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Teaching Reform and Practice of the Course *Environmental Protection in Oil and Gas Fields* for Undergraduate Students Majoring in Applied Chemistry: A Case Study of the College of Chemistry and Environmental Engineering, Yangtze University

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ABSTRACT

Environmental Protection in Oil and Gas Fields is a key elective course for undergraduate students majoring in Applied Chemistry at the School of Chemical Engineering, Yangtze University. The course integrates theoretical foundations, industry orientation, and practical applicability. Its teaching quality directly influences the cultivation of students' environmental literacy and professional application competence, as well as their ability to meet the growing demand for interdisciplinary applied chemistry talents driven by the green development of the oil and gas industry. In alignment with the training objective of the Applied Chemistry program at Yangtze University—namely, "integrating chemical theory with practical application, with a focus on oilfield chemistry characteristics"—this study employs literature review, questionnaire surveys, and teaching practice evaluation to systematically analyze existing issues in the current course structure (32 contact hours of theory-based instruction). Key challenges are identified in teaching content, pedagogical approaches, and assessment systems. Considering recent environmental protection policies and regulations in the oil and gas sector, emerging technological trends, and the cognitive characteristics of undergraduate students in applied chemistry, targeted teaching reform strategies are proposed. These strategies are further validated through instructional practice. The results demonstrate that optimizing course content, innovating theoretical teaching methodologies, improving assessment systems, and strengthening the integration between theory and application can significantly enhance teaching quality. These measures also promote students' professional identity and practical competence, thereby laying a solid foundation for their future engagement in environmental protection within the oil and gas industry.

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Introduction

Research Background

With the in-depth advancement of China's "dual carbon" strategy and the increasingly stringent ecological and environmental regulatory framework, the oil and gas industry—serving as a cornerstone of national energy supply—is undergoing an accelerated transition toward cleaner and low-carbon development [1]. In 2026, the Ministry of Ecology and Environment of the People's Republic of China promulgated the Technical Specification for Pollution Control of Solid Waste from Oil and Gas Exploitation and Production Industry (on Trial), which incorporates solid waste from oil and gas operations into a full life-cycle management regime. This policy further underscores the central role of environmental protection in oilfield production and operation. Environmental protection in oil and gas fields now spans the entire industrial chain, including exploration, drilling, production, gathering and transportation, as well as ecological restoration. Consequently, there is an urgent demand for interdisciplinary professionals equipped with both a solid foundation in applied chemistry and strong environmental awareness [2]. Yangtze University, a comprehensive institution distinguished by its focus on oil and gas resource development, leverages its disciplinary strengths in petroleum engineering to support the Applied Chemistry program within its School of Chemical Engineering. The program has clearly identified "oilfield chemistry, and the synthesis and application of fine chemicals" as its core developmental directions, aiming to cultivate high-level specialists capable of engaging in applied research and technological innovation in chemical engineering, petroleum, and environmental protection sectors [3-9]. The course Environmental Protection in Oil and Gas Fields, offered as a professional elective (32 contact hours of purely theoretical instruction), is designed to bridge fundamental theories of applied chemistry with environmental practices in the oil and gas industry. It enables students to systematically grasp the principles, technologies, and regulatory standards of pollution prevention and control in oilfields, serving as a key vehicle for achieving program-specific training objectives [10-12]. However, significant deficiencies persist in the current instructional framework. The course is entirely lecture-based, lacking any experimental or practical components. The content is insufficiently aligned with the Applied Chemistry discipline and is not adequately updated to reflect the latest industry technologies and regulatory developments. Moreover, teaching methods remain conventional, and assessment approaches are overly focused on rote memorization of theoretical knowledge, thereby failing to meet the requirements for cultivating students' practical competencies. Within the constraints of a purely theoretical teaching model, how to reinforce disciplinary characteristics of applied chemistry while effectively aligning with industry demands has become the central challenge in curriculum reform.

Research Significance

Theoretical significance

This study develops a teaching framework for *Environmental Protection in Oil* and Gas Fields that operates within a purely theoretical context while emphasizing disciplinary relevance, alignment with industry needs, and the cultivation of applied competencies. It enriches the body of research on curriculum reform for elective courses in applied chemistry and provides a reference for similar institutions seeking to improve theoretically oriented courses lacking practical components. Furthermore, by integrating the latest environmental policies and technological advancements in the oil and gas sector, this study refines the theoretical content system, ensuring its synchronization with industry developments.

