CSCanada
Higher Education of Social Science
Volume 27, Number 2, 2024, pp. 30-36
DOI:10.3968/13608

ISSN 1927-0232 [Print]
ISSN 1927-0240 [Online]
www.cscanada.net
www.cscanada.org

Exploration and Practice of a Multimodal Collaborative Teaching Model: A Case Study of the "Silicate Petrology" Course

SUN Yi[a],*; SU Xiaoli[a]; LIU Shuxing[a]

[a] School of Materials Science and Engineering, Jingdezhen Ceramic University, Jingdezhen, China.
*Corresponding author.

Supported by the Teaching reform Project for Jiangxi Province "Multi-Synergistic Coupling Effects and Implementation of 'Two Properties and One Degree' Course Modules Under the Perspective of Golden Courses: A Case Study of the 'Silicate petrography' Course" (Number: JXJG-2022-11-4) and "'Standardized, Process-Oriented, and Value-Added' Course Effectiveness Evaluation System Construction and Implementation: A Case Study of the 'Silicate Petrography' Course" (Number: JXJG-23-11-7).

Received 21 October 2024; accepted 30 November 2024
Published online 26 December 2024

Abstract

Silicate Petrology is a foundational course in the Engineering of Inorganic Non-Metallic Materials program, essential for equipping scientists and engineers with the professional knowledge required for research and production in inorganic materials. Traditional teaching methods have faced significant challenges, including misalignment with industry needs, lack of relevance, limited student engagement, and inadequate objectivity, all of which hinder the development of innovative, application-oriented talent. In response, the course team implemented the principles of New Engineering Education, emphasizing "Outcome-Based Education (OBE)" and "Course Ideological and Political Education (CPE)" to align the curriculum with industry advancements and disciplinary demands. This restructuring led to a teaching model defined by "One Core, Three Phases, Five Modules, and Full Process." This student-centered model integrates OBE, CPE, blended learning, and virtual simulations to form a collaborative, modular approach. Additionally, the "Two-Dimensional Multi-Aspect" evaluation method promotes higher-order skill development and a holistic educational experience. The revised model has been successfully implemented, demonstrating significant impact and widespread applicability.

Key words: Silicate petrology; Course modules; Multimodal collaborative

Sun, Y., Su, X. L., & Liu, S. X. (2024). Exploration and Practice of a Multimodal Collaborative Teaching Model: A Case Study of the "Silicate Petrology" Course. *Higher Education of Social Science*, *27*(2), 30-36. Available from: URL: http://www.cscanada.net/index.php/hess/article/view/13608
DOI: http://dx.doi.org/10.3968/13608

The concept of "modular theory" was first introduced in 1976 by Professor Michael Gazaniga, director of the Perception Neuroscience Research Center at Dartmouth College (Ren, 2019). This theory has profoundly influenced various fields, particularly education, where it has been adapted into a modular teaching model by numerous scholars (Hou, 2011; Wang, 2000; Cai, 2012). Modular teaching significantly enhances learning flexibility, improves the efficiency and quality of instruction, and promotes the systematicity and coherence of knowledge. It fosters practical skills, nurtures an innovative spirit, accommodates diverse learning needs, optimizes the allocation of educational resources, and drives educational innovation and development.

The "Silicate Petrology" course, integral to the Engineering of Inorganic Non-Metallic Materials program, awards 2 credits over 32 class hours. This required course targets second-year undergraduates in the Inorganic Non-Metallic Materials Engineering program and third-year students in the Powder Materials Engineering program (Sun, 2019). Since its inception in 1958, the course has evolved significantly over more than 60 years, undergoing two major phases:

In its initial phase (1958-2012), the course encompassed "Crystallography and Mineralogy" and "Crystal Optics and Optical Mineralogy", focusing on developing specialized talent for the ceramic industry's raw materials. With rapid industry evolution, the content was refined and targeted, leading to the merger of these subjects into "Silicate Petrology" in 1998. This phase emphasized instructor-led instruction, textbook-based learning, classroom teaching, and examination-based assessment.

