# Case-based Teaching of Core Courses in Pharmaceutical Engineering Guided by "Three Authenticities Leading, Tiered Progression"

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***Abstract:*** In response to the problems in the teaching of core Pharmaceutical Engineering courses, such as disconnection between theory and practice, and lack of industry-alignment and gradient design in case-based teaching, this paper proposes a case-based teaching model guided by "Three Authenticities Leading, Tiered Progression". By integrating the authentic job tasks, authentic production cases and authentic technical problems of pharmaceutical enterprises into the case design, and constructing a gradient case system following a progressive logic of unit operation → integrated process flows → innovation optimization, integrating online-offline blended teaching and diversified evaluation methods, this paper achieves the deep alignment between case-based teaching and industry demands as well as students' capability development. This model resolves the dilemma of "Vocational Deficiency and Academic Fragility" in Pharmaceutical Engineering teaching at vocational undergraduate institutions, while providing an operationalizable blueprint for localized and practice-driven reform of case-based teaching in engineering disciplines.

***Keywords:*** Three Authenticities Leading; Tiered Progression; Pharmaceutical Engineering; Core Courses; Case-based Teaching

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## 1.Introduction

Pharmaceutical Engineering is an engineering discipline with theory-practice synergy. Core courses, such as Pharmaceutical Technology, Quality Management Engineering for Drug Production, and Pharmaceutical Preparation Engineering, directly align with the job requirements of the production frontlines in the pharmaceutical industry [1]. Current case-based teaching is extensively applied in core courses of Pharmaceutical Engineering. However, there are still some problems, such as disconnection between case content and enterprise reality, lack of gradation in case design, and emphasis on theory over practical operation in teaching implementation, failing to cultivate students' holistic competencies to solve complex production problems. The "Three Authenticities Leading, Tiered Progression" teaching philosophy takes the authentic industry demands as the core, and capability advancement of students as the logic to integrates the authentic industrial factors of with gradient-based teaching design, providing a new framework for the case-based teaching reform of core courses in Pharmaceutical Engineering. Based on this, this paper explores the practical pathways of case-based teaching for the core courses in Pharmaceutical Engineering from three dimensions: case design, teaching implementation, and teaching safeguards, aiming to make case-based teaching truly become a bridge connecting the classroom and the workshop, as well as theory and practice.

## 2.The Core Essence of the "Three Authenticities Leading, Tiered Progression" Case-based Teaching

### 2.1 *Three Authenticities Leading: Anchoring the Industrial Authenticity of Case-based Teaching*

"Three Authenticities Leading" is the substantive core of the case-based teaching. It requires case design to entirely rely on the production reality of the pharmaceutical industry, and to abandon fictitious and simplified case content, so that students can immerse themselves in real-world problem-aligned scenarios in the classroom [2]. The authentic job tasks are aligned precisely with the core job requirements of pharmaceutical enterprises, such as

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production operation, quality inspection, and process optimization, and convert the SOP of those positions into teaching cases. The authentic production cases refer to typical examples from the real-world production process of pharmaceutical companies, including normal production procedures, common fault handling, and quality deviation analysis, etc. The authentic technical problems refer to the real-world technical challenges that pharmaceutical companies encounter in process improvement, cost control, and compliant production, which are regarded as advanced tasks for case-based teaching. The integration of the Three-Authenticity factors enables case-based teaching to transcend the simple application of theoretical knowledge. Instead, it enables the authentic solution of real-world industry problems, achieving seamless alignment between course teaching and position-specific capabilities.

### 2.2 *Tiered Progression: Gradual Design Tailored to Students' Capabilities*

"Tiered Progression" is the implementation logic of case-based teaching, requiring to design cases according to three tiers: "unit operation → integrated process flows → innovation optimization", which progress tier by tier and gradually advance, based on students' knowledge reserve and the development patterns of their capabilities. The fundamental tier focuses on unit operation cases, targeting individual pharmaceutical process unit such as material mixing, tableting, and sterilization, and designs simple and specific cases to enable students to master basic operational skills and theoretical basis. The progressive tier focuses on integrated process cases, integrate multiple unit operations, and design cases centered on complete workflows—from formulation production to process validation— to cultivate students' holistic process management capabilities and problem analysis proficiency. The advanced tier focuses on innovation optimization cases, and designs open-ended cases based on real-world technical problems in pharmaceutical enterprises, such as process optimization in the consistency evaluation of generic drugs and the efficiency improvement in the extraction process of traditional Chinese medicine, to cultivate students' innovative thinking and engineering practice abilities [4]. Tiered design enables students at different stages to get learning tasks that are suitable for them, avoiding inefficient learning led by that the cases are either too difficult or too easy.

