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Reforming the Management System of Engineering Practice Courses for High Education

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Abstract: ***Engineering practice courses serve as the core vehicle for universities to cultivate undergraduates' ability to "solve complex engineering problems". However, the traditional model is plagued by issues such as short practice cycles, outdated content, over-reliance on reports for assessment, and insufficient communication between teachers and students, making it difficult to meet the demand for innovative talents. In 2022, the Ministry of Education advocated for "the integration of industry and education, and the integration of science and education". Drawing on this, this paper explores relevant reforms: integrating the undergraduate tutorial system with two-level supervision (university and faculty) and student feedback; achieving the integration of industry, academia, and research through teaching by off-campus experts and decomposing scientific research projects into four annual sub-topics; embedding real projects, advancing four-year practice under the "project team leader responsibility system", and adopting assessment that combines process and results. These reforms have enhanced the effectiveness of practical teaching, promoted universities to shift from "teaching-oriented" to "learning-centered" education, and helped cultivate innovative engineering talents capable of meeting industrial needs.***

Keywords: Engineering Practice Courses, Emerging Engineering Education, Academia and Research, Project-Based Management, Undergraduate Tutorial System**.**

1. Introduction

The role and reform path of engineering practice courses in university education engineering practice courses are the primary vehicle for universities to cultivate undergraduates' ability to "solve complex engineering problems" — a competency critical for bridging theoretical knowledge and real-world application. Notably, the Engineering Education Accreditation Standards, a cornerstone for ensuring engineering program quality, tie 6 out of its 12 graduation requirements to practical learning [2]. These requirements, which include applying engineering principles to design solutions and addressing ethical implications of technical decisions, highlight that practice is not a supplementary module but a core component of preparing qualified engineers.

Against the backdrop of "Emerging Engineering Education," which aims to align programs with technologies like intelligent manufacturing and renewable energy, traditional internship models (e.g., "metalworking" and "electrical engineering" tutorials) have become outdated [1]. These models focus on repetitive skill training—such as operating basic machinery—rather than fostering innovative thinking. For example, a typical 4-week metalworking internship rarely integrates digital simulation tools or automated systems, leaving graduates ill-equipped to meet society's demand for innovation-driven engineering talents [5]. Universities nationwide have thus prioritized reforming engineering practice teaching to refine "top-notch innovative talent cultivation mechanisms." While some progress has been made—such as short-term enterprise internships or lab projects—key issues persist: practical cycles are short (2–8 weeks annually) and content superficial; curricula lack coherence, with freshman and senior practice disconnected[5]; textbooks and lectures fail to reflect tech frontiers (e.g., 5G in smart infrastructure); assessment relies solely on summary reports, missing skills like teamwork; and communication gaps leave supervisors with projects unable to find students, and students with ideas unable to join teams. These widespread problems demand macro-level solutions.

In 2022, the Ministry of Education issued Several Opinions on Strengthening Organized Scientific Research in Universities, advocating "integration of industry and education" (co-designing curricula with enterprises) and "integration of science and education" (translating research into teaching). The policy aims to cultivate talents with composite capabilities to tackle tech and industrial challenges. This paper explores engineering practice course (3) reform through these two integrations, focusing on coherent curricula [2][5], resource sharing, and multi-dimensional assessment to resolve long-standing issues.

2. Integration of Undergraduate Tutorial System with Course Management

Practical courses for Emerging Engineering majors — encompassing fields like intelligent manufacturing, AI-driven environmental engineering, and digital construction—are defined by their heavy reliance on interdisciplinary integration (e.g., fusing computer programming with mechanical design, or data analytics with ecological monitoring) and digital tools (such as cloud-based simulation platforms, remote sensing software, and collaborative coding environments). This reliance fundamentally reduces their dependence on physical venues (a computer science major's AI model training can be completed entirely online, while an environmental engineering project may use real-time remote monitoring data instead of on-site sampling), fixed time slots (students can contribute to group tasks across different time zones via shared project management tools), and specialized equipment (many hands-on operations can be simulated via digital twins [1], eliminating the need for expensive on-campus hardware).