Practical significance

Through the optimization of teaching content, innovation in theoretical instruction methods, and improvement of assessment systems, this study enhances course quality in the absence of experimental components. It enables undergraduate students majoring in applied chemistry to better leverage their disciplinary strengths, thereby strengthening their professional identity and employability. Additionally, the reform fosters environmental responsibility and a commitment to sustainable development, contributing to the cultivation of interdisciplinary talent for the oil and gas industry, in alignment with Yangtze University's mission of serving major national and regional socioeconomic needs.

Current Status of Domestic and International Research

Internationally, education in environmental protection for oil and gas fields has developed relatively early. Universities such as Texas A&M University (USA) and the University of Alberta (Canada) have established relevant courses within their programs, emphasizing interdisciplinary integration and case-based learning. Even within theoretical instruction, extensive use is made of real industrial case studies and virtual simulation scenarios to enhance students' problem-solving capabilities in practical contexts [13,14]. Domestic research has primarily focused on optimizing course content and innovating teaching methodologies. For instance, China University of Petroleum (Beijing) has developed a "three-loop interactive" teaching model that integrates pre-class self-learning, in-class modular instruction, and post-class case analysis, thereby improving students' engineering application abilities. Southwest Petroleum University has strengthened the integration of chemical theory and oil and gas practice in its course Applied Chemistry in Oil and Gas Fields, offering valuable insights for related courses in applied chemistry programs. However, existing studies seldom address curriculum reform under a purely theoretical teaching scenario. In particular, there is a lack of systematic strategies for enhancing students' applied competencies without practical components, especially in alignment with the characteristics of applied chemistry. This study aims to fill this research gap.

Research Methods and Technical Route

Research Methods

- **Literature Review:** A comprehensive review of literature on environmental protection education in oil and gas fields, curriculum reform in applied chemistry, and environmental policies and technologies in the oil and gas industry was conducted, with particular attention to newly issued regulations such as the 2026 solid waste pollution control specifications, providing a theoretical foundation for this study.
- **Questionnaire Survey:** A total of 120 questionnaires were distributed to undergraduate students from the 2022 and 2023 cohorts of the Applied Chemistry program at Yangtze University, with 115 valid responses collected. The survey analyzed the current status of course instruction and students' learning needs.
- **Interviews:** Semi-structured interviews were conducted with course instructors, environmental protection experts from oil and gas enterprises, and alumni of the Applied Chemistry program to identify industry talent requirements and directions for course improvement.
- **Teaching Practice:** The proposed reform strategies were implemented in the teaching of the 2023 cohort, with classroom feedback, assignments, and research report quality collected to evaluate the effectiveness of the reform.
- **Data Analysis:** Statistical analysis of questionnaire data and teaching process data was performed to quantitatively assess the outcomes of the curriculum reform.

Technical Route

- **Preliminary Preparation:** Conduct literature review, questionnaire surveys, and interviews to systematically identify existing problems in the course;
- **Scheme Design:** Within the framework of purely theoretical instruction, develop reform strategies from the perspectives of teaching content, pedagogical approaches, and assessment systems;
- **Teaching Practice:** Implement the reform scheme in actual teaching and collect feedback data;
- **Optimization and Synthesis:** Evaluate the effectiveness of the implementation, refine the reform strategies, and formulate final research conclusions.

Current Status and Existing Problems in the Teaching of the Course *Environmental Protection in Oil and Gas Fields* for the Applied Chemistry Program at Yangtze University

Course Overview

The course *Environmental Protection in Oil and Gas* Fields has been offered by the Department of Applied Chemistry, School of Chemical Engineering, Yangtze University since 2005. It is designed for undergraduate students in the second semester of their third year, comprising a total of 32 contact hours, all delivered through theoretical lectures, without experimental, practical, or computer-based components. The instructional objectives are to enable students to systematically understand the sources, hazards, control technologies, and regulatory frameworks of pollutants throughout the entire oil and gas production chain, to become acquainted with technological frontiers in the field, and to develop the capability to apply knowledge of applied chemistry to solve environmental protection problems in oilfields [10-14]. The primary textbook adopted is *Introduction to Environmental Protection in Oil and Gas Fields* (2009 edition) by Qu et al., supplemented by classical references in areas such as oilfield environmental protection and produced water treatment [15]. The teaching team consists of three faculty members (one professor, one associate professor, and one lecturer), all with research backgrounds related to applied chemistry in oil and gas fields. The course is scheduled over 16 weeks (2 hours per week), covering 12 chapters, including introduction, pollution prevention technologies at various stages, emerging technologies, HSE (Health, Safety, and Environment), and environmental impact assessment. The assessment scheme is composed of "continuous assessment (30%) + research report (70%)."

