Exploration of Teaching Reform Combining Industry, Academia, and Research in the Course of Inorganic Non-metallic Materials and Technology

Shenglin Zhong*

Longyan University, Longyan, 364012, China
**Corresponding author: 19305074016@163.com*

Abstract: *The course of Inorganic Non-metallic Materials and Technology is a crucial foundational component of the Materials Science and Engineering program, carrying both the construction of theoretical knowledge systems and the cultivation of engineering application abilities and research literacy. However, the traditional teaching model faces problems such as the disconnection between theory and practice, outdated content, and insufficient student innovation capacity, making it difficult to meet the rapid development of the materials discipline and the evolving needs of industry. Based on the integration of industry, academia, and research, this study systematically explores the teaching reform of the course. Starting from the course characteristics and teaching challenges, the research analyzes the applicability and necessity of industry–academia–research integration in materials discipline education, proposes the concept of integrating knowledge transmission, technical application, and research innovation, and further discusses approaches for course content expansion, teaching method optimization, and the cultivation of students' comprehensive competencies. The study indicates that the integration of industry, academia, and research can effectively enhance the course's contemporaneity and applicability, promote multi-dimensional talent development, and provide new insights for the reform of materials-related courses.*

Keywords: *Inorganic Non-metallic Materials; Course Teaching; Integration of Industry, Academia, and Research; Teaching Reform; Innovation Ability*

Introduction

The course of Inorganic Non-metallic Materials and Technology holds a foundational and central position within the discipline of Materials Science and Engineering, covering the full spectrum of knowledge from material composition and structural design to process control and performance optimization. This course not only serves as a crucial pathway for students to grasp the fundamental principles of materials science but also functions as a key stage for cultivating their engineering awareness and research capabilities. However, with the continuous emergence of novel materials and advanced technologies, the traditional teaching model and content system exhibit significant shortcomings in terms of update speed, application orientation, and competency development. The separation between theory and practice, the disconnection between teaching content and industrial development, and the insufficient innovation ability of students limit the course's effectiveness in meeting the frontiers of the discipline and the demands of engineering practice. Based on this context, exploring a teaching reform model that integrates industry, academia, and research has become an essential approach to enhance both the course's value and the quality of talent cultivation. By deeply combining research outcomes, industrial requirements, and teaching processes, the course can achieve an organic unity of knowledge transmission, technical application, and innovation ability development, thereby promoting the systematic optimization of materials discipline education.

1. Analysis of Course Characteristics and Teaching Challenges

1.1 Knowledge System and Disciplinary Positioning of the Course on Inorganic Non-metallic Materials and Technology

The course on Inorganic Non-metallic Materials and Technology is a core course within the Materials Science and Engineering program, featuring a knowledge system that spans material composition, microstructure, performance rules, and process control, reflecting a high degree of integration between theory and engineering application. The course content not only covers the structure and preparation principles of traditional materials such as ceramics, glass, cement, and refractory materials but also progressively extends to emerging directions, including functional ceramics, optoelectronic glass, composite materials, and advanced multifunctional composites, reflecting the interdisciplinary nature and developmental forefront of the materials discipline. By analyzing material formation, evolution, and phase transformation mechanisms through thermodynamic and kinetic principles, the course emphasizes an integrated design approach that links microstructure control with macroscopic performance optimization, providing students with a complete knowledge framework from fundamental theory to process application.

The disciplinary positioning of the course determines its critical role in the talent cultivation system. On one hand, it undertakes the important function of theoretical teaching within the materials discipline, helping students establish a systematic and logical understanding of the field; on the other hand, it serves as a primary channel for students to comprehend the feasibility of engineering processes, master process optimization methods, and enhance research literacy. The course requires students not only to possess solid foundations in physical chemistry and materials science but also to develop engineering abilities in process analysis, performance evaluation, and problem-solving. This dual positioning renders the course indispensable within the disciplinary system, providing a robust theoretical foundation and methodological support for students' subsequent research and engineering practice [1].

1.2 Disconnection Between Theory and Application in Course Teaching

Although the course content is systematically and comprehensively designed, the actual teaching process often exhibits a disconnection between theoretical knowledge and engineering application. The course primarily focuses on theoretical knowledge such as material microstructure, phase transformation rules, and performance analysis, while its integration with material production processes, performance testing, and practical applications remains insufficient. During the learning process, students tend to remain at the level of concept memorization and formula comprehension, lacking the ability to translate theory into engineering solutions. In addition, the connections between knowledge points are not sufficiently tight, making it difficult for students to form an overall cognitive framework, which results in clear deficiencies in enhancing engineering literacy and comprehensive analytical ability.

