



Teaching Research and Practice of 'General Chemistry' in Agriculture and Forestry Education Focused on Cultivating Innovative Ability

Xia Gong¹, Guixia Tan¹, Yangping Wen¹, Linyu Wang^{1,*}, Tingting Sun¹, Changxi Deng¹, Lei Gong¹, Rongrong Chen², Ji Zhang³, Zongde Wang⁴, Jiangbo Xiong⁵ and Yanhua Zeng⁶

¹ College of Chemistry and Materials, Jiangxi Agricultural University, Nanchang 330045, China

² College of Bioscience and Bioengineering, Jiangxi Agricultural University, Nanchang 330045, China

³ College of Forestry, Jiangxi Agricultural University, Nanchang 330045, China

⁴ College of Life Science, Gannan Normal University, Ganzhou 341000, China

⁵ College of Land Resource and Environment, Jiangxi Agricultural University, Nanchang 330045, China

⁶ College of Agriculture, Jiangxi Agricultural University, Nanchang 330045, China

Abstract

Taking the "General Chemistry" course—a public foundational course for agriculture-related majors and a postgraduate entrance examination subject in agricultural and forestry universities—as the research object, this study adheres to the Outcome-Based Education (OBE) philosophy and the "Four-Integration" principle (integrating science and agriculture, science and education, industry and education, and ideological-political education). It reconstructed advanced teaching content of "connection points–knowledge points–thematic inquiry series" to address the misalignment between course content and agricultural development needs, while seamlessly integrating ideological-political elements including scientific exploration spirit,

passion for agriculture, and ecological civilization concepts. A blended teaching model characterized by "three combinations, one passthrough, and six enhancements" was created to overcome students' insufficient ability in solving practical agricultural problems. A diversified evaluation model featuring "whole-process, three-dimensional, dual-assessment" was established to resolve the lack of process-based evaluation of students' professional application skills. The teaching reform practices have demonstrably improved students' course objective attainment rates and scientific reasoning performance, providing preliminary evidence for the cultivation of innovative capabilities.

Keywords: innovative capabilities, general chemistry, thematic inquiry series, ideological and political system, teaching model, evaluation model.



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*Corresponding author:

✉ Linyu Wang

linyuwang@jxau.edu.cn

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1 Introduction

The cultivation of innovative capacity is a cornerstone of quality higher education. This global priority traces back to the 1998 Boyer Commission Report, "Reinventing Undergraduate Education: A Blueprint for America's Research Universities", issued by U.S. research universities [1]. The report triggered a widespread initiative to refocus undergraduate education on research and innovation. This focus was further solidified in the U.S. Framework for 21st Century Learning (2011) [2], which established innovation, critical thinking, communication, and collaboration as core competencies. Subsequently, educational systems worldwide, including those in the European Union, Japan, Singapore, and New Zealand, have placed innovation at the heart of their core competency frameworks. In alignment with this global trend, China's 2016 core competency framework introduced "Practical Innovation" [3], and China's sustained higher education reform agenda has progressively repositioned talent cultivation goals toward nurturing curiosity, creative thinking, and a willingness to experiment [4].

As the fundamental building block of talent development, curriculum is a powerful lever for change. Consistently, the Key Tasks of the Department of Higher Education of the Ministry of Education for 2023 emphasizes using targeted curriculum reform to drive broader innovations in talent cultivation models. Within this context, the push for "New Agricultural Sciences" and the digital transformation of education demand a new type of agricultural graduate: one who is ethically grounded, possesses a solid knowledge base, and is innovative, interdisciplinary, and application-oriented.

"General Chemistry" a required foundational course for agriculture-related majors and a key component of graduate entrance examinations, is critical for developing such talent. However, this course now faces significant challenges. For example, evolving expectations under the New Agricultural Sciences initiative, students entering university with varying levels of chemistry background due to recent reforms in the Gaokao (National College Entrance Examination), and constraints of reduced class hours and the inherently abstract nature of chemical concepts. To address these challenges, this research explores and implements a reformed approach to the "General Chemistry" curriculum for agricultural disciplines. Conducted within a digital learning environment, the reform is fundamentally designed to systematically

foster students' innovative abilities.

2 Overall Design of the "General Chemistry" Teaching Reform

"General Chemistry" is a foundational course for first-year undergraduates in agriculture-related majors at higher education institutions of agriculture and forestry. It serves as the cornerstone for further studies in university-level chemistry. The course systematically introduces fundamental chemical concepts, principles, and methods, tracing their historical development. It examines the nature of material from atomic and molecular perspectives, elucidates chemical principles, and dialectically analyzes the relationships between the microscopic and macroscopic worlds, thereby fostering a micro-level understanding of chemical systems. The course objectives are: (1) To equip students with a command of fundamental chemical concepts, principles, and methods; (2) To cultivate scientific thinking, enabling students to articulate, analyze, and solve chemistry-related problems in their field from a chemical perspective, while fostering a spirit of scientific inquiry, a commitment to agriculture, and an awareness of ecological civilization.

Guided by the Outcome-Based Education (OBE) philosophy [5, 6], the teaching team addressed key instructional challenges by implementing a comprehensive reform in three core areas: content, pedagogy, and assessment (Figure 1). Specifically, reconstruct the advanced teaching content of "connection points - knowledge points - thematic inquiry series"; create a blended teaching model of "three combinations - one passthrough - six improvements"; build a diversified evaluation model of "whole process - three dimensions - dual assessment". These initiatives were designed with a minimum course objective attainment threshold of 0.7, which served as the benchmark for evaluating teaching effectiveness.

