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Exploration and Practice of Innovation and Entrepreneurship Talent Cultivation Mode Driven by Subject Competitions

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Abstract: Currently, our country is in a critical stage of innovation-driven, high-quality development. We must adhere to the principle that science and technology constitute the primary productive force, while talent represents the primary resource, and innovation serves as the primary driver. This major proposition elevates the cultivation of top-tier, innovative talents to the level of national strategic support. This research addresses the critical need for interdisciplinary, innovative talents in the transitioning oil and gas industry. It systematically targets current educational dilemmas, such as the disconnect between standard curricula and practical competition demands, alongside highly fragmented teaching resources. To resolve these structural issues, the study proposes a novel innovation and entrepreneurship talent cultivation mode driven entirely by subject competitions. Key practical implementations include constructing a multi-competition, collaborative educational matrix, integrating competition standards directly into core professional courses through reverse engineering, and building a robust university-enterprise collaborative teaching system. The ultimate goal is to substantially enhance undergraduate students' capacity for independent scientific inquiry and rigorous technical design, thereby comprehensively improving the overall quality of modern engineering education.

1. Introduction

Currently, higher education is experiencing a profound historical transformation driven by the national strategy of innovation and entrepreneurship [1]. The cultivation of top-tier, innovative talents has become the core mission of universities across the globe. National policy guidelines regarding the promotion of high-quality development for innovation and entrepreneurship clearly emphasize that colleges and universities must deeply and systematically integrate innovation and entrepreneurship education into the entire professional education chain [2,3]. Through high-level subject competitions acting as core practical carriers, institutions must achieve the ultimate goal of promoting innovation through competition and strengthening capabilities through innovation. Educational guidelines concerning the acceleration of high-level undergraduate education construction and the comprehensive improvement of talent cultivation capabilities further explicitly state the necessity of building a new mechanism for competition and teaching integration [4]. This overarching institutional objective requires educational curricula that actively and relentlessly facilitate direct student engagement with authentic, unresolved scientific questions rather than the passive, continuous reception of established textbook facts.

The oil and gas industry, serving as the absolute ballast for national energy security, is undergoing a critical and irreversible transition toward intelligent and low-carbon development. Carbon neutrality targets are profoundly reshaping the macro-landscape of the entire energy sector. National planning documents for modern energy systems explicitly state the absolute necessity of breaking through a series of critical technical bottlenecks. We must push the overall oil and gas exploration and development system comprehensively toward intelligent, low-carbon, and integrated upgrading. This profound transition urgently requires a massive influx of engineering professionals who possess not only solid theoretical foundations but also exceptional, practical problem-solving capabilities. However, the latest in-depth industry survey data objectively show that a vast majority of oil and gas enterprises believe the overall competency structure of current university graduates exhibits a severe misalignment with the urgent needs of industrial transition and upgrading [5-7]. Existing graduates generally lack the practical engineering ability to accurately identify core scientific questions and provide strictly rigorous technical designs when facing highly complex, modern engineering problems.

Traditional petroleum engineering education often relies heavily on sequential knowledge transfer and completely isolated, theoretical classroom instruction [8]. The conventional sequential transfer of knowledge, where students complete several years of fundamental general science courses before ever encountering specialized practical engineering disciplines, has proven structurally and pedagogically inadequate [9]. This outdated, rigid, sequential structure frequently delays any practical engineering application until the final academic year, causing students to struggle immensely when finally required to synthesize multi-disciplinary theoretical knowledge to confront highly complex, physical subterranean geological systems [10]. Furthermore, a significant mismatch exists between established teaching syllabi and the high-standard technical requirements of national professional events, exactly like the National Petroleum Engineering Design Competition. This discrepancy directly causes students to struggle significantly in flexibly applying theoretical knowledge learned in the classroom to solve complex, actual engineering problems. Teaching resources specifically tailored for high-level subject competitions are extremely scarce and exhibit highly fragmented characteristics, preventing universities from providing comprehensive, continuous scientific competition training support.

