

Research Article

From "Knowledge Transmission" to "Research Innovation": Teaching Reform Practice of the Graduate Course "Advanced Marine Pharmaceutical Engineering"

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Abstract

The marine biomedical industry is a national strategic emerging industry, and there is an urgent demand for high-level biomedical talents with innovative scientific research thinking. Graduate course teaching is a key link in cultivating scientific research and innovation ability. However, at present, graduate courses in marine pharmacy such as *Advanced Marine Pharmaceutical Engineering* generally suffer from problems such as teaching content lagging behind industry frontiers, monotonous teaching methods, weak practical links, and rigid evaluation systems. Combining the learning characteristics of biomedical graduate students and taking "cultivation of scientific research and innovation ability" as the core objective, this paper systematically explores the teaching reform path of the course *Advanced Marine Pharmaceutical Engineering* from four dimensions: reconstruction of teaching content, innovation of teaching methods, establishment of practical platforms, and optimization of evaluation mechanisms. It proposes reconstructing the course content system driven by "cutting-edge scientific research cases," replacing "receptive learning" with "research-based learning" to innovate teaching methods, making up for practical shortcomings through "project-based training combining virtual and real elements," and guiding the development of innovation ability through "process-oriented multiple evaluation," thereby forming a four-in-one course reform plan of "research-teaching-practice-evaluation," so as to provide reference for the construction of biomedical graduate courses.

Keywords

Marine Pharmaceutical Engineering, Graduate Teaching Reform, Scientific Research and Innovation Ability, Biomedicine

1. Introduction

Driven by the dual strategies of building a maritime power and "Healthy China 2030" [1], the marine biomedical industry has become an important growth pole of China's strategic emerging industries [2]. Because of their novel structures and unique activities, marine drugs have become an important source for innovative drug research and development [3].

However, there is a significant structural contradiction between the rapid development of the industry and the supply of talent: what enterprises need are research and development talents who can independently identify problems, design solutions, and promote technology transfer, whereas students trained through traditional graduate courses often "understand

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knowledge but cannot conduct research" and "can perform operations but lack innovative thinking."

Advanced Marine Pharmaceutical Engineering is a core professional course offered to graduate students majoring in biomedicine and related fields. Its content covers the discovery and screening of active substances from marine drugs, the biosynthesis and structural modification of marine drug-source molecules, the formulation processes and quality control of marine drugs, and the engineering preparation of marine biological products, possessing distinct interdisciplinary attributes and an engineering application orientation. This course should not only serve as a carrier of knowledge transmission, but also become a platform for training scientific research and innovation ability [4]. However, the current teaching practice of this course still mainly follows the traditional model of "teacher lecturing-student memorization-final examination," which is clearly misaligned with the "research-oriented" essence of graduate education [5].

Combining the learning characteristics of biomedical graduate students and the course attributes of Marine Pharmaceutical Engineering, and drawing on the experience of graduate course reform at home and abroad, this paper explores the course teaching reform path centered on the cultivation of scientific research and innovation thinking from four dimensions: teaching content, teaching methods, practical platforms, and evaluation mechanisms.

2. Current Teaching Status and Problems of the Course *Advanced Marine Pharmaceutical Engineering*

2.1. Course Attributes and Learning Characteristics

Advanced Marine Pharmaceutical Engineering is intended for graduate students majoring in biomedicine and related fields, with student backgrounds covering pharmacy, bioengineering, biotechnology, chemistry, and so on. This group has several notable characteristics. First, they already possess a certain amount of basic professional knowledge, including organic chemistry, biochemistry, microbiology, pharmacology, etc., but their knowledge structures are uneven. Second, they have had preliminary exposure to scientific research practice; some students completed graduation theses or participated in research projects during their undergraduate studies, but lack systematic training in scientific research thinking. Third, their learning motivation is more pragmatic, as they pay attention to the relevance of course content to their own research directions and career development, and lack patience for courses that are pursued merely "for the sake of learning." Fourth, they possess relatively strong abilities in independent learning and information acquisition, but their critical thinking and ability

to solve problems independently still require systematic training [6].

