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# Construction of a "One-Core, Two-Integration, Three-Progression" Practical Teaching System for Pharmaceutics in Pharmaceutical Engineering from the Perspective of Emerging Engineering Education

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***Abstract:*** *Driven by the dual imperatives of the Emerging Engineering Education (EEE) initiative and the transformation and upgrading of the pharmaceutical industry, the practical teaching of Pharmaceutics in pharmaceutical engineering programs faces an urgent need to transition from a "skills training ground" toward an "arena for competence construction and value shaping." To address the deep-rooted problems inherent in traditional practical teaching-namely, the overemphasis on theory at the expense of practice, recipe-style laboratory exercises, insufficient industry-education integration, and superficial integration of value-based education-this paper synthesizes multiple educational theories, including Outcome-Based Education (OBE), the BOPPPS+E closed-loop instructional model, virtual-actual integrated training, and the CIPP multi-dimensional evaluation framework, to propose a reform framework characterized by "One Core, Two Integrations, and Three Progressive Stages." The framework is anchored on establishing the independent status of practical teaching, driven by the dual engines of "virtual-actual integration" and "industry-education collaboration," and structured around a three-tier progressive content sequence-from normative competency, through design competency, to research competency-thereby constructing a student-centered practical teaching system. The study posits that the key to overcoming the dilemmas of practical teaching lies in achieving three fundamental transformations: elevating practical teaching from an appendage to theory into a primary vehicle for competence development; transforming students from passive executors into active designers; and reorienting teachers from disseminators of knowledge into facilitators of learning and shapers of values.*

***Keywords:*** *Pharmaceutics; Practical Teaching System; Project-Based Learning; Virtual-Actual Integration; Industry-Education Collaboration*

## 1. Introduction

Against the backdrop of both the Emerging Engineering Education (EEE) initiative and the "Made in China 2025" strategy, the reform of practical teaching in Pharmaceutics for pharmaceutical engineering majors has become a critical link in cultivating innovative and application-oriented talents [1]. As a core course in pharmaceutical engineering, Pharmaceutics investigates the fundamental theories of pharmaceutical formulations, formulation design, preparation processes, and quality control, and it is characterized by a strong practical orientation. Its teaching quality bears directly on students' professional competencies in drug research and development, manufacturing, and quality assurance [2]. However, traditional practical teaching suffers from problems such as disconnection from industrial demands and outdated instructional content, rendering it inadequate for accommodating the rapid evolution and transformation of the pharmaceutical industry [3].

As the pharmaceutical industry transitions toward high-quality development, the demand for talent has shifted from mere mastery of theoretical knowledge toward the possession of comprehensive practical competencies and innovative thinking [4]. Through deepening industry-education collaboration and reconstructing the practical teaching system, students are enabled to engage with

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authentic production scenarios during their academic tenure, gaining exposure to advanced technologies and equipment in enterprises, thereby narrowing the gap between academic preparation and job requirements [5]. Concurrently, the rapid advancement of artificial intelligence technologies has infused new momentum into pedagogical reform. The maturation and deployment of AI-enabled applications-including personalized learning path generation, intelligent question-answering and learning analytics, and virtual simulation with data-driven decision support-have translated the concept of "student-centered" precision teaching from theoretical ideal into practical reality [6].

## 2. Analysis of Current Status and Problem Diagnosis

Based on long-term teaching practice feedback from the program and a comprehensive review of the relevant literature, the problems inherent in the current practical teaching of Pharmaceutics for pharmaceutical engineering majors can be categorized into five principal dimensions.

### *2.1 Insufficient Teaching Resources and Disconnection from Industrial Practice*

Laboratory equipment is outdated, and facilities compliant with Good Manufacturing Practice (GMP) are lacking; the application of virtual simulation remains superficial, leaving students with little exposure to advanced equipment and technologies [7]. Given the rapid renewal cycle of pharmaceutical manufacturing equipment, the existing laboratory instruments lag behind the current process equipment employed in the industry, resulting in a notable gap between instructional content and the forefront of the discipline [8]. Moreover, certain specialized dosage forms-such as injections and ophthalmic preparations-demand stringent environmental cleanliness that conventional laboratories are unable to meet, rendering many experiments either unfeasible or improperly conducted [9].