3 Reconstruct the Advanced Teaching Content of "connection points - knowledge points - thematic inquiry series"

"General Chemistry" is a first-semester course for freshmen in agriculture-related majors at agricultural and forestry universities. Guided by the principles of "emphasizing continuity, strengthening foundations, prioritizing integration, and enhancing distinctive features", and in accordance with cognitive rules in education, the course has developed a bridging MOOC

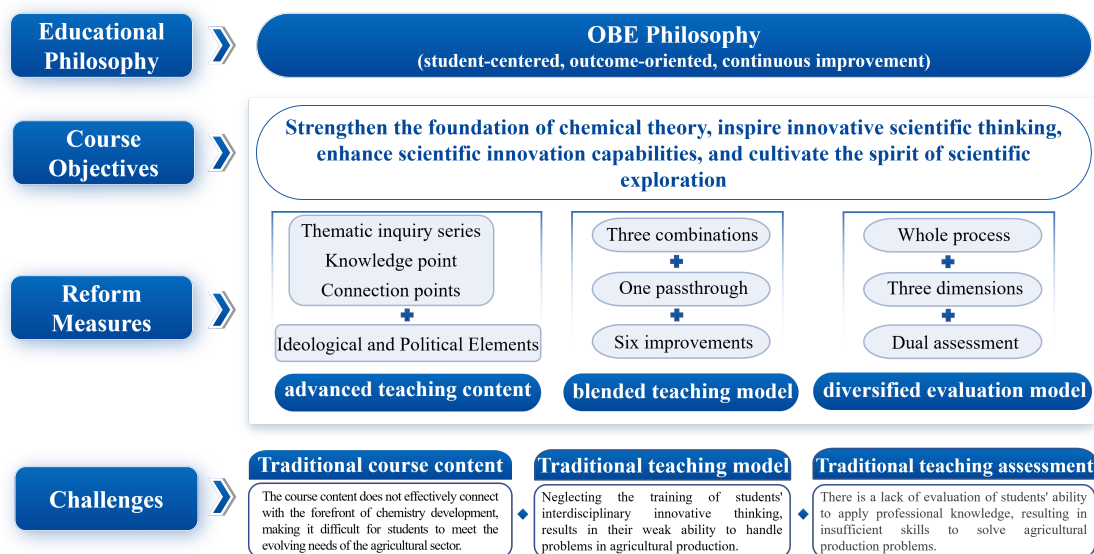


Figure 1. Design Framework for the "General Chemistry" Course Teaching Reform.

to connect high school and university chemistry. It firmly follows the main logical thread of knowledge by systematically organizing key concepts and principles. By incorporating agricultural research projects and real-world problems from agribusiness, a series of discussion topics has been designed to achieve the integration of science and agriculture, the merging of research and education, and the combination of industry and academia, thereby highlighting the features of modern agriculture and forestry. The progressively structured content "Connection points - Knowledge points - Thematic inquiry series" has been innovatively designed to incorporate ideological and political education. This provides strong support for solidifying students' chemical theoretical foundation and cultivating their scientific innovative thinking and spirit of exploration.

3.1 Focus on Students with Weak Foundations and Create Mini-lessons for the High School-to-college Transition

In response to the varying levels of student preparation following the revised Gaokao system, where some students did not take chemistry as a high school elective and others enter with a weak foundation, the teaching team has developed a series of micro-lecture videos. These videos focus on key high school concepts and theories essential for success in the university-level "General Chemistry" course (Table 1). All video resources have been uploaded to the independently developed "General Chemistry" online platform, a provincial-level top-quality open course in Jiangxi. Students are encouraged to utilize these materials for self-directed learning during the university orientation and military training period.

Table 1. Micro-lecture Videos for High School-University Chemistry Transition Points.

General Chemistry	High School Chemistry Bridge Content
Calculation of relevant metric relationships	Chemistry 1: Understanding the chemistry discipline, elements, and the material world
Chemical Thermodynamics	Principles of chemical reactions: Energy conversion, direction and limits of chemical reactions
Chemical Kinetics	Principles of chemical reactions: Reaction rates
Atomic structure	Structure and properties of material: Atomic structure
Molecular structure	Structure and properties of material: Chemical bonds and intermolecular forces
Acid-base reaction Precipitation-dissolution reaction Coordination reaction Redox reaction	Principles of chemical reactions: The behavior of substances in aqueous solutions

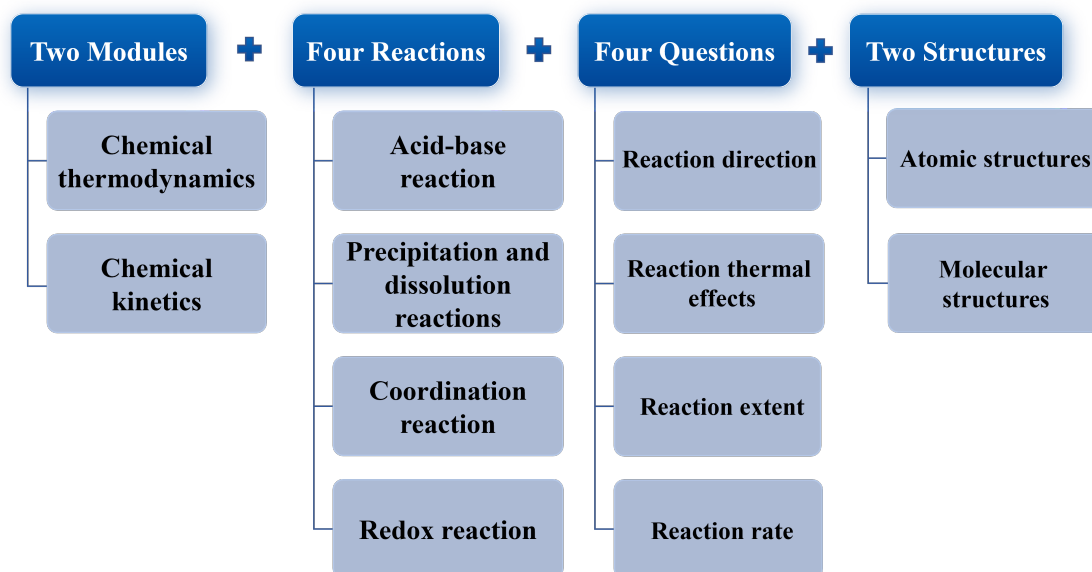


Figure 2. Modularization of Knowledge Points in the "General Chemistry" Course.