These characteristics determine that graduate course teaching cannot simply continue the "knowledge transmission" model of the undergraduate stage, but should shift toward a training paradigm that is "problem-oriented, research-based, and ability-targeted" [7].

2.2. Core Problems in Current Teaching

Teaching content is disconnected from industry frontiers. The field of marine pharmaceutical engineering undergoes rapid technological iteration. From traditional activity screening to biosynthesis based on gene cluster mining, from natural product isolation to synthetic biology modification, and from conventional formulations to targeted delivery systems, the boundaries of knowledge are constantly expanding. However, existing course content mostly relies on classic textbooks, and the knowledge system is relatively fixed, with poor channels for cutting-edge research achievements and new industrial technologies to enter the classroom. There is a "time lag" between what students learn and what enterprises need [8].

Teaching methods replace "inquiry" with "reception." The classroom is still dominated by teacher lecturing, with students in a passive state of reception. Marine pharmaceutical engineering involves a large amount of content such as process routes, reaction mechanisms, and separation and purification strategies. If taught only through lectures, students find it difficult to truly understand the scientific logic behind technological choices. The "research-oriented" nature of graduate students is suppressed in the classroom, and critical thinking and problem awareness cannot be stimulated [5].

Practical links involve more "observing" than "doing." Limited by experimental conditions, safety management, and class schedule arrangements, course practice mostly remains at the level of visits and demonstrations, and students have limited opportunities to truly participate in the entire process of marine drug preparation. Even when there are experimental links, they are mostly confirmatory operations in which students "fill prescriptions according to the given formula," lacking autonomy in scheme design and making it difficult to form a complete closed loop of scientific research training involving "discovering problems-analyzing problems-solving problems."

The evaluation system is misaligned with ability objectives. Assessment methods are mainly final written examinations or course papers, which make it difficult to measure students' scientific research and innovation ability. Written examinations emphasize knowledge memorization, while course papers may degenerate into the "transportation" of literature. Process-oriented evaluation is absent, and key abilities such as intellectual growth, scheme design, and teamwork during course learning lack effective records and feedback [9].

3. Course Reform Path Centered on Scientific Research and Innovation Ability

3.1. Reconstruction of Teaching Content: Using "Cutting-Edge Scientific Research Cases" as Knowledge Carriers

The selection of content for graduate courses should not pursue "breadth and completeness," but rather "refinement and depth," using typical scientific research cases as threads to embed knowledge learning in real research contexts.

Reorganizing knowledge modules according to the "full chain of drug discovery." Break the traditional chapter structure arranged linearly as "active substances-separation and purification-structure identification-formulation development," and reorganize the content according to the real logic of marine drug research and development. For example, taking the research and development process of a certain marine-derived candidate drug as the main line, connect "marine microbial fermentation-mining of active metabolites-analysis of biosynthetic gene clusters-structural modification and structure-activity relationships-formulation design and quality control" into a complete narrative. In this process, what students understand is no longer isolated knowledge points, but research-oriented thinking about "why it is done this way," "what else can be done," and "where the bottlenecks are."

Introducing a "scientific research papers into the classroom" mechanism. Before teaching each chapter, students are required to search recent high-level literature from the past three years around the core issues of that chapter, complete a brief "literature flash report," and exchange ideas in class. The teacher then selects cases from the latest research results that are highly consistent with the course content, analyzing the researchers' ideas, the reasons for technological choices, and the ingenuity of experimental design. For example, when teaching marine antitumor active substances, typical cases from Chinese research teams in the discovery of marine-derived candidate drugs can be introduced, allowing students to understand the scientific logic of "from the ocean to the pharmacy" in specific research contexts.

Setting up special discussion topics on "frontier controversies." In marine pharmaceutical engineering, there are many disputes over technological routes that are still being explored, such as "which is superior, total synthesis or biosynthesis of natural products," and "the synergy and substitution between 'blue biotechnology' and traditional screening in marine drug development." Introducing these controversial issues into the classroom guides students to form their own judgments based on literature evidence and cultivates critical thinking [6].