### *2.2 Outdated Teaching Models and Impediments to Innovative Thinking*

The teacher-centered "cramming" method of instruction, coupled with a monolithic approach to evaluation, constrains the development of students' innovative thinking and undermines the cultivation of problem-solving competencies [10]. "Recipe-style" laboratory manuals encourage students to perform procedures mechanically without grasping the underlying rationale-a phenomenon often described as "knowing the how but not the why"-thereby depriving them of autonomy and the courage to innovate as they merely follow prescribed steps [11]. Furthermore, most students execute experiments according to predetermined formulations and standardized processes established by instructors, leaving limited room for independent design and predisposing them to rigid patterns of thinking [12].

### *2.3 Insufficient Industry-Education Integration and Absence of School-Enterprise Collaborative Education*

Enterprise engagement remains lukewarm, and partnerships tend to be unstable, resulting in limited internship opportunities and insufficient exposure to authentic work experiences for students [13]. Moreover, practical teaching content generally lacks simulation of the core processes involved in pharmaceutical R&D and manufacturing, rendering it disconnected from actual production workflows. Consequently, students acquire little knowledge of, and receive minimal training in, critical industrial competencies such as process scale-up, multi-batch stability verification, and GMP systems [14].

### *2.4 Irrational Faculty Structure and Shortage of "Dual-Qualified" Teachers*

Faculty members generally lack hands-on industrial experience, while industrial experts often possess insufficient pedagogical competence. Moreover, in laboratory courses, most instructors employ outdated and uninspired teaching methods, making it difficult for them to help students grasp the purpose and significance of experiments from an overarching and holistic perspective through the limited number of available experimental projects [15].

### *2.5 Superficial Integration of Value-Based Education and the Disconnect Between "Educating the Person" and "Training the Professional"*

The superficial and "label-sticking" integration of value-based education elements into the

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curriculum has created a notable disconnect between "educating the person" and "training the professional" [16]. Moreover, many faculty members lack a deep understanding of the value-based educational potential embedded in laboratory courses, with most value-oriented content confined to operational safety considerations, while deeper professional values—such as work ethic and pharmaceutical ethics-remain insufficiently addressed [17].

Underlying these interconnected problems is a fundamental conceptual misjudgment: practical teaching has long been regarded merely as an adjunct to theoretical instruction and a mere "workshop" for skill training, while its formative value-embodied in the cultivation of craftsmanship spirit, scientific ethics, and other educational outcomes-has been systematically overlooked. As a consequence, practical teaching occupies a marginal position within the curriculum, typically serving as a subordinate component of theoretical courses[18] . The prevailing assessment approach, which prioritizes final reports over process and emphasizes outcomes over competencies, fails to provide an authentic measure of students' hands-on performance (As shown in Figure 1).