The subsequent phase (2013-present) has witnessed continuous innovation in instructional design, teaching methods, delivery modes, and assessment approaches. The course has been recognized as a provincial-level exemplary course, a top-tier blended online and offline course at the provincial level, a university-level model course in ideological and political education, and a first-class offline course at the university level. These accolades reflect a shift towards a student-centered teaching model that emphasizes resource utilization, smart classrooms, and outcome-focused assessment, illustrating the course's dynamic evolution and responsiveness to educational advancements.

The current teaching team for the "Silicate Petrology" course is comprised of one professor, two associate professors, and one lecturer. This team dedicates itself to the specialty of ceramics, aligning closely with professional training objectives. Starting from a deep understanding of students' knowledge systems and domains, the team prioritizes ceramic-focused content. Utilizing modular teaching as a foundational strategy, the team has developed a robust teaching model characterized by "One Core, Three Stages, Five Modules, and Full Process." This framework supports a "One Center with Four Elements Collaborative" teaching approach, enhancing the integration of various educational components. Additionally, the team has refined the "Two-Dimensional Multi-Aspect" evaluation method to better assess and promote student learning outcomes. These comprehensive reforms have not only yielded positive results but also demonstrated significant exemplary and radiating effects, underscoring the success of the innovative teaching strategies implemented.

1. ANALYSIS OF REAL PROBLEMS IN THE COURSE

The "Silicate Petrology" course encompasses a broad spectrum of topics across 19 chapters, covering crystal formation, macroscopic symmetry elements, minerals' chemical compositions, mineral morphology and physical properties, classification and nomenclature of minerals, fundamentals of crystal optics, and optical properties of crystals under various polarized lights. Comprehensive analysis of student performance, course evaluations, and reflective observations has highlighted several critical issues:

1.1 Misalignment

Traditional teaching methodologies tend to focus excessively on knowledge transmission at the expense of skill development, often neglecting learner engagement in favor of direct instruction(Sun, 2019). This approach fails to align with the advanced, innovative, and challenging goals of developing "golden courses" and leads to unclear objectives that do not correspond with the program's graduation requirements, thereby reducing the effectiveness of student training. Transitioning from an instructor-centered to a learner-centered educational philosophy, and standardizing teaching quality to improve educational outcomes, remain pivotal.

1.2 Inadequate Adaptation

The complexity and breadth of the course content are disproportionate to the available instructional time, totaling only 32 class hours. Moreover, the slow pace of updates to textbook content and structure does not match the rapid advancements in the ceramics industry, resulting in a limited knowledge base among students and diminishing their interest in the subject. A strategic adaptation to match industry progression while effectively utilizing educational resources is essential to expand student knowledge and foster engagement.

1.3 Lack of Participation

Student engagement is critically low, with poor control over the learning process, which fails to meet the diverse and personalized needs of the student body. Enhancing student initiative and integrating digital teaching tools are necessary to transcend the limitations of traditional instructional environments, boost interaction, and encourage higher-order thinking and innovation.

1.4 Lack of Objectivity in Assessment

The existing course evaluation methods are overly simplistic, failing to offer a comprehensive, objective, and precise measurement of student learning outcomes. Overcoming the constraints of single-dimensional assessment methods is crucial to foster active student participation, invigorate classroom dynamics, and emphasize the development of student skills and qualities, thus increasing their sense of achievement and satisfaction.

2. MAIN MEASURES OF MULTIMODAL COLLABORATIVE MODULAR TEACHING

To tackle the identified challenges of misalignment, inadequacy, non-participation, and lack of objectivity ("Four Misalignments") in teaching "Silicate Petrology," significant reforms have been implemented to augment students' higher-order capabilities and foster comprehensive educational development. These reforms integrate OBE.

Course Ideological and Political Education (CPE), blended learning, and virtual simulations, with modular teaching serving as the pivotal link. This strategic integration facilitates a balanced, multimodal collaborative approach, effectively addressing the diverse elements of teaching reform. Moreover, these reforms enhance alignment with the professional needs of the industry and fulfill the pedagogical demands of "New Engineering Education." Specific initiatives include:

2.1 Innovate teaching philosophy, clarify course objectives, strengthen ideological and political education, and standardize teaching documents (addressing issue one: misalignment)

