

In-depth Exploration of Teaching Reform in "Petroleum and Natural Gas Geology Curriculum Design" Oriented by Field Geological Practice—A Case Study of Shandong University of Petroleum and Chemical Technology

Yuzuo Liu^a, Jiao Wang^{b,*}, Jie Chen^c

*College of Petroleum Engineering, Shandong Institute of Petroleum and Chemical Technology,
Dongying City, China*

^a2540639420@qq.com, ^b896221370@qq.com, ^c93680706@qq.com

**Corresponding author*

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Abstract: Field geological practice serves as a critical link connecting theoretical teaching and engineering practice, playing an irreplaceable role in enhancing students' abilities in geological phenomenon identification, data collection and analysis, and comprehensive research. Taking the "Petroleum and Natural Gas Geology Curriculum Design" course at Shandong University of Petroleum and Chemical Technology as an example, this paper analyzes current issues in curriculum design, including disconnection between teaching content and field practice, weak hands-on skills of students, and an evaluation system that prioritizes results over process. Combined with the requirements of field practice for students' geological thinking, on-site operation, and teamwork abilities, this study proposes a reform strategy of "practice-led, integration of learning and application." This strategy includes reconstructing a "theory-practice-application" curriculum content system, innovating field scenario-based teaching models, strengthening practice data-driven design links, and improving a diversified evaluation mechanism. The aim is to cultivate high-quality applied talents meeting the needs of the oil and gas exploration industry.

1. Introduction

"Petroleum and Natural Gas Geology Curriculum Design" is a core practical component for resource exploration engineering majors, aiming to train students in comprehensively applying geological theories to solve practical problems. Its teaching quality directly affects students' mastery of hydrocarbon accumulation theory, exploration technology, and engineering practice^[1]. As an important extension of this curriculum design, field geological practice effectively compensates for the limitations of "theoretical instruction alone" in classroom teaching through observation, data collection, and comprehensive analysis in real geological scenarios. However, current curriculum design still faces several challenges: teaching content primarily relies on simulated data and theoretical verification, disconnecting from complex field geological conditions; students lack

systematic training in field profile measurement, sample collection, and analysis; and the evaluation system focuses on final report outcomes while neglecting ability development during field practice^[2].

Shandong University of Petroleum and Chemical Technology, targeting "strengthening field practice and deepening theoretical application," has explored a field geological practice-oriented curriculum design reform path. Aligned with the Syllabus of Petroleum and Natural Gas Geology Curriculum Design and the requirements of the textbook Experiments, Exercises, and Curriculum Design for Oil and Gas Geology and Exploration, the university integrates field practice resources, optimizes teaching links, and innovates evaluation mechanisms to achieve in-depth integration of curriculum design and field practice, providing a practical paradigm for oil and gas geological talent cultivation^[3].

2. Analysis of Current Teaching Status in Curriculum Design

Based on teaching practice at Shandong University of Petroleum and Chemical Technology and industry talent demand surveys, the current "Petroleum and Natural Gas Geology Curriculum Design" exhibits the following prominent issues.

2.1 Disconnection between Teaching Content and Field Practice, Insufficient Scenario-Based Training

Traditional curriculum design mostly uses virtual work area data (e.g., simulated data of the Dongying Sag). Students complete tasks such as source rock evaluation and reservoir-forming model mapping based on preset parameters, lacking intuitive cognition of real geological phenomena. For instance, the "reservoir rock physical property analysis" module relies solely on laboratory data, with students not participating in field outcrop profile observation, rock sample collection, or physical property parameter measurement. This leads to a one-sided understanding of the micro-macro connections between reservoir pore types, throat characteristics, and other properties.

2.2 Single Practice Link and Weak Hands-on Ability of Students

Curriculum design focuses on indoor map compilation and report writing, while field practice exists as an independent link, lacking organic integration with curriculum design. Students primarily engage in "observation and recording" during field practice without systematic training in the full process of "geological phenomenon identification-data collection-indoor analysis-result expression." For example, although students are required to compile "hydrocarbon accumulation model maps," their inability to acquire key geological evidence (e.g., field structural fracture characteristics, stratigraphic contact relationships) results in map compilation lacking empirical support.

