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Application and Exploration of Innovative Teaching Methods in Pharmaceutical Botany

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Abstract: Pharmaceutical Botany is a core compulsory foundational course for students majoring in Pharmacy and Chinese Materia Medica in China. It integrates theory and practice and serves as a key bridge between basic botany and applied research in traditional Chinese medicine. The course features fragmented knowledge points, numerous specialized terms, a heavy memorization load, and abstract theoretical content. The traditional "lecture-based" single teaching model struggles to meet the training objectives for innovative pharmaceutical talents in the new era. Based on our team's long-term frontline teaching-reform practice, this paper integrates multiple modern innovative teaching methods and constructs a comprehensive stereoscopic innovative teaching system for Pharmaceutical Botany across four dimensions: theoretical teaching innovation, practical teaching optimization, diversified assessment and evaluation, and curriculum value guidance. Theoretical teaching relies on multimedia visualization, CBL combined with flipped classrooms, interest-oriented task-driven learning, short review writing, and Latin name-specific teaching reforms to fully stimulate students' autonomous learning motivation. Practical teaching introduces the Plan-Do-Check-Act (PDCA) cycle for refined management and establishes an integrated virtual-actual practical education system using living plant platforms, field practice bases, and digital virtual resources. At the assessment level, it abandons the drawbacks of traditional summative assessment and establishes a whole-process, multi-dimensional formative evaluation mechanism. Meanwhile, the concept of "micro-ideological and political education" is subtly integrated throughout the teaching process, achieving the organic unity of knowledge transmission, ability cultivation, and value guidance. Teaching practice shows that this innovative teaching system can effectively improve the classroom teaching atmosphere, significantly enhance students' professional learning interest, independent inquiry ability, and practical skills in plant identification, providing a referable practical paradigm for the teaching reform and quality improvement of the Pharmaceutical Botany course.

Keywords: Pharmaceutical Botany; Innovative teaching; Teaching reform; Autonomous learning; Curriculum-based ideological and political education

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1. Introduction

Pharmaceutical Botany is an interdisciplinary basic discipline integrating plant morphology, taxonomy, and the application of traditional Chinese medicine resources. It mainly studies the morphological structure, growth and development, classification and identification, resource development, and rational utilization of medicinal plants. It serves as an important prerequisite for core courses such as Pharmacognosy, Natural Product Chemistry, Chinese Materia Medica Identification, and Chinese Medicine Resource Science for Pharmacy and Chinese Materia Medica majors, playing a key connecting role in the professional talent training system [1]. The quality of course teaching directly determines the solidity of students' foundational knowledge in traditional Chinese medicine and affects their subsequent professional course learning and career development. However, this course presents several teaching challenges, such as fragmented knowledge points, abstract and obscure theories, a large amount of memorization content, and a disconnect between theory and practice. The traditional teacher-centered "cramming" lecture model easily leads to passive knowledge reception, insufficient learning motivation, fragmented knowledge memorization, and difficulty in flexibly applying theoretical knowledge; therefore, it fails to meet the training requirements of higher pharmaceutical education in the new era for innovative, practical, and versatile talents.

With the rapid development of educational information technology and the continuous deepening of university curriculum reforms, diversified innovative teaching methods are gradually being applied to medical and pharmaceutical courses, providing new ideas and paths for improving the quality and efficiency of Pharmaceutical Botany teaching. A systematic review of global botany education suggests that current botany education is showing three core trends: transformation to active learning, digital empowerment, and holistic education. Traditional lecture-based teaching has gradually been replaced by new, interactive, and diversified teaching models [2]. This trend provides an important international reference for the reform of Pharmaceutical Botany courses in China. Since 2008, our teaching team has continuously conducted teaching reforms in Pharmaceutical Botany, successively implemented the construction of a living plant assessment system, optimization of standardized Latin name teaching, innovation of the field practice model, integration of flipped classroom and CBL teaching, Plan-Do-Check-Act (PDCA) practical teaching management, and integration of micro-ideological and political education. Gradually, we have built a stereoscopic innovative teaching system that meets the course characteristics, suits students' learning conditions, and