Global Research in Higher Education
ISSN 2576-196X (Print) ISSN 2576-1951 (Online)
Vol. 9, No. 3, 2026
www.scholink.org/ojs/index.php/grhe

Original Paper

Strategies for Cultivating the Practical Skills of High School and Vocational Pre-service Teachers Based on Integrated Chemical and Biological Teaching Methods

Ruiyang Gong[1], Xinyue Luo[1] & Yuling Zhao[1*]

[1] Zhejiang Normal University, Zhejiang, 321000, China

[*] Corresponding author: Yuling Zhao, Zhejiang Normal University, E-mail: yulingzhao@zjnu.cn

Received: June 20, 2026 Accepted: July 6, 2026 Online Published: July 8, 2026

doi:10.22158/grhe.v9n3p1 URL:http://dx.doi.org/10.22158/grhe.v9n3p1

Abstract

Against the backdrop of educational reform, cultivating high school teachers with interdisciplinary teaching capabilities has become a crucial task in education. This paper, based on the "Chemistry + Biological Sciences Undergraduate-Master's Integrated Program" at a teacher-training university, explores strategies for developing the practical competencies of high school teachers through integrated chemistry-biology instruction. Considering both the professional training curriculum and institutional resources, specific teaching strategies are proposed: curriculum integration, establishment of practical training bases, enhancement of educational research capabilities, innovation in teaching methods, interdisciplinary teamwork, and continuous professional development. These strategies aim to provide references for cultivating the practical skills of interdisciplinary high school teachers and promote the synergistic development of chemistry and biological sciences education in high schools.

Keywords

Chemical Biology Integrated Teaching, High School Teachers, Practical Skills, Training Strategies

1. Introduction

With the continuous advancement of China's basic education system and the comprehensive implementation of core competency concepts, interdisciplinary teaching and integration have become a significant trend and clear developmental direction in this field. As two fundamental pillars of natural sciences, chemistry and biological sciences share profound intrinsic connections and extensive overlaps in knowledge frameworks, thinking methodologies, and even research objectives. Their organic integration not only helps students overcome knowledge barriers inherent in conventional disciplinary learning, fostering more holistic and interconnected scientific perspectives, but also significantly promotes the comprehensive development of their systematic thinking, inquiry skills, and innovative capabilities—crucial for cultivating a new generation with high scientific literacy. However, this integrated approach also presents new challenges to high school teachers' professional competence and practical educational work. Zhejiang Normal University has established the "Chemistry + Biological Sciences Undergraduate-Master's Integrated Program," aiming to cultivate an outstanding faculty capable of mastering both disciplines and possessing interdisciplinary expertise. Through this integrated curriculum and blended teaching approach, the university effectively combines high-quality instructional resources and practical platforms for chemistry and biological sciences, thereby nurturing educators with "dual-disciplinary literacy" and a "comprehensive educational perspective."

2. Background and Significance of Integrated Chemical and Biological Teaching

2.1 Background

The "Chemistry + Biological Sciences" integrated undergraduate-master's program represents a significant initiative tailored to the evolving landscape of modern basic education. This innovative talent development approach addresses the growing demands for teacher workforce cultivation in the contemporary era (Xu, F. L., 2018). Currently, science education has shifted from disciplinary specialization to interdisciplinary integration, placing greater emphasis on cross-disciplinary connections and collaboration within university curricula. However, existing teacher training systems remain predominantly discipline-specific, struggling to meet the practical needs of interdisciplinary teaching. The pilot program effectively combines outstanding teaching resources from chemistry and biology—two core disciplines—with the traditional strengths of teacher education in faculty training, establishing an integrated undergraduate-master's talent development model. In terms of curriculum, it comprehensively covers essential chemistry courses such as Inorganic Chemistry and Analytical Chemistry, alongside Plant Biology, Zoology, Molecular Biology, and Genetics, while also introducing specialized interdisciplinary subjects like Philosophy of Science and History of Science. By seamlessly integrating theoretical knowledge with experimental training and adopting a tiered, progressive training methodology, the program aims to cultivate educators with solid foundations in both biology and chemistry, coupled with cross-disciplinary capabilities in educational design and implementation.