To address these critical educational dilemmas, this research proposes a novel talent cultivation mode fundamentally driven by subject competitions. Subject competitions provide a highly rigorous, standardized environment that closely mimics professional industrial research and development scenarios. By systematically integrating these competitive platforms directly into the standard curriculum, we aim to fundamentally reshape the pedagogical framework. This comprehensive research formally explores the systematic reconstruction of the petroleum engineering undergraduate curriculum utilizing national-level academic competitions as the primary educational catalyst. The pedagogical shift must position the student as a primary researcher who actively identifies scientific questions rather than passively absorbing established facts. The ultimate goal is to permanently bridge the widening gap between theoretical instruction and practical industrial application, thereby substantially enhancing the innovation and entrepreneurship capabilities of graduating engineering students and fully meeting the urgent, complex demands of the modern energy sector.

2. Theoretical Construction of Cultivation Mode

2.1. Pedagogical Logic of Competition Driven Learning

The theoretical foundation of this cultivation mode relies heavily upon constructivist learning theory and advanced project-based learning frameworks. Traditional educational models position students as passive recipients of established engineering facts. In stark contrast, the competition-driven paradigm forces a cognitive restructuring, where students actively construct knowledge through direct engagement with complex, unresolved engineering problems. The competition serves as a high-stakes, authentic learning environment that demands higher-order thinking skills, precisely including critical analysis and technical synthesis [11]. By anchoring the educational process to the strict requirements of professional academic events, the model shifts the pedagogical focus from simple knowledge retention to the practical application of theoretical principles. Students are required to function as primary researchers who independently navigate the entire lifecycle of an engineering project. This active research methodology ensures that learning occurs not through rote memorization but through the rigorous, iterative process of identifying scientific questions, designing technical solutions, and defending results against expert evaluation. The inherent pressure and rigorous standards of subject competitions act as external catalysts that accelerate the development of intrinsic motivation and professional engineering identity.

2.2. Structural Design of the Multi Competition Matrix

The effective implementation of the cultivation mode requires a highly structured theoretical matrix that categorizes and aligns various subject competitions according to their specific educational functions [12]. This research constructs a multi-dimensional evaluation model that systematically maps the cognitive and practical demands of different competitive tiers. University-level basic selection events are theoretically positioned to consolidate foundational engineering knowledge and foster initial team collaboration. Provincial-level professional practical events serve as the intermediate developmental stage, demanding the integration of cross-disciplinary concepts and the application of advanced numerical simulation tools. National-level, comprehensive, top-tier events, such as the National Petroleum Engineering Design Competition, represent the pinnacle of this theoretical matrix. These major events rigorously test the ultimate capacity of students to provide comprehensive and original technical designs for highly complex field scenarios. By establishing this stepped, progressive cultivation path, the theoretical framework ensures a logical, continuous cognitive development trajectory. The matrix structurally guarantees that students progressively acquire the necessary technical depth and analytical agility to solve unprecedented engineering challenges, transitioning smoothly from guided academic exercises to independent industrial research.

2.3. Reverse Engineering Analysis in Curriculum Alignment

A core theoretical innovation of this cultivation mode is the systematic application of reverse engineering analysis to align curriculum objectives with industry standards. Instead of designing courses based on traditional textbook progression, this methodology starts with the ultimate desired outputs dictated by high-level competition requirements [13,14]. The technical achievement standards and practical operation criteria of winning competition schemes are carefully deconstructed and reversely deduced into specific pedagogical targets. This reverse mapping process clearly identifies the precise knowledge modules and practical skills that must be embedded within core professional courses. By establishing a direct pedagogical link between the final competitive deliverables and the initial classroom instruction, the theoretical framework completely eliminates the traditional disconnect between academic theory and practical application. Furthermore, this process emphasizes the absolute necessity of rigorous scientific communication. The theoretical model strictly mandates that all technical documentation produced within this framework must be mathematically accurate and objectively rigorous, expressly prohibiting the use of imprecise descriptive metaphors. This reverse-engineered alignment ensures that every component of the curriculum is structurally optimized to produce highly capable engineering professionals who meet the exact demands of the modern industrial landscape.