With the continuous emergence of novel inorganic non-metallic materials and the increasing diversification of material processing methods, the course content updates relatively slowly, leading to a gap between teaching and the industrial forefront. Some teaching components lack the integration of research outcomes or advanced technological processes, resulting in students' limited understanding of innovations in material preparation and application scenarios. The course also lacks task-driven or problem-oriented open learning contexts, making it difficult for students to develop interdisciplinary integration abilities through learning. This disconnection not only restricts students' grasp of the developmental trends in materials science but also affects the effectiveness and forward-looking nature of the course in meeting modern engineering and research demands.

1.3 Limitations of Student Competency Development under Traditional Teaching Models

Traditional teaching models place strong emphasis on knowledge delivery and result verification, positioning students in a passive learning state. Classes primarily rely on blackboard writing and projection as teaching methods, with content organized around the completeness of theoretical knowledge, while neglecting the cultivation of students' active exploration and critical thinking. Under this teaching approach, although students can grasp certain foundational theories of materials, their abilities in process design, performance prediction, engineering problem diagnosis, and material innovation remain markedly insufficient. The course lacks systematic competency training and space for autonomous learning, making it difficult for students to develop problem-solving skills that integrate theory with practice.

Laboratory teaching primarily focuses on basic and verification experiments, with fixed objectives and operational procedures, offering few opportunities for open-ended, innovative, or research-oriented training. Students often lack the ability to independently design experimental schemes, adjust process parameters, or explore the relationships between material structures and properties, and they struggle to enhance research capabilities through data analysis, experimental optimization, and result synthesis.

This mode of cultivation leads to deficiencies in independent thinking and integrated application abilities when students face complex engineering problems or material innovation tasks, limiting their readiness to meet future research and industrial demands. The course urgently requires the introduction of interactive, research-oriented, and interdisciplinary teaching strategies to comprehensively enhance students' knowledge application skills and innovation potential [2].

2. Teaching Reform Concept Based on the Integration of Industry, Academia, and Research

2.1 Applicability and Necessity of Industry–Academia–Research Integration in Materials Discipline Teaching

The course on Inorganic Non-metallic Materials and Technology embodies both theoretical and engineering dimensions, with teaching objectives aimed not only at establishing a systematic and comprehensive knowledge framework but also at cultivating students' comprehensive abilities to transform theoretical knowledge into engineering applications and research competence. Traditional single-mode classroom teaching often emphasizes knowledge transmission, leaving students with limited ability to integrate materials science theory with practical process applications, and making it difficult for them to develop systematic thinking when facing complex engineering problems. The integration of industry, academia, and research provides multidimensional instructional support for the course. By introducing real industrial application scenarios, cutting-edge research cases, and explorations of innovative technologies, students can better understand the dynamic relationships among material structure, performance, and processing, while honing their problem-solving abilities through practice. This model extends course teaching to the cultivation of technical application skills and research thinking, offering strong support for enhancing students' overall competencies and innovation potential.

The development of the materials discipline is closely tied to industrial demand, with emerging areas such as new ceramics, functional glass, composite materials, and high-performance heat-resistant materials continuously appearing. This requires that course content remain closely aligned with the latest research advances and engineering practices. The integration of industry, academia, and research not only allows teaching content to stay synchronized with technological developments but also provides students with interdisciplinary cognitive training and practical skills development during the learning process, helping them form a complete learning chain from theory to application to innovation. Through this model, students can master the core theories of the materials discipline while understanding their practical value in engineering design and research exploration, thereby enhancing the course's applicability, forward-looking nature, and comprehensive educational function.

2.2 Intrinsic Logic and Collaborative Pathways of Industry–Academia–Research Elements

The integration of industry, academia, and research is not a simple accumulation of resources, but a deep coupling and systematic collaboration among industry, scientific research, and teaching. Industry provides technological demands and application scenarios, research expands knowledge frontiers and drives theoretical innovation, while university teaching undertakes the core function of talent cultivation. In the course of Inorganic Non-metallic Materials and Technology, these three elements should form a systematic interactive logic, in which research drives knowledge updates, industry requirements clarify teaching objectives, and course instruction facilitates knowledge transformation and competency development, thereby establishing a complete educational chain from fundamental theory to engineering application. This logical relationship ensures that course content and teaching objectives closely align with industrial frontiers while providing students with a continuous pathway for knowledge acquisition and skill development [3].