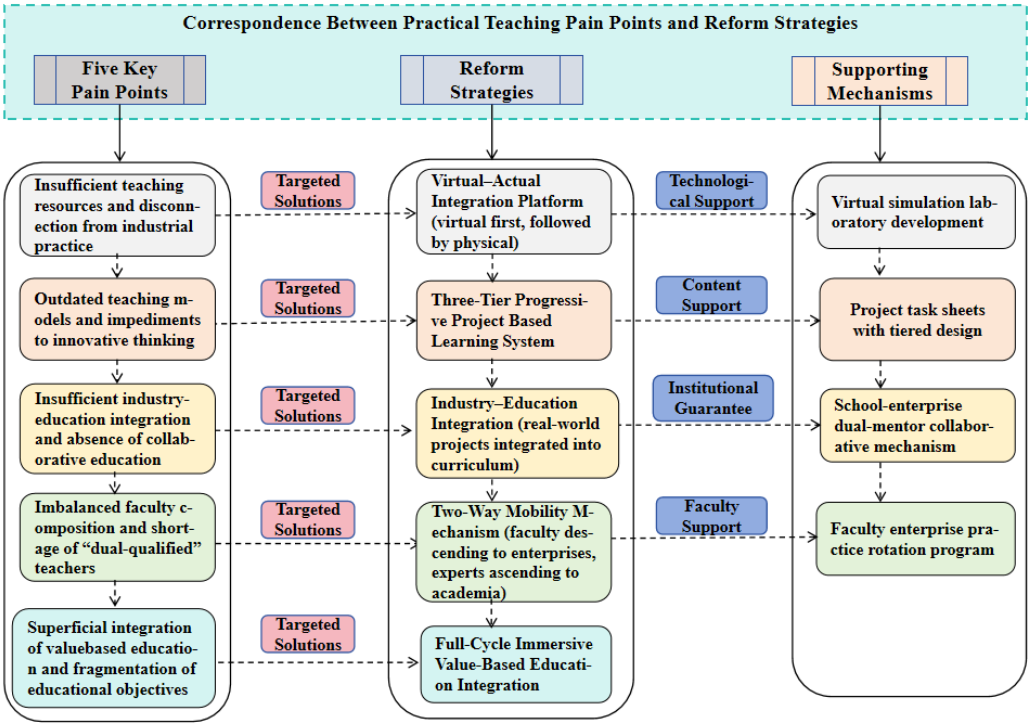


*Figure 1. Correspondence between practical teaching pain points and reform strategies.*

## 3. Reform Philosophy and Theoretical Framework

### *3.1 Core Philosophy: From "Knowledge Verification" to "Competence Construction and Value Shaping"*

The reform is guided by a core philosophy centered on "student-centeredness, project-based learning, seamless industry connection, and value-oriented guidance throughout." It draws upon the "student-centered, teacher-facilitated" principle emphasized by the BOPPPS+E instructional model [18], as well as the "Conceive-Design-Implement-Operate" (CDIO) engineering education paradigm [19], to achieve a fundamental transformation of practical teaching from "knowledge verification" to "competence construction and value shaping."

The BOPPPS+E instructional model decomposes the teaching process into seven core elements-Bridge-in, Objective, Pre-Test, Participatory Learning, Post-Assessment, Summary, and Extension-which span the entire instructional arc from pre-class preparation, through in-class delivery, to post-class consolidation, with a strong emphasis on student engagement throughout [18]. The CDIO framework, in turn, approaches engineering education from a practice-oriented perspective, requiring students to navigate the complete project lifecycle from conceptualization to product realization [19]. These two frameworks are highly congruent in their shared commitment to "learning by doing" and

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"student-centeredness," thereby providing a robust theoretical foundation for the present reform. Specifically, BOPPPS+E addresses the question of how to teach through structured instructional design, whereas CDIO addresses the question of what competencies to cultivate through a systematic engineering problem-solving pathway-together, they correspond respectively to the pedagogical and curricular dimensions of the reform (As shown in Figure 2).

