Article

Ideological and Political Teaching Practice in the Principles and Technologies of Heat Exchange Course at an Application-Oriented Undergraduate University

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Abstract: This paper first describes the current status of ideological and political education (IPE) in the course Principles and Technologies of Heat Exchange for the Energy and Power Engineering program at Dongguan University of Technology. It then proposes the pedagogical approach for integrating IPE into the course, followed by a detailed discussion of practical teaching strategies, and concludes with a summary of the teaching outcomes. The practical component includes: the development of a threefold objective framework-knowledge transmission, ability cultivation, and value shaping-based on the "dual-module" concept, and the formulation of an IPE plan that balances depth, breadth, and relevance; the establishment of a "three-mentor" teaching team consisting of professional faculty, industry experts, and enterprise engineers, leveraging university-enterprise internship bases and research centers, and mapping a concentric-circle model for ideological education; and the identification of course-specific ideological elements in alignment with the regional energy industry, forming a "four-dimension" framework that reflects both disciplinary characteristics and local industry features.

Keywords: ideological and political education; principles and technologies of heat exchange; energy and power engineering; application-oriented undergraduate universities

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1. Introduction

The course Principles and Technologies of Heat Exchange is a core compulsory course for the Energy and Power Engineering program at Dongguan University of Technology and serves as a critical link to the needs of the Pearl River Delta's (PRD) key industries, including new energy, electronic information, and intelligent manufacturing [1,2]. This course integrates the theoretical foundations of heat transfer and fluid mechanics with practical experience in the production of heat exchange equipment within the regional industry [3]. It aims to enable students to understand the heat transfer bottlenecks and energy consumption issues in local enterprises related to new energy vehicle thermal management, electronic device cooling, and industrial waste heat recovery [4,5]. Students acquire skills in heat exchanger selection, design, optimization, and performance testing that are tailored to regional industrial needs, thereby addressing practical efficiency improvement and energy-saving challenges in local enterprises [6].

As emphasized by President Xi Jinping at the National Conference on Ideological and Political Work in Universities, "All other courses must guard their respective channels and cultivate their respective fields of responsibility, aligning with ideological and political theory courses to achieve synergistic effects" [7,8]. Anchored in the regional industrial context, the course at Dongguan University of Technology has actively reformed IPE, integrating it with the cultivation of practical skills in heat exchanger design, equipment

selection, and performance optimization while emphasizing students' ideological awareness and commitment to serving regional development [9]. This paper starts from the current deficiencies in the course's IPE, aligns with the university's orientation toward application-oriented talent cultivation and regional industrial demands, and constructs a comprehensive IPE framework to achieve professional leadership and moral education goals.

2. Current Status of Ideological and Political Education in the Course

The course targets third-year students of the Energy and Power Engineering program, a critical stage for career planning. IPE at this stage must closely align with regional industrial development and employment needs. Currently, several challenges exist (Figure 1):

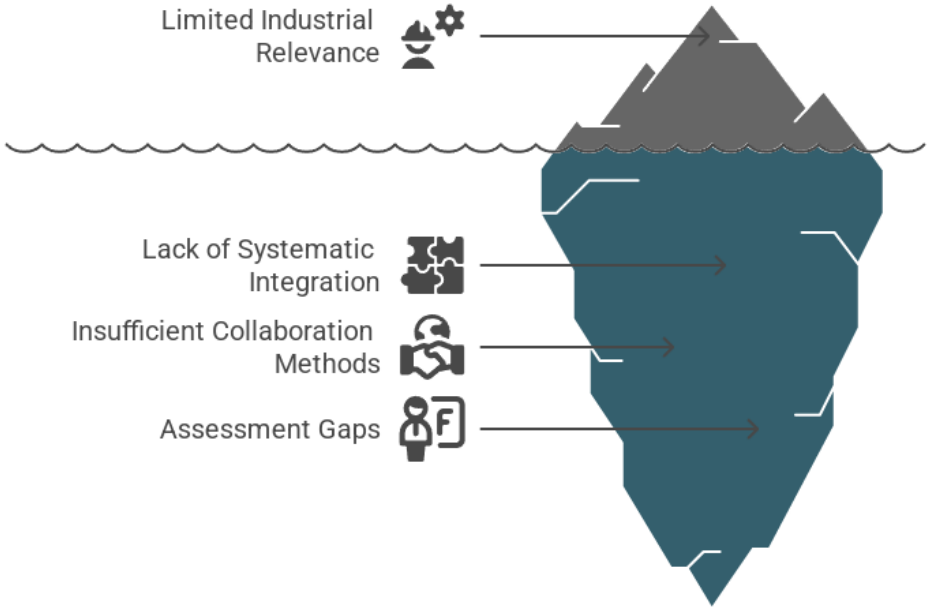

Figure 1. Weak Integration of Ideological Education with Regional Industries.