The syllabus serves as a foundational document that guides course instruction and standardizes pedagogical practices. Historically, syllabi have focused predominantly on the acquisition of knowledge and skills, often overlooking the integral development of student qualities. Traditional methods, largely lecture-based, concentrated on the mechanics of teaching—what instructors teach, the content they cover, and their methods of evaluating student comprehension and mastery. Such approaches are increasingly seen as inadequate for meeting the dynamic demands of modern educational reforms and do not align with the elevated standards of "golden courses." In response, our course team has undertaken a rigorous alignment with national standards for constructing "golden courses." Our reformative focus is to enhance students' higher-order abilities and promote comprehensive quality education. We have thus redefined course objectives to include not only knowledge transmission and skill development but also the cultivation of quality attributes through an organic integration of OBE principles and Course Ideological and Political Education (CPE). The redesigned syllabus is structured around the decomposition of professional graduation requirements. It emphasizes the acquisition of knowledge, the mastery of skills, and the cultivation of personal and professional qualities that are directly beneficial to students' growth and employability. The focus shifts from speculative learning metrics, such as styles and timing, to the concrete benefits of educational content. We aim to ensure that students not only understand and comprehend this knowledge and these skills but are also able to master and apply them flexibly. Assessment and evaluation criteria have been meticulously developed to verify the achievement of these objectives. With a robust system for monitoring the attainment of course objectives, we propose targeted measures for continuous improvement, thereby ensuring that the course remains aligned with the highest educational standards and effectively addresses the evolving needs of our students (Xu, 2019).

2.2 Restructure the teaching system, establish five major modules, enrich teaching resources, and iterate teaching content (addressing issue two: inadaptability)

The "Silicate Petrology" course encompasses a comprehensive curriculum spanning 19 chapters. To enhance educational outcomes, the course team has initiated a significant transformation in the teaching approach, moving away from the traditional sequential chapter-by-chapter delivery. Instead, instruction is now deeply integrated with the specific needs of the ceramic mineral industry. This alignment is guided by the dual objectives of addressing both the course goals and the unique capability requirements of our students. Embracing a philosophy centered on strategic educational design—'designing how to teach for better learning'—the curriculum has been restructured into a modular format. This format comprises five distinct teaching modules: Basic Theory of Crystallography, Basic Theory of Crystal Optics, Basic Theory of Mineralogy, Ideological and Political Education, and Knowledge Application Expansion. Such modularization not only enhances the relevance and modernity of the curriculum but also ensures that updates can be integrated seamlessly, reflecting the latest developments in mineral application and structures in new energy materials.

To support this innovative teaching approach, a comprehensive array of both online and offline educational resources has been developed. These resources include an updated syllabus, textbooks, detailed lecture notes, an array of teaching videos (14 videos totaling 258 minutes), extensive online resources (35 items), assorted course materials (29 items), a robust question bank (270 questions), and thorough course objective surveys. These materials are designed to fulfill the diverse learning needs of our student body comprehensively. Furthermore, the online component of the course, "Silicate Petrography," launched in 2020, has become increasingly utilized. It has achieved significant engagement, with over 580,000 page views and more than 500 students enrolled, demonstrating its effectiveness and popularity among students.

2.3 Highlighting school characteristics, innovating teaching methods, enhancing teacher-student interaction, and achieving holistic education (addressing issue three: lack of participation)

The "Silicate Petrology" course is meticulously designed to embody the high-level objectives it sets, ensuring both the scientific rigor and operational feasibility of its pedagogical strategies. Central to this approach is the adept use of advanced modern information technology, which fosters innovation, diversity, and interactivity in teaching methods. The course employs the Chaoxing Learning smart teaching tools and adopts a hybrid teaching model articulated around "one core, three stages, and five modules." This model is intricately structured to enhance the identification of crystal forms, both macroscopic and microscopic, of ceramic mineral raw materials, and spans pre-class, in-class, and post-class phases across the teaching modules.

In the Pre-Class Online Phase, using the Chaoxing Learning platform, students engage in video learning, quizzes, and interactive sessions with instructors that cover the theory modules of Crystallography, Crystal Optics, and Mineralogy.

The In-Class Offline Phase, conducted in smart classrooms, integrates quizzes to assess comprehension and facilitates discussions on critical concepts and challenging topics. Teaching is student-centric, with instructors using guided questions to evaluate online learning outcomes and applying problem-driven, flipped classroom, and group discussion techniques to deepen understanding and extend knowledge. This phase also incorporates research findings and ideological and political education into the curriculum to broaden students' perspectives.