## 3.The Design and Implementation of the "Three Authenticities Leading, Tiered Progression" Case-based Teaching

### 3.1 *Gradual Case Development Based on Three-Authenticity Factors*

Case development is the cornerstone for teaching implementation. It demands that a "university-enterprise collaborative" case development mechanism is established, and a case development team composed of university professional teachers and enterprise technical experts is formed to ensure the authenticity and professionalism of cases [3]. Firstly, it is necessary to identify and organize work content, skill requirements and typical problems of the core positions in the pharmaceutical industry through enterprise research and job interviews, and then build the three- authenticity case material libraries for each core course. Secondly, it is necessary to process and design the materials following the principle of Tiered Progression. The fundamental-tier cases clearly define the operation steps and problems. The progressive-tier cases establish a process-based problem chain. The advanced-tier cases only offer the problem background and target requirements, maintaining openness. Finally, corresponding teaching resources are provided for each case, including enterprise production videos, virtual simulation operation software, industry standard documents, etc., to ensure that the case-based teaching has sufficient resource support. For instance, in the "Pharmaceutical Production Quality Management Engineering" course, the fundamental tier designs "cases on workshop cleaning verification", the progressive tier designs "cases on quality deviation handling in tablet production", and the advanced tier designs "cases on compliance optimization in GMP certification for pharmaceutical enterprises", thus forming a gradient case system.

### 3.2 *The Implementation of Online-Offline Blended Case-Based Teaching*

Vocational undergraduate institutions should employ a blended teaching model of "online preview + offline

discussion + practical operation verification" based on the hands-on characteristics of the core courses in Pharmaceutical Engineering to operationalize Tiered Progression pedagogy. The online activities rely on the online teaching platforms to release case materials, preview materials and fundamental questions, enabling students to independently study the background knowledge of the cases, and conduct analysis and give solutions of the fundamental-tier cases. Teachers can monitor students' learning situation through the online platforms and design targeted offline teaching content. The offline activities mainly consist of classroom discussions, practical training, practical operation. The fundamental-tier case studies drive structured critical analysis through in-class team discussions, enabling students to master essential operational knowledge. The progressive-tier cases studies conduct workflows simulation in the practical training workshop using physical devices. The advanced-tier case studies organize students to carry out scheme design and argumentation in project groups. Corporate technical experts engage in the guidance through online or offline platforms to answer students' questions about the real-world production of enterprises. The practical operation verification activities rely on the GMP training workshop on campus or the school-enterprise cooperation practical training bases to enable students to convert the results of case analysis into actual operation, verify the feasibility of schemes, and achieve the goal of "learning by doing and doing by learning" [5].

### 3.3 *Multidimensional and Whole-Process Case-based Teaching Evaluation*

Vocational undergraduate institutions should transcend the monolithic evaluation method centered on examination results, and establish a "multi-dimensional, full-process, and value-added" case-based teaching evaluation system to comprehensively assess students' performance in case-based learning. The evaluation entities should include teachers, enterprise mentors, and students. The university teachers evaluate students' theoretical application capabilities, the enterprise mentors evaluate students' operational standardization and industry-alignment, and students focus on their peers' performance in teamwork. The evaluation content covers three dimensions: knowledge, skills, and literacy. It not only assesses students' mastery of relevant theoretical knowledge from the cases, but also focuses on their hands-on skills, problem-solving capabilities, and craftsmanship spirit. The evaluation process emphasizes the entire process and added value, recording students' performance in fundamental-tier, progressive-tier and advanced-tier case studies, and comparing the changes in students' capabilities before and after case studies, rather than merely focusing on the final results. For instance, after the case studies are completed, they can conduct a holistic evaluation through various methods such as case analysis reports, practical operation assessments, and proposal defenses, so that the evaluation truly becomes a driving force for students' capability enhancement [6].