3.2 Grasp the Main Logic of the Course, Achieving Modularization of Knowledge Points

Clarify the logical framework of the "General Chemistry" course content—"Two Modules – Four Reactions – Four Questions – Two Structures"—to restructure knowledge points and achieve modularization of course content (Figure 2). The "Two Modules" refer to chemical thermodynamics and chemical kinetics. The "Four Reactions" encompass acid-base reactions, precipitation-dissolution reactions, coordination reactions, and oxidation-reduction reactions. The "Four Questions" are the direction of chemical reactions, the thermal effects of chemical reactions, the extent of chemical reactions, and the rates of chemical reactions. The "Two Structures" refer to atomic structure and molecular structure. The course's logical framework employs the fundamental principles of chemical thermodynamics and chemical kinetics (two modules) to address the direction, thermal effects, extent, and rate (four questions) of acid-base reactions, precipitation-dissolution reactions, redox reactions, and coordination reactions (four reactions). It further enables mechanistic analysis using microscopic atomic and molecular structures (two structures).

3.3 Integrating Science and Education with Industry-education Collaboration, Designing Thematic Inquiry Series

Focusing on core course knowledge points, this initiative closely integrates Jiangxi Agricultural University's "Six Ones" scientific and technological innovation achievements, "one pig (breeding pig),

one rice plant (rice), one bee (honeybee), one bamboo (Moso bamboo), one fruit (kiwifruit), one flower (colorful rapeseed flower)", and leverages the university's 63 science and technology courtyards and 205 science and technology special envoys. Leveraging research projects and university-enterprise collaborations led by chemistry faculty and agricultural/forestry/animal science instructors, the curriculum extracts chemical principles from disciplinary frontiers, industrial practices, and social services. This transforms research resources into teaching materials, yielding a thematic inquiry series with distinct modern agroforestry characteristics. Covering farmland, soil, forests, lakes, and aquaculture, it broadens and deepens course content while breaking disciplinary barriers to innovate teaching approaches (Table 2). For instance, when teaching "Acid-Base Equilibrium", the thematic inquiry "why does soil pH not change drastically during acid precipitation?" was integrated. When covering "Precipitation-Dissolution Equilibrium", the thematic inquiry "why do plants absorb dihydrogen phosphate ions but not phosphate ions?" and "why is quicklime applied to cadmium-contaminated soil during rice grain filling?" were incorporated. When teaching "Coordinate Equilibrium", integrate the thematic inquiry series "the chemical mechanism behind the diverse colors of rapeseed flowers" and "the chemical mechanism behind the varying shades of honey". When teaching "Oxidation-Reduction Equilibrium", integrate the thematic inquiry series "why rice is more prone to cadmium contamination during dry seasons, while it is less prone in years with

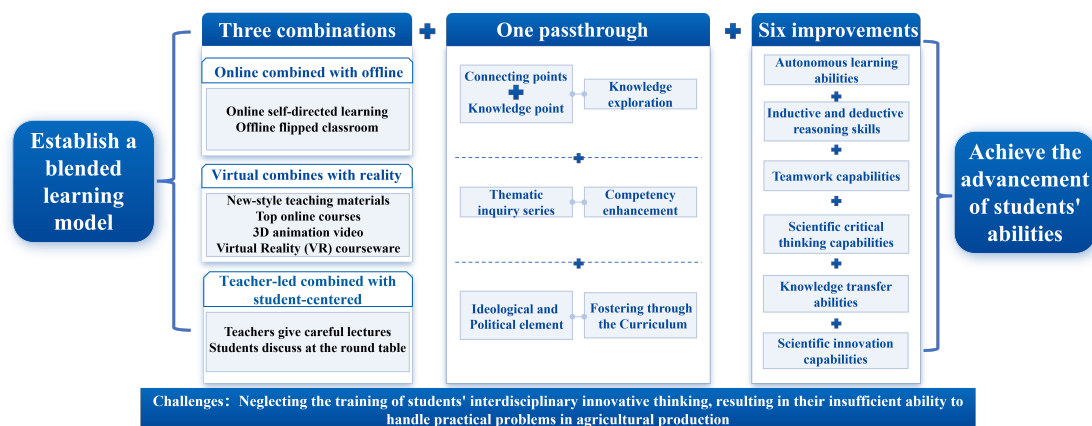


Figure 3. The blended teaching model of "three combinations - one passthrough - six improvements".

abundant rainfall". Through the thematic inquiry series, a bridge between for knowledge and application was built, which would develop knowledge transfer ability, stimulate students' intrinsic motivation and sense of professional achievement.

3.4 Clarify the Theme of Ideological and Political Education, Building a Repository of Related Elements

Course-based ideological and political education represents an implicit form of ideological and political instruction. By thoroughly exploring the ideological and political elements of the new era embedded within the connection points, knowledge points, and topic repository of the "General Chemistry" course, three main ideological and political themes including love and understanding of agriculture, the concept of ecological civilization, and the spirit of scientific exploration were extracted. This has led to the construction of a course-based ideological and political education system for "General Chemistry" characterized by clear thematic focus, rich ideological and political content, and comprehensive coverage throughout the course (Table 2). For instance, when teaching the knowledge point "The effect of oxidation-reduction potential on metal ion forms," the topic "why is rice more prone to cadmium contamination during dry seasons, while it is less likely to exceed cadmium standards in rainy years? Long-term consumption of cadmium-contaminated rice can cause itai-itai disease." is derived from the instructor's National Natural Science Foundation project on "In-situ Passivation Remediation of Heavy Metal-Contaminated Farmland Soils". Through topic discussions, this approach enhances students' scientific inquiry skills and knowledge transfer abilities, advocates for safeguarding the red line of

arable land to protect the food supply for 1.4 billion people, and inspires students' understanding and affection for agriculture.