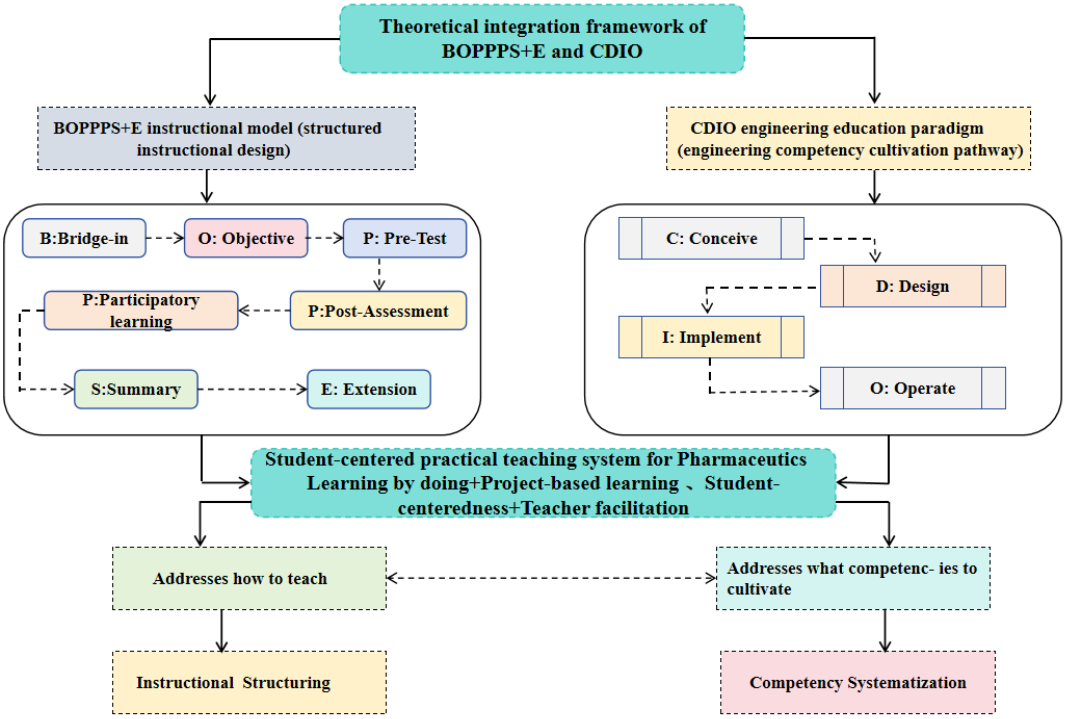


*Figure 2. Schematic diagram of the theoretical integration of BOPPPS+E and CDIO frameworks.*

### *3.2 Reform Framework: "One Core, Two Integrations, and Three Progressive Stages"*

One Core: The independent status of practical teaching is to be established, positioning it as the central vehicle for cultivating students' engineering innovation capability and professional competencies. To this end, the Comprehensive Practice of Pharmaceutics is to be designated as a standalone course (1.5–2 credits), placed on an equal footing with theoretical instruction rather than serving as a subordinate component [20].

Two Integrations: Virtual-Actual Integration: A "virtual first, followed by physical, with mutual verification between the two" strategy is adopted, wherein virtual simulation is employed for preview and trial-and-error, while physical experimentation is used for validation and refinement [21]. The virtual simulation platform is utilized to model the entire GMP-compliant manufacturing process—from material requisition to product packaging—within a pharmaceutical production line, with students engaging in the simulated environment through role-playing [22]. Industry–Education Integration: Through the introduction of "real-world projects" and "full-cycle participation of industry mentors," a seamless alignment between talent cultivation and industrial demands is achieved [22]. Practical technical challenges drawn from enterprises are presented as open-ended projects, for which student teams compete to develop solutions, with both enterprise engineers and academic faculty providing collaborative guidance [23].

Three Progressive Stages: A three-tier progressive content sequence—"normative → design-oriented → research-oriented"—is constructed, replacing the closed "experimental protocol" with open-ended "project task sheets" [24](As shown in Figure 3).

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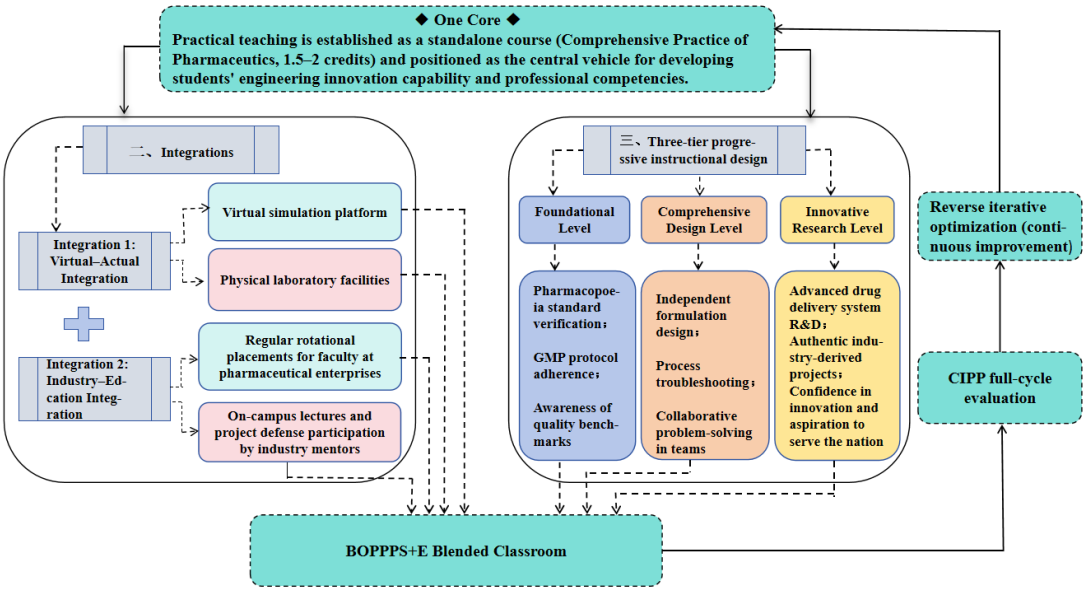