2.3 Result-Oriented Evaluation System Neglecting Process Ability Development

The existing evaluation emphasizes final design reports (50%) and map quality (40%), while insufficiently assessing data accuracy, logical analysis, and teamwork during field practice. For instance, students may complete reports by applying templates but fail to deeply explore abnormal geological phenomena encountered in the field (e.g., the relationship between fault sealing and hydrocarbon migration), hindering the cultivation of critical thinking and innovation.

2.4 Inadequate Field Practice Guidance Ability of Teachers

Some teachers lack on-site oilfield work experience, relying on textbook cases for guidance and

struggling to integrate complex field geological conditions (e.g., identification of oil and gas reservoir in complex fault blocks) into teaching. For example, in the "trap effectiveness evaluation" module, teachers fail to connect theoretical explanations with observed field features (e.g., unconformities, lithologic pinch-outs), leaving students' understanding of trap formation mechanisms at a theoretical level.

3. Teaching Reform Strategies Oriented by Field Geological Practice

To address these issues, Shandong University of Petroleum and Chemical Technology takes field geological practice as the core link and promotes reforms in four dimensions: teaching content, teaching model, practice resources, and evaluation mechanism.

3.1 Reconstructing the "Theory-Practice-Application" Curriculum Content System, Strengthening Field Scenario Integration

Centered on the "analysis of basic elements of hydrocarbon accumulation" module in the curriculum design syllabus, first-hand data from field practice (e.g., measured data from outcrop profiles in a block of the Shengli Oilfield, rock thin-section identification results) are used as basic materials. For example, students collect source rock samples during field practice, conduct indoor geochemical experiments (TOC content determination, vitrinite reflectance analysis) for the "source rock evaluation" module, and compile "hydrocarbon migration path prediction maps" using observed structural fracture data, achieving closed-loop training of "field data-indoor analysis-result application."

Based on exercises such as "trap analysis and measurement" and "oil and gas reservoir analysis and measurement" in Experiments, Exercises, and Curriculum Design for Oil and Gas Geology and Exploration, a "field geological problem diagnosis" link is added. For instance, targeting "sandstone lenticular reservoirs" discovered during practice, students are required to complete trap effectiveness evaluation and resource estimation by measuring stratum thickness, analyzing sedimentary facies distribution, and mapping structural contour maps, fostering their ability to solve complex geological problems.

3.2 Innovating Field Scenario-Based Teaching Models to Promote "Learning by Doing and Thinking by Learning"

A dual-tutor team consisting of "in-school teachers + enterprise engineers" conducts "small-class" teaching at field practice sites. For example, in the "reservoir characteristics analysis" module, enterprise engineers guide students to measure reservoir permeability using portable property meters, while in-school teachers simultaneously explain the theory of "pore structure and reservoir productivity relationship," prompting students to analyze the geological causes of data anomalies (e.g., high porosity but low permeability), strengthening the guiding role of theory in practice.

Following the "research plan design" requirements in the syllabus, students are divided into "data collation group," "field investigation group," and "data analysis group" to simulate oil and gas exploration team collaboration. For the task of "analyzing main controlling factors of hydrocarbon accumulation," the field investigation group collects fault zone samples, the data analysis group identifies fault zone filling types via microscopic thin-section observation, and the data collation group integrates regional tectonic evolution history. Together, they demonstrate "the control of fault sealing on hydrocarbon accumulation," cultivating teamwork and responsibility awareness.

3.3 Strengthening Practice Data-Driven Practice Links, Building a "Field-Indoor" Linkage Platform

A digital sharing platform is built by integrating historical field practice data (e.g., outcrop profile measurement data, rock sample analysis reports, logging curves). Students must use platform data for "work area geological modeling" in curriculum design. For example, based on 3D seismic profiles and drilling data from the practice area, they compile "hydrocarbon reservoir type distribution maps" and verify model rationality by comparing observed oil and gas shows in the field.

