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Article

Research on the Theoretical Foundation, Connotation Dimension and Construction Path of Chemistry Curriculum Ideological and Political Education

Xiong Tian [1,*] and Qingling Liao [2]

[1] Hainan Vocational University of Science and Technology, Haikou, Hainan, China
[2] Northwest Normal University, Lanzhou, Gansu, China
* Correspondence: Xiong Tian, Hainan Vocational University of Science and Technology, Haikou, Hainan, 571126, China

Abstract: Driven by the intensifying mission to foster virtue through education within the Chinese higher education landscape, the strategic integration of value-based guidance into academic curricula has emerged as the primary vehicle for achieving a comprehensive and holistic instructional environment. Chemistry, as a discipline, is uniquely defined by its combination of rigorous scientific theory and extensive practical utility. Consequently, embedding ideological elements into chemistry courses is not merely a critical step in enhancing the caliber of professional training; it is also instrumental in nurturing students' logical reasoning, ethical standards, and civic accountability. By synthesizing domestic and international scholarly progress from the last five years, this study dissects the multi-layered theoretical framework that supports value-integrated chemistry education. It provides a detailed analysis of six essential pillars—including scientific integrity, patriotism, and cultural pride—and distills an operational model characterized by "six dimensions and four pillars" derived from current pedagogical practices. Furthermore, the paper addresses existing bottlenecks, such as undeveloped assessment tools and fragmented resource utilization, by proposing targeted optimization strategies. This research aims to offer a fresh theoretical benchmark for innovating and standardizing the practical implementation of ideological-political education in chemistry, ultimately laying a solid groundwork for preparing a new generation of chemical experts who possess both professional excellence and unwavering social convictions.

Keywords: Marxism; chemistry course ideological and political; patriotic spirit; ideological and political education; lide tree people

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1. Introduction

Fulfilling the essential mission of character cultivation through a holistic educational framework relies heavily on the strategy of "integrating values into academic curricula." This paradigm, which facilitates a comprehensive teaching environment, was pioneered in 2014 following an initiative by Shanghai's educational authorities. By shifting value-based instruction from isolated political theory classes to the broader spectrum of professional disciplines, it established what is now known as the "Grand Ideological-Political" educational model. This approach has since gained nationwide traction, particularly within the chemistry field, where scholarly interest has surged. Statistical evidence highlights this trend: publications in this area jumped from a negligible 11 articles in 2018 to over 200 in 2020, with a 2021 special edition of *University Chemistry* alone featuring 60 relevant studies [1]. Given this rapid expansion, there is a compelling need to evaluate the theoretical underpinnings and practical methodologies of value-integrated chemistry education to ensure its structured and scientific progression.

2. The Theoretical Foundation of Chemistry Curriculum Ideological and Political Education

Establishing a firm theoretical basis is vital for ensuring that ideological elements are effectively woven into the chemistry syllabus. Rather than being a monolithic application of one concept, the system constitutes a cohesive entity resulting from the convergence of multiple academic fields. Current literature reveals that research in this area is anchored by four foundational theories. These provide the necessary groundwork for implementing integrated education across four key areas: the mechanics of cognition, methods of instruction, developmental objectives, and orientation toward practice.

2.1. Constructivist Learning Theory: Follow the Law of Cognitive Development

Grounded in the constructivist emphasis on active knowledge building, the cognitive logic of chemistry's ideological-political integration focuses on creating meaning-rich environments. Recognition of values occurs when students engage with real-world chemical scenarios—including laboratory work and technological inquiries—rather than through passive reception. By adopting an "experiential and reflective" learning posture, students independently structure their moral frameworks. This method ensures that value integration is neither vague nor merely symbolic, thus adhering to the objective principles of cognitive development.

2.2. Recessive Ideological and Political Education Theory: Innovative Education Implementation Methods

Within the chemistry syllabus lies a wealth of latent ethical facets. The historical struggles of scientists, the broader societal consequences of new technologies, and home-grown breakthroughs serve as ideal pedagogical gateways for seamlessly integrating moral guidance into academic training. For instance, when covering "Artemisinin's Structure and Synthesis," highlighting the arduous journey of Tu Youyou and her colleagues allows students to concurrently master professional principles and cultivate a sense of duty toward community-focused scientific progress. This approach effectively realizes the goals of "recessive" education, ensuring that value cultivation occurs as a natural byproduct of technical learning.