*Figure 3. Integrated practical teaching framework of "One Core, Two Integrations, and Three Progressive Stages".*

## 4. Reconstruction of Course Content: From "Isolated Experiments" to "Project-Based Learning"

The traditional "recipe-style" laboratory manuals-which prescribe every procedural step in detail-are to be abolished and replaced with open-ended "project task sheets" that define objectives and constraints while leaving the specific approach to student inquiry and decision-making(As shown in Figure 4.) Drawing upon the experience of transforming research outcomes into exploratory experimental projects [11] and the "verification-comprehensive-innovative" three-tier progressive framework [12], three major instructional modules are designed (Table 1 ).

*Table 1. The "Three-Tier Progressive" Practical Teaching Chain.*

| Module Level | Core Objective | Specific Content and Format | Value-Based Education Integration Points |
|---|---|---|---|
| Foundational Level (Normative) | Solidify foundational knowledge and establish standard practices | Students are tasked with preparing Vitamin C tablets that comply with the Chinese Pharmacopoeia standards. Quality specifications and key equipment parameters are provided, while students are required to independently consult the pharmacopoeia and design the Standard Operating Procedure (SOP) [25]. | Emphasize the legal authority of the Chinese Pharmacopoeia and the binding nature of national standards, cultivating students' awareness of regulatory compliance and quality benchmarks. |
| Comprehensive Design Level (Design-Oriented) | Integrate knowledge and cultivate design capabilities | Students are tasked with designing an enteric-coated tablet for a drug that causes gastric irritation. The project follows a complete R&D workflow: literature review → formulation design → excipient selection → process determination → preparation → quality evaluation → report writing [26]. | Introduce real-world cases where formulation instability compromised therapeutic efficacy, instilling a sense of responsibility in "pharmaceutical practice for the people"; foster communication, collaboration, and collective spirit through team-based project work. |
| Innovative Research Level (Research-Oriented) | Stimulate potential and bridge to frontiers | Students engage in the preparation and evaluation of advanced drug delivery systems such as sustained/controlled release formulations, microspheres, and nanoparticles; participate in competitive bidding for enterprise-derived technical challenges; and integrate their work with the "Innovation and Entrepreneurship Training Program" and undergraduate thesis projects [27]. | Sharing stories of Chinese pharmaceutical pioneers (e.g., Yinqiao Jiedu Tablets, Suxiao Jiuxin Pills) to build innovation confidence and national service aspiration [27]. |

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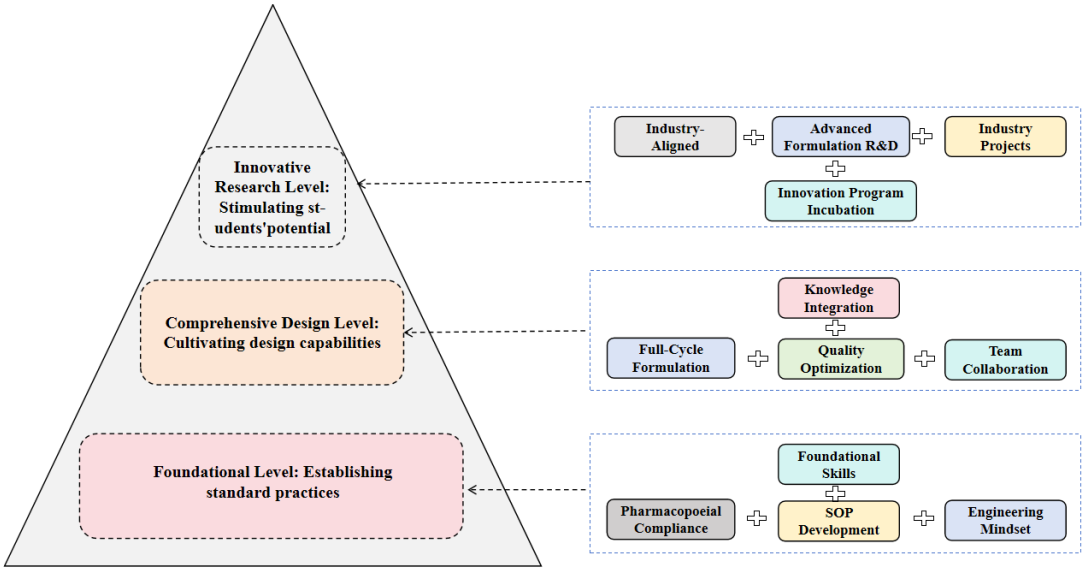