4 Create a blended teaching model of "three combinations-one passthrough-six improvements"

Freshmen possess active minds and a strong thirst for knowledge, yet they remain accustomed to traditional lecture-based teaching methods. This approach fails to sufficiently stimulate their innovative thinking, adequately ignite their spirit of exploration, or effectively cultivate their creative abilities. Therefore, grounded in constructivist theory and leveraging digital teaching resources and AI-assisted intelligent platforms—including the independently developed online course system, the Chaoxing learning management platform with its automated assessment and learning analytics functions, and VR courseware enabling immersive chemical structure visualization—the teaching team embraces the OBE teaching philosophy. By innovating the roundtable discussion format, we establish a blended learning model featuring "three combinations-one passthrough-six improvements" (Figure 3) to ensure the cultivation of students' scientific innovation capabilities. The "Three combinations" center on student development, it integrated online self-directed learning and offline flipped classrooms; combining the teaching team's newly developed "General Chemistry" textbook with top online courses, 3D animations, and VR courseware; and pairing instructor-led instruction with student roundtable discussions. The "One passthrough" connects the pathway from "knowledge points - thematic inquiry series - competency enhancement - ideological and political education". The "Six improvements" focus on

Table 2. Key points, thematic inquiry, and capacity building of each chapter.

Chapters	Key points of each chapter	Thematic inquiry series (partial listing)	Capacity building and ideological and political education (partial listing)
Introduction	The knowledge system of General Chemistry	Outline the core framework of the "General Chemistry" course—comprising two modules, four problems, four reactions, and two structures—and explain its pivotal role in agriculture-related disciplines.	Cultivate students' inductive and deductive reasoning skills, ignite their passion for learning, and instill the aspiration to study for the rise of China.
Chapter 1: States of materials	Osmotic pressure	Topic 1: Why do different plants require different watering schedules and amounts?	Enhance students' ability to integrate theory with practice and transfer knowledge, enabling knowledge internalization and fostering a sense of professional accomplishment.
	Surface adsorption	Topic 2: Why is it necessary to add an appropriate amount of sea salt to the water when farming marine fish?	Enhance students' ability to connect theory with practice and transfer knowledge, while stimulating their intrinsic motivation to learn.
	Ion exchange adsorption	Topic 3: Why can charcoal from burned branches be used to purify river water for drinking during wilderness survival?	Enhance students' scientific reasoning and innovation abilities, and inspire their spirit of scientific exploration.
Chapter 2: Chemical thermodynamics	Gibbs free energy change determines the direction of a chemical reaction.	Topic 4: What is the principle behind using ammonium sulfate as the leaching agent in the in-situ leaching process for ionic rare earth ores? Can it be replaced with magnesium sulfate?	Tackling pollution caused by the mining of ion-type rare earth ores requires an investment of 38 billion yuan and a remediation period of up to 70 years. Integrating the Two Mountains Theory helps to instill the concept of ecological civilization in students.
		Topic 5: How to address water pollution issues arising from uranium mining and smelting operations?	Enhance students' ability to connect theory with practice and realize the internalization of knowledge.
		Topic 6: Why is potassium aluminum sulfate used to treat raw water after it enters the water treatment plant?	Enhance students' ability to connect theory with practice and transfer knowledge, and stimulate their sense of professional achievement.
Chapter 3: Chemical kinetics	Shift in Chemical Equilibrium	Topic 7: Determining the reaction of automotive exhaust gases by calculating the change in Gibbs free energy $\text{NO} + \text{CO} \rightarrow \text{N}_2 + \text{CO}_2$. This reaction can proceed in the forward direction, converting toxic CO and NO into harmless atmospheric components. But why does it still cause air pollution?	Cultivate students' scientific innovation capabilities. Transitioning from theoretical feasibility to industrial practice requires selecting appropriate materials, developing suitable processes, and preparing highly efficient catalysts—all of which stimulate students' spirit of scientific inquiry.
		Topic 8: What caused the explosion at the benzene plant involved in the Songhua River pollution incident? What principles underlie in-situ blasting in engineering?	Cultivate students' scientific reasoning skills and enhance their awareness of operational standards.
		Topic 9: Why does the color of silica gel change before and after absorbing water?	Enhance students' scientific reasoning skills and cultivate their "dynamic equilibrium" chemical thinking.
Chapter 4: Acid-base equilibrium	Buffer solution	Topic 10: Why do photochemical smog events cause widespread tire aging and blowouts despite rubber aging occurring at a very slow reaction rate?	Enhance students' scientific reasoning skills and foster their understanding of ecological civilization.
		Topic 11: Why does the soil pH not undergo a drastic change during acid deposition?	Enhance students' ability to apply theoretical knowledge to practical situations.
Chapter 5: Precipitation-dissolution equilibrium	Precipitation-dissolution equilibrium of phosphates	Topic 12: Why do plants absorb dihydrogen phosphate ions instead of phosphate ions?	Enhance students' scientific innovation ability, ability to connect theory with practice, and knowledge transfer skills, achieve knowledge internalization, and inspire students' love for agriculture and enthusiasm for learning.
		Topic 13: Why is sulfate ion pollution commonly seen in groundwater contamination, while phosphate ion pollution is rarely observed?	
Chapter 6: Coordination equilibrium	Formation of coordination compound	Topic 14: Why is quicklime applied to cadmium (Cd)-contaminated soil during the grain-filling stage of rice?	
		Topic 15: Why does illegal discharge of acidic wastewater by factories cause heavy metal pollution, damage aquatic ecosystems, and pose risks to human health?	Introduce the Japanese Itai-itai disease incident, connect it with agricultural production practices, achieve knowledge transfer and internalization, and cultivate an appreciation for farmers' love for agriculture, and the concept of ecological civilization.
Chapter 7: Redox equilibrium	Types of coordination compound	Topic 16: Children's hyperactivity is often caused by the accumulation of Pb in the body. Which type of substance among acids, bases, salts, precipitants, redox agents, and chelating agents might be used for treatment, and why?	Introduce examples of lead (Pb) pollution caused by the fall of ancient Rome and automobile exhaust to enhance students' ability to connect theory with practice and transfer knowledge, and to foster the concept of ecological civilization.
		Topic 17: Why can copper sulfate be used as a fungicide?	Enhance students' ability to connect theory with practice and stimulate their sense of professional achievement.
Chapter 8: Atomic structure	Effect of redox potential on the forms of metal ions	Topic 18: The chemical mechanisms behind the diverse colors of rapeseed flowers	Stimulate students' enthusiasm for learning, enhance their ability to connect theory with practice, and cultivate their spirit of scientific exploration.
		Topic 19: The chemical mechanism behind the variation in honey color	
Chapter 9: Molecular structure	Atomic structure and basic properties of elements		
	Valence bond theory of complexes		