The Post-Class Consolidation Phase includes post-class exercises, supplementary materials, and periodic thematic research projects. Students collaborate in groups to delve into thematic research, including literature reviews, and engage in continued online interactions with instructors. For instance, in the mineralogy module on layer silicate minerals, virtual simulation experiments are used to elucidate the formation processes of clay minerals, significantly enhancing both the efficiency and motivation of student learning. This structured implementation ensures a comprehensive, integrative learning experience that not only addresses theoretical knowledge but also emphasizes practical skills and critical thinking, essential for students' academic and professional growth.

2.4 Breaking Single Assessment, Building Diverse Evaluations, Increasing Challenge Levels, and Implementing Feedback Mechanisms (Addressing Issue Four: Lack of Objectivity)

The "Silicate Petrology" course has adopted a comprehensive evaluation framework called the "Quantitative and Qualitative Two-Dimensional Evaluation Module" to assess student performance holistically. This framework divides assessment into two main components: a quantitative evaluation module and a qualitative evaluation module. The quantitative module incorporates formative assessments, which include components such as online learning (10%), daily performance (7.5%), homework (12.5%), and thematic research reports (20%). Examination scores constitute 50% of the quantitative evaluation, with a specific focus on fostering students' abilities and moving away from solely objective-type questions to encourage deeper understanding and application of knowledge. The qualitative evaluation module complements this by including course surveys and transcripts of seminar meetings, which offer insights into the subjective experiences and engagement of students (Ma 2020). Teachers systematically integrate data from both quantitative and qualitative assessments to compile an "Analysis Report on Course Objective Achievement." This report critically evaluates all aspects of the course structure—from teaching content and methodologies to assessment techniques, providing a detailed account of areas where the course meets its objectives and identifying opportunities for improvement. The goal of this evaluation process is to create a closed-loop system that facilitates continuous enhancement of the course, ensuring that educational strategies and content evolve in response to feedback and contribute to the upward spiral of teaching quality.

3. CHARACTERISTICS OF COURSE REFORM

3.1 Innovation in Teaching Model

The "Silicate Petrology" course is intricately designed to align with the advancements in the ceramics industry, implementing a structured teaching model known as "One Core, Three Stages, Five Modules, Full Process." This model is crafted to integrate directly with the specific needs and developments within the ceramic mineral raw materials sector. The "One Core" aspect of the model focuses on these school-specific materials, emphasizing their critical role in the curriculum. The "Three Stages" of the model—pre-class, in-class, and post-class—outline a dynamic teaching implementation approach that ensures comprehensive engagement and learning continuity at all phases of instruction. Each stage is tailored to foster an immersive and interactive learning environment, preparing students for the complexities of real-world ceramic materials applications. The "Five Modules" of the course—crystallography, mineralogy, crystal optics, course ideological and political education, and knowledge expansion—encapsulate the major areas of study, each contributing uniquely to the holistic understanding of the subject matter. This modular approach facilitates a focused yet diverse educational experience, allowing students to gain deep insights into each specific area while maintaining a cohesive educational trajectory. Finally, the "Full Process" represents the continuous cycle of course objectives, teaching content, implementation, evaluation, and feedback. This comprehensive framework ensures that every element of the course is revisited and refined based on ongoing assessments and feedback, promoting a cycle of continuous improvement and alignment with both educational and industry standards. Through this structured approach, the course aims to achieve and exceed its set objectives, preparing students effectively for their future roles in the ceramics industry.

3.2 Innovation in Teaching Content

The course has actively departed from traditional teaching paradigms to better align both its educational objectives and the evolving dynamics of the ceramics industry. This strategic realignment involves a thorough reassessment and update of the teaching content, ensuring that it not only meets but anticipates the needs of the industry. To achieve this, the course modules have been extensively reconstructed to incorporate the most current industry developments and research findings directly into the classroom setting. In addition to technical and scientific training, elements of ideological and political education have been seamlessly integrated into each module, enriching the educational scope of the course. This integration serves to fortify the course's educational function, providing students with a well-rounded understanding of the societal and ethical contexts of their future professional practices. This approach ensures that the curriculum remains modern and relevant, continually adapting to incorporate the latest advancements in the field. Through these updates, the course strives to maintain its relevance and efficacy, preparing students to contribute meaningfully to the ceramics industry and to engage with the broader societal impacts of their work.