2.3. Marx's Theory of All-Round Development of Human Beings: Clarifying the Goal of Educating People

Abundant latent ethical values are embedded within the chemistry curriculum, offering numerous "subtle gateways" for character development. Rather than being forced, moral guidance can be seamlessly woven into professional training by exploring the societal consequences of chemical advancements, domestic technological milestones, and the historical struggles of pioneering researchers. A prime example is the study of artemisinin's molecular architecture in Organic Chemistry. By highlighting the tenacious and grueling research journey led by Tu Youyou, educators can achieve a dual purpose: enabling students to grasp complex chemical properties while simultaneously nurturing a commitment to "altruistic technological progress." This approach effectively realizes the mission of non-explicit value education, turning technical knowledge into a vehicle for social responsibility.

2.4. Dewey's Moral Education Theory: Strengthening the Characteristics of Practice Orientation

Dewey's pragmatic and moral educational philosophy highlights the necessity of aligning learning with societal application and fostering a sense of civic duty. This is exemplified in the "New Energy Materials" course, where the topic of lithium-ion battery life cycles and recycling is introduced. Educators lead students in exploring the ecological benefits of green technologies alongside the environmental hazards posed by discarded batteries. By deliberating on the equilibrium between technical progress and societal accountability, students gain firsthand insight into the ethical boundaries and professional responsibilities inherent in scientific inquiry, facilitating a seamless convergence of academic expertise and value-based instruction.

These four theoretical pillars synergize to create a comprehensive framework that prioritizes learner autonomy while emphasizing the indispensable nature of ethical guidance. By balancing the mechanics of knowledge acquisition with the development of emotional resonance, these theories offer a robust conceptual infrastructure for the structured advancement of chemistry education.

The Connotation Dimensions of Value-Integrated Chemistry Education: Synthesizing findings from extensive scholarship with the unique attributes of the chemistry discipline, this study identifies six core facets of its educational connotation: scientific integrity, national pride, moral orientation, analytical methodologies, ethical awareness, and cultural pride [2]. These dimensions transcend mere technical proficiency by integrating value-driven objectives into the curriculum. Collectively, they form a tripartite system of "expertise, capability, and character," providing a holistic framework for student development that covers both cognitive requirements and value-level goals [3].

3. Connotation Dimensions of Chemistry IPE

3.1. Scientific Integrity and Rigor

The essence of the chemistry discipline lies in the scientific spirit, which serves as a vital pillar for value-integrated education. Within this framework, students are guided to honor empirical laws, maintain a commitment to factual accuracy, and courageously venture into uncharted academic territories. For instance, in laboratory settings, the emphasis is placed on strict adherence to safety protocols and standardized data collection. Students are trained to record findings with absolute honesty, ensuring that any discrepancies from expected results lead to analytical inquiry rather than data manipulation. By fostering a culture of integrity, educators encourage students to critically evaluate existing theories through literature synthesis and experimental validation, thereby enhancing their innovative and analytical capacities [4].

3.2. National Identity and Patriotism

Fostering a sense of national pride is a central objective of ideological integration within chemistry. This involves illustrating China’s significant milestones in chemical research and the discipline's pivotal role in national development to inspire a commitment to public service. A case in point is the "Medicinal Chemistry" course, where the dedication of scientists like Tu Youyou (artemisinin research) and Chen Wei’s group (vaccine development) is highlighted to showcase the spirit of overcoming adversity for the nation [5]. Similarly, in "Material Chemistry," discussions on domestic breakthroughs in photoresist technology and carbon fiber applications for the aerospace industry serve to demonstrate China’s growing technological sovereignty and scientific prowess [6,7].

3.3. Ethical Values and Socialist Core Principles

The values dimension focuses on embedding core societal principles within the chemistry syllabus. The goal is to harmonize professional instruction with ethical guidance, helping students develop robust moral judgment and professional conduct [8]. In practical terms, classroom debates on "academic honesty and research ethics" help solidify these concepts. Collaborative laboratory exercises further emphasize the necessity of teamwork and mutual support. Furthermore, courses like "Chemical Engineering Design" encourage students to strike a balance between commercial efficiency and social welfare, instilling a strong sense of professional accountability [9].

3.4. Methodological Thinking

Cognitive methodologies represent a core competency in chemistry and a key dimension of its ideological-political connotation [10]. Educators aim to sharpen students' scientific reasoning through specialized knowledge instruction, enabling them to tackle complex problems with systematic methods. In "Analytical Chemistry," for example, rigor is cultivated through the study of error analysis and data processing. Meanwhile, "Structural Chemistry" provides a platform for developing spatial reasoning and systematic logic by challenging students to construct and interpret intricate atomic and molecular models.