2.2 Significance

The implementation of integrated chemical and biological education primarily serves to achieve precise alignment with educational objectives, aligning with China's strategic imperative of "deepening educational reform." Against the backdrop of ongoing curriculum reforms guided by core competencies, the new high school curriculum standards have significantly emphasized the need for interdisciplinary integration and practical application—particularly in science subjects, where there is a strong emphasis on transcending disciplinary boundaries through cross-disciplinary project-based learning (Li, P. H., 2021). This approach combines expertise from both chemistry and biology to foster a deep understanding of the fundamental connections between material science and life sciences, while focusing on key concepts such as “chemical reactions within cells” and “material cycling and energy flow in ecosystems,” thereby delivering comprehensive, integrated curricula. Such an approach not only helps students build a cohesive knowledge network but also enhances their scientific inquiry skills, systematic thinking abilities, and innovative capabilities, providing robust support for the holistic development of students during their foundational education phase.

From the perspective of teachers’ professional development, interdisciplinary teaching skills represent a key characteristic of modernized professional competence. In cross-disciplinary teaching practice and research, educators no longer confine themselves to the knowledge frameworks and instructional approaches of individual subjects; instead, they adopt a broader scientific education perspective to understand how these principles interpret real-world phenomena and enhance our comprehension of chemical processes. By deeply examining the interconnections between disciplines, they transform this understanding into more integrated and inspiring classroom instruction, significantly enhancing teachers’ capabilities in textbook analysis, instructional design, inquiry organization, and comprehensive assessment. This shift transforms teaching from mere knowledge transmission into a process that fosters interdisciplinary thinking among students, ultimately elevating and transcending the teacher’s professional role.

Fundamentally, the approach should begin with fostering individuals’ comprehensive literacy and cultivating students’ lifelong learning capabilities. The courses offered under integrated teaching methods effectively guide students to examine real-world scientific issues from multiple dimensions and perspectives. For instance, when exploring the theme of “environmental protection,” students can analyze the composition of pollutants using knowledge of chemical elements and employ biological science methodologies for assessment, thereby developing a holistic and dialectical understanding of the subject.

3. Strategies for Developing High School Teachers’ Practical Skills Based on Integrated Chemical and Biological Teaching

3.1 Curriculum Integration and Interdisciplinary Teaching

Under the training framework of the “Chemistry + Biological Sciences” undergraduate-to-master’s bridging program, comprehensive literacy is enhanced through integrated and interdisciplinary approaches. Achieving this goal requires transcending traditional disciplinary boundaries by offering the “Integrated Course in Chemical and Biological Sciences,” which organically integrates chemistry and biological sciences, and establishing a comprehensive teaching model centered on “core concepts and scientific principles” with practical problems as its foundation (Fu, L. Q., 2021).

Focusing on cellular metabolism, energy conversion, and the structure and function of biomolecules, this distinctive course integrates knowledge of reaction mechanisms, energy changes, intermolecular forces, metabolic pathways, signal transduction, and gene expression to develop a comprehensive understanding of chemical processes in living organisms. Building on this foundation, methods such as the "Integrated Experiment in Biochemistry and Molecular Biology" enable students to extract, chemically modify, and analyze DNA, or investigate catalytic mechanisms through enzyme reactions, thereby enhancing their practical understanding of these fields.

In practice, efforts should focus on challenging scientific issues within real-world contexts, providing proactive guidance to teacher education students in conducting interdisciplinary project research. This project will enable simulations of future secondary education and research practices, fostering the integration of biological sciences with chemical knowledge, skills, and research methodologies.

For example, we can design a comprehensive research project on "the effects of environmental pollution on organisms" based on real-world issues. This project will focus on typical regions, employing modern analytical techniques such as spectral analysis and chromatography to conduct systematic monitoring of characteristic environmental pollutants (e.g., heavy metals, organic contaminants), enabling effective identification and quantitative analysis of toxic substances. Building on this foundation, plant culture experiments, animal behavior observations, and cell culture assays will be utilized to investigate plant growth and development, cellular structure and function, and physiological metabolic processes in detail, thereby elucidating their potential chain effects on both plants and animals.