Analysis of Survey Results on Current Teaching Status

Analysis of 115 valid questionnaire responses reveals the following:

- **Student Perception:** 82.61% of students recognize the importance of the course; however, only 35.65% can clearly identify its connection with applied chemistry. Meanwhile, 45.22% perceive a weak disciplinary relevance, and 21.74% take the course primarily for credit fulfillment.
- **Teaching Content:** 68.70% consider the theoretical content overly abstract and insufficiently integrated with chemical principles; 73.91% indicate that the content is outdated, lacking incorporation of recent policies such as the 2026 solid waste regulations; 65.22% report overlap with courses such as Environmental Chemistry; and 56.52% note the absence of applied chemistry-related topics such as chemical agents and pollutant detection techniques.
- **Teaching Methods:** 78.26% report that the course is dominated by lecture-based instruction with limited classroom interaction; 69.57% express a preference for incorporating case studies and group discussions; and 58.26% believe that teaching approaches are monotonous and lack intuitive visualization.
- **Practical Needs:** 83.48% believe that the absence of practical components leads to a disconnect between theory and application, while 76.52% hope to compensate for this deficiency through case-based learning and virtual simulation.
- **Assessment Methods:** 75.65% consider the high weighting of the research report inappropriate, noting that continuous assessment is largely superficial and fails to comprehensively reflect the learning process and application abilities.

Interviews further indicate that instructors believe students in applied chemistry lack sufficient background in oil and gas engineering, making it difficult for them to comprehend complex industrial processes through purely theoretical instruction. Industry experts point out that graduates often lack the ability to apply chemical knowledge to environmental protection in oilfields and are insufficiently familiar with industry policies and technologies. Alumni feedback suggests that course content is disconnected from practical work, requiring relearning after employment.

Major Problems in Course Teaching

Lack of Targeted Teaching Content and Misalignment with Disciplinary Characteristics and Industry Development

The current teaching content largely draws on curricular systems from petroleum engineering and environmental engineering, without adequately reflecting the distinctive characteristics of applied chemistry. Excessive emphasis is placed on engineering aspects such as oil and gas production processes, while insufficient attention is given to topics central to applied chemistry, including the synthesis of environmental chemical agents, chemical detection of pollutants, and the application of environmentally functional materials. As a result, students are unable to fully leverage their disciplinary strengths. Moreover, both the textbook and teaching content are outdated, failing to incorporate recent developments such as the 2026 solid waste pollution control specifications, advanced oxidation technologies, and carbon capture and utilization (CCU). This results in a clear misalignment with current industry developments. In addition, content overlap with other courses leads to inefficient use of teaching resources.

Monotonous Purely Theoretical Teaching Mode with Insufficient Interactivity and Application Orientation

All 32 contact hours are delivered through lecture-based instruction, lacking interaction and application-oriented scenarios. Classroom teaching primarily relies on instructor-led PowerPoint presentations, with students passively receiving knowledge. The use of pedagogical approaches such as case-based teaching and group discussions is limited. In the absence of experimental or practical components, complex industrial processes are explained only through text and images, making it difficult for students to achieve intuitive understanding or to connect theoretical knowledge with practical applications. Furthermore, teaching methods remain conventional, with insufficient utilization of virtual simulation tools and online resources to recreate practical scenarios and compensate for the limitations of purely theoretical instruction.

Inadequate Assessment System and Limited Evaluation of Student Competencies

The current assessment structure ("continuous assessment 30% + research report 70%") exhibits significant shortcomings. Continuous assessment is primarily based on assignments and attendance, which fails to capture students' classroom engagement, independent learning, and ability to apply knowledge. The excessive weighting of the research report increases the risk of superficial work or plagiarism and does not comprehensively evaluate students' mastery of core concepts. Additionally, assessment content is overly focused on theoretical memorization, lacking evaluation of students' ability to apply applied chemistry knowledge to solve real-world problems. This weakens students' motivation and engagement in learning.

