engineering technical knowledge often exist as "two separate entities"; knowledge from disciplines such as philosophy, sociology, and law has not yet been organically integrated, making it difficult to support the cultivation of the comprehensive ethical integration capabilities required by the new engineering disciplines [29].

4.3 Interviews

To conduct an in-depth and multifaceted exploration of the actual state of engineering ethics course development in the context of the new engineering disciplines, the specific challenges encountered in the teaching process, as well as the personal experiences and intrinsic needs of teachers and students as core participants in the courses, this study employed semi-structured interviews. The selection of interviewees strictly adhered to three principles: disciplinary representativeness, experiential typicality, and background diversity. The teacher sample consisted of three frontline instructors with long-term experience teaching "Engineering Ethics" or related courses. Among them, one has an academic background in philosophy and ethics and is responsible for the university-wide general education course in Engineering Ethics; the other two come from engineering disciplines and teach specialized required courses for specific engineering departments. This configuration aims to capture course design philosophies from different disciplinary perspectives, the teaching tensions they face, and differences in their understanding of policy orientations [27]. The student sample comprised nine students from new engineering disciplines who had systematically completed engineering ethics courses. They spanned the undergraduate, master's, and doctoral levels, with academic fields covering multiple core areas of the new engineering disciplines. The students were drawn from a mix of top-tier comprehensive universities, industry-focused

"Double First-Class" universities, and regionally key universities, with the aim of comprehensively reflecting students' acceptance of engineering ethics education, the extent of its internalization, and their future expectations across different cognitive levels, engineering contexts, and institutional cultures.

Table 4: Basic Information on Interview Participants

No.	Gender	Age	Occupation/Status	Employer or Educational Institution	Academic Background
T1	Female	43	University Faculty	Top-tier Comprehensive University	Ph.D. in Philosophy
T2	Male	44	University Faculty	Industry-specific "Double First-Class" University	Ph.D. in Engineering
T3	Male	39	University Faculty	Regional Key University	Ph.D. in Engineering
D1	Male	29	Third-year Ph.D. Student	Industry-specific "Double First-Class" University	Intelligent Manufacturing
D2	Female	26	First-year Ph.D. Student	Top-tier Comprehensive University	Biomedical Engineering
M1	Female	23	Second-year Master's Student	Top-tier Comprehensive University	Electronic Information Engineering
M2	Female	23	First-year Master's Student	Industry-specific "Double First-Class" University	Robotics Engineering
M3	Male	24	First-year Master's Student	Regional Key University	Artificial Intelligence
U1	Male	20	Junior	Regional Key University	Software Engineering
U2	Male	21	Junior	Industry-specific "Double First-Class" University	Cybersecurity Major
U3	Female	20	Second-year Undergraduate	Industry-specific "Double First-Class" University	Intelligent Science and Technology
U4	Female	22	Senior	Top-tier Comprehensive University	Computer Science

After systematically organizing and coding the transcribed texts from interviews with 12 faculty members and students, four core themes were identified, revealing the practical challenges faced by engineering ethics courses in the context of the New Engineering discipline.

Table 5: Coding of Interview Transcripts

Selective Coding (Core Themes)	Axial Coding (Subthemes)	Open-ended Coding (Initial Concept)