Through the implementation of this project, students will independently develop experimental plans, integrate research methodologies from two disciplines, conduct comprehensive collection and analysis of various data, and ultimately produce a scientific, rigorous research report along with feasible solutions. Grounded in real-world problems, this interdisciplinary project not only thoroughly develops students' skills in chemical analysis, biological detection, data processing, and scientific argumentation but also enhances their ability to identify, analyze, and solve problems under complex circumstances through systematic thinking.

3.2 Development of Practice Centers and Educational Practice Programs

The establishment of practical training bases and internship programs is crucial for enhancing the practical application skills of comprehensive educators. Normal universities should collaborate with key high schools across the province—such as Zhenhai High School, Hangzhou No.2 High School, and Jinhua No.1 High School—to establish long-term, stable partnerships. Throughout the practice process, emphasis should be placed on developing students' overall competencies.

The establishment of practical training bases and high-quality internships are crucial components for enhancing the effectiveness of comprehensive teacher education. Normal universities should forge long-term, stable partnerships with leading secondary schools in the province—such as Zhenhai High

School, Hangzhou No.2 High School, and Jinhua No.1 High School—to jointly develop collaborative educational platforms and systematically strengthen students' comprehensive practical competencies.

During the internship, students should be guided to closely observe teaching practices in chemistry and biology, and to learn about the design approaches and organizational strategies of interdisciplinary courses. By observing experienced teachers how they organically integrate chemical reaction principles with biological processes, students can gain insight into concrete pathways for curriculum integration. Additionally, students should be encouraged to examine the implementation methods of "comprehensive practical activities" and "project-based learning" under the new curriculum framework, and understand how these approaches enhance students' scientific inquiry literacy in real-world contexts.

During practical teaching sessions, students should carry out phased teaching practices in biology and chemistry under the guidance of instructors at designated bases. They progress from participating in collective lesson planning and receiving collaborative guidance to delivering independent lessons, ultimately attempting interdisciplinary integrated instruction. For instance, focusing on the theme "Chemical and Biological Principles in Fermentation Engineering," a comprehensive internship course can be designed covering modules such as reaction mechanism analysis, microbial culture techniques, and metabolite detection. Through such courses, secondary school students can understand the conversion patterns of carbohydrates under enzymatic catalysis, observe microbial growth characteristics, and employ chemical methods to analyze fermentation products, thereby deepening their comprehension and application of scientific knowledge through hands-on experience.

In terms of teaching and research activities, students should be guided to focus on reflecting on and researching their teaching practices. Under the themes "Challenges and Solutions in Integrated Chemistry-Biology Teaching at the High School Level" and "Case Studies on Interdisciplinary Teaching Design Based on Core Competencies," a series of seminars should be organized to systematically identify experiences and issues in teaching practice, conduct in-depth analyses of specific challenges encountered during interdisciplinary instruction implementation, explore effective strategies for addressing these challenges, and facilitate the transformation of fragmented practical experiences into systematic and rational teaching insights.

Through the phased progression of "internship – practical training – research" and the integrated teaching-practice model that emphasizes both academic subjects equally, participants gain extensive interdisciplinary learning experiences in real classroom settings. Teachers must possess comprehensive skills in curriculum development, classroom management, and academic assessment, along with strong adaptive and creative problem-solving abilities to adapt to diverse educational contexts. Comprehensive internship training enhances educators' practical competencies and professional adaptability, laying a solid foundation for cultivating outstanding, versatile teaching professionals.

3.3 Enhancement of Educational Research Capabilities

As an outstanding teacher, the most fundamental competency is research capability. To achieve this, it is essential to integrate teaching research methodologies such as “Teaching and Research Methods,” “Research Topics in Chemistry Teaching,” and “Research Topics in Biological Science Teaching.” This enables students to master research techniques including scientific literature retrieval, study design, data collection and analysis, and paper writing, with particular emphasis on the distinctive features of teaching research in chemistry and biological sciences. The goal is to foster students’ understanding of the nature of science, develop interdisciplinary thinking skills, and address cutting-edge issues like innovative experimental teaching. While mastering these research methods, teachers should provide students with diverse research training opportunities and encourage them to participate in instructors’ research projects or submit independent research proposals (Wang, R., & Zhang, Q. W., 2018, pp. 82-87).