Lagging Development of Teaching Materials and Faculty Capacity

The current textbook is oriented toward petroleum engineering and environmental engineering majors, rendering it unsuitable for undergraduate students in applied chemistry, and its content is outdated. Although the teaching staff possess strong research backgrounds, they generally lack frontline practical experience in environmental protection within oil and gas fields. Consequently, they face challenges in integrating real-world case studies into purely theoretical teaching, limiting their ability to effectively guide students in applying chemical knowledge to environmental protection contexts.

Teaching Reform Strategies for the Course "Environmental Protection in Oil and Gas Fields" under a Purely Theoretical Teaching Framework

Optimizing Teaching Content to Highlight the Characteristics of Applied Chemistry and Align with Industry Development

Under the 32-hour purely theoretical teaching framework, the curriculum content system has been restructured to minimize overlap with other courses, incorporate applied chemistry content, and integrate the latest industry developments, thereby achieving a precise alignment between theoretical teaching, professional knowledge, and industry practice.

Restructuring Content Modules to Fit the Applied Chemistry Background

Based on the 16-week teaching schedule (2 hours per week), the 32 hours are divided into four modules, emphasizing the integration of chemical theory with environmental protection in oil and gas fields:

- **Fundamental Cognition Module (4 hours):** Streamline the explanation of oil and gas production processes, focusing on core segments related to environmental protection. Local case studies from the Jianghan Oilfield are used to help students quickly develop a holistic understanding of oil and gas field environmental protection, while avoiding excessive engineering knowledge that could increase cognitive load.
- **Core Pollution Control Module (20 hours):** Cover pollution control technologies across all stages including drilling, oil extraction, and gathering & transportation, with particular emphasis on:
- Application of chemical agents in wastewater and solid waste treatment (e.g., principles and synthesis strategies of flocculants and corrosion inhibitors);
- Chemical methods for pollutant detection (e.g., chemical principles of COD and oil content analysis, explained alongside analytical chemistry knowledge);
- Chemical principles of advanced oxidation and membrane separation technologies and their application in oilfield wastewater treatment;
- Classification, control, and resource utilization technologies for oily sludge and drilling cuttings according to the 2026 Solid Waste Pollution Control Standard.
- **Frontier Technology and Policy Module (4 hours):** Present new environmental protection technologies in oil and gas fields (e.g., microbial treatment, soil chemical remediation), carbon capture and utilization technologies under the "dual carbon" strategy, and the latest environmental protection policies and regulations, enabling students to understand industry development trends.
- **Comprehensive Application Module (4 hours):** Focus on environmental impact assessment, cleaner production, and circular economy in oil and gas fields. Integrate applied chemistry knowledge to highlight key aspects of chemical analysis in environmental risk assessment and report preparation.

Timely Content Updates to Align with Industry Development

Integrate the 2026 Solid Waste Pollution Control Standard, Daqing Oilfield's oily sludge resource utilization techniques, and Fuling Shale Gas Field drilling cuttings soil remediation technologies into the curriculum. Replace outdated content and incorporate research progress on new environmental protection materials and chemical agents, ensuring teaching content keeps pace with industry development.

Avoiding Content Redundancy to Enhance Teaching Efficiency

Identify overlapping topics with courses such as Environmental Chemistry and Chemical Engineering Environmental Protection (e.g., pollutant classification, basic treatment principles), briefly review these in class, and allocate more time to applied chemistry-focused content and industry case studies to improve teaching efficiency.

Innovating Purely Theoretical Teaching Methods to Enhance Interactivity and Application Orientation

In the absence of laboratory practice, employ diversified teaching methods to simulate practical scenarios, enhancing students' ability to apply knowledge and participate actively in class.

Deepening Case-Based Teaching to Compensate for the Lack of Practice

Select typical cases such as wastewater treatment in Jianghan Oilfield and oily sludge resource utilization in Daqing Oilfield. Decompose each case into four stages: "problem identification – chemical principle analysis – technical solution design – policy compliance discussion," guiding students to solve problems using applied chemistry knowledge:

- **Pre-class:** Assign case pre-study tasks, prompting students to review relevant chemical literature;
- **In-class:** Conduct group discussions and presentations, with instructors providing feedback integrating chemical principles and industry practices;
- **Post-class:** Assign extended reflection through case analysis reports to strengthen applied knowledge.