3.5. Ethical Awareness and Responsibility

The ethical dimension encompasses a deep understanding of research morality, ecological preservation, and workplace safety [11]. The objective is to ensure that students recognize the ethical boundaries of chemical applications, fostering the philosophy of "science for the greater good." For instance, "Environmental Chemistry" uses pollution mitigation cases to explore the role of chemistry in sustainable development and ecological ethics. Additionally, "Chemical Safety" instruction utilizes historical accident analysis to underscore the imperative of rigorous safety standards in industrial production [12].

3.6. Cultural Pride and Heritage

This dimension involves the recognition and celebration of both traditional Chinese chemical wisdom and modern scientific achievements. Cultivating cultural pride helps students internalize the essence of their heritage while strengthening their national identity. In "Natural Medicinal Chemistry," the exploration of traditional extraction techniques alongside modern pharmaceutical applications illustrates the continuity of Chinese medical wisdom. Furthermore, the "History of Chemistry" introduces the seminal contributions of ancient scholars such as Shen Kuo and Song Yingxing, highlighting the enduring legacy and ingenuity of Chinese scientific thought throughout the ages.

4. The Construction Path of Ideological and Political Education in Chemistry Course

The development of ideological and political education within the chemistry curriculum is a complex, multi-layered undertaking that requires comprehensive planning across various stages, including objective formulation, curricular design, pedagogical innovation, and assessment refinement. In recent years, scholars and institutions have explored diverse construction strategies, notably the "six-dimensional, four-pillar" architecture and various tripartite implementation models. This research examines the construction roadmap by focusing on the overall structural framework, specific implementation modes, and the professional development of educators.

4.1. General Framework: "Six Dimensions, Four Constructions"

The "six dimensions and four constructions" model has emerged as a representative achievement, utilizing six conceptual layers as its core. By organizing the process into four operational levels—namely goals, content, methods, and evaluation—this framework ensures a seamless fusion between value-led guidance and professional instruction.

4.1.1. Goal Construction: Clarify the "Trinity" Education Goal

Goal formulation serves as the cornerstone of this educational initiative, with a central focus on harmonizing the three pillars of ethical grounding, professional expertise, and inventive capacity. Ethical grounding is the fundamental mission, emphasizing the development of students' worldviews and moral fiber through the cultivation of scientific integrity, national identity, and cultural awareness. Meanwhile, professional expertise remains a core priority, ensuring students master chemical principles while refining their analytical and laboratory skills, such as data processing and error analysis. Finally, inventive capacity acts as a developmental target, fostering critical thinking and problem-solving abilities. These three objectives are intrinsically linked and unified into a cohesive system for student development.

4.1.2. Content Construction: to Realize the Visual Embedding of Ideological and Political Elements

Regarding content construction, the primary strategy involves creating a visual matrix that maps ideological elements directly onto the technical curriculum. By tagging specific textbook chapters, laboratory modules, and case resources with relevant ethical dimensions, educators can create a comprehensive blueprint for integration. For example, in the study of metallic compounds within inorganic chemistry, the discussion of local rare-earth resource utilization naturally aligns with patriotism, while topics such as metal corrosion prevention provide entry points for exploring environmental ethics and social responsibility. This systematic approach allows teachers to identify natural intersections between academic content and value-based instruction.

4.1.3. Method Construction: Adopt a Student-Centered Teaching Model

In terms of methodological innovation, the focus is on adopting student-centered models that prevent the metaphorical "decoupling" or the so-called "two skins" effect between professional and value education. Strategies such as case-based inquiry, task-oriented projects, and inverted instructional models allow for active student participation. Case teaching uses specific chemical narratives to introduce ethical dilemmas into classroom discourse, while project-driven tasks encourage teamwork and professional accountability during the problem-solving process. Additionally, the inverted classroom model guides students to engage with material independently, using class time for high-level group discussions and presentations that enhance learning initiative.