For example, practical research projects such as “Research on Integrated Chemical-Biological Education Models in the Network+ Environment,” “Mechanisms of Subject Integration on Middle School Students’ Scientific Inquiry Skills,” and “Curriculum Design for High School Biology Based on Core Competency Concepts.” By participating in the entire process—including project applications, data collection, paper writing, and result sharing—students gain a deeper understanding of fundamental principles in biology and chemistry education while developing problem-solving skills, critical thinking, and scientific communication abilities through hands-on practice. Additionally, students are encouraged to transform their research findings into personalized learning resources and instructional designs, such as creating interdisciplinary teaching case studies, compiling teaching improvement reports, attending academic conferences, or competing in educational competitions. This approach fosters a virtuous cycle between teaching research and pedagogical innovation, laying a solid research foundation for continuous curriculum reform and advancing disciplinary development in high school education.

3.4 Innovation in Teaching Methods and Application of Technology

To meet the demands of modern educational development, while comprehensively reforming the talent cultivation in the pilot program bridging undergraduate and graduate studies in Chemistry and Biological Sciences, emphasis must also be placed on innovating teaching methodologies and integrating them with cutting-edge technologies (Zhai, S. F., 2023, p. 61). This conceptual shift not only aligns with the trend of digital transformation but also aims to cultivate outstanding educators suited for future educational models. Given the inherent characteristics of these disciplines—such as strong practicality and abstract concepts—traditional classroom instruction often falls short in meeting students’ learning needs. Therefore, it is essential to incorporate various information technology tools—including virtual simulation experiments, digital inquiry platforms, and online learning systems—into teacher training programs. By leveraging modern tools to expand educational scope and duration, we can optimize teaching processes and lay a solid foundation for future educators to develop proficiency in information-based teaching practices.

The application of virtual simulation technology in practice effectively addresses various practical challenges. For instance, before conducting experiments involving hazardous chemicals or complex biological and anatomical procedures, students can first perform simulated trials in a “virtual” laboratory setting. This immersive approach allows them to experience the experimental process firsthand, observe key details, and grasp essential operational principles. This blended virtual-real teaching model not only ensures classroom safety but also prevents potential hazards, significantly enhancing the effectiveness and quality of chemistry and biology experiment instruction. Through repeated simulations, learners develop a clear understanding of experiments, enabling them to participate more confidently and efficiently in hands-on practice while focusing better on observing phenomena and exploring underlying principles.

During course implementation, we should strongly advocate a “comprehensive” educational approach that combines online and offline interactive methods to establish self-directed learning communities. Through digital teaching platforms, instructors can provide students with extensive instructional materials—including micro-lectures, interactive animations, and virtual experiments—enabling independent foundational self-study. In classroom settings, students can engage in advanced activities such as in-depth discussions, collaborative investigations, and problem-solving through offline interactions. For instance, when teaching the module “Structure and Function of Proteins,” students should first learn how to view molecular structure demonstrations via the platform before reviewing key concepts through visual presentations. In chemistry-related sessions, group-based protein isolation experiments or thematic discussions on “structure-function relationships” are recommended. This approach not only transcends traditional classroom time and space constraints but also fosters autonomous learning, collaborative inquiry, and creative thinking development.

Students in the Graduate Program in Educational Metamorphosis have not only mastered advanced teaching methodologies but also gained profound insights into the advantages and value of the information age. These experiences have directly shaped their educational philosophies and practices, enabling them to consciously leverage modern educational technologies to optimize and reform teaching processes upon entering the workforce, thereby becoming a vital force in advancing educational modernization. Building on this foundation, the program introduced the “Dual-Instructor Integration” teaching approach, representing a valuable initiative for educational reform and innovation in teacher training institutions. Educators can publish instructional materials—including micro-lecture videos, demonstration videos, and specialized literature—through online platforms, facilitating self-directed learning of fundamental concepts in classrooms. Classroom activities should emphasize group discussions, problem-based exploration, and collaborative experiments; for instance, organizing group debates on “energy conversion and material synthesis during photosynthesis” or conducting integrated experiments on “water quality monitoring and ecological assessment.” Students should also be encouraged to utilize digital tools for designing and developing cross-institutional educational resources. By creating dynamic molecular structure models, interactive animations of biological metabolic pathways, and interdisciplinary knowledge maps, students’ capabilities in educational design and resource integration are enhanced. Through systematic pedagogical innovation and skills training, students can effectively optimize teaching processes using modern tools, fostering learning engagement and improving instructional efficiency—all aimed at advancing classroom reforms aligned with smart education ecosystems.