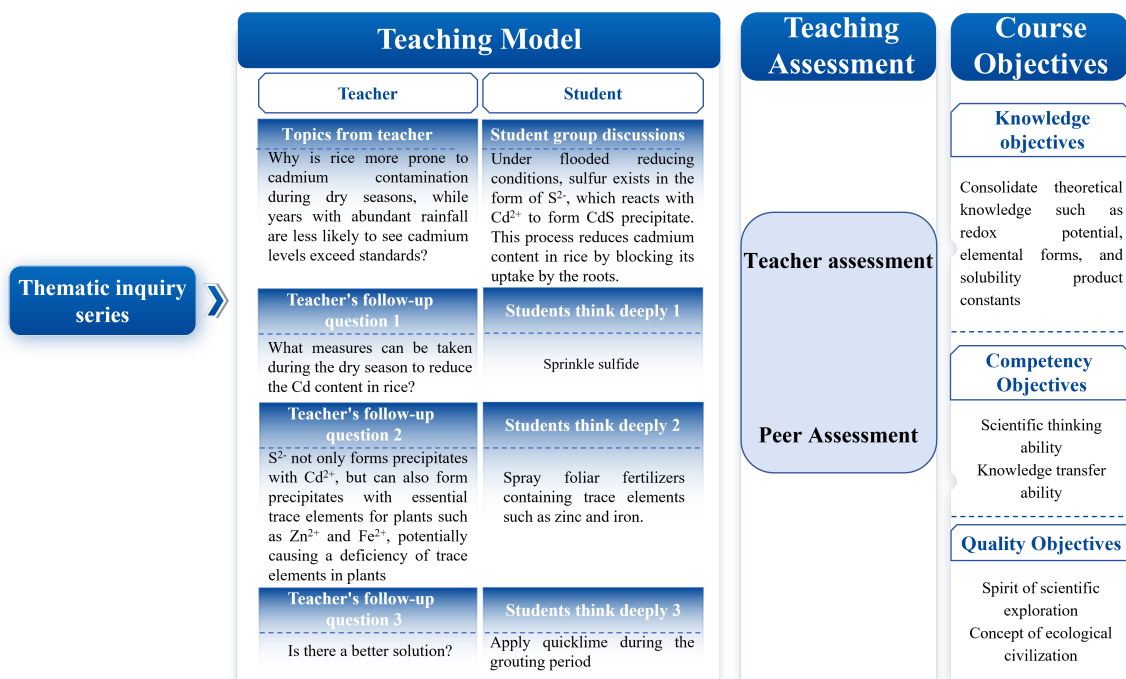


Figure 4. Examples of Inquiry-based instructional design for thematic inquiry series.

developing students' autonomous learning abilities, inductive and deductive reasoning skills, teamwork capabilities, scientific critical thinking, knowledge transfer abilities, and scientific innovation capabilities.

The implementation process for the "General Chemistry" teaching design is outlined below. Prior to class, instructors distribute online learning assignments one week in advance and conduct an online assessment (pre-test) to promote personalized learning. In class, the lesson adheres to a problem-based research approach, focusing on scientific thinking training. The BOPPPS model has demonstrated effectiveness across diverse disciplinary contexts [7, 8], and is employed here to structure teaching segments including problem-based video instruction, focused classroom lectures, post-class assessments, and summaries. Diverse activities such as student selection, rapid response, questionnaires, voting, thematic discussions, and roundtable debates are designed. Evidence-based feedback enables precise teaching implementation. After class, assignments, preview tasks, and pre-tests are distributed via Learning Pass.

For example, when teaching the concept of "ion exchange adsorption", the teacher introduced an international collaborative project and refined an inquiry-based question: "What is the principle behind using ammonium sulfate as a leaching agent in the

in-situ leaching process for ionic rare earth ores? Could magnesium sulfate be substituted instead?". Students engage in roundtable discussions, analyzing from the perspective of ion exchange capacity: the charge of Mg^{2+} (+2) is larger than that of NH_4^+ (+1), making Mg^{2+} more effective than NH_4^+ at exchanging rare earth ions. However, from an ecological perspective, magnesium sulfate ($MgSO_4$) acts as a laxative. If the leaching agent leaks and contaminates water sources, humans and animals consuming polluted water may experience diarrhea and dehydration, potentially leading to death in severe cases. During the roundtable discussion, the collision of diverse viewpoints sparked intellectual insights, helping students transcend cognitive limitations and broaden their thinking. Finally, the instructor introduced that pollution control from mining ion-type rare earth ores requires an investment of 38 billion yuan and a remediation period of 70 years. Integrating this with General Secretary Xi Jinping's the Two Mountains Theory, the session fostered ecological civilization concepts and achieved ideological and political education.