The "Loss of Substance" in the Curriculum System	Low credit weighting, marginalized positioning	"Engineering Ethics accounts for only 1 credit" "Compared to core courses worth 3–4 credits, the time commitment is incomparable"
	Weak Position in the Curriculum	"When making room for emerging technology courses, ethics courses are often cut back"
	Disconnect Between Theory and Practice	"Recognition of its importance fades during the course experience"
The "Contextual Detachment" in Knowledge Transmission	Curriculum Lags Behind Technological Advancements	"Repeated analysis of classic cases, with little attention paid to new issues such as algorithmic bias"
	Theory fails to translate into practical judgment	"Students learn utilitarian theory but lack the ability to make judgments regarding specific research decisions"
The "Methodological Monotony" in Teaching Practice	A desire for contextualized, practical learning	"Instead of writing book reports, we should incorporate an ethical risk assessment component into our projects"
	Lecture-based teaching dominates	Most students report that "teachers lecture, students listen" remains the norm
The "Interdisciplinary Disconnect" in the Faculty	Lack of technical understanding among philosophy instructors	"When students ask about the technical principles behind algorithmic bias, I struggle to break it down"
	Engineering faculty lack a strong grounding in ethical theory	"I'm good at pointing out engineering risks, but I'm not good at structuring discussions using ethical theories"
	Shortage of Interdisciplinary Faculty	"We most look forward to 'engineer-philosopher' type teachers, but they are few and far between"
	Faculty's own professional development needs	All indicate a need for interdisciplinary training opportunities
	Lack of institutional support	Calls for reforming evaluation mechanisms to support interdisciplinary teaching innovation
The Shared Aspirations of Teachers and Students for Change	Students' expectations for the integration of cutting-edge practices	A desire for learning content that directly addresses the ethical implications of new technologies; Expectations for Seamless Integration with Major Courses and Research Projects

	Faculty's Expectations for Institutional Support	Opportunities to collaborate with practitioners such as engineers; Calls for Course Development Resources and Platform Support

(1) “Loss of Substance” in the Curriculum System

Engineering ethics education faces a positioning dilemma within the current new engineering talent development system. Nearly all surveyed students affirmed the importance of engineering ethics, recognizing its relevance to technology for good and social responsibility. However, this sense of recognition quickly dissipates in the context of actual course experiences and academic planning, transforming into a perception of secondary importance that can be easily disregarded. (D1: Engineering ethics accounts for only 1 credit in the curriculum, and the assessment is lenient. Compared to core courses that carry 3–4 credits and have rigorous assessments, it cannot compare in terms of either the time students invest or the importance they place on it.) This widespread mindset—which treats ethics as an external adornment rather than an intrinsic dimension of engineering activities—directly contradicts the fundamental tenets of engineering philosophy: ethics is an essential element embedded throughout the entire lifecycle of engineering—from conception and design to implementation and evaluation—and is an inseparable part of engineering practice. (T2: When curriculum planners need to make room for emerging technology courses, “soft courses” such as engineering ethics are often the first to be cut.) This reflects the deep-seated inertia of a technology-first mindset still entrenched in the consciousness of engineering education administrators.

(2) “Contextual Detachment” in Knowledge Transmission

There is a severe disconnect between course content and the rapidly evolving practices of new engineering disciplines, and teaching methods are ineffective at translating ethical theory into practical judgment. Students commonly complain about the outdated nature and disconnect of textbooks and case studies. (U2: Courses repeatedly analyze classic cases but rarely address current ethical challenges such as bias in recommendation algorithms and the boundaries of data privacy.)This prevents ethics education from resonating deeply with students' current professional studies and future career aspirations. A further problem is that teaching remains confined to the level of advocating abstract principles. (M3: The course explains theoretical frameworks such as utilitarianism in detail, but when faced with the decision of whether to use an open-source dataset that performs exceptionally well but has potential flaws in its data sources, I do not know how to make a prudent and responsible judgment.)This dilemma sharply highlights a core concern of engineering epistemology. Current engineering ethics education has largely failed to successfully “translate” universal ethical principles into practical wisdom applicable to complex, dynamic, and uncertain engineering contexts, resulting in students acquiring ethical knowledge without developing ethical thinking and decision-making capabilities [30].

(3) “Methodological Monotony” in Teaching Practice

Current teaching models have limitations in fostering the internalization of ethical literacy among students. Although universities have made some attempts, the “teacher lectures, students listen” model remains dominant. Students have expressed a strong desire for teaching methods that are more interactive, contextual, and practical. (U4: Instead of writing a book report on robot ethics after class, it would be better to directly incorporate an ethical risk assessment component into the course design project, requiring us to submit an analytical report on the impact of the robot’s operational workflow on worker safety, psychological well-being, and potential social exclusion effects when designing the workflow.)These demands align precisely with the methodology advocated by engineering philosophy, which trains students’ ethical judgment through systems thinking, scenario simulation, and value integration in complex, real-world scenarios [31]. However, implementing such teaching methods faces significant challenges, with the most critical bottleneck being faculty resources.