3.3 Innovation in Teaching Methods

The course employs an innovative teaching methodology known as the "One Center, Four Elements Collaborative." This approach positions students at the epicenter of the learning experience, emphasizing their active involvement and engagement. It integrates four critical elements of modern educational practices: OBE, course ideological and political education, blended learning, and virtual simulation. This method underscores the progressive and interactive nature of the teaching forms utilized in the course. By combining these diverse educational tools and philosophies, the course not only enriches the learning environment but also makes it more engaging and exploratory for students. Such an approach significantly enhances the overall effectiveness and quality of teaching, directly impacting students' understanding and retention of course material. Moreover, this teaching method actively fosters students' innovative thinking and awareness, crucial for their development in a competitive academic and professional landscape. By encouraging the exploration of new ideas and approaches, the course promotes the enhancement of higher-order cognitive abilities among students. This, in turn, contributes to the comprehensive development of quality education, ensuring that graduates are well-prepared to meet the challenges of their future careers and societal contributions.

3.4 Innovation in Evaluation Methods

The course has adopted an innovative assessment strategy known as the "Two-Dimensional Multidimensional" evaluation method. This approach assesses student learning achievements through both quantitative and qualitative dimensions, offering a comprehensive, multi-faceted view of student progress and engagement. By integrating diverse metrics and feedback mechanisms, this method provides a broad perspective on educational outcomes, allowing for a detailed analysis from multiple angles. This evaluation strategy not only enhances the rigor of academic assessment but also actively stimulates student initiative and increases the intellectual challenges within the learning process. The dual focus on quantitative data and qualitative insights facilitates a deeper understanding of student needs and performance, enabling instructors to provide timely and precise feedback. Such an approach fosters an environment of continuous improvement, where educational strategies can be dynamically adjusted to enhance teaching effectiveness and student learning experiences. This method ensures that the course remains responsive to student progress and evolving educational goals, thereby maintaining high standards of academic excellence and relevance.

4. EFFECTIVENESS OF COURSE REFORM AND PROMOTION AND APPLICATION

4.1 Reform Effectiveness

4.1.1 Significant Improvement in Students' Petrographic Knowledge, Innovative Abilities, and Comprehensive Quality

The comprehensive reform of the "Silicate Petrology" course modules has led to a significant enhancement in student engagement and the cultivation of their innovative skills. Since the introduction of these reforms, there has been a noticeable surge in student interest, underpinned by the success of the online course "Silicate Petrography," which has been in use since 2020 and has amassed over 580,000 page views. Over the past three years, there has been a marked improvement in students' achievement of course objectives, coinciding with an increase in their participation in innovation and entrepreneurship competitions, such as the Challenge Cup. Furthermore, the depth of knowledge acquired through the course has enabled students to engage more profoundly with the field; many have gained early access to laboratory work, contributing to research projects, publishing scientific papers, and securing patents. These engagements have not only enhanced their academic and professional profiles but also led to the course and its instructors receiving prestigious recognitions, including the "Provincial May Fourth Red Flag League Branch," "University Advanced Class Collective," and "University-Level May Fourth Red Flag League Branch." These accolades reflect the effectiveness of the curricular innovations and the substantial impact on both the academic community and the broader industry.

4.1.2 Significant Improvement in Teachers' Professional Ethics, Teaching Abilities, and Educational Research Levels

The instructional team of the "Silicate Petrology" course has demonstrated a commitment to professional growth and pedagogical excellence by continuously engaging with the latest teaching philosophies. This proactive approach has led to significant enhancements in their teaching methodologies and overall pedagogical skills. Over the past five years, the team has spearheaded 13 teaching reform projects, including five that achieved provincial recognition, and participated in over 20 research initiatives. Their scholarly output includes nine papers focused on teaching reform and more than ten papers in scientific research, underscoring their robust teaching and research capabilities. These efforts have contributed to the sustainable development and success of the course, earning the instructors widespread recognition and numerous awards. Notable accolades include the "Provincial Golden Youth Teacher (Distinguished Teaching Master)," "Second Prize in the National University Inorganic Non-Metallic Materials Youth Lecture Competition," "Third Prize in the Provincial Youth Lecture Competition," and "First Prize in the University Teaching Document Evaluation." Additionally, instructors have been honored as "Good Teacher in the Hearts of Students in the New Era" (across two editions), "Excellent Teacher," and "Advanced Individual in Teaching and Nurturing." These awards reflect not only their exceptional commitment to education but also their profound impact on both their students and the academic community.

