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Integrating Knowledge, Competence, and Values in Bilingual Physical Chemistry Instruction

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Abstract: ***Bilingual instruction in Physical Chemistry, a core theoretical course in science curricula, is both essential and challenging due to linguistic barriers, extensive content, and foundational demands that often result in a disconnect between language and subject matter. To systematically address these pedagogical issues, this paper proposes a comprehensive course-design framework with four integrated objectives: cultivating dialectical thinking through materialist philosophy, fostering patriotism and national pride by linking content to China's scientific progress, motivating diligent study for national rejuvenation in a global context, and developing environmental awareness alongside socialist values. Implementation of this framework is expected to enhance classroom design and teaching efficacy, ultimately achieving a unified integration of knowledge acquisition, competency building, and value education.***

Keywords: Bilingual education; Physical Chemistry; Curriculum design; Pedagogical framework; Value integration; Higher education.

1. INTRODUCTION

As the fundamental task of education, cultivating morality and nurturing talents is not only the epochal mission entrusted to higher education by the state, but also the unswerving professional aspiration of every university teacher. In the new era, the university classroom has long transcended its role as a mere venue for knowledge transmission; it has become a high ground for the deep integration of value orientation, character building, and competence development. Therefore, university teachers should consciously and organically integrate the system of socialist core values into the disciplinary knowledge system, the teaching curriculum system, the textbook compilation system, and the assessment and evaluation system, thereby constructing a "three-pronged education" pattern that involves all staff, the entire process, and all aspects—achieving a resonant synergy between knowledge instruction and value guidance. In this process, teachers are expected not only to impart solid professional theories and technical skills, but also to lead by example, guiding students to establish correct worldviews, outlooks on life, values, and a proper sense of honour and disgrace. This helps them maintain a clear mind in an era of multicultural contention and information fragmentation, and strengthens their confidence in the path, theory, system, and culture of socialism with Chinese characteristics. Ultimately, the goal is to cultivate socialist builders and successors with well-rounded development in morality, intelligence, physical fitness, aesthetics, and labour skills—individuals who possess both the will and the ability to serve their country and who can shoulder the historic task of national rejuvenation.

However, there is often a certain tension between ideal educational objectives and actual teaching practices. How to transform macro-level educational concepts into operable, evaluable, and continuously improvable teaching actions is a critical issue facing current higher education reform. This is particularly challenging for science and engineering majors, where course content is predominantly based on mathematical logic, formula derivation, and experimental operations. The knowledge system is highly objective, and its value implications are relatively implicit, making the integration of ideological and political education lack a natural discursive interface and prone to either forced grafting or superficial formalisation. In actual teaching, many STEM teachers, while recognising the necessity of curriculum-based ideological and political education, frequently encounter confusion in implementation: How can one naturally infuse patriotic feelings and scientific spirit into the curriculum without diluting the core professional content? How can cutting-edge scientific and technological achievements be effectively combined with practical cases of socialist core values? How can the linguistic objectives of bilingual teaching be balanced with the value-oriented goals of ideological and political education? These questions go straight to the deep logic of instructional design and urgently require systematic theoretical guidance and replicable practical models.

Taking physical chemistry as an example, this course serves as a core foundational subject for numerous engineering disciplines, including chemistry, chemical engineering, materials science, environmental engineering, and biotechnology. It features strong theoretical foundations, abstract concepts, extensive formulas, and rigorous logical reasoning. At the same time, its historical development is rich in scientific methodology and philosophical thinking materials. Moreover, physical chemistry—from classical thermodynamics to statistical mechanics, from interfacial science to electrochemistry—is closely connected to energy utilisation, environmental protection, material innovation, and national strategic needs, offering natural entry points for curriculum-based ideological and political education. Introducing a bilingual teaching mode further increases the complexity of course design: it requires accurate delivery of specialised knowledge, enhancement of students' academic English proficiency, and, within a cross-cultural context, the highlighting of Chinese scientists' contributions and the wisdom of Chinese solutions. Therefore, using the bilingual physical chemistry course as a sample to deeply explore the instructional system design of ideological and political education holds typical demonstrative value and broad promotional significance.