(4) “Interdisciplinary Disconnect” in the Faculty

Faculty development has emerged as a key dynamic factor constraining the improvement of engineering ethics education. The shortage of qualified faculty is not merely a matter of insufficient numbers, but rather a lack of interdisciplinary knowledge and practical experience. (T1: When students ask why a specific algorithmic model amplifies bias, I often struggle to break it down from a technical principles perspective, which can cause the ethical analysis to remain superficial.T2: I may be skilled at identifying risk points in engineering solutions, but I am not adept at using systematic ethical theoretical frameworks to organize discussions and guide students in thinking about the value conflicts, attribution of responsibility, and issues of justice underlying those risks.) This “island dilemma”—where those who understand ethics do not understand engineering, and those who understand engineering do not deeply grasp ethics—makes it difficult for engineering ethics education to achieve true interdisciplinary integration. (M1: The teachers we most hope for are “engineer-philosophers” who possess extensive hands-on engineering R&D experience and, at the same time, engage in profound reflection on philosophy and ethics; however, such faculty members are extremely rare in reality.)From a practical perspective, this dilemma highlights the inherent requirement for the faculty that the holistic view of engineering emphasized by engineering philosophy demands,namely, the need to break down disciplinary barriers and cultivate or establish a teaching community capable of bridging technology and values, and integrating theory and practice [26] .

5. Research Findings

Based on the aforementioned analysis of policy documents, review of university course materials, and in-depth descriptions of faculty and student interviews, the study found that the development of engineering ethics courses under the New Engineering framework is currently at a critical juncture of transformation. The challenges it faces are systemic and profound, and its future direction requires a fundamental paradigm shift. As a holistic discipline that reflects on the essence and methods of engineering activities, the philosophy of engineering provides indispensable theoretical and practical wisdom for understanding these challenges, addressing the needs of faculty and students, and envisioning future development pathways.

5.1 Deep-Seated Challenges in Engineering Ethics Curriculum Development

The challenges facing the development of engineering ethics courses are not accidental or superficial issues of teaching management, but rather a manifestation of deep-seated contradictions within the paradigm shift of engineering education [32]. From an ontological perspective, the positioning of ethics in engineering education remains ambiguous. Although policy documents emphasize its central role, in the specific curriculum designs and teaching practices of universities, engineering ethics is often treated as a supplement to engineering and technical knowledge, essentially reflecting the long-standing imbalance between technical rationality and value rationality in engineering education. From an epistemological and methodological perspective, the content and methods of engineering ethics instruction are severely at odds with the nature of engineering knowledge as “practical wisdom.” Instructional content relies too heavily on ethical principles and historical case studies, failing to integrate in a timely and in-depth manner the ethical contexts of cutting-edge fields in the new engineering disciplines. Teaching methods are dominated by lectures and superficial case discussions, lacking in-depth practical training such as project-based learning and interdisciplinary workshops. This makes it difficult for students to establish effective connections between ethical theory and engineering practice, hinders the development of their ability to make prudent ethical judgments, and prevents engineering ethics education from meeting the intrinsic requirements of the new engineering disciplines to cultivate the ability to solve complex problems [33]. From the perspective of teaching personnel, there is an extreme shortage of faculty members who possess both deep ethical literacy and cutting-edge engineering practice experience. Faculty with a background in philosophy often feel they lack sufficient technical understanding, while those with an engineering background struggle with the systematic application of ethical theories. This hinders deep interdisciplinary integration and leads to teaching that often devolves into a mere patchwork of knowledge. Furthermore, existing faculty evaluation and incentive systems do not sufficiently recognize interdisciplinary teaching and curriculum innovation, further weakening the intrinsic motivation for faculty transformation.