*Figure 4. Three-tier progressive project relationship diagram (pyramid diagram).*

## 5. Upgrading of Teaching Conditions and Restructuring of Faculty

### *5.1 Deep Integration of the Virtual Simulation Platform*

By means of 3D virtual simulation software, a modern pharmaceutical manufacturing facility is modeled in compliance with GMP requirements [22]. The training follows a "virtual pre-simulation, followed by physical practice, and then virtual-actual comparative review" logic: prior to physical tableting, students optimize process parameters and anticipate quality issues on the virtual platform; virtual simulation of aseptic filling is conducted before actual operation [21]. The platform covers the complete process workflows for tablets, injections, and microfluidics, allowing flexible adjustment of process parameters and simulation of various production faults such as delamination and machine jamming [8]. For high-risk operations-such as VR simulation of sterile preparation production and AR-based troubleshooting for tableting machines-virtual experiments are prioritized to mitigate equipment damage and safety risks. The platform is equipped with an operation guidance and evaluation system that objectively scores students based on their operational proficiency and accuracy in accordance with the specific standard operating procedures [22](As shown in Figure 5).

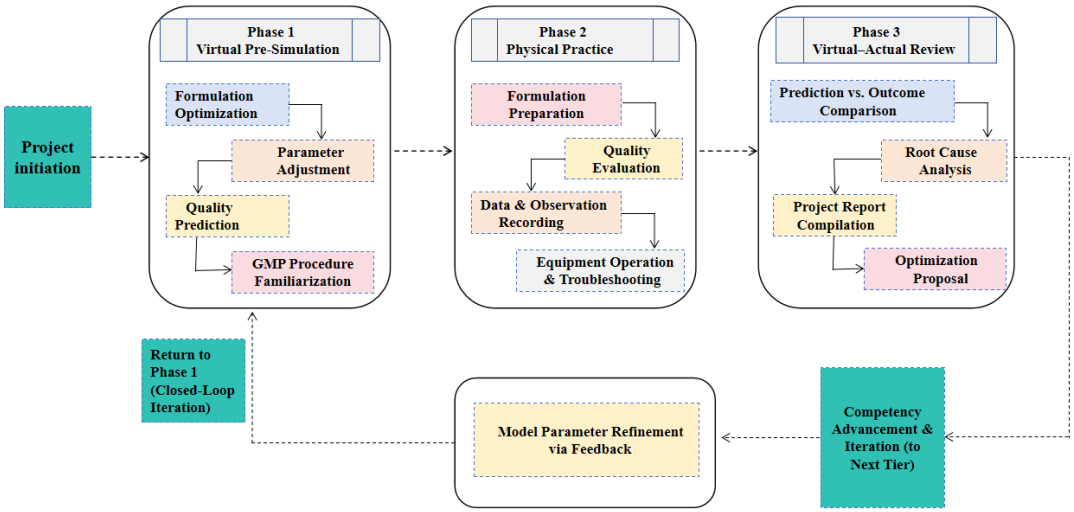


*Figure 5. "Virtual First, Physical Second, Mutual Verification" practical training flowchart.*

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### *5.2 Development of a "Dual-Qualified" Faculty*