This paper, based on the above practical needs, systematically elaborates on the necessity and feasibility of implementing ideological and political education in the bilingual physical chemistry course, and provides a detailed instructional system design covering teaching objectives, content, methods, and assessment mechanisms. Regarding necessity, this paper argues from three dimensions: national strategic demands, the educational attributes of the discipline, and students' developmental patterns. It points out that this course not only trains scientific thinking and logical reasoning but should also inspire students' sense of mission and responsibility on major national issues such as carbon neutrality, new energy development, and green chemical engineering. In terms of instructional system design, this paper proposes a parallel "three-line" framework—the main knowledge line, the concealed ideological-political line, and the auxiliary language line. By excavating typical events from the history of the discipline (e.g., the original contributions of Chinese scientists in solution theory and electrochemistry), analysing value-based choices in major engineering problems (e.g., safety ethics and ecological ethics in chemical production), and designing interactive activities such as group discussions and case analyses, various ideological-political elements—including patriotism, scientific spirit, rule-of-law awareness, and ecological civilisation—are seamlessly embedded into the entire process of pre-class preparation, classroom lectures, laboratory practice, and post-class extension.

Furthermore, this paper addresses common cognitive biases and operational difficulties that STEM teachers often encounter when implementing curriculum-based ideological and political education, and proposes corresponding countermeasures and suggestions. These include sharing case libraries through collective lesson planning, expanding ideological-political space via blended teaching, and tracking educational outcomes using formative assessment. The aim is to provide a reference framework that is both theoretically solid and practically flexible for similar professional courses. We believe that only when every specialised course finds its own appropriate path for integrating ideological and political education, and when every teacher consciously internalises value guidance as an organic component of instructional design, can higher education truly achieve the essential return from "teaching books" to "educating people," thereby laying a solid talent foundation for the great rejuvenation of the Chinese nation. We hope that the explorations in this paper will stimulate deeper reflection and active practice among fellow educators, jointly advancing curriculum-based ideological and political education from a novel “freshness” to a normalised “routine,” and from an isolated “ornamental display” to a widespread “landscape” of educational practice.

2. THE NECESSITY OF BILINGUAL PHYSICAL CHEMISTRY COURSES

The physical chemistry course is based on disciplines such as physics and chemistry, with rich chemical phenomena and systems as objects. It extensively adopts theoretical achievements and experimental techniques from physics, explores, summarizes, and studies the basic laws and theories of chemistry, and constitutes the theoretical foundation of chemical science. The establishment of bilingual courses can better ensure the integration of professional English and the subject through bilingual teaching, enable students to become proficient in using English unconsciously, and cultivate their positive adaptation and communication with different cultures. It is also conducive to teachers introducing advanced educational concepts and classroom teaching models from abroad, and can cultivate students' diverse thinking and innovative abilities. Therefore, bilingual teaching in physics and chemistry can not only directly enhance students' language application and expression abilities, but also lay a solid foundation for future students to become research-oriented and innovative talents.

General Secretary Xi Jinping pointed out at the National Conference on Ideological and Political Work in Colleges and Universities [2, 3]: "We must adhere to taking moral education as the central link, integrate ideological and political work into the entire process of education and teaching, and achieve full process and all-round education for all staff. In 2020, the Ministry of Education issued the "Guidelines for the Construction of Ideological and Political Education in Higher Education Curriculum", which clearly pointed out that it is necessary to comprehensively promote and deeply explore the elements in the curriculum, educate and nurture students, guide them to establish correct worldviews, outlooks on life, and values, cultivate students' innovative consciousness and ability, and endow them with a sense of social responsibility and a sense of mission for the times. As a professional teacher in universities, we should fully explore the elements contained in each knowledge point of this course according to its teaching content, integrate the content into the teaching process, strengthen patriotism education and scientific literacy education for students, cultivate students to become qualified successors of socialism, and shoulder our own mission for the rejuvenation of the Chinese nation.