This unique attribute empowers academic supervisors to adopt diverse, student-centric guidance approaches: for instance, blending synchronous online workshops (to teach digital tool basics) with offline mini-labs (for hands-on verification of simulated results), or tailoring project-based group activities to students' interests and proficiency levels—providing pre-recorded programming tutorials for beginners before they join a smart sensor development project, while assigning advanced students to lead sub-tasks like algorithm optimization [1][2]. Such flexibility fosters a dynamic learning environment where students are not constrained by traditional classroom limits, but it also elevates the complexity of managing course content and supervisor performance [2]. For cross-disciplinary projects (e.g., developing a smart campus energy management system), it requires aligning practical tasks with the training objectives of multiple majors (ensuring computer students master system integration and electrical students grasp energy efficiency principles), while also monitoring supervisors' guidance intensity—for example, ensuring that part-time industry mentors provide at least two feedback sessions per project phase—and the quality of their feedback (avoiding generic comments like "good work" in favor of specific suggestions like "adjust the load forecasting algorithm to incorporate weather data").

The current mainstream management model for these courses mirrors the graduate seminar system: academic supervisors lead undergraduates in hands-on projects, holding biweekly progress briefings to review milestones (e.g., completing a prototype's first draft), address bottlenecks (such as debugging a faulty data transmission module), and adjust plans (extending a phase if key equipment is delayed).This model excels in adaptability—easily integrating emerging technological trends like AI-driven fault diagnosis or green energy optimization—and encourages close mentor-student interaction, but it struggles with full-process quality management. Challenges include inconsistent tracking of individual student engagement (some students contribute less in online groups, with their participation only measured by final submissions), vague benchmarks for evaluating practical outcomes (no clear definition of "innovative" vs. "routine" solutions), and inadequate documentation of iterative improvements [3] (students rarely record how feedback was incorporated into revised prototypes), all of which hinder systematic optimization of teaching efficacy.

To mitigate these issues, the Academic Affairs Office must establish rigorous management frameworks. This includes designing standardized rubrics for practical tasks—breaking down assessments into "scheme design" (weighted 30%, with "excellent" requiring interdisciplinary integration), "execution process" (40%, rewarding proactive problem-solving), and "outcome optimization" (30%, valuing iterative improvements)—and specifying supervisors' responsibilities, such as conducting weekly one-on-one check-ins to discuss individual progress [3]. Full-process supervision spanning project initiation (reviewing feasibility), execution (monitoring task completion), and closure (evaluating outcome alignment with goals) is also essential. A two-level supervision mechanism should be established: university-level teams (comprising assurance staff and quality assurance staff) audit compliance with national Emerging Engineering policies, while faculty-level committees (led by discipline heads) assess alignment with professional training standards [1]. Both conduct scheduled quarterly reviews and unscheduled spot checks, focusing on indicators like task completion rates and student skill improvement (e.g., whether students can independently use new digital tools post-practice).

Meanwhile, multiple student feedback channels should be institutionalized: anonymous online surveys (sent after each project phase to rate guidance quality), monthly focus groups (with 5–8 students per major to discuss pain points like "insufficient industry context"), and physical suggestion boxes in practice labs. Weekly teaching meetings—attended by supervisors, program coordinators, and student representatives—then analyze this data: for example, if freshmen consistently report "difficulty understanding project requirements," the group may develop a pre-project orientation module. Effective practices, such as peer review sessions for project drafts (where students exchange feedback using the standardized rubrics), are codified into actionable guidelines (including review timelines and feedback templates) and disseminated [3] to all teaching teams, ensuring consistent quality across courses.

3. Tripartite Integration of Industry, Academia, and Research to Ensure Practical Effectiveness

Inviting off-campus experts and industry leaders to teach undergraduates in person can effectively enhance students' political acumen and ideological awareness. Through frontline cases, students gain insight into national, industrial, and professional needs, thereby developing the strong sense of responsibility and mission essential for cybersecurity work. A high-level educational platform should be built, which is industry demand-oriented, government-promoted, and university-led, integrating industrial resources to systematically cultivate top-notch innovative cybersecurity talents who are "both politically reliable and professionally competent". Transforming frontline research projects into engineering practice topics for undergraduates is a common approach to talent cultivation under the integration of industry, academia, and research [4]. However, there exist difficulties in implementation during teaching practice. Engineering practice topics for innovative talent cultivation should possess both advanced nature and applicability: the former requires topics to reflect the current state of industrial development, while the latter demands that topics are suitable for training undergraduates to enhance their innovative capabilities. The contradiction between the two mainly lies in the fact that undergraduates' foundations—including their theoretical knowledge and hands-on skills—are insufficient to meet the requirements of completing advanced projects.