3.2. Innovation of Teaching Methods: From "Lecturing" to "Research-Based Learning"

The formation of scientific research and innovation ability depends on continuous thinking training involving "posing problems-constructing hypotheses-verifying reasoning-reflecting and revising." Classroom teaching methods should create opportunities for such training.

Case-driven inquiry-based teaching. Using real scientific research projects or industrial cases as materials, design "question chains" to guide students to go deeper layer by layer [7]. For example, given the structural information and preliminary activity data of a marine active compound, students are required to: (1) analyze possible defects in its druggability; (2) propose reasonable strategies for structural modification; (3) design synthesis or biosynthetic routes; and (4) discuss potential challenges in formulation development. Students complete scheme design in groups, and scheme defense and peer review are conducted in class. The teacher does not provide "standard answers," but guides students to compare and argue among multiple possible paths.

Flipped classroom and research-based presentations. Some modules suitable for independent learning (such as reviews of technical methods in marine drug research and development, relevant regulations and quality control standards, etc.) are arranged for pre-class online learning, while classroom time is used for in-depth discussion and presentations [10, 11]. Each student or group selects a topic related to the course, completes a literature review, proposes research questions, designs a preliminary research plan, gives an academic presentation, and accepts questioning from teachers and classmates. This process trains multiple core scientific research abilities, including literature retrieval and evaluation, logical induction, and academic expression.

"Scientific research logs" and visualization of thinking. Students are required to keep "scientific research logs" during the course, recording their thoughts after each class: Which knowledge point is relevant to my current research? Can the methods in the literature be transplanted to my topic? Which viewpoint in the classroom discussion made me re-examine my original understanding? These logs do not pursue completeness or standardization, but emphasize genuine traces of thinking. The teacher reads them regularly and gives personalized feedback, helping students establish connections between course learning and their own research topics.

3.3. Establishment of Practical Platforms: Project-Based Training Combining Virtual and Real Elements

Practice is an irreplaceable link in cultivating scientific research and innovation ability. In response to practical constraints such as limited experimental conditions, safety risks, and tight class hours, a three-tier progressive practical system

of "virtual simulation-micro-experiments-project-based training" can be adopted [12].

Virtual simulation addresses the dilemma of "being unable to see and unable to do." Marine drug preparation involves multiple links such as fermentation, separation, purification, and formulation, some of which have harsh process conditions or high safety risks. With the help of virtual simulation platforms, students can "completely" run the entire process from strain inoculation to product purification, adjust parameters, observe phenomena, and analyze data. The virtual environment also allows "trial and error"—students can try different extraction solvents and different chromatographic conditions, and observe their effects on yield and purity. This kind of "cost-free trial and error" is difficult to achieve in real experiments.

Micro-experiments strengthen core skills. On the basis of the complete process cognition provided by virtual simulation, miniaturized and modular experimental projects that can be completed in conventional laboratories are designed. For example, taking a typical active substance of marine origin as the target, students complete a series of operations from pre-treatment of microbial fermentation broth, solvent extraction, and thin-layer chromatography analysis to preliminary activity detection. The experiments emphasize "independent design of schemes": given the target product and crude extract, students design separation and purification steps and justify them, rather than operating according to a standard procedure.

Project-based learning connects with real problems. In the later stage of the course, a "simulated research project" segment is set up. Students, in groups of 3-4, complete the entire process from literature investigation, research scheme design, and feasibility argumentation to the display of "preliminary experiment" results around topics such as "the development of the medicinal value of a certain marine biological resource" or "the engineering preparation of a certain marine active ingredient." The teacher plays the role of "mentor," providing guidance through regular discussions but not replacing students' decision-making. This process simulates the operating logic of real scientific research projects, training not only technical operations, but also comprehensive abilities in project planning, teamwork, and problem solving [8].

3.4. Optimization of the Evaluation

Mechanism: Process-Oriented, Diversified, and Ability-Oriented

Evaluation is the baton. To cultivate scientific research and innovation ability, the evaluation system must shift from "testing knowledge" to "assessing ability" [9].