3.5 Interdisciplinary Team Collaboration and Communication

Interdisciplinary teamwork serves as the organizational foundation for advancing integrated chemical biology education in China and holds significant importance for enhancing the quality of teacher development in basic education. It is essential to strengthen the training of educators, frontline secondary school teachers, and educational researchers in interdisciplinary teaching theories for chemical biology, forming a cross-disciplinary teaching and research team that collaborates on curriculum development, instructional guidance, and project research (Shen, X. Y., Wang, M., & Ling, Y. Z., 2020, pp. 24-27).

For instance, an “Integrated Science Teaching Research Center” has been established, focusing on chemistry education and biological science instruction. Through regular joint lesson planning, teaching visits, and case studies, the center implements interdisciplinary teaching models such as “Chemistry-Biology Integrated Experiments” and “Scientific Inquiry Activity Design,” ensuring that instructional content combines disciplinary depth with broad integration. In daily teaching practices, students engage in collaborative learning and project work through group partnerships, collaborating on curriculum design, experimental investigations, and teaching simulations to cultivate teamwork skills, integrate multidisciplinary perspectives, coordinate tasks, and resolve disagreements. Furthermore, cross-disciplinary collaboration and exchange are promoted through events like the “Chemistry-Biology Teaching Symposium” and “Two Subject Teaching Innovation Seminar,” which invite domestic and international experts, educational researchers, and outstanding high school teachers to share successful teaching experiences and research findings. These initiatives provide students with a platform for communication, broaden their horizons, and stimulate critical thinking.

Simultaneously, teacher trainees should be systematically engaged in school classrooms for direct interaction. Through field-based observations and experiences working collaboratively with frontline teachers to develop school-specific curricula, jointly design thematic teaching plans, and conduct comprehensive student assessments, they gain firsthand understanding of the profound significance and practical implementation strategies of interdisciplinary collaboration within a genuine professional practice environment. This immersive experience not only demonstrates how to integrate biological and chemical knowledge but also provides concrete insights into classroom dynamics such as role allocation, idea exchange, resource integration, and the development of teaching themes from multiple disciplinary perspectives among educators. Compared to purely theoretical courses, reality-based observation and internships significantly enhance comprehension of the core principles of interdisciplinary education.

Building on this foundation, through systematic group collaboration training and a multi-level communication framework, students gradually develop an open and inclusive professional mindset, work habits, collaborative spirit, and a growth-oriented approach centered on continuous reflection. Through diverse group interactions, they learn to articulate their ideas clearly while demonstrating respect for and understanding of others' professional perspectives; how to engage in effective communication and negotiation when facing differing opinions; and how to assume leadership roles within collaborative teams. The development of these skills provides a solid foundation for future careers as secondary school teachers or participation in interdisciplinary research groups.

The teamwork experience and professional insights gained by students through practical activities are of great significance for future curriculum integration and educational reform. As educators, they can not only swiftly integrate into the school's teaching research environment but also play a leadership role in interdisciplinary educational innovation, thereby injecting new vitality into secondary education science and technological advancement.

3.6 Continuous Professional Development and Self-Reflection

Teachers' professional growth is a continuous, dynamic process of development. Upon joining the school, an electronic career development portfolio should be established for each teacher, comprehensively documenting achievements in academic performance, teaching practice, instructional research, competition awards, and community service. The content of these portfolios is regularly evaluated to assess progress at key stages, enabling teachers to clearly identify their strengths, weaknesses, and future development pathways. In practical teaching settings, reflective internship guidance should be emphasized, requiring teachers to write detailed self-reflections after each internship, observation session, or simulated lesson, focusing on aspects such as successes and shortcomings in instructional design and implementation, challenges in interdisciplinary integration, student learning feedback, and changes in their professional understanding (Yao, Y. H., 2008).