A two-way mobility mechanism characterized by "faculty descending to enterprises and experts ascending to academia" is to be established [15]. For the "faculty descending" component, instructors teaching the Pharmaceutics course are required to undertake no fewer than two weeks of frontline rotational practice annually at partner pharmaceutical enterprises, participating in small-batch formulation trials and workshop-level quality control, thereby accumulating hands-on industrial experience that can subsequently inform and enrich their teaching [28]. For the "experts ascending" component, senior engineers and production supervisors from enterprises are invited each semester to deliver specialized lectures on campus and to participate in the final defense sessions for comprehensive- and research-level projects, providing both online and offline guidance to student project teams [23]. Concurrently, the practical teaching competencies of early-career faculty are to be enhanced through mentoring initiatives (e.g., pairing experienced instructors with junior colleagues) and teaching skills competitions [15].

## 6. Conclusion

This paper has addressed the deep-rooted problems inherent in traditional practical teaching-namely, the overemphasis on theory at the expense of practice, recipe-style laboratory exercises, insufficient industry-education integration, and superficial integration of value-based education-by synthesizing multiple educational theories, including Outcome-Based Education (OBE), the BOPPPS+E closed-loop instructional model, virtual-actual integrated training, and the CIPP multi-dimensional evaluation framework, to propose a reform framework characterized by "One Core, Two Integrations, and Three Progressive Stages." The core value of this framework lies in the realization of three fundamental transformations: at the conceptual level, practical teaching is elevated from an appendage to theory into a primary vehicle for competence development; at the pedagogical level, the role of teachers is reoriented from that of knowledge disseminators to facilitators of learning and shapers of values; and at the learning level, students are transformed from passive executors of recipe-style procedures into active designers and inquirers who engage in project-based tasks. This system establishes a coherent pathway that integrates theoretical instruction, laboratory training, school-enterprise collaboration, and value-oriented guidance throughout the entire educational process, thereby providing a systematic and replicable implementation paradigm for the comprehensive reform of the Pharmaceutics course in pharmaceutical engineering programs, while also offering valuable reference for practical teaching reforms in other engineering disciplines.

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## References

*[1] Zhou Y Y, Bu X Y, Zhao Z G, et al. Construction and evaluation of comprehensive practical teaching system for pharmaceutical engineering in medical universities under the background of emerging engineering education[J]. Journal of Tonghua Normal University, 2023, 44(6): 133-138.*
*[2] Liu J X, Ji H Y, Lan G Z, et al. Teaching reform based on innovative talent cultivation: A case study of Pharmaceutics course[J]. Chinese Medicine Modern Distance Education of China, 2025, 23(3): 195-197.*
*[3] Zhang Q, Zuo W B, Li Z F, et al. Reflections and explorations on teaching reform of Pharmaceutics laboratory course[J]. Science & Technology Wind, 2025(27): 77-79.*
*[4] Ji P, Zhang Z R, Xu L, et al. Discussion on teaching reform of pharmaceutical and chemical engineering courses based on “1+1” model: A case study of Pharmaceutics[J]. Yunnan Chemical Technology, 2024, 51(12): 183-187.*
*[5] Luo Q H, Feng D K, Wen B Y, et al. Reform and research of Pharmaceutics practical course based*