To resolve the aforementioned contradiction, the first step is to focus on topic selection. The research content and objectives of scientific research projects are formulated based on scientific issues or industrial development needs, whereas engineering practice topics should be designed [4] in line with the training objectives specified in the professional training program. Therefore, a professional teaching guidance team should first be established, consisting of teachers proficient in both research and teaching. This team will conduct itemized analysis and review of the research content and solutions of candidate projects to identify practical projects suitable for the major.

Supervisors are responsible for decomposing and transforming scientific research projects: each topic is broken down into four iteratively improved sub-topics in accordance with the curriculum progress outlined in the training program [1]. Undergraduates participating in practice are required to complete the practical topics each year based on the objectives and requirements of the sub-topics. The fourth sub-topic serves as the graduation project topic, ensuring the coherence of the four-year practical process.

4. Integration of Project-Based Management with Course Assessment

To address the pain points in university students' practical teaching—such as vague goals, weakened processes [1], and simplistic evaluation—real projects are embedded into the curriculum system. Teaching objectives are set around clear project tasks to enhance students' active exploration and teamwork in the practical process. Meanwhile, an assessment method integrating process-oriented and result-oriented evaluation is adopted, incorporating all stages of project initiation, implementation, demonstration, and review into assessment indicators to achieve full-process tracking and feedback on ability development. This model promotes students' comprehensive application of knowledge to solve practical problems, significantly improves the relevance, effectiveness, and educational impact of practical teaching, and drives universities to shift from "teaching-oriented" to "learning-centered" education.

Project-based management emphasizes taking real projects as the carrier, deeply integrating clear task objectives, teamwork, process monitoring, and comprehensive evaluation into the entire teaching process. Compared with traditional practical teaching—which prioritizes results over processes and suffers from low student participation—project-based management can promote students' active learning and continuous progress through mechanisms such as phased planning, milestone acceptance, and reflective demonstration [5]. It also balances knowledge application with ability cultivation, highlighting the improvement of core competencies like problem-solving, communication and collaboration, and innovative practice, thus making "doing projects" truly a process of "learning by doing" and "growing through doing."

In the four-year consistent practical teaching system, introducing project-based management with the "project team leader responsibility system" as the key can effectively solve the pain points in practical teaching, including loose organization, lack of process supervision, and unstable outcome quality. Students are grouped into project teams with clear role assignments—such as project team leaders, technical directors, and document directors—and full-process project management is implemented: freshmen engage in introductory projects to cultivate interest and collaborative awareness; sophomores participate in curriculum projects to strengthen engineering methods and task execution [2]; juniors undertake comprehensive projects to connect with real enterprise needs; and seniors complete graduation projects to produce innovative outcomes. Supporting mechanisms such as milestone acceptance, phased reporting, team evaluation, and teacher supervision are established to achieve visualized processes, traceable responsibilities, and controllable quality, thereby promoting the continuous development of students' comprehensive abilities.

For example, the four-year consistent practical teaching project for cybersecurity majors— "Campus Network Security Inspection and Attack-Defense Drill":

(1) Freshmen: Project team leaders organize basic equipment inspections to cultivate a sense of standardization;

(2) Sophomores: Teams take on small projects of vulnerability detection and repair, with the introduction of project planning and schedule management;

(3) Juniors: Teams connect with enterprise security testing tasks, with project team leaders organizing attack-defense drills and result reporting;

(4) Seniors: Complete security strategy optimization or tool development in graduation projects to produce applicable outcomes.

In this process, the project team leader serves as both an organizer and coordinator, and more importantly, a core role in ability improvement, achieving the training goal of students "transforming from followers to leaders."

5. Conclusion

This study explores the limitations of traditional engineering practice courses in universities (including issues such as short cycles, outdated content, over-reliance on report-based assessment, and poor communication between teachers and students), and investigates reform pathways aligned with the development of "Emerging Engineering Education" and the Ministry of Education's 2022 policy of "integration of industry and education, and integration of science and education."

The study verified three core strategies: first, the integration of the undergraduate tutorial system with course management (resolving the conflict between flexibility and quality through standardized assessment rubrics and a two-level supervision mechanism); second, the tripartite integration of industry, academia, and research (decomposing research projects into four-year progressive sub-topics to balance the advancement and applicability of topics); third, the integration of project-based management with assessment (building a four-year consistent practical system through role division and process-result evaluation). These reforms have improved teaching quality, driven universities' transformation from "teaching-oriented" to "learning-centered," and cultivated talents with innovative capabilities.

The limitations of this study lie in the untested universality of the model across more disciplines; future research will further verify the model in more fields and deepen enterprise collaboration.

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