## 4.Safeguard Systems for the "Three Authenticities Leading, Tiered Progression" Case-based Teaching

### 4.1 *University-Enterprise Collaborative Faculty Team Construction*

The implementation of case-based teaching requires a teaching team that integrates theoretical knowledge with industrial experience. A dual-mentor teaching team should be forged through "mutual recruitment between universities and enterprises and bidirectional cultivation". On the one hand, vocational education institutions should arrange for in-house professional teachers to assume a temporary post for personal training and development in pharmaceutical companies, engage in production and technology R&D, accumulate real-world work experience in the enterprises, and enhance teachers' case development and practical guidance capabilities. On the other hand, they should engage technical experts and workshop directors from pharmaceutical companies as external part-time teachers to participate in case development, classroom teaching and practical training guidance, and integrate the operational experience and technical requirements from enterprises into the teaching process. At the same time, they should establish a mechanism for university-enterprise teaching research communication, regularly organize case-based teaching discussions among university teachers and enterprise experts, jointly optimize the case design

and teaching implementation methods, and ensure that teaching teams' capabilities meet the requirements of case-based teaching.

### 4.2 *Virtual-Real Combined Teaching Platforms*

The case-based teaching of core Pharmaceutical Engineering courses involves a large number of practical operation activities. Some high-risk and high-cost production operation struggles to be conducted in class, requiring the establishment of a virtual-real combined teaching platforms featuring "online virtual simulation + offline physical training". Online, vocational undergraduate institutions should develop virtual simulation cases, such as pharmaceutical preparation technology and GMP workshop operation based on virtual simulation-based teaching software, enabling students to conduct repeated operation in virtual environment to master the essential knowledge of high-risk operation. Offline, they should improve the construction of on-campus GMP practical training workshops, drug analysis laboratories, and other practical training facilities, and equip them with production equipment and enterprise-consistent testing equipment, enabling students to complete hands-on verification for progressive-tier and partial advanced-tier cases. At the same time, they should establish off-campus practical training bases in collaboration with leading regional pharmaceutical enterprises to provide students with on-site case studies and practice opportunities in the enterprise environment, enabling them to truly enter the production lines and experience the real-world production atmosphere of enterprises firsthand.

### 4.3 *Adaptively Updated Case Resource Management*

The technologies and policies evolve rapidly in the pharmaceutical industry. Therefore, the case content needs to be updated adaptively to ensure temporal relevance and technological acuity in case-based teaching. Vocational undergraduate institutions should establish an adaptive update mechanism for case resources, manage the case material libraries according to course categories, and enable the university-enterprise collaborative case development team to regularly update and optimize the cases, integrate with new technologies, new processes, and new policies in the pharmaceutical industry promptly, such as integrating new technologies like continuous production and intelligent detection into case design, and embodying the requirements of the latest GMP regulations in quality control cases. Concurrently, they should collect feedback from students and teachers regarding the implementation of case-based teaching, and adjust the difficulty, content and supporting resources of the cases to ensure that the case resource libraries always align with teaching reality and industry demands.

### 4.4 *Post-Course-Curriculum-Competition-Certificate-Research-Innovation Integrated Teaching Implementation Mechanism*

The case-based teaching in core Pharmaceutical Engineering courses guided by "Three Authenticities Leading, Tiered Progression" requires to rely on the implementation mechanism for the deep integration of posts, curriculum, competition, certificates, research and innovation to closely integrate case-based teaching with job requirements, skills competition, vocational certificates, and scientific research innovation, achieving resonance between teaching objectives and the talent cultivation requirements in the industry. In the case design activities, vocational undergraduate institutions should take apart and integrate the skill requirements of core positions in the pharmaceutical industry, the assessment standards of vocational skills competition, and the assessment content of Occupational Qualification Certificates into tiered cases. The fundamental-tier cases are aligned with the essential operational knowledge of the positions and certification-mandated knowledge anchors. The progressive-tier cases are benchmarked against the practical operation question types of the skills competition and the advanced capability requirements of the positions. And the advanced-tier cases are designed with open-ended tasks based on corporate scientific research innovation projects and technical breakthrough requirements. During the teaching implementation process, vocational undergraduate institutions should use cases as vehicle to organize skill competition simulation, pre-exam practical training, and small-scale scientific research innovation projects, enabling students to simultaneously enhance their position-specific hands-on skills, combat-ready capabilities for competition,