Specifically, the collaboration among industry, academia, and research manifests in resource sharing, goal unification, and process interaction. Industrial demands supply the course with authentic engineering contexts, process cases, and problem scenarios; research outcomes inject cutting-edge, exploratory, and innovative content into teaching; and course instruction systematically transforms these elements into structured knowledge training and competency development tasks. This collaborative pathway not only enhances the contemporaneity and applicability of course content but also creates multidimensional learning channels for students, fostering a positive cycle among knowledge acquisition, skill cultivation, and innovation ability enhancement. Moreover, by guiding students to participate in research projects or industry investigations, instructors can further strengthen the course's practical relevance and cutting-edge nature, achieving a high degree of alignment among teaching content, learning methods, and competency development objectives.

2.3 Organic Integration of Knowledge Transmission, Technical Application, and Research Innovation

The reform of the course on Inorganic Non-metallic Materials and Technology should emphasize the organic integration of knowledge transmission, technical application, and research innovation. Knowledge transmission, as the foundation of the course, encompasses material chemistry, microstructure design, performance regulation, and process principles, providing students with a theoretical foundation and forming a systematic understanding. Technical application represents an important extension of the course; by introducing process optimization, performance testing methods, and engineering application cases of novel materials, students can comprehend the practical value of knowledge and its engineering feasibility. Research innovation serves as the driving force for the continuous development of the course, stimulating students' interest in exploring the unknown and their research potential by guiding them to focus on frontier material issues, design innovative experiments, and analyze complex process procedures.

This teaching concept, integrating the three elements, transcends the limitations of traditional courses with single objectives, achieving multidimensional talent cultivation. Knowledge transmission provides students with a theoretical basis for understanding and analyzing problems, technical application equips them with tools to solve engineering issues, and research innovation cultivates their abilities to identify problems, propose solutions, and conduct independent exploration. During the teaching process, students gradually form a complete cognitive chain from theoretical understanding to technical application and then to innovative exploration, realizing a high degree of unity among theory, practice, and innovation. This integration not only optimizes the educational value of the course but also provides systematic, cutting-edge, and sustainable support for talent development in the materials discipline, offering scientific guidance and practical direction for course reform [4].

3. Exploration and Optimization Pathways of Teaching Reform

3.1 Multidimensional Expansion of Course Content and Reorganization of Knowledge Structure

The teaching content of the course on Inorganic Non-metallic Materials and Technology needs to break through the limitations of a traditional single-discipline approach and build a knowledge system with multidimensional expansion. In course design, in addition to covering fundamental theories and process content of traditional materials such as ceramics, glass, cement, and refractory materials, emerging directions including functional ceramics, optoelectronic glass, composite materials, and high-performance heat-resistant materials should also be introduced, enabling students to engage closely with the forefront of materials science and engineering and develop a systematic understanding of new material design, preparation, and performance optimization. The course design emphasizes not only the systematicity of theoretical knowledge but also the integration of theory and practice through typical engineering cases and application scenarios, allowing students to comprehend the intrinsic relationships among material structure, performance, and process optimization, thereby avoiding superficial concept memorization and formula-based understanding.

The reorganization of the knowledge structure requires transforming scattered knowledge points into a highly systematic logical network, forming a complete cognitive chain from microstructural analysis to macroscopic process control. In content organization, the progressive logic should reflect the sequence from material composition, microstructure, and phase transformation to process parameter control and performance regulation, while integrating research findings, cutting-edge technologies, and engineering cases into course modules, providing students with interdisciplinary thinking training and problem-solving pathways. This approach not only helps students develop systematic cognition and holistic analytical abilities but also enhances their capacity for cross-domain comprehensive judgment when facing complex engineering problems.

Furthermore, the expansion of course content should pay attention to the integration of material application contexts and industrial technology trends. By introducing application cases of functional materials in fields such as new energy, information electronics, aerospace, and environmental engineering, students can connect theoretical knowledge with practical technological demands during the learning process. In this way, the course not only strengthens its disciplinary forefront but also enhances students' understanding of research directions and engineering value in materials science, laying a solid foundation for cultivating high-level innovative talent.