In addition, when teaching the concept "The effect of oxidation-reduction potential on metal ion forms" (Figure 4), teaching process is designed as below:

(1) the teacher introduces "Itai-Itai Disease" incident, integrating it into the comprehensive inquiry topic: "Why is rice more prone to cadmium contamination

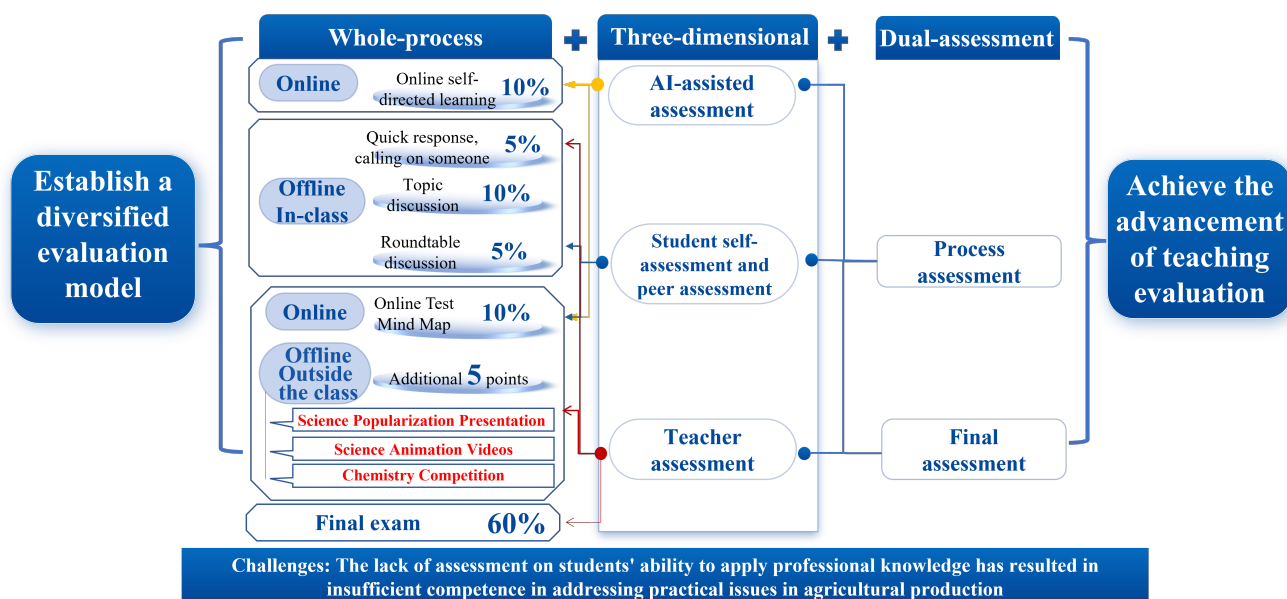


Figure 5. Diversified evaluation model of "whole process - three dimensions - dual assessment".

during dry seasons, while it is less likely to exceed cadmium limits in years with abundant rainfall?";

(2) Guide students to apply a series of knowledge points for comprehensive analysis;

(3) The teacher uses the redox reaction mechanism to explain as that under flooded conditions, the rice paddy soil becomes oxygen-deficient, creating a reducing environment. Sulfur exists as S^{2-} , which reacts with cadmium ions to form CdS precipitation. This blocks cadmium from entering the plant through the root ion channels, effectively reducing cadmium levels in rice.

(4) Teacher follows up: What method can be used during the dry season to reduce Cd content in rice?

(5) Students respond: Applying sulfide compounds to the soil.

(6) Teacher further questions: Based on the solubility product constant of sulfides, S^{2-} not only forms precipitates with Cd^{2+} but also with essential plant micronutrients like Zn^{2+} and Fe^{2+} , potentially causing micronutrient deficiencies in plants.

(7) Guide students to consider remedial measures: While applying sulfide, foliar spraying of trace element fertilizers should also be conducted to integrate soil and crop management.

(8) Teacher follows up: Is there a better solution?

(9) Guided by the teacher, students consider approaches based on solubility product constants and soil pH adjustment. During the rice grain-filling

stage, applying quicklime increases soil pH to form $Cd(OH)_2$ precipitation.

This enhances students' ability to analyze and solve soil heavy metal pollution issues in agricultural practice using fundamental chemical principles, achieving knowledge transfer and internalization while fostering scientific inquiry and ecological awareness.

5 Building a Diversified Evaluation Model of "whole-process, three-dimensional, and dual assessment"

Leveraging the Chaoxing online platform, we adopt a combination of "online and offline evaluations, in-class and out-of-class evaluations", "AI-assisted evaluation, student evaluation, and teacher evaluation", and "formative assessment and summative assessment" to build a diversified evaluation model of "whole-process, three-dimensional, and dual-assessment" (Figure 5). Transformed classrooms from knowledge-centered to competency-focused, discussion-based, and debate-oriented learning environments, achieving an advanced level of teaching assessment and addressing the key issue of "the lack of evaluation on students' ability to apply professional knowledge and their insufficient competency in solving real agricultural production problems".

During students' online self-directed learning and teachers' offline classroom lectures, online self-assessments are conducted, with the Chaoxing system providing AI-driven automatic evaluations that generate real-time learning analytics, enabling

Table 3. Effect of the teaching reform for the "General Chemistry" course.

Research sample			Number of people and proportion for different scores					Average
			≥90	80-89	70-79	60-69	≤60	
Reform class	Weiyi Agricultural 2401	Exam paper score	4 13.80%	8 27.60%	7 24.10%	6 20.70%	4 13.80%	74.55
		Overall score	8 27.60%	12 41.40%	8 27.60%	1 3.45%	0 0.00%	83.97
Control class	Weiyi Resources and Environment 2401	Exam paper score	1 3.33%	3 10.00%	7 23.33%	6 20.00%	13 43.33%	64.43
		Overall score	1 3.33%	14 46.67%	12 40.00%	3 10.00%	0 0.00%	78.49

data-informed and personalized instructional adjustments—a key feature of digitally intelligent education environments. During classroom activities, teachers use Chaoxing for real-time evaluation. In offline classroom teaching, process evaluations such as student self-assessment, peer assessment, and teacher evaluation are carried out through activities like student-to-student questions and answers, teacher-to-student questions and answers, quick response quizzes, questionnaires, thematic discussions, and roundtable debates.