1) Lack of systematic integration with regional industries: The course covers multidisciplinary knowledge and complex theoretical systems, involving various types of heat exchangers and industrial applications. While instructors incorporate historical development, scientists' achievements, and national energy strategies, the integration with PRD's new energy and intelligent manufacturing industries is weak. Ideological elements are loosely connected to professional knowledge and regional industrial needs, often applied randomly, lacking systematic planning. Furthermore, the lack of structured curriculum mapping between ideological concepts and specific industrial applications limits students' ability to contextualize abstract values within real-world engineering scenarios. This gap may reduce students' motivation to internalize ideological principles as they fail to see practical relevance.

2) Limited industrial relevance and engagement: Traditional ideological cases are insufficiently linked to PRD's new energy and electronic information industries, lacking regional characteristics and timeliness. They also overlook students' employment-oriented career needs, failing to cultivate awareness of local enterprise norms and professional standards. Expanding case studies to include current enterprise practices, emerging technologies, and regional market trends could enhance engagement. Incorporating project-based learning with real industrial problems would further bridge the gap between theory and practice, fostering both professional competence and ideological understanding.

3) Insufficient university-enterprise collaborative methods: IPE is mostly delivered via didactic lectures or case-based teaching without fully leveraging local industry partnerships. Students rarely experience on-site enterprise practice, leading to passive learning, minimal emotional engagement, and weak synergy between professional courses, industry practice, and ideological education. Developing structured internship programs, joint workshops with industry experts, and mentorship schemes can create experiential learning opportunities. These strategies not only reinforce ideological education but also cultivate industry-relevant skills, problem-solving abilities, and professional ethics among students.

4). Assessment does not integrate IPE with industry competence: Evaluations focus primarily on mastery of theoretical knowledge and calculation skills in heat exchanger design, neglecting the assessment of ideological literacy and industry service awareness. Integrating reflective reports, industry-based project evaluations, and practical problem-solving assessments can provide a more holistic measure of students' ideological understanding and professional readiness. This approach encourages students to apply values and ethical principles actively in real-world engineering contexts.

3. Ideological and Political Education Approach in the Course

Based on the principles of teaching and the university's mission of "industry-education integration, service to the region," the teaching team constructed a comprehensive framework for course IPE described as "dual-module, three-mentor, four-dimension, five-module, six-evaluation, multi-method" (Figure 2). This framework integrates ideological elements and regional industrial requirements throughout the teaching process, transforming the classroom into an effective platform for cultivating talents "rooted in Dongguan, serving the Greater Bay Area."

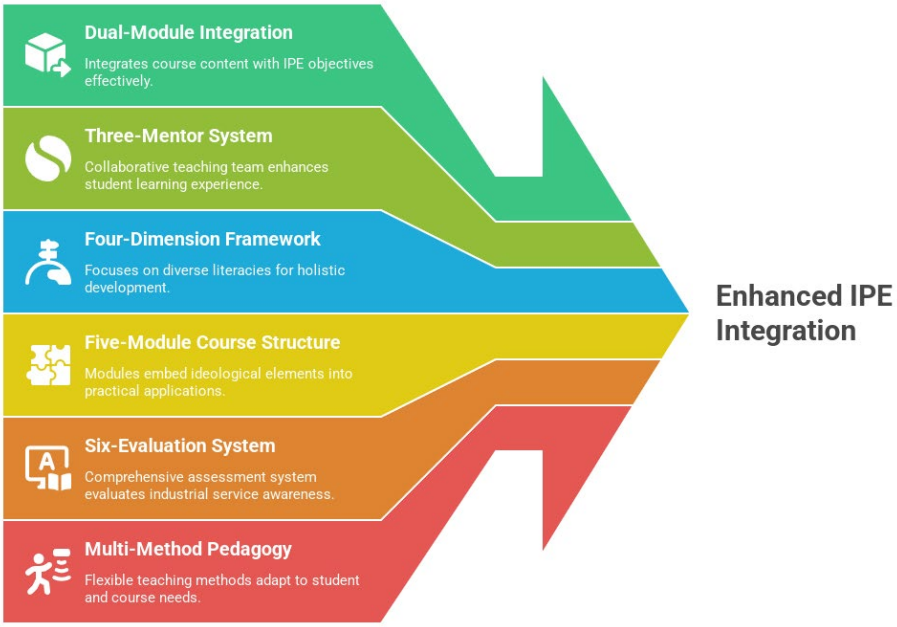

Figure 2. Pathways to Integrated Engineering Education.

The framework aims to systematically connect ideological education with professional competency development, ensuring students perceive the relevance of political literacy in practical engineering contexts. It also encourages reflective learning, enabling students to link ethical principles and regional service awareness to their technical work.