The course is of great importance and necessity, mainly reflected in:

Firstly, the course has gradually developed over the years, with a complete knowledge system the establishment covers a wide range of areas. For students majoring in materials science, chemistry, chemical engineering, biology, mining, metallurgy, and other fields, this course serves as an important foundational theoretical course, guided by course knowledge. It may expand and design courses from multiple levels such as material systems, principles, and properties, which is beneficial for students to receive education unconsciously through systematic learning and research, laying a preliminary foundation for subsequent professional courses.

Secondly, the course of Materials Physics and Chemistry is generally offered in the sophomore year, targeting lower grade students who have just started to learn relevant professional courses and have limited understanding of their field. Their worldview, values, and career outlook are still gradually being established. Through the learning process of related courses, it is beneficial to strengthen students' education in engineering ethics, cultivate their spirit of striving for excellence as a great craftsman, and inspire their patriotism and sense of mission to serve the country through science and technology.

Bilingual physical chemistry education not only provides a good theoretical knowledge system and teaching effectiveness, but also enables students to receive comprehensive education. Therefore, the education of bilingual physical chemistry courses has important value and practical significance [5,6].

3. PROBLEMS IN THE IMPLEMENTATION OF BILINGUAL TEACHING CURRICULUM

On the basis of familiarizing oneself with the knowledge system of this discipline, it is essential for contemporary university teachers to have a deep understanding of professional courses and carry out curriculum education to cultivate students' basic qualities and responsibilities. Based on the talent cultivation objectives of this major and the knowledge structure framework and characteristics of this course, we will fully explore the elements contained in the physical chemistry course, provide students with humanistic education on patriotism and dialectical materialism, and comprehensively enhance their ideological and moral cognition level. How to conduct curriculum education reasonably and effectively in the teaching process, but there are still significant challenges in the specific implementation process.

Firstly, for universities in the southwestern region, the proportion of local students is relatively high and English is relatively weak, making bilingual teaching difficult. On the basis of difficulty in understanding relevant professional English vocabulary, it poses significant challenges to this course. How to teach bilingual courses in a simple and understandable way, so that students can better understand the essence of the content, undoubtedly requires higher teaching skills from teachers and increases the difficulty for science and engineering students to accept. It is difficult to provide timely feedback on students' learning outcomes and systematically evaluate their effectiveness in the process of curriculum education. It is also important to improve educational methods and strategies in a timely manner to enhance the effectiveness of this course.

Secondly, the knowledge points of physical chemistry teaching are relatively basic, with a wide range of design knowledge. The connection between knowledge points and case studies is not effective and tight enough, making it difficult to choose suitable knowledge carriers. How to introduce education at the appropriate time is easy to form "two skins" that are detached from the professional knowledge in the textbook, and achieve natural introduction

with appropriate educational content, which can play a finishing touch for theoretical courses. The relevant requirements have high demands on the teaching design and skills of teachers themselves, and there is undoubtedly great difficulty in achieving the "silent moistening" of education.

In addition, the education of physical chemistry courses still needs to be constantly explored and summarized, and relevant teaching cases still need to be continuously polished and improved. The reference value of teachers' curriculum education materials is insufficient. Therefore, how to efficiently carry out physical chemistry curriculum education is an urgent problem to be solved, and bilingual physical chemistry curriculum education still needs further comprehensive and efficient teaching design.

4. TEACHING DESIGN OF BILINGUAL PHYSICAL CHEMISTRY COURSE

To address the pedagogical challenges inherent in bilingual Physical Chemistry instruction and align with the contemporary higher-education goal of integrating moral and intellectual cultivation, this paper proposes a systematic course-design framework. Grounded in the course's knowledge content, the framework systematically identifies and extracts implicit educational elements embedded within key knowledge points, refines contextualized case materials, and restructures the teaching model. The objective is to holistically enhance instructional quality and amplify the course's educational impact at the university level, thereby achieving a coherent integration of knowledge transmission, competency development, and values education [7].