3.2 Enhancing Interaction and Research Orientation in Teaching Methods

Optimizing teaching methods is a crucial aspect of course reform. By enhancing classroom interaction and fostering open-ended exploration during the learning process, students' active learning and deep-thinking abilities can be effectively stimulated. Problem-based inquiry teaching guides students to develop independent thinking patterns while analyzing material process issues and solving practical engineering problems, cultivating systematic problem-solving skills. Discussion-based, project-based, and seminar-style teaching methods provide students with opportunities for expression, communication, and critical thinking, transforming the classroom into a space for knowledge generation and the collision of innovative ideas. Such interactive teaching not only deepens students' understanding of course content but also helps them acquire the ability to translate theoretical knowledge into engineering applications [5].

Research-oriented teaching emphasizes the integration of scientific thinking throughout all course modules. By introducing the latest research findings, new material preparation technologies, and unresolved engineering challenges, and transforming them into classroom discussions and practical tasks, students learn to master research methods such as literature retrieval, experimental design, data analysis, and result interpretation while exploring and solving open-ended problems. This approach overcomes the limitations of traditional knowledge transmission, providing students with direct exposure to research practice and innovation, while fostering critical thinking and scientific judgment.

Furthermore, research-oriented teaching methods can guide students through tiered project training and problem challenges, leading them from analyzing specific material preparation steps to optimizing process flows and proposing innovative design solutions, thereby forming a closed loop between theoretical learning and research training. The multidimensional classroom interaction combined with research guidance not only enhances students' academic literacy but also equips them with the capacity for independent thinking, systematic analysis, and innovative design when facing complex material engineering problems.

3.3 Mechanism for Cultivating Students' Innovation Ability and Comprehensive Competence

The cultivation of students' innovation ability should run through all stages of the course, forming a closed loop from knowledge acquisition to experimental operation and engineering application. During the knowledge learning stage, designing interdisciplinary and open-ended problems can stimulate students to establish connections among knowledge modules such as material structure design, process optimization, and performance regulation, thereby forming cross-domain integrative thinking. In the experimental and process operation stages, students are encouraged to independently design experimental schemes, analyze experimental data, and optimize process conditions, enabling them to verify theory in practice and explore methods for material innovation and performance enhancement. This comprehensive and continuous design gradually develops students' independent research capabilities and innovative thinking, achieving an efficient integration of theoretical understanding and practical skills.

The cultivation of comprehensive competence should build upon knowledge transmission by systematically integrating engineering awareness, research literacy, academic expression, and teamwork ability. Through interdisciplinary tasks, collaborative projects, and comprehensive experimental designs, the course closely combines material preparation, performance testing, and process optimization, allowing students to enhance communication and coordination skills, information retrieval and data processing abilities, as well as academic presentation and scientific writing skills within team cooperation. Through this multidimensional competency training, students not only deepen their understanding of materials science theories and process technologies but also demonstrate comprehensive competence in solving complex problems and executing innovative projects, providing a solid foundation for long-term development in research, engineering development, and industrial applications. This mechanism ensures that the course achieves an organic integration of theory, skills, and innovation ability in talent cultivation, offering systematic support and scientific assurance for training high-level innovative talent in materials-related disciplines [6].

Conclusion

The teaching reform of the course on Inorganic Non-metallic Materials and Technology requires coordinated optimization across course content, teaching methods, and competency development mechanisms. The concept of integrating industry, academia, and research injects new vitality into the course, making the knowledge system more cutting-edge, teaching methods more diversified, and students' innovation ability and comprehensive competence systematically enhanced. By multidimensionally expanding course content, reorganizing the knowledge structure, introducing interactive and research-oriented teaching methods, and establishing mechanisms for cultivating innovation ability and comprehensive competence, the course can achieve deep integration between theory and application. However, the teaching reform based on industry–academia–research integration remains in an ongoing exploratory stage. Future efforts should further strengthen interdisciplinary resource integration, optimize knowledge updating mechanisms, and expand students' engagement in research and engineering applications. As the reform pathways continue to be refined, this course is expected to play an increasingly critical role in talent cultivation within the materials discipline and provide a reference for the optimization of similar courses.

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