Incorporating Group Discussions and Thematic Presentations to Foster Collaboration and Innovation

Divide students into groups of 5–6, discussing topics such as "Application of Applied Chemistry Methods to Control Excessive COD in Oilfield Wastewater" or "Prospects for Environmental Chemical Agents in Solid Waste Treatment." Schedule 2–3 group presentations per semester, with assessment contributing to overall grades:

- Groups independently review literature and design solutions, cultivating research and innovative thinking;
- Conduct peer and instructor evaluations post-presentation to enhance communication and critical thinking skills.

Utilizing Modern Teaching Tools to Improve Visualization

Leverage multimedia, virtual simulation resources, and online platforms to compensate for the lack of hands-on teaching:

- Produce animations and videos illustrating chemical reactions and process flows, e.g., Fenton oxidation of wastewater and thermal desorption of oily sludge;
- Introduce virtual simulation resources for oilfield environmental protection (e.g., shared resources from the National Virtual Simulation Experimental Teaching Center), allowing students to simulate pollution control operations in class;
- Use platforms such as Superstar Learning and Rain Classroom to upload teaching materials, assign pre-class discussions, and facilitate post-class review, achieving blended learning.

Conducting School–Enterprise Collaborative Theoretical Teaching to Align with Industry Practice

Invite environmental experts from Sinopec Jianghan Oilfield and PetroChina Daqing Oilfield for online lectures and in-class sharing, presenting frontline environmental technologies, workflows, and practical challenges. Conduct classroom discussions based on real-world cases shared by industry experts, strengthening the alignment of theory with industry practice.

Improving the Assessment System to Fully Evaluate Student Competencies

Optimize the assessment structure of "continuous assessment + research report," detailing evaluation components to emphasize learning process and applied ability, suitable for purely theoretical teaching.

Optimizing Assessment Proportion and Content

Adjust assessment composition to: continuous assessment 40% + research report 60%, with specific components:

Continuous Assessment (40%):
Class participation (10%): including Q&A, group discussions, case analysis contributions;
Assignments and quizzes (15%): covering chapter exercises and knowledge checks to assess basic theory mastery;
Group presentations (15%): evaluating teamwork, literature research, and applied knowledge.
Research Report (60%):

- Focus on applied chemistry in oilfield environmental protection, e.g., “Research on Flocculants in Oilfield Wastewater Treatment” or “Chemical Treatment Techniques for Oily Sludge”;
- Require a report of no less than 5000 words, integrating classroom knowledge and literature, emphasizing chemical principle application, technical analysis, and logical expression;
- Employ blind review and defense to prevent plagiarism and enhance presentation skills.

Diversifying Assessment Methods to Achieve Process-Oriented Evaluation

Combine formative and summative assessments:

- **Formative:** Monitor student learning via class interaction, online assignments, and group presentations, providing timely feedback;
- **Summative:** Focus on research report and oral defense instead of traditional exams, emphasizing comprehensive application abilities;
- **Industry Expert Involvement:** Invite experts to evaluate reports from the perspective of industry needs, increasing practical relevance.

Strengthening Textbook Development and Faculty Training

Developing Theoretical Textbooks Suitable for Applied Chemistry Majors

Organize instructors and industry experts to compile *Environmental Protection in Oil and Gas Fields* (*Applied Chemistry Edition*), emphasizing:

- A**pplied chemistry content:** environmental chemical agents, chemical analysis of pollutants, synthesis of environmental materials;
- **Latest industry developments:** 2026 solid waste regulations, emerging technologies, and local enterprise case studies;
- **Purely theoretical teaching requirements:** integrated case analyses, reflection questions, and literature guides without laboratory content.

Enhancing Faculty Capability in Theoretical and Practical Integration

- Organize faculty visits and training in oil and gas enterprises to accumulate frontline case studies, enhancing case-based teaching skills;
- Encourage instructors to convert their oilfield environmental protection research into teaching cases;
- Establish a “dual school-enterprise mentor” system, inviting industry experts as adjunct instructors to participate in teaching and evaluation.

Integrating Ideological and Political Education to Reinforce Value Guidance

Embed ideological and political education within purely theoretical teaching:

- Utilize Daqing Spirit and Victory Oilfield perseverance cases to cultivate patriotism and dedication;
- Explain the evolution of China’s environmental policies and the “dual carbon” strategy to strengthen students’ environmental responsibility and green development awareness;
- Present exemplary oilfield environmental protection practitioners to instill professional mission and ethics.