5.2 Faculty and Student Needs and Expectations for Engineering Ethics Education

Both faculty and students have clearly recognized the limitations of current engineering ethics education and harbor strong expectations for its transformation. Students’ demands manifest as a desire for content that is more cutting-edge, practical, and integrated; they yearn for learning materials that address the ethical challenges posed by emerging technologies, rather than repeatedly discussing historical cases; they expect teaching methods to provide immersive, participatory experiences, rather than passive lectures and abstract writing;They hope that ethical reflection will be seamlessly integrated with core professional courses, research projects, and graduation projects, truly becoming an integral part of engineering thinking [29] . Faculty members' demands, meanwhile, focus on capacity building and support. Recognizing the limitations of their own knowledge structures, they urgently need systematic interdisciplinary training and opportunities to collaborate with practitioners such as engineers to bridge the gap between theory and practice. At the same time, they call for greater institutional support from the university, including reforming faculty evaluation mechanisms, providing resources and platforms for curriculum development and pedagogical innovation, and establishing stable mechanisms for collaborative teaching teams [27] . The needs and expectations of both faculty and students collectively point to the necessity of systematically restructuring engineering ethics education—from content to form, and from philosophy to institutional framework.

5.3 Core Insights from Engineering Philosophy for Engineering Ethics Education

Engineering philosophy offers fundamental insights to address the aforementioned challenges and needs. First, engineering ontology suggests that a return to ontological foundations in curriculum positioning is essential. Ethics education should not be a mere appendage of engineering education but rather its core dimension, permeating the entire process and all aspects of talent cultivation. This implies clearly defining and reinforcing the central role of ethical literacy in educational objectives, curriculum systems, and graduation requirements, while ensuring rigid safeguards through multiple mechanisms such as credit allocation, process-based assessments, and graduation criteria [28] . Second, engineering epistemology suggests that a contextual shift in teaching content must be promoted. Engineering ethics instruction should aim to cultivate practical wisdom, shifting the focus from imparting universal ethical norms to training students' ability to identify, analyze, weigh, and make ethical decisions in specific, complex, and dynamic engineering contexts. Furthermore, engineering methodology suggests that we must advocate for diversified and systematic teaching methods. We should widely adopt problem-based, project-based, and design-based teaching approaches, uphold the dynamic interaction between people and technology, and highlight the values of stakeholders [34]. We should encourage interdisciplinary team-based learning and utilize systems thinking tools to guide students in comprehensively considering the multiple factors within engineering systems. Finally, a holistic view of engineering suggests that we must build a collaborative ecosystem for implementation. The effective implementation of engineering ethics education cannot rely solely on a single course or a few instructors; rather, it requires the construction of a diverse, collaborative educational ecosystem encompassing universities, enterprises, and government agencies. On campus, disciplinary barriers must be broken down to form interdisciplinary teaching and research communities; off campus, industry-education integration must be strengthened by introducing industry-based ethical practice resources to jointly build practical teaching platforms.

5.4 Building a New Ecosystem for Engineering Ethics Courses Based on Engineering Philosophy

Based on the above discussion, the future development of engineering ethics courses in the context of the New Engineering discipline should be dedicated to building a new ecosystem comprising five interrelated elements: “conceptual reshaping—systemic restructuring—methodological innovation—faculty support—ecological collaboration”.

In terms of conceptual reshaping, we must establish a holistic view of engineering education that embeds ethics. At the institutional level, the concepts of “unity of principle and practice” and “embedded ethics” advocated by engineering philosophy should be formally incorporated into the educational philosophy and talent development objectives of engineering education. Ethical literacy should be explicitly defined as a core competency indicator for graduates, and corresponding curriculum mapping and evaluation mechanisms should be established.

Regarding system restructuring, design an integrated, modular curriculum system. Moving beyond the model of a single standalone course, construct a multidimensional curriculum system comprising “required core courses + major-embedded modules + cutting-edge thematic workshops + practical project components” [30] . Core courses lay the theoretical foundation, embedded modules integrate ethical issues into core professional courses, workshops focus on cutting-edge topics, and practical components implement ethical assessments. This achieves the vertical integration of ethics education across undergraduate, master’s, and doctoral levels, as well as horizontal interdisciplinary integration.