4.1 Expand the educational landscape and cultivate students' dialectical thinking in materialist philosophy

The physical chemistry course is highly theoretical and logical, and is known as the "philosophy of chemistry". The course contains rich Marxist materialism and dialectical thinking. Therefore, physical chemistry has a natural advantage in promoting Marxist materialist methodology and dialectical thinking.

For example, when teaching the third law of thermodynamics, entropy is a measure of the degree of disorder in a system, and entropy increase is a spontaneous process. In contrast, work is an ordered form of energy expression, and by doing work, the system becomes more ordered. This process highlights the significance of work (labor). Quoting an English passage from the overseas travelogue of Apollo to evaluate China's prosperity and flourishing, looking back at the brilliant history of the Chinese nation for five thousand years, the hard work of the Chinese working people has created a prosperous and thriving society. And it has further expanded to the centennial of the founding of the Party, the arduous struggle of the Chinese people led by the Communists, and now our country has gradually become stronger. From the historical practice of the Party, focusing on national epidemic prevention and control, social and economic development, etc., we have further strengthened our confidence in the path, theory, and system of socialism with Chinese characteristics led by the Party. As a young generation of college students, we are more determined to follow the Party. Therefore, emphasizing Marxist materialism, the great rejuvenation of the Chinese nation cannot be achieved without our efforts and dedication, in order to have a highly orderly country that is prosperous, democratic, civilized, and harmonious.

When teaching the Gibbs free energy criterion in thermodynamics, chemical reactions can only proceed when ΔG is less than or equal to zero, which solves the problem of possibility. The speed and specific pathway of the reaction need to be determined by chemical kinetics, which means that kinetics solves practical problems and highlights the dialectical relationship between possibility and reality. Through the teaching of knowledge in this course, we aim to deeply explore the philosophical connotations of each knowledge point and cultivate students' dialectical thinking in materialist philosophy.

4.2 Analyze the current situation of science and technology in China, stimulate students' patriotism and national pride

When introducing the second law of thermodynamics, the teaching process combines the working principle of heat engines and the issue of heat engine efficiency, interspersed with the spontaneous strengthening process of aircraft engines in China, naturally introducing world leading technologies such as high-speed rail, Guizhou's "China Eye", quantum communication, 5G technology, transportation and water conservancy facilities, and asking students to list the major scientific and technological breakthroughs made by the country in recent years, fully enhancing students' subjective initiative and mobilizing classroom activity and enthusiasm.

Expand to the competitiveness of "Made in China" in the international market, describe the leading role played by China in the construction process of the "the Belt and Road", and actively respond to the "economic globalization"

to show the responsibility of a big country. Since the reform and opening up, under the leadership of the Party, the Chinese people have made remarkable progress in the past three decades, greatly improving students' classroom participation and national pride, and stimulating students' patriotic feelings.

4.3 Encourage students to work hard to serve their country and cultivate the dream of national rejuvenation, taking into account the current international situation