The teaching team innovatively incorporated evaluations such as science outreach presentations, animated video production, and chemistry competitions, significantly boosting students' enthusiasm for serving the community and participating in academic contests. For example,

(1) Students use the four major chemical reactions to simulate natural water landscapes, combine elements of garden design, and create videos of water gardens; From the perspective of wilderness survival, they make charcoal using dead branches and fallen leaves, and use stones, sand, and charcoal to make water purifiers, removing suspended particles through filtration and then sterilizing by boiling, creating videos on how to prepare drinking water; From the perspective of ecological and environmental protection, aluminum beverage cans are collected and used to produce aluminum tetrachloride hydroxide by reacting with a strong alkali. This is then reacted with a strong acid, followed by evaporation, concentration, cooling, and vacuum filtration to prepare the water purifier potassium aluminum sulfate, along with making videos on the preparation of the water purifier. Participating in the "Enlightening minds, nurturing hearts—hand in hand, protecting blue skies, clear waters, and pure lands" science popularization activity with a chemistry-themed video work, awarded 5 extra

points. This activity won the First Prize in the Labor Education Exhibition Works category of the Labor Education List in Jiangxi Province, and the Forestry Science and Technology Award in the Popular Science Activity category of the Jiangxi Forestry Society.

(2) Students created animations of chemical mechanisms and were awarded 5 additional points. Their animated videos, such as "The Mystery of Bone Pain—Mechanism of Cadmium Rice Formation" and "Buddha in the sky, Demon on the earth—Ozone Layer Depletion" won awards in the National College Student Online Editing Competition.

(3) The students' project "The Physicochemical Principles in 'Foil Ink Shining Gold'" won the First Prize and Best Creativity Award in the Jiangxi Province Science Experiment Presentation Competition.

6 Effects of Teaching Reform and Teaching Reflection

Taking the Weiyi Agricultural 2401 class and the Weiyi Resources and Environment 2401 class in the first semester of the 2024-2025 academic year as research samples—with the former serving as the reform class and the latter as the control class—educational research and reform practices were conducted. The results indicate (Table 3, Figures 6 and 7) that the Weiyi Agricultural 2401 as reform class achieved an excellent rate of 13.80% on written exams, with an average score of 74.55, and the attainment rates for course objective 1 and 2 were both 0.84. As a comparison, Weiyi Resources and Environment 2401 only achieved an excellent rate of 3.33% on written exams, with an average score of 64.43, their achievement rate for course objective 1 and 2 was 0.80 and 0.77, respectively. Both the reformed class and the control class surpassed the minimum course objective attainment threshold of 0.7, with attainment rates for course objective 1 reaching or exceeding 0.80, indicating

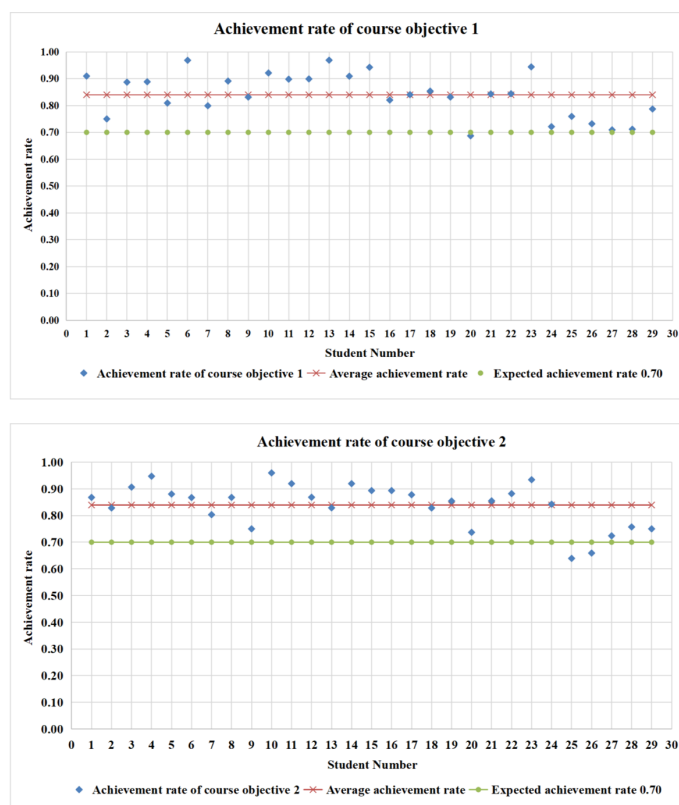


Figure 6. The achievement degree of the course objectives of Class 2401 of Weiyi Agriculture.

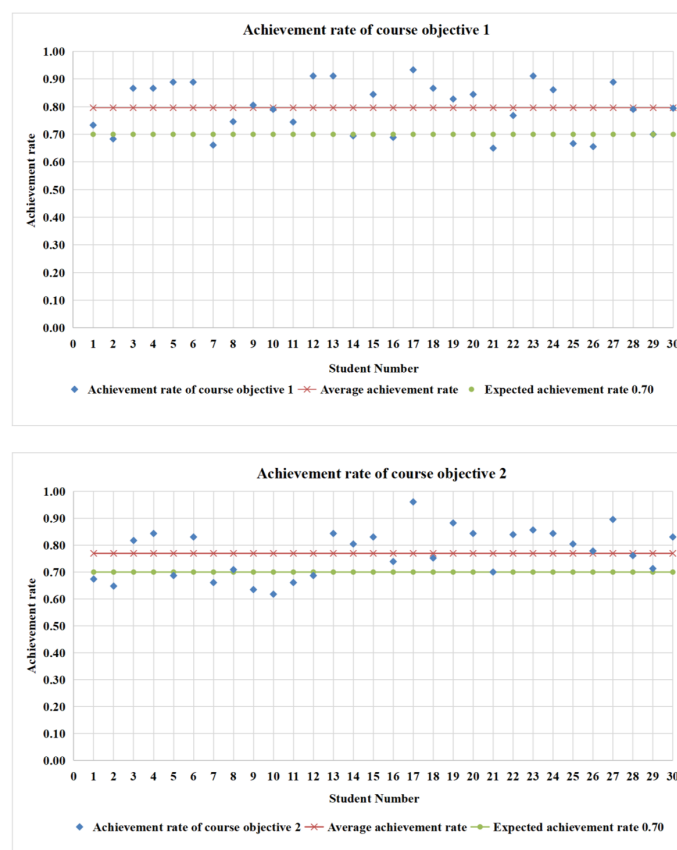


Figure 7. The achievement degree of the course objectives of Class 2401 of Weiyi Resources and Environment.