4.2 Promotion and Application

The initial success of the "Silicate Petrology" course reform has been prominently featured on the university's official website, serving as an exemplary model and effectively disseminating the innovative strategies employed. This exposure has significantly contributed to the course's reputation for educational excellence and innovation. Additionally, the course has actively participated in various teaching competitions at the provincial-ministerial, university, and college levels, consistently showcasing its pioneering educational practices and outcomes. The course leader has engaged in extensive knowledge exchange with peer institutions, discussing and sharing insights on course construction, which has further enhanced the course's impact and received widespread acclaim across the academic community. These collaborative interactions have not only bolstered the course's standing but have also facilitated continuous improvement through the adoption of best practices. Furthermore, the achievements and innovative aspects of the course have been promoted and shared through academic journals, conferences, and digital platforms like WeChat public accounts, ensuring broad visibility and impact within and beyond the academic sector.

5. CONCLUSION

The "Silicate Petrography" course has transcended traditional educational boundaries, effectively breaking the limitations typically associated with single-element teaching methods such as blended learning, ideological and political education, and virtual simulation technologies. This transformation has significantly enhanced the development of students' higher-order cognitive abilities and fostered comprehensive educational growth. The course achieves a seamless integration and synergistic coupling of multiple advanced teaching elements, thereby setting a benchmark in curriculum innovation. Centered around student needs, the course has implemented a flexible, coordinated, and efficient operational framework that includes distinct modules for course objectives, teaching content, implementation, and evaluation. This structure promotes a dynamic cycle of "evaluation-feedback-improvement-revaluation," ensuring continuous enhancement aligned with educational outcomes. Furthermore, the course has pioneered a new paradigm in engineering education, characterized by the integration of "multiple synergistic 'two properties and one degree' course modules." This approach not only meets the diverse and personalized needs of students but also enhances the digital and informational capabilities of teachers. By serving as a model for educational reform, the "Silicate Petrography" course provides valuable insights and strategies that can be adopted by other engineering courses within the university and across the province. Its innovative framework and successful implementation exemplify the potential for transformative educational practices in the engineering discipline, contributing to the broader academic community and industry alike.

REFERENCES

Cai, J. M. (2012). Construction of a Modular Teaching System Based on Competency Orientation: A Case Study of Hefei University. *University of Science and Technology of China Press*.

Hou, J. H., & Cai, J. M. (2011). Implications of Modularized Teaching in German Higher Education for the Development of Applied German Language Programs. *China University Teaching*, (2), 95-96.

Ma, L. S., Wang, Z. S., Cheng, H. et al. (2020). Exploration and Practice of Course Objective Achievement Evaluation Oriented Towards Engineering Education Accreditation. *Journal of Chuzhou University*, *22*(5), 112-115.

Ren, L. L. (2019). Research on modular teaching mode in university English - A case study of "new edition advanced university English integrated course". *Chinese Civil and Commercial Law,* (10), 249.

Sun, Y., Li, X. Y., Xie, Z. X. et al. (2019). Curriculum Reform in

Silicate Petrography Course Based on OBE System. *China Light Industry Education*, (4), 77-80.

Wang, S. Y. and Liu, H. (2000). Application Design and Practice of Modularized Teaching. *Journal of Shandong University of Technology*, (05), 82-85.

Xu, W., Li, Q. Y., Wang, Z. H. et al. (2019). Research on the Construction of an Undergraduate Teaching Quality Assurance System Based on "Continuous Improvement and Closed-Loop Feedback" - A Case Study of Beijing Jiaotong University. *Industry and Information Technology Education*, (3), 21-25.