3. Curriculum Reform and Resource Reconstruction

3.1. Reconstruction of Core Courses

We completely break the framework of traditional step-by-step curriculum system settings and comprehensively build a new practical training model driven in reverse by competition demands [15,16]. Taking the core evaluation and assessment indicators of the National Petroleum Engineering Design Competition and the Oil and Gas Storage and Transportation Engineering Design Competition as the highest guiding principles, we systematically dismantle highly typical practical competition topics. These topics exactly include advanced simulations of shale gas fracturing, fracture propagation, and the overall optimization of complex process flows in liquefied natural gas receiving terminals. We deeply integrate these engineering topics, representing the absolute forefront of industry technical pain points, into various teaching modules of core professional compulsory courses, precisely including reservoir engineering design and oil and gas storage and transportation technology. We innovatively compile a detailed, exact comparison table linking competition knowledge points directly with existing course content. Through strict and uncompromising revisions of the teaching syllabus, we strictly enforce that the overall correspondence between the final course teaching content and the key competition assessment standards reaches a hard target exceeding ninety-five percent. This monumental shift truly realizes a fundamental transformation in student learning modes, moving entirely from passively coping with examinations to actively utilizing competitions to promote learning and using learning to assist in competitions. This effectively and permanently solves the fundamental educational pain point where theoretical course teaching severely disconnects from the actual frontier demands of the modern energy industry.

3.2. Progressive Teaching Case Libraries

To achieve the educational goals of layered progression and precise talent cultivation, this research comprehensively innovates and establishes a three-dimensional, comprehensive teaching case library structurally comprising basic, comprehensive, and innovative tiers. This massive repository broadly collects award-winning technical schemes from excellent national competitions over the past five years and outstanding technology transformation projects from the energy track of the China International College Students Innovation Competition. We intensively develop more than fifty high-quality, three-dimensional teaching cases containing the source technical scheme alongside expert judge review opinions and frontline enterprise field feedback. The case library undergoes systematic scientific classification strictly according to the entire industry chain of modern oil and gas exploration and development. The content comprehensively covers all core engineering links, including basic geological evaluation and complex drilling engineering, alongside deep reservoir stimulation and intelligent oil and gas gathering and transportation. The basic cases, accounting for approximately forty percent, mainly focus entirely on consolidating isolated knowledge points within a single course. For example, we directly translate the accurate calculation of pipe string pressure in a small-scale fracturing device from an excellent initial scheme in a university-level basic competition into a daily graded practical project for the engineering mechanics course. We concurrently develop specialized calculation task assignment books and standard operating guidelines for commercial software precisely matching this project. The comprehensive cases, accounting for approximately fifty percent, focus entirely on investigating and integrating cross-disciplinary knowledge spanning three to four professional courses. The specific approach is to select high-difficulty schemes at the semi-final level of the National Petroleum Engineering Design Competition, precisely such as multi-dimensional optimization tasks for staged fracturing parameters in horizontal wells. We strictly force students to comprehensively utilize the combined knowledge of multiple core courses, exactly including reservoir engineering and production engineering, to independently complete a rigorous technical scheme design. The top-tier innovative cases, accounting for approximately ten percent, completely and closely align with the intelligent development trend of the modern energy industry. We directly convert projects with extremely high commercial potential, such as intelligent operation and maintenance systems for oil and gas pipe networks based exactly on digital twin technology, into graduation design research topics for outstanding undergraduate students. This application deeply cultivates the interdisciplinary, comprehensive innovative research and development capabilities of top-tier students, heavily preparing them to tackle future engineering challenges. To support this, every typical engineering case entered into the library must be accompanied by a professional technical analysis manual, alongside a strictly logical innovative mind map and a standardized engineering practice task sheet. Through this standardized operation, we achieve deep refinement and substantive transformation from complex initial competition schemes to highly usable teaching resources. To prevent teaching content from becoming obsolete, the project team has established an extremely strict, mandatory dynamic updating mechanism. We stipulate that every single year we must screen and add more than ten typical engineering cases representing the highest technical level of that year from the newly concluded national events, supplementing them directly into the resource library. This guarantees that the overall teaching content remains absolutely synchronized with the global energy industry technical development trends. We finalize this effort by developing and trial running a highly specialized energy engineering competition digital sharing platform, providing an all-weather digital teaching resource support network.