exam-taking ability for certificates, and innovation and research capabilities while solving case-related problems. Concurrently, they should establish a teaching collaboration mechanism that integrates posts, curriculum, competition, certificates, research and innovation, regularly align with the human resources departments of enterprises, vocational skills assessment institutions, and industry competition organizational units, update the corresponding post standards, competition rules and certification-mandated knowledge anchors in the cases in a timely manner to ensure that the case-based teaching always suffice the industry reality and industry evaluation standards.

### 4.5 *Construction of a Multi-Dimensional and Value-Added Teaching Evaluation System*

To align with the characteristics of the "Three Authenticities Leading, Tiered Progression" case teaching method, it is necessary to establish a multi-dimensional and value-added teaching evaluation system to transcend the constraints of the single summative assessment and achieve a holistic evaluation of students' learning process, capability enhancement, and literacy development. The evaluation entities should enable a three-party collaboration among full-time teachers, enterprise project mentors, and students. Full-time teachers focus on evaluating students' application of theoretical knowledge and the logicality of their case analysis. Enterprise mentors focus on evaluating whether students' operation is standardized, and whether their solutions are effective to real-world problems. Student peer evaluation pays attention to their performance of comprehensive qualities such as teamwork skills, communication and expression skills. The evaluation entities should enable a three-party collaboration among full-time teachers, enterprise project mentors, and students. Full-time teachers focus on evaluating students' application of theoretical knowledge and the logicality of their case analysis. Enterprise mentors focus on evaluating whether students' operation is standardized, and whether their solutions are effective to real-world problems. Student peer evaluation pays attention to their performance of holistic competencies such as teamwork skills, communication and expression skills. The evaluation content covers three dimensions: knowledge, skills, and literacy. The knowledge dimension assesses students' mastery and transfer application capabilities of the core pharmaceutical theories. The skills dimension evaluates students' practical competencies such as position-specific operation skills and process optimization capabilities in case studies. The literacy dimension focuses on the craftsmanship spirit, professionalism, and innovative thinking embodied by students during the case-solving process. The evaluation methods integrate process analytics with value-added competency analytics. Online teaching platforms are used to record the whole-process performance of students in fundamental-tier progressive-tier, and advanced-tier, case studies. The learning outcomes of students at different stages are compared to measure the enhancement in their capabilities, rather than solely judging the learning efficacy based on the final scores. Concurrently, the evaluation results should be promptly fed back to both students and teachers. Students can use the evaluation results to specifically address their weaknesses in capabilities, while teachers can optimize the case design and teaching implementation methods based on the feedback, forging an "evaluation → feedback → optimization" closed-loop teaching ecosystem to promote the continuous quality improvement of case-based teaching.

## 5.Conclusion

Case-based teaching in core Pharmaceutical Engineering courses guided by "Three Authenticities Leading, Tiered Progression" represents an optimization and upgrade to traditional case-based teaching. Its essence lies in integrating industrial authenticity and competency gradation throughout the entire teaching process. Through the university-enterprise collaborative development of Three-Authenticity gradient cases, implementation of online-offline blended teaching, multi-dimensional and full-process evaluation, construction of dual-mentor faculty teams, and support from virtual-real combined platforms, case-based teaching can truly become an effective vehicle for cultivating students' engineering practical competencies and innovation capabilities. This model not only resolves the problem of disconnection between theory and practice in the teaching of Pharmaceutical Engineering, and enhance students' position-fit competency and employment competitiveness, but also provides a localized and

practical reference for case-based teaching reform in other engineering disciplines. In the future teaching practice, it is necessary to further deepen university-enterprise cooperation, continuously optimize case design and teaching implementation methods, so that the case-based teaching model guided by "Three Authenticities Leading, Tiered Progression" can play a greater role in the cultivation of Pharmaceutical Engineering professionals.

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