In terms of methodological innovation, we promote contextualized and participatory teaching models. We are vigorously developing a case repository closely integrated with China’s major engineering projects and emerging technology industries. We are popularizing teaching methods such as project-based learning, simulated ethics hearings, role-playing, and value-sensitive design competitions [32] . We utilize digital technology to build virtual simulation platforms that simulate complex ethical decision-making scenarios.

In terms of faculty support, we will cultivate and incentivize interdisciplinary teaching communities. We will establish special programs to provide systematic interdisciplinary training in engineering and ethics for existing faculty; reform faculty evaluation, appointment, and assessment systems to assign appropriate weight to interdisciplinary teaching and curriculum innovation; encourage the formation of teaching teams that span departments, universities, and industry-academia partnerships; and recruit full-time and part-time faculty with interdisciplinary backgrounds and practical experience.

In terms of ecosystem collaboration, foster a culture of ethics education characterized by diverse and collaborative governance. Universities should proactively collaborate with leading enterprises, engineering professional associations, and science and technology ethics committees to jointly establish practice bases, share case resources, co-develop teaching materials, and co-organize ethics activities. This will promote the establishment of industry-recognized engineering ethics competency certification or evaluation systems, more closely linking educational outcomes with professional development, and fostering a cultural environment across society characterized by “ethics first, shared responsibility” [35] .

6. Conclusion and Outlook

This study systematically analyzes the current challenges from the perspective of engineering philosophy, revealing the underlying tensions between technology and values, knowledge and practice, and disciplines and the broader context. The solution lies in a profound transformation—from educational philosophy and curriculum systems to the implementation ecosystem—guided by the holistic, practical, and value-oriented wisdom of engineering philosophy.

Rooted in the specific context of China's New Engineering initiative, many aspects of this study's conclusions reflect the particularities of the Chinese context. First, there is a pronounced policy-driven nature, with the advancement of engineering ethics education being highly linked to the national strategy of "ideological and political education in the curriculum"—a phenomenon rarely seen in other countries; second, indigenous philosophical concepts such as "the unity of Dao and Qi" form a unique interpretive framework; third, the structural disconnect in the faculty revealed by the interviews reflects, to some extent, the characteristics of talent reserves during the rapid expansion phase of China's higher engineering education. Nevertheless, the core findings of this study possess cross-cultural universality: namely, that ethics education faces marginalization, teaching content lags behind technical practice, teaching methods are monotonous, and there is a shortage of interdisciplinary faculty. These findings hold particular reference value for developing countries currently advancing engineering education reforms. The "Five-in-One" new curriculum ecosystem framework proposed in this study also provides transferable design principles for the restructuring of engineering ethics education systems in other countries.

Nevertheless, this study has the following limitations. First, the sample size is limited. Although stratified sampling and maximum diversity sampling strategies were employed, the statistical generalizability of the conclusions remains constrained; future research could validate these findings by expanding the sample size and incorporating quantitative surveys. Second, the course materials are concentrated in 2025; while intended to capture the latest trends, they fail to illustrate diachronic changes. Third, the interviews primarily focused on faculty and students, and have not yet incorporated diverse perspectives such as those of academic administrators or industry engineers. Future research could build upon this foundation by conducting multi-year longitudinal studies, incorporating more stakeholder perspectives, and using comparative studies to test the applicability of this framework across different types of universities.

Looking ahead, research and practice in engineering ethics education from a philosophy of engineering perspective can be further deepened across multiple dimensions. At the theoretical level, it is necessary to further refine the integration of the "Five Theories" framework of philosophy of engineering with curriculum design and evaluation criteria, developing more operational teaching design models and academic assessment standards. In terms of practical implementation, efforts should be made to explore differentiated and categorized curriculum implementation models tailored to the distinct positioning of research-oriented and application-oriented universities, as well as different engineering discipline clusters. At the same time, against the backdrop of global interconnectedness in engineering education, research must, while rooted in China's local practices and cultural traditions, strengthen dialogue and mutual learning with cutting-edge theories and exemplary models in international engineering ethics education. This will contribute to an engineering ethics education framework that embodies Chinese characteristics while integrating global wisdom, ultimately laying the ethical foundation for cultivating a cohort of outstanding engineers who will lead the way in harnessing technology for the greater good.

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