Constructing a "whole-process ability profile." Course evaluation is decomposed into several ability dimensions, and corresponding observation points and evaluation indicators are set in each teaching link. For example, literature flash reports evaluate "information acquisition and critical reading ability"; classroom discussions evaluate "logical expression

and questioning ability"; scheme design evaluates "problem definition and innovative thinking"; experimental operations evaluate "technical standardization and problem solving"; and project presentations evaluate "comprehensive integration and academic communication." Each dimension is combined into the course grade according to a certain weight, forming a multidimensional evaluation of students' scientific research and innovation ability.

Introducing "peer review" and "self-reflection." In classroom presentations and project displays, a student mutual evaluation mechanism is set up. Evaluation is not limited to "whether it is good or not," but pays more attention to "where it can be better" and "what would happen if another approach were taken." At the same time, students are required to submit "learning reflection reports," reviewing their thinking changes during the course: At what moment did a new understanding emerge? Which question made them realize the deficiencies of their original cognition? Reflective ability itself is an important metacognitive ability for scientific research and innovation.

"De-standardizing" the final assessment. There is no unified written examination at the end of the course. Instead, it is replaced by a "research proposal" or "technical review + research proposal." Students are required to complete an academically standardized research proposal around a specific issue related to marine pharmaceutical engineering, including problem formulation, literature basis, research ideas, technical routes, expected results, and innovation points. The evaluation criteria focus on "the authenticity of the problem," "the reasonableness of the ideas," "the appropriateness of the methods," and "the standardization of expression," rather than the coverage rate of knowledge points.

4. Guarantee Conditions for the Implementation of Reform

The effective implementation of course reform requires support from multiple aspects. Transformation of the teacher's role. The shift from "knowledge transmitter" to "research guide" places higher demands on teachers. Teachers need to continuously track frontier developments in the field of marine pharmaceutical engineering, possess the ability to transform scientific research achievements into teaching cases, and at the same time master the methods and skills of research-based teaching. Teachers' teaching competence can be enhanced through collective lesson preparation, teaching seminars, and enterprise practice [13].

Integration of teaching resources. The construction of virtual simulation platforms, access to frontier literature databases, and connection with school-enterprise cooperative training bases are important supports for course reform. Relying on the school's existing platforms, stable cooperation mechanisms can be established with marine drug research institutions and biomedical enterprises to transform industrial

resources into teaching resources [14].

Support from the institutional environment. Graduate course reform requires institutional support in aspects such as training programs, class schedule arrangements, and assessment methods. For example, research-based teaching requires more flexible class scheduling, practical links require the support of a laboratory open-access system, and diversified evaluation requires adaptation by the academic affairs management system. These require coordination and guarantee at the school level.

5. Conclusion

As a core professional course for biomedical graduate students, *Advanced Marine Pharmaceutical Engineering* should have teaching objectives that go beyond "enabling students to understand the basic knowledge of marine pharmacy" and instead point toward "cultivating high-level innovative talents capable of independently conducting marine drug research." The realization of this objective requires systematic reform from four dimensions: making course content "frontier-oriented," making teaching methods "research-oriented," making practical training "project-based," and making the evaluation system "ability-oriented."

Teaching reform centered on scientific research and innovation ability is essentially a transformation of graduate courses from "the endpoint of knowledge transmission" to "the starting point of scientific research training." When what students experience in the classroom is not passive reception but active inquiry, not standard answers but multiple possibilities, and not isolated knowledge points but real problem situations, the course can truly become the soil for the growth of innovative talents. This reform direction has generalizable reference value for the construction of graduate courses in marine pharmacy, and also responds to the urgent demand of the maritime power strategy for high-quality biomedical talents.

Author Contributions

Huang Liping: Conceptualization, Funding acquisition, Investigation, Resources, Writing – original draft, Writing – review & editing

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Conflicts of Interest

The author declares no conflicts of interest.

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Biography



Huang Liping (1986-), female, born in Zhanjiang, Guangdong, Ph.D., Professor at the School of Chemistry and Chemical Engineering, Lingnan Normal University, mainly engaged in research on pharmacology teaching models for pharmaceutical engineering.