4.1.4. Evaluation Construction: Establish a Three-Level Evaluation System of "Cognition-Emotion-Behavior"

Finally, evaluation construction is centered on a tri-level matrix that assesses students across the cognitive, affective, and behavioral domains. The cognitive tier gauges the mastery of professional and ideological knowledge through reflective reports and academic essays. The emotional tier monitors shifts in student values and attitudes via observational rubrics, surveys, and structured interviews. Lastly, the behavioral tier evaluates the practical application of these values by analyzing laboratory conduct, collaborative project performance, and involvement in social service. This multi-layered system ensures that the impact of education is measured comprehensively, moving beyond traditional testing.

4.2. Specific Implementation Mode

Building upon the overarching "six dimensions and four pillars" architecture, various academic institutions have innovated specific pedagogical models tailored to the unique requirements of the chemistry discipline. These approaches provide a diverse set of practical frameworks for embedding ethical guidance within scientific instruction. One notable example is the "tri-dimensional core" model, which centers on the pillars of national pride, scientific integrity, and ethical responsibility. This model is integrated across five key instructional phases: theoretical lectures, laboratory experiments, scientific inquiry, field studies, and off-campus internships. For instance, in the "Chemistry and Community" general course, theoretical modules explore the societal repercussions of chemical advancements to foster national identity. Laboratory sessions incorporate green chemistry principles to enhance ethical awareness, while discussions on cutting-edge domestic research stimulate a sense of national achievement. Furthermore, site visits to chemical plants and environmental agencies allow students to observe the practical application of ecological governance, while internships at industrial bases offer firsthand experience with professional standards and workplace ethics.

Another effective strategy is the case-centric model, where specific narratives serve as the primary vehicle for connecting moral dilemmas with technical expertise. The selection of these cases prioritizes contemporary relevance and instructional typicality. In courses such as "Principles of Chemical Engineering," the analysis of wastewater treatment optimization in industrial settings encourages students to navigate ethical constraints while solving engineering challenges. Additionally, the curricular resource mapping model utilizes visual blueprints to help faculty pinpoint ideal integration points across various chapters. These maps systematically organize value elements, entry strategies, and pedagogical methods, thereby reducing the burden of lesson preparation and ensuring a more structured delivery of ideological resources. Finally, a specialized focus on laboratory safety and morality ensures that ethical literacy is cultivated alongside technical proficiency. This involves integrating safety protocols and hazardous material regulations directly into the experimental process, guiding students to handle chemical waste responsibly and reflect on the moral implications of scientific conduct.

4.3. Ways to Improve Teachers' Ability

As the primary agents of instructional delivery, educators' ideological quality and pedagogical versatility are decisive factors in the success of value-integrated curricula. Consequently, enhancing the comprehensive competencies of faculty is a critical link in the development of the chemistry syllabus. Current institutional strategies focus on theoretical political study, collaborative research, shared resource repositories, and the refinement of incentive structures. To begin with, faculty members must engage in regular study of educational policies and ethical guidelines. This ongoing theoretical grounding ensures that they can accurately navigate value orientations and prevent any deviation from the core educational mission during their teaching.

Furthermore, regularized pedagogical research has become a standard practice for professional growth. Through specialized workshops, case-oriented seminars, and interdisciplinary team collaborations, universities assist teachers in mastering the skills required to identify and embed ethical elements within a technical syllabus. In addition, the development of collaborative case repositories is essential for resource sharing. National or provincial platforms for sharing chemistry-based instructional cases—such as those involving sustainable materials or pharmaceutical ethics—allow faculty to access high-quality, up-to-date materials, thereby enhancing the diversity and timeliness of their lessons. Lastly, institutionalized reward systems act as a powerful catalyst for faculty engagement. By incorporating the achievements of value-integrated research into career advancement reviews and performance assessments, and by establishing dedicated instructional funds, institutions can encourage a continuous commitment to pedagogical innovation and ensure a steady rise in the overall quality of education.

5. Conclusion

The theoretical foundation of ideological and political education in the chemistry curriculum covers multiple perspectives such as constructivism, implicit ideological and political education, the Marxist theory of all-round development, and Dewey's empiricism, which provides solid theoretical support for the realization of the "knowledge-ability-value" trinity. Based on the six-dimensional model, colleges and universities have formed diversified teaching paths such as "six dimensions, four constructions" and "three dimensions and one core," and realized the deep integration of ideological and political elements and chemical majors through specific means such as case-driven methods, experimental safety, and resource mapping. In general, the ideological and political education of the chemistry curriculum is moving from concept exploration to systematization and normalization, providing an important path for cultivating chemical talents with scientific literacy, social responsibility, and cultural self-confidence in the new era.

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