For instance, by organizing events such as "Educational Reflection Seminars" or "成長 Narrative Sharing Sessions," we can create a safe and open environment where students can openly discuss challenges they encounter in the classroom. Through peer support and evaluation by supervisors, they can develop improvement strategies, fostering shared learning experiences and collaborative intellectual growth. Throughout this process, students should be guided to stay informed about recent developments in chemistry and biology education as well as basic education reform, regularly consult relevant publications, attend academic lectures, conduct research, and continuously enhance their professional competence and educational philosophy. Additionally, students should be encouraged to establish personalized long-term career development plans, defining key learning priorities, competency goals, and achievable pathways at each stage. Integrating methods such as professional development portfolios, reflective practice, and strategic planning can effectively stimulate students' intrinsic motivation for growth.

4. Conclusion

Under the innovative talent cultivation model of the "Chemistry + Biological Sciences Undergraduate-Master's Integrated Program," comprehensive training strategies—including curriculum integration, establishment of practical bases, enhancement of teaching and research capabilities, innovation in instructional methods, interdisciplinary teamwork, and continuous professional development—have effectively equipped future high school teachers with practical competencies. Through deep integration of core interdisciplinary knowledge systems and the design of cross-disciplinary teaching modules and integrated experimental frameworks, teacher trainees develop a cohesive knowledge framework. Leveraging established internship partnerships with leading high schools, they undergo full-process practical training encompassing teaching practice, observation, and research activities. This approach also strengthens their ability to apply interdisciplinary teaching methodologies in real-world settings, enhances pedagogical research techniques, cultivates scientific literacy for identifying, analyzing, and solving educational challenges, promotes the adoption of modern educational technologies, innovates blended teaching models, improves digital instructional design and implementation skills, fosters interdisciplinary teaching teams, and supports educational research. Ultimately, through career development portfolios and reflective teaching guidance, these strategies foster intrinsic motivation for lifelong learning and self-improvement. These interconnected approaches not only lay a solid foundation for integrating chemistry and biological sciences in secondary education but also provide valuable insights and support for advancing interdisciplinary teaching practices across the middle school curriculum. On this basis, it is essential to further optimize the integrated undergraduate-master's training program, conduct a detailed review of the training objectives and evaluation criteria at each stage, and prioritize strengthening the teaching faculty with solid disciplinary expertise, rich teaching experience, and an interdisciplinary perspective. Additionally, the collaborative training system between high schools should be enhanced to establish a robust training framework and resource support system for cultivating more outstanding, versatile educators capable of driving reforms in secondary education.

References

Fu, L. Q. (2021). Challenges and explorations in managing interdisciplinary public-funded teacher education students under the new liberal arts framework: A case study of the History program (interdisciplinary training combining History and Geography) at Fujian Normal University. *Theoretical Observation*, *2021*(12).

Li, H. H. (2017). *Survey on the Training Needs of High School Teachers under the New College Entrance Examination System: A Case Study of Ningbo City* (p. 15). Ningbo: Ningbo University.

Li, P. H. (2021). From Specialized Discipline Treatment to Interdisciplinary Integration: The Fundamental Theory of New Liberal Arts Development from the Perspective of "World-Engaged Scholarship". *Heilongjiang Higher Education Research*, *2021*(11).

Shen, X. Y., Wang, M., & Ling, Y. Z. (2020). Construction and practice of a teacher training model based on the "3Y" objectives. *Teacher Training for Primary and Secondary Schools*, *2020*(7), 24-27.

Wang, R., & Zhang, Q. W. (2018). Teaching transformation and its responses among high school teachers under the context of elective course selection and class rotation. *China Journal of Education*, *2018*(6), 82-87.

Xu, F. L. (2018). Research on Reforming University Education Models Based on Critical Education Theory. *Journal of Heilongjiang Institute of Education*, *2018*(6).

Yao, Y. H. (2008). Pre-service training for "research-oriented" teachers and the quality of teacher education students' graduation theses. *Chinese University Teaching*, *2008*(7).

Zhai, S. F. (2023). *Research on the Current Status and Countermeasures for Professional Development of Experienced High School Teachers under the New College Entrance Examination Reform* (p. 61). Yantai: Ludong University.