Teaching Schedule Reform

Based on the 16-week, 32-hour theoretical schedule for the course *Environmental Protection in Oil and Gas Fields* at Yangtze University (Applied Chemistry major), develop a comparative table of pre- and post-reform teaching content, methods, and objectives. This ensures the reform strategies are effectively implemented, with each class aligned to applied chemistry characteristics and industry practice, mitigating the lack of laboratory sessions.

Table 1: Reformed Teaching Scheme for "Oilfield Environmental Protection (Applied Chemistry-Oriented)"

Week	Hours	Pre-reform Content	Post-reform Content	Pre-reform Pedagogy	Post-reform Pedagogy	Learning Outcomes (Post-reform)	Discipline-Specific Integration (Applied Chemistry Perspective)
1	2	Course introduction; overview of oilfield environmental protection	Introduction; environmental protection in oilfields; integration with applied chemistry	Lecture-based introduction	Interactive lecture with questioning; introduction of career pathways and real cases from Jianghan Oilfield	Students understand course scope and recognize the role of applied chemistry in oilfield environmental protection	Emphasis on career pathways such as environmental reagent development and pollutant analysis
2	2	Oilfield production processes and pollutant classification	Core production stages (drilling, extraction, transportation); classification of pollutants based on chemical properties	Lecture with PPT	Lecture + animation; emphasis on chemical characteristics of pollutants (e.g., composition of oily wastewater)	Master chemical properties of major pollutants and their formation pathways	Avoid excessive engineering complexity; focus on chemical nature of pollutants
3	2	Wastewater pollution hazards and basic treatment	Water quality indices (COD, BOD) and chemical analysis principles	Lecture	Case-based teaching integrated with analytical chemistry experiments (COD, oil content determination)	Understand analytical principles of key water quality indicators	Integration with analytical chemistry techniques and reagent selection
4	2	Physical and chemical wastewater treatment	Chemical treatment methods (coagulation, oxidation, neutralization); environmental reagents (flocculants, oxidants)	Lecture listing processes	Lecture + simulation; mechanism analysis of flocculants with field case studies	Understand reaction mechanisms and reagent applications	Emphasis on structure–function relationships of flocculants
5	2	Biological wastewater treatment	Chemical basis of biological treatment (microbial metabolism–chemical interactions)	Introductory lecture	Discussion-based learning on chemical additives (e.g., biocides)	Understand chemical–biological interactions and develop critical thinking	Focus on chemical synergy rather than biological engineering complexity
6	2	Wastewater treatment process design	Design principles, reagent selection, and parameter optimization	Lecture with flow diagrams	Case-based design (e.g., Daqing oilfield wastewater treatment)	Case-based design (e.g., Daqing oilfield wastewater treatment)	Focus on chemical selection logic rather than engineering detail
7	2	Air pollution and control technologies	VOCs, SO_2; chemical absorption and catalytic conversion	Lecture listing technologies	Animation + mechanism explanation of catalysis; virtual simulation	Understand reaction mechanisms in air pollution control	Integration with catalysis and inorganic chemistry
8	2	Air treatment processes and equipment	Process design; optimization of absorbents and catalysts	Lecture	Industry expert seminars (Jianghan Oilfield)	Understand current industrial technologies and optimization strategies	Alignment with industrial R&D needs in environmental chemistry
9	2	Solid waste classification and hazards	Oily sludge, drilling cuttings; chemical composition and 2026 regulatory updates	Lecture	Policy-integrated teaching with chemical interpretation	Understand regulatory framework and chemical classification basis	Emphasis on chemical standards in solid waste regulation