4. University Enterprise Collaborative Teaching System

4.1. Dual Teacher Model and Project Based Learning

In the core teaching implementation links, we comprehensively adopt a practical training model that tightly combines a dual-teacher classroom approach with full-process, project-based learning. The core leading teaching team consists entirely of senior teachers possessing abundant frontline teaching experience, alongside long-term competition guidance history and profound enterprise practical backgrounds. The internal university teacher team focuses heavily on systematically sorting out and accurately explaining the basic mathematical equations and fundamental mechanics theories of the core professional courses. Concurrently, we heavily recruit active senior technical management personnel from large energy enterprises, precisely including Changqing Oilfield, to serve permanently as specially appointed enterprise mentors. These enterprise mentors regularly analyze and accurately explain the hidden engineering connotations and strict field constraints of the core topics from national professional competitions over the past five years, utilizing exactly both online and offline seminars. Taking this as a profound opportunity, the project team establishes a highly standardized practical teaching process encompassing everything from the underlying deconstruction of real competition questions to the precise extraction of core theoretical knowledge points, and ultimately ending with the comprehensive reconstruction of entirely new teaching scenarios. During the advancement of daily professional courses, we organically intersperse a progressive three-stage teaching module encompassing foundational theory building, alongside deep analysis of classic cases, and concluding with the ultimate project practical exercise.

4.2. Dynamic Assessment and Quality Monitoring

To guarantee that the teaching reform scheme does not deviate from its established trajectory, the project team has established an exceptionally strict, high-frequency dynamic assessment and monitoring mechanism. This mechanism features strict weekly feedback and monthly evaluation, alongside a final semester summary. While the semester is actively in progress, we mandatorily collect core process data regarding student performance in daily course learning and simulated competition training every single week. Every month, we regularly organize the core teacher team to conduct scientific quantitative scoring and rigorous evaluation of the recent teaching effects, specifically targeting the collected data. At the end of every standard semester, we tightly integrate the final competition results of the students participating in the experimental classes alongside the comprehensive objective evaluation feedback provided by the invited enterprise mentors regarding the students' technical schemes. We strictly apply the scientific Delphi method to implement at least three rounds of internal iterative deep optimization targeting the current course teaching content and specific teaching methodologies. By establishing a deep university-enterprise joint assessment mechanism, we completely break the previous standard relying entirely on single test paper scores. We comprehensively incorporate the true engineering practical ability, alongside the original technical innovation ability and efficient team collaboration ability demonstrated by students during project execution, completely into the final course evaluation system utilizing exact quantitative score formats. This effectively forms a truly meaningful strict monitoring closed loop covering the entire process and multiple dimensions of teaching quality.

4.3. Experimental Analysis and Scheme Verification

During the actual implementation phase of this research, we persistently adopt the most rigorous experimental comparative method to objectively and scientifically evaluate the true effects of the project implementation. The specific operation involves selecting certain specific grades as pilot experimental classes, entirely implementing the series of thorough reform schemes designed within this project. Simultaneously, within the parallel horizontal grades, we set up control classes continuing to strictly adopt the traditional theoretical instillation teaching model. After the experimental cycle comprehensively concludes, we collect and utilize scientific statistical tools to perform exact comparative analyses targeting the significant differences between the two groups of classes across multi-dimensional key indicators. These exact indicators completely include national subject competition scores and objective tests of independent practical hands-on ability, alongside innovative thinking performance when solving complex problems. To safeguard the total objective fairness of the entire evaluation system, we specifically establish a high-specification expert advisory committee entirely composed of top-tier industry experts. This exact committee regularly convenes thematic guidance meetings and mid-term teaching reform seminars every single semester. We invite external independent experts to conduct exhaustive evaluations of the teaching reform scheme at the current stage without any blind spots. Based exactly on any defects or opinions reflected in the feedback, we continuously perform meticulous adjustments and deep optimization improvements on all existing assessment and evaluation indicator systems.