Dual-module: The dual threads of the course content and IPE objectives ("serving regional industry, cultivating craftsmanship") are integrated with local enterprise cases,

embedding ideological elements into teaching materials. This approach ensures that theoretical concepts are consistently reinforced through real-world examples, helping students internalize values such as responsibility, sustainability, and ethical engineering practices.

Three-mentor system: Professional faculty, industry experts, and enterprise engineers form a collaborative teaching team. Faculty integrate theory and IPE, industry experts interpret regional energy policies and trends, and enterprise engineers guide practice and professional development. The inclusion of multiple mentors provides diverse perspectives and enriches students' learning experience, fostering both technical competence and an understanding of socio-political contexts relevant to their future careers.

Four-dimensional framework: IPE elements focus on political literacy (including regional service awareness), humanistic literacy (teamwork and communication), scientific literacy (innovation and exploration), and professional literacy (ethics and adherence to standards). By embedding these four dimensions, the framework promotes well-rounded development, preparing students not only for technical challenges but also for leadership, collaboration, and ethical decision-making in industry settings.

Five-module course structure: Modules include "Heat Exchanger Development and Industrial Applications in the Greater Bay Area," "Heat Transfer Fundamentals and Fluid Mechanics Applications," "Typical Heat Exchanger Structures and Performance (emphasizing NEVs and electronic cooling)," "Heat Exchanger Design and Optimization (aligned with local enterprises)," and "Laboratory and Enterprise Practice." The four-dimensional ideological elements are embedded in all modules. This module design enables students to experience the seamless integration of theory, practice, and ideological guidance. Each module encourages application of learned principles in local industrial contexts, enhancing both professional skills and regional awareness.

Six-evaluation system: Combines formative and summative assessment, IPE evaluation, teacher assessment, enterprise assessment, and self-assessment, including dimensions of industrial service awareness and practical innovation ability. This comprehensive evaluation strategy ensures students are assessed not only on technical knowledge but also on their engagement with ethical, humanistic, and regional service-oriented aspects, reinforcing the importance of holistic development.

Multi-method pedagogy: Integrates online, offline, and enterprise-based teaching to flexibly adapt to student and course needs, promoting regional industrially contextualized IPE. The adoption of a blended pedagogy allows for dynamic adaptation to diverse learning scenarios, increasing accessibility, student engagement, and the practical relevance of ideological education, while fostering continuous feedback and iterative improvement in teaching quality.

4. Ideological and Political Education Practice

4.1. Dual-Module-Based IPE Plan

Knowledge, ability, and values are integrated with regional industrial needs to cultivate application-oriented talents with socialist core values, innovation, and engineering literacy capable of serving local NEV and intelligent manufacturing industries. Depth is ensured by analyzing local NEV battery thermal management, chip cooling, and industrial waste heat recovery, stimulating students' patriotism and social responsibility. Breadth is enhanced through case libraries in collaboration with local enterprises, while warmth is cultivated through guidance on career development and emotional resonance with local engineers.

This dual-module plan emphasizes the intertwining of technical competency and ideological education, enabling students to understand how their professional skills contribute to regional economic development and societal progress. It also encourages students to reflect on ethical responsibilities and sustainability in engineering practice.

4.2. Three-Mentor Teaching Team

Leveraging university-enterprise cooperation, faculty, industry experts, and enterprise engineers collaboratively guide students in theoretical and practical learning, forming a "concentric-circle" model for IPE and strengthening alignment with local industrial practices. The three-mentor system provides layered support: academic mentors ensure conceptual understanding, industry experts contextualize knowledge within current industrial trends, and enterprise engineers facilitate hands-on application, fostering an integrated learning ecosystem that bridges theory, practice, and ideological growth.

4.3. Four-Dimensional Ideological Elements

Political literacy, humanistic literacy, scientific literacy, and professional literacy are embedded in the five-course modules. Examples include local NEV battery thermal management breakthroughs, collaborative projects on chip cooling, innovations in microchannel and phase-change heat exchangers, and professional ethics in enterprise engineering practice. Embedding these four dimensions ensures that students gain a holistic understanding of engineering challenges while cultivating critical thinking, ethical decision-making, and teamwork abilities. The integration reinforces the notion that technical solutions should align with social responsibility and regional development goals.

4.4. Multi-Method Teaching ("Three Integrations, Three Promotions")

Combines classroom instruction, enterprise-based projects, online modules, laboratory practice, and cultural immersion to integrate knowledge acquisition, professional practice, and ideological cultivation. This multi-method approach fosters active learning and engagement, allowing students to apply theoretical knowledge in real-world contexts. It also promotes continuous reflection, encouraging students to connect professional practice with broader ideological and societal considerations.