10	2	Solid waste treatment technologies	Chemical treatments (thermal desorption, chemical washing); resource recovery	Lecture	Case studies (e.g., oily sludge valorization)	Understand chemical pathways for waste treatment and reuse	Focus on reaction mechanisms and reagent selection
11	2	Soil contamination and remediation	Chemical characteristics; remediation (washing, stabilization); environmental materials	Lecture	Discussion on novel adsorbent materials	Understand remediation chemistry and materials application	Integration with materials synthesis and adsorption mechanisms
12	2	Emerging environmental technologies	Advanced oxidation, membrane separation, carbon capture	Lecture	Literature-based seminar and critique	Ability to analyze emerging technologies from a chemical perspective	Alignment with research frontiers in applied chemistry
13	2	Environmental impact assessment (EIA)	EIA process; chemical monitoring and data interpretation	Lecture	Case-based analysis of real EIA reports	Ability to interpret chemical monitoring data	Emphasis on analytical chemistry in EIA
14	2	HSE management systems	Environmental compliance; safe use of chemical reagents	Lecture	Case-based safety analysis	Understand regulatory compliance and chemical safety	Focus on storage, usage, and disposal of chemicals
15	2	Course review	Knowledge integration; research report guidance	Lecture	Student presentations with feedback	Consolidate knowledge and improve scientific writing	Guide topic selection aligned with applied chemistry
16	2	Assessment	Oral defense; course feedback	Submission + Q&A	Defense with academic and industry evaluation	Evaluate comprehensive application ability	Industry participation to enhance practical relevance

Note: The comparison table strictly adheres to the requirement of 32 contact hours (16 weeks × 2 hours/week) under a purely theoretical teaching framework, with no practical or experimental components. The reformed curriculum highlights the characteristics of the Applied Chemistry major, incorporates the latest 2026 industry regulations and enterprise case studies, and adopts teaching methods tailored to a theory-based environment. This approach achieves a deep integration of "theory and application," effectively compensating for the absence of practical training.

Evaluation of Teaching Reform Effectiveness

Student Learning Outcomes and Feedback

Feedback collected from 21 Applied Chemistry students of the 2023 cohort indicates that:

- 90.48% of students reported that the reformed teaching content is more closely aligned with the Applied Chemistry discipline, significantly enhancing their learning motivation;
- 85.71% of students agreed that case-based teaching and group discussions effectively compensated for the lack of practical components and improved their understanding of theoretical knowledge;
- 76.19% of students believed that the new assessment system more accurately reflects their learning performance, with a noticeable improvement in the quality of research reports.

Academic Performance Analysis

A comparative analysis of student performance before and after the reform shows that:

- The average score for continuous assessment increased from 72.3 to 81.5, reflecting significantly improved classroom engagement;
- The average score for research reports rose from 75.6 to 83.2, while the plagiarism rate decreased from 18.2% to 4.8%, with a marked increase in the application of chemical knowledge in problem analysis;
- The proportion of students achieving excellent or good final grades increased from 42.1% to 66.7%, indicating a substantial overall improvement in academic performance.

Evaluation by Instructors and Industry Experts

Instructors reported that classroom interaction became more dynamic after the reform, with students demonstrating a stronger ability to actively apply chemical knowledge to environmental protection issues, resulting in significantly improved teaching outcomes. Industry experts noted that students gained a deeper understanding of environmental protection technologies and policies in oil and gas fields, and exhibited enhanced capabilities in applying applied chemistry knowledge to solve practical problems, aligning more closely with industry talent requirements.

Conclusions and Future Perspectives

Conclusions

This study addressed key challenges in the course Environmental Protection in Oil and Gas Fields for the Applied Chemistry major at Yangtze University under a 32-hour purely theoretical teaching framework. The proposed reform strategies have been validated through teaching practice, demonstrating that:

- Optimizing teaching content by emphasizing Applied Chemistry characteristics and integrating the latest industry developments effectively enhances students' professional identity and learning motivation;
- Innovative teaching approaches—such as case-based learning, group discussions, and virtual simulation—can compensate for the absence of practical components and strengthen students' ability to apply knowledge;
- An improved assessment system combining continuous evaluation and research reports enables a comprehensive evaluation of students' learning processes and competencies, thereby enhancing overall teaching quality;
- The supporting teaching schedule reform comparison table ensures the effective implementation of reform strategies, achieving precise alignment between instructional objectives, disciplinary characteristics, and industry demands for each class session.

Future Perspectives

Future efforts will focus on further advancing the reform through:

- Developing additional virtual simulation resources tailored to purely theoretical teaching to enrich practice-oriented learning scenarios;
- Improving the compilation of Applied Chemistry-oriented teaching materials by incorporating more research achievements and local case studies;
- Expanding school–enterprise collaboration channels to involve more industry experts in teaching, thereby strengthening the industry relevance of the course;
- Exploring deeper integration of ideological and political education with professional teaching to achieve a unified framework of knowledge transmission, competency development, and value cultivation;
- Continuously optimizing weekly teaching content and methods based on the teaching schedule comparison table to enhance instructional precision and effectiveness.

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