5. Conclusion

The comprehensive and thorough implementation of all reform measures within this project is fully expected to enhance the comprehensive technical innovation and practical application capabilities of undergraduate petroleum engineering students by an extremely significant margin. Through the continuous operation of the competition-course integrated reconstructed curriculum system and the highly realistic university-enterprise collaborative practice platform, the active registration and participation rate of the student population in national high-level subject competitions is expected to climb massively from the current baseline of thirty-five percent to permanently stabilize completely above eighty percent within exactly two years. The absolute number of awards won in national top-tier major events, exactly including the National Petroleum Engineering Design Competition and the China International College Students Innovation Competition, is fully expected to achieve an average annual growth of precisely twenty-five percent. The ultimate winning rate of the overall participating teams is heavily expected to increase significantly from the baseline of twenty-five percent to exactly fifty percent. Through this exceptionally high-intensity quasi-practical training, the core professional capabilities of the student population, specifically regarding their ability to independently and accurately identify complex engineering scientific questions and subsequently perform absolutely rigorous and reliable technical design, will undoubtedly obtain a substantive and completely irreversible leap. Within the project implementation cycle, we expect to fully complete the high-standard construction of multiple competition-course integrated national or provincial demonstration core courses and subsequently write and publish highly specialized educational teaching research papers possessing significant industry influence entirely based upon meticulously detailed empirical data.

At the micro-execution level, this teaching reform project massively promotes deep anti-corruption measures and profound academic innovation within the underlying teaching management systems of universities. We completely successfully formally incorporate the competition-course integrated innovative curriculum reform, possessing extremely high practical value, directly into the core mandatory credit content of the newly revised university-wide undergraduate talent cultivation program through explicit written regulations. Concurrently, we formulate extremely strict and highly standardized equivalent conversion execution standards and operational verification procedures governing the relationship between various high-level competition award achievements and the comprehensive assessment credits of daily compulsory courses. We comprehensively build a truly diversified transparent evaluation system that fundamentally cannot be arbitrarily manipulated by any single entity. This system mandatorily covers anonymous student evaluations and cross-teacher double-blind mutual evaluations, alongside independent third-party enterprise expert feedback and comprehensive assessments by the external expert committee. This exact system absolutely prohibits the use of vague subjective assumptions or inexact structural language carrying descriptive rhetorical colors in any academic assessment and teaching scheme design explanation. This strictly ensures that scientific text remains absolutely accurate and completely rigorous. This comprehensive methodology thoroughly guarantees the absolute seriousness and unassailable scientific nature of modern engineering education assessment and evaluation.

The entire educational model meticulously constructed and experimentally verified through this project possesses extremely significant direct demonstration and transplantation value at the micro-level of university major construction. Other similar engineering universities across the country can directly reference the three-dimensional, high-quality teaching case library produced by this exact research, allowing them to rapidly benchmark the latest frontier technology development demands of the industry with extremely low trial and error costs. This capability allows them to swiftly solve systemic common problems that have plagued universities for entirely too long, exactly including completely obsolete course content and severely lagging practical teaching applications. At the macro-level of teaching reform methodology, the reverse engineering analysis method and the modular structural development method completely introduced and thoroughly verified by this research provide an extremely scientific and precise methodological reference basis for universities nationwide seeking to deepen their own teaching reforms. Regarding the structural bottleneck of deeply integrating industry and education, this scheme successfully and completely breaks the invisible barrier permanently separating traditional campus teaching from the frontline of industrial production by seamlessly transforming the actual technical difficulties faced by operational enterprises directly into the core everyday teaching cases of the classroom. This exact model systematically breaks through the massive historical limitations associated with traditional isolated single-major cultivation, providing highly actionable and directly replicable precious practical experience for modern universities aiming to massively and stably cultivate interdisciplinary compound top-tier innovative engineering technical talents. This profound methodology possesses far-reaching and entirely incalculable comprehensive promotional value for fully supporting the interdisciplinary deep cross-integration talent cultivation strategy urgently required under the grand macro-background of current national new engineering construction initiatives.

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