Students are required to include a "field practice problems and solutions" chapter in their curriculum design reports, recording typical geological contradictions encountered (e.g., "mismatch between structural traps and oil shows," "inconsistency between reservoir properties and sedimentary facies belts") and proposing explanations through indoor experiments (e.g., mercury intrusion porosimetry, fluid inclusion thermometry) and literature research. For example, students confirmed the existence of "fracture-pore dual media" through cast thin-section observation to explain "low porosity but high permeability reservoirs," deepening their understanding of reservoir heterogeneity.

3.4 Improving Diversified Evaluation Mechanisms, Highlighting Process Ability and Practical Contribution

A four-dimensional evaluation system is established: "field practice (30%) + data quality (20%) + map innovation (30%) + report logic (20%)". The study assesses the accuracy of geological phenomenon identification (e.g., source rock color, reservoir lithology description), the standardization of data collection procedures (e.g., error ranges in attitude measurements), and team collaboration efficiency. It further evaluates the reliability of field sample analysis data (e.g., parallel sample errors in geochemical experiments) and the consistency between map compilation results and field observations (e.g., matching degree of structural contours with topography). Additionally, the study emphasizes optimizing reservoir-forming models based on new field discoveries. Furthermore, it focuses on the completeness of the reasoning chain from "field phenomena-indoor analysis-conclusion derivation."

4. Planned Reform Implementation

Shandong University of Petroleum and Chemical Technology launched the curriculum design reform in 2025, with specific measures as follows:

The original 1-week indoor curriculum design is adjusted to "3-day field practice + 4-day indoor design." The practice area is designated as the Haojia area of Shengli Oilfield, where students complete field tasks such as "measuring source rock outcrop profiles of the 3rd Member of Shahejie Formation" and "analyzing reservoir properties of Liangjialou Oilfield," and conduct curriculum design based on practice data.

A joint "oil and gas geological practice base" is built with Shengli Oilfield, introducing core samples donated by enterprises (e.g., sandstone cores from the 2nd Member of Shahejie Formation in Tuo Zhuang Oilfield) and logging data, and developing a "field-indoor" linkage teaching case library (including typical reservoir outcrop photos, drilling pictures, etc.).

In the resource exploration engineering curriculum design, the proportion of "field practice" and "data quality" assessment is increased to 50%. The excellent rate of the "field problem analysis" chapter in student reports has risen from 42% before the reform to 78%, with significantly improved consistency between map compilation and field reality.

5. Reform Effect Evaluation and Reflection

After the reform, students' efficiency in completing the full process of "field data collection-indoor comprehensive analysis-result expression" has increased by 35%. Students won one first prize and eight second prizes in the 4th Shandong Provincial College Students Geological Skills Competition.

Restricted by funding and safety factors, only 30% of students can participate in a single practice. A hybrid model of "virtual simulation + field practice" and a "digital outcrop library" are planned to achieve high-quality resource sharing.

Teachers will be selected to participate in oilfield exploration projects (e.g., shale oil exploration in Shengli Oilfield) to transform on-site cases into teaching resources and increase the proportion of "dual-qualified" teachers.

6. Conclusion

The reform of "Petroleum and Natural Gas Geology Curriculum Design" oriented by field geological practice effectively addresses the disconnection between theory and practice in traditional curriculum design through "content scenarioization, teaching linkage, and evaluation processualization." Practice at Shandong University of Petroleum and Chemical Technology shows that this reform not only strengthens students' field practice ability and geological thinking but also cultivates their engineering literacy and innovative awareness, delivering "hardworking, observant, and analytical" high-quality talents to the oil and gas exploration industry. Future efforts will focus on deepening university-enterprise collaborative education mechanisms, promoting seamless integration of curriculum design with field practice and industry needs, and providing talent support for the high-quality development of the petroleum industry.

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