that both traditional teaching and teaching reform effectively enable students to master fundamental chemical concepts, principles, and methodologies. While the achievement of course objective 2 in the reformed class was significantly higher than that in the control class, indicating that teaching reforms can better help students develop scientific thinking. These reforms enhance students' ability to express, analyze, and solve chemistry-related scientific problems in agricultural and forestry disciplines from a chemical perspective. They also cultivate students' spirit of scientific exploration, foster their affection for agriculture, and instill ecological civilization concepts. A questionnaire survey conducted in the reformed class revealed that 85% of students expressed high approval for inquiry-based thematic teaching, roundtable discussions, and supplementary assessments. They strongly endorsed transforming agricultural production challenges into teaching content. In future teaching practice, the teaching team will further engage with the Science and Technology Institute, carry out school-enterprise cooperation, address real problems faced by agricultural-related enterprises, explore the chemical principles involved, use research to support teaching, and enhance students' scientific and innovative abilities.

7 Conclusion

In summary, this study designed an inquiry-based series of thematic question banks that highlight modern agricultural and forestry characteristics, build bridges for knowledge transfer, and stimulate students' intrinsic motivation and sense of professional fulfillment. The implementation of blended teaching methods and diversified assessment approaches, conducts roundtable discussions, and includes additional assessments such as popular science presentations, animated video production, and chemistry competitions. These approaches significantly increase student classroom participation, enhance their enthusiasm for joining the "Chemistry+" science association and serving society, and increase the number of students participating in and winning academic competitions. These outcomes serve as observable proxies for the development of scientific reasoning and innovative thinking, though direct measurement of innovative capabilities through validated assessment instruments remains a direction for future work.

Data Availability Statement

Data will be made available on request.

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Conflicts of Interest

The authors declare no conflicts of interest.

AI Use Statement

The authors declare that no generative AI was used in the preparation of this manuscript.

Ethical Approval and Consent to Participate

This study constitutes a routine teaching reform practice and was exempted from formal ethical review by the Institutional Review Board of Jiangxi Agricultural University. All student participants were informed of the purposes of data collection prior to the study. Participation in the questionnaire survey was entirely voluntary, and students were explicitly notified that their examination scores would be used for educational research purposes in anonymized and aggregated form only. No individual-level data were reported. All procedures were conducted in accordance with applicable institutional guidelines for educational research involving human participants.

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Xia Gong received the Ph.D. degree in Agriculture from Jiangxi Agricultural University, Jiangxi 330045, China, in 2013. (Email: gx13870698760@outlook.com)



Guixia Tan received the Ph.D. degree in Silviculture from Jiangxi Agricultural University, Nanchang 330045, China, in 2014. Her research interests include soil remediation, electrokinetic remediation technology, contaminated land restoration, and environmental functional materials. (Email: tgx98101225@jxau.edu.cn)



Yangping Wen received the Ph.D. degree in genetics and breeding of crops from Jiangxi Agricultural University, Nanchang 330045, China, in 2013. Her research interests include chemistry of materials for agricultural sensors and farmland improvement, mainly focus on optical/electrical sensors and their agricultural analysis. (Email: wenyangping1980@jxau.edu.cn)



Rongrong Chen received the Ph.D. in Animal Genetics Breeding and Reproduction from Jiangxi Agricultural University, Nanchang, 330045, China, in 2009. (Email: r_r_chen@163.com)



Linyu Wang received the Ph.D. degree in Chemical from Jiangxi Normal University, Jiangxi 330022, China, in 2022. (Email: linyuwang@jxau.edu.cn)



Ji Zhang received the Ph.D. degree in wood science and technology from Beijing Forestry University, China, in 2018. Her research interests include essential oil micro-nano encapsulation technology, and purification technology and comprehensive utilization of *Camellia oleifera* processing residues. (Email: zhangji@jxau.edu.cn)



Tingting Sun received the Ph.D. degree in Chemistry from Nankai University, China, in 2009. (Email: suntting@mail.jxau.edu.cn)



Zongde Wang received the Ph.D. degree in Chemical engineering of forest products from Nanjing Forestry University, Jiangsu 210037, China, in 2001. (Email: zongdewang@163.com)



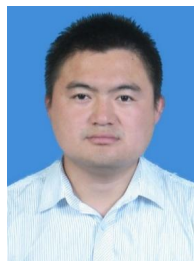
Changxi Deng received the MSc degree in Chemistry from Xiamen University, China, in 2006. (Email: dcxi80@sina.com)



Jiangbo Xiong received the M.S. degree in Agriculture from Jiangxi Agricultural University, Nanchang, 330045, China, in 2007. (Email: xjb13879103690@126.com)



Lei Gong received the Ph.D. degree in Industrial Catalysis from Nanchang University, Jiangxi, China, in 2012. (Email: gonglei@jxau.edu.cn)



Yanhua Zeng received the Ph.D. degree in Agriculture from Nanjing Agricultural University, China, in 2015. Her research interests on plant science, including plant productivity, physiology and ecology, involving to chilling, high temperature, drought and flood stress, and planting techniques. He served as an Editor for the Journal Crop and Environment, and Journal of Integrative, etc. (Email: zyh74049501@163.com)