4.5. Innovative Assessment ("Six-Evaluation System")

Evaluates students' knowledge, ideological literacy, industrial service ability, and practical competence through a combination of formative, summative, teacher, enterprise, and self-assessment, ensuring alignment between IPE and regional industrial needs. The six-evaluation system not only measures technical mastery but also captures students' development in ethics, collaboration, and service awareness. By incorporating feedback from multiple perspectives, it enhances learning outcomes and ensures that students are well-prepared for professional and civic responsibilities in the Greater Bay Area.

5. Teaching Outcomes

5.1. Integrated Industry-Based Teaching System

The course successfully implemented the dual-module, three-mentor, four-dimension, five-module, six-evaluation, multi-method framework, forming a "knowledge + ability + value + industrial service" model. 51 IPE resources, including 30 local enterprise cases, were developed. The course received recognition as a model IPE course at the university level.

This integrated system demonstrates how structured ideological and professional education can be effectively combined with regional industry needs. It not only provides students with practical experience but also strengthens collaboration between the university and local enterprises, ensuring that learning outcomes are closely tied to real-world industrial challenges. Moreover, the modular design allows for continuous updates and adaptation, enabling the curriculum to respond dynamically to emerging technologies, regional industry trends, and policy changes, thus maintaining long-term relevance and impact.

5.2. Achievement of Learning Objectives

Over 90% of students effectively applied course knowledge to professional courses and local enterprises. Average course scores improved from 62 (2018 cohort) to 80 (2022 cohort), pass rates from 70% to 90%, and local employment in NEV and intelligent manufacturing increased significantly.

These improvements highlight the effectiveness of embedding ideological education within technical courses. Students not only achieved better academic performance but also demonstrated enhanced employability, aligning their professional competencies with regional economic priorities. Furthermore, the structured integration of industry cases and practical exercises enhanced students' problem-solving skills, critical thinking, and ability to innovate under real-world constraints. Students reported increased confidence in engaging with industrial projects and applying theoretical knowledge to practical engineering challenges.

5.3. Enhanced Innovation and Regional Service Awareness

Students participated in national innovation competitions and local community projects, integrating technical expertise with social responsibility, demonstrating significant improvement in creativity, entrepreneurship, and commitment to regional development.

Participation in these activities fostered a sense of social accountability and encouraged students to apply their skills to community and regional development initiatives. By linking technical projects with societal needs, students developed a comprehensive understanding of how professional expertise can contribute to sustainable development and regional economic growth. In addition, students gained exposure to cross-disciplinary collaboration, learning to integrate engineering, business, and social perspectives, which further strengthened their ability to address complex challenges in regional industry and contribute meaningfully to innovation ecosystems.

5.4. Long-Term Impacts and Future Directions

The teaching model not only achieved immediate learning outcomes but also laid the foundation for long-term professional growth. Graduates demonstrate stronger alignment with regional industrial needs and are more likely to engage in entrepreneurial initiatives or innovative projects that address local challenges. The success of this approach suggests that extending the dual-module and three-mentor system to other engineering courses could enhance the overall effectiveness of IPE integration across the university. Furthermore, continuous feedback from industry partners allows for iterative refinement of the curriculum, ensuring sustained relevance and responsiveness to evolving regional and technological demands.

6. Conclusion

The Principles and Technologies of Heat Exchange course at Dongguan University of Technology has constructed a systematic IPE framework aligned with the university's application-oriented mission and regional industrial characteristics. By integrating ideological education with professional knowledge, industry practice, and innovative multidimensional assessment, the course has effectively cultivated application-oriented talents with technical competence, social responsibility, and patriotic dedication to the local industry. This model provides a replicable reference for industry-integrated IPE in engineering courses at application-oriented undergraduate universities.

The success of this course demonstrates the effectiveness of embedding ideological and political education into technical curricula, showing that students can achieve both professional mastery and ideological growth simultaneously. Furthermore, the framework fosters stronger university-industry collaboration, ensuring that graduates are well-prepared to meet the evolving demands of local industries, particularly in NEVs, intelligent manufacturing, and energy sectors. The model's modular, multi-mentor, and multi-

method approach allows for continuous adaptation, making it suitable for scaling to other engineering disciplines. In addition, by emphasizing regional service awareness and social responsibility, the course contributes to the cultivation of engineers who are not only technically skilled but also socially conscious, innovative, and capable of leading sustainable regional development initiatives. Finally, this framework serves as a valuable reference for higher education institutions seeking to integrate ideological education with practical professional training, ensuring that future engineers can contribute effectively to both industry and society. Future updates should integrate emerging technologies and industry trends to enhance students' skills, adaptability, and professional ethics.

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