On the one hand, in introducing the "impossibility caused by the second type of perpetual motion machine", we strengthen students' understanding that "practice is the only criterion for testing truth", guide students to be practical and down-to-earth in their work, not aim too high, and correctly position themselves, recognize themselves, and clarify the combination of their career planning and social development. Further expanding naturally to the problems and shortcomings faced by China's technological development, combined with the successful return of Huawei's Meng Wanzhou and the technology blockade and suppression of Chinese enterprises by the United States during the Sino US trade war, a series of "bottlenecks" in China's technological and economic development are listed. Standing at the forefront of the strategic needs and policy guidance for the development of key technologies in our country, we encourage students to actively strive to learn and serve the motherland, closely integrate their "small destiny" with the "big destiny" of the country, contribute their own small strength to the realization of the rejuvenation of our nation, and realize their own life value. On the other hand, by teaching the patriotic dedication of the older generation of physical chemists, we can set an example for students to learn and strengthen their will to serve the country. When explaining the content of equilibrium, introduce the life story of Academician Huang Ziqing. Academician Huang Ziqing is a renowned physical chemist in China and one of the important founders of physical chemistry in the country. Academician Huang Ziqing accurately determined the benchmark point of thermodynamic temperature scale - the triple point of water (with a measured value of 000980oC), this data was adopted by the International Conference on Temperature Standards and designated as one of the international temperature standards. Academician Huang Ziqing was also selected into the US "World Celebrity List" as a result. Academician Huang Ziqing was born into an era of internal and external troubles and disasters. After obtaining his doctoral degree abroad, he was on the eve of Japan's full-scale invasion of China. People around him advised him not to return to China for the time being, but he said he wanted to share the same fate with his motherland. Faced with various threats and temptations from the United States, he resolutely returned to China to serve and devoted his life to the teaching and research of physics and chemistry in our country. Taking the patriotic sentiment of physical chemists as a starting point, and cultivating students' national rejuvenation dreams with the power of role models.

4.4 Cultivate students' ecological and environmental protection concepts, establish correct socialist values

Green mountains and clear waters are as valuable as mountains of gold and silver. Ecological civilization construction is an important component of building a socialist modernized strong country. Under the background of "ecological tourism industry construction" in Guizhou, cultivate students' awareness and concept of caring for the environment and ecological protection. In the chapter on "Electrochemistry", the reasons for the increasingly widespread use of batteries in daily life are discussed, including the application of lithium-ion batteries in mobile phones, laptops, and other fields. The case of electric vehicles is also specifically introduced. In recent years, the government has supported the development of new energy such as electric vehicles and provided significant financial subsidies. However, there are still shortcomings in the field of new energy, such as inconvenient charging and low temperature performance degradation of batteries. New energy has not been widely popularized and further research and development investment is needed. Encourage students to engage in related new energy research and contribute to the sustainable development of science and technology in China's future.

Combining with the current carbon quota policy, we will further expand China's emphasis on environmental ecology and various measures, and always adhere to the implementation of sustainable development strategy. In today's rapidly developing Chinese economy, China has always placed "economic construction as the center" and incorporated environmental protection into basic national policies such as the national economic and social development plan, in order to prevent and control environmental pollution and ecological damage in economic development. For example, providing substantial funding subsidies for various types of exhaust emission control equipment in industrial production, shutting down some small and medium-sized industries with severe pollution, and planning the industrial production chain reasonably. At the same time, the government has spent a lot of money and material resources to repair the damaged ecological environment. For example, a lot of afforestation has been carried out in Tengger Desert, which has changed from yellow sand to a large oasis. By explaining the country's environmental policies, cultivating students' awareness of environmental protection, educating them not

to forget their original intention in future life and work, not to damage the ecological environment for personal interests, and establishing correct socialist values.

5. CONCLUSION

Through the educational curriculum and teaching design described in this article, educational materials can be naturally introduced and deeply condensed and sublimated, adding the finishing touch to the basic theoretical course, constantly summarizing, exploring, and improving to form a systematic and vivid curriculum education. By designing a systematic teaching approach for bilingual physics and chemistry courses, the elements related to this course can be expanded and organically integrated with the course content, which can overcome the problems of high teaching skill requirements, difficulty in real-time feedback, and easy detachment from the textbook to form "two skins" during the course implementation process. Expected to achieve the tripartite unity of knowledge goals, ability goals, and educational goals [9], cultivate students' patriotism, establish correct values, develop good philosophical dialectical thinking, stimulate students' motivation to study hard, contribute knowledge to serving the motherland and national rejuvenation, and truly achieve the "silent nourishment" of education.

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