ISSN 2663-8169 Vol. 8, Issue 10: 70-77, DOI: 10.25236/IJNDE.2026.081009

*on school-enterprise linkage and "post-course-competition-certificate" integration[J]. Modern Vocational Education, 2025(15): 117-120.*
*[6] Liu D Z, Cheng Y, Huan M L, et al. Reflections on "AI+VR" empowering Pharmaceutics course from "knowledge acquisition" to "competence enhancement"[J]. Northwest Pharmaceutical Journal, 2025, 40(4): 268-273.*
*[7] Wang M, Sun L, He H, et al. Application of outcome-based online-offline blended teaching in Pharmaceutics theory course[J]. Health Vocational Education, 2024, 42(10): 83-86.*
*[8] Sun S P, Liu L J, Li Q. Exploration of virtual simulation teaching application in Pharmaceutics experimental teaching under emerging engineering education[J]. Heilongjiang Education (Theory and Practice), 2023(4): 29-31.*
*[9] Fu L N. Analysis of virtual simulation technology application in Pharmaceutics teaching[J]. Science Consult (Technology & Management), 2021(36): 183-184.*
*[10] Deng T, Yu C Q, Li Y, et al. Design and practice of Pharmaceutics course evaluation scheme based on OBE concept[J]. China Medicine and Pharmacy, 2025, 15(18): 152-156.*
*[11] Zhang J F, He X Y. Exploratory undergraduate Pharmaceutics experimental teaching based on transformation of research outcomes[J]. Research and Exploration in Laboratory, 2024, 43(5): 159-162, 205.*
*[12] Song Y D, An Y. Reflections and explorations on Pharmaceutics experimental teaching in pharmaceutical higher vocational colleges[J]. Continuing Medical Education, 2025, 39(8): 95-98.*
*[13] Liu A. Application of action-oriented teaching method in Pharmaceutics course teaching[J]. Teachers, 2021(26): 88-89.*
*[14] Yang C Y. Application and exploration of task-driven theory-practice integrated teaching in Pharmaceutics[J]. Guangdong Vocational Technology and Education Research, 2021(2): 59-60.*
*[15] Yang H Y, Zhou Z L, Chen Z M, et al. Application of "micro-video + mobile teaching platform" model in Pharmaceutics experimental teaching[J]. Strait Pharmaceutical Journal, 2021, 33(2): 95-98.*
*[16] Ding W Y, Li F, Xie T F, et al. Application of case-based teaching method in Pharmaceutics teaching[J]. Journal of Guangxi University of Chinese Medicine, 2024, 27(4): 91-94.*
*[17] Huang J M, Yuan X F, Na R H, et al. Application of case-based teaching method in Pharmaceutics teaching[C]//Proceedings of the 2025 Conference on Psychiatry and Mental Health (Series I), 2025.*
*[18] Gao Y T, Sun X F, Liu X H, et al. Application of "BOPPPS+E" teaching model in Pharmaceutics course[J]. Central South Pharmacy, 2024, 22(3): 821-826.*
*[19] Tang H L, Huang Q J, Liang D, et al. Application practice of goal-oriented BOPPPS model in Pharmaceutics experimental teaching[J]. Shandong Chemical Industry, 2021, 50(3): 180-181.*
*[20] Yang Y, Wang W X, Xiong S B, et al. Application of virtual experiment teaching in Pharmaceutics teaching[J]. Pharmaceutical Care and Research, 2014, 14(6): 462-464.*
*[21] Zhang Y, Ma Y, Ling J J, et al. Application of virtual-actual integrated experimental teaching system in Pharmaceutics[J]. Chinese Medicine Modern Distance Education of China, 2026, 24(2): 22-25.*
*[22] Shao X. Application of virtual simulation software in Pharmaceutics experimental teaching[J]. Information and Computer (Theoretical Edition), 2024, 36(1): 23-26.*
*[23] Zheng B, Yang S, Fan B. Application of online-offline blended teaching model in Pharmaceutics experiments[J]. Basic Medical Education, 2021, 23(1): 59-61.*
*[24] Wang X M, Qin L H, Yi J, et al. Application practice of blended teaching in Pharmaceutics experimental teaching[J]. Basic Medical Education, 2022, 24(1): 47-50.*
*[25] Gao Y N, Yu J Q, Liu Y, et al. Exploration of Rain Classroom application in Pharmaceutics experimental teaching[J]. Science and Education Culture, 2023(7): 135-138.*
*[26] Pan Y. Application and practice of flipped classroom teaching method in Pharmaceutics teaching[J]. Guangdong Chemical Industry, 2021, 48(1): 223, 228.*
*[27] Tao J F, Huang H Y, Huang J Y, et al. Application of blended interactive classroom teaching model in Pharmaceutics laboratory course[J]. Research and Practice in Medical Education, 2025, 33(2): 269-274.*
*[28] Huang Y Z, Liang X, Gui S Y, et al. Construction and optimization of Pharmaceutics practical teaching system from the perspective of industry-education integration: A case study of school-enterprise collaborative education model[J]. Science & Technology Wind, 2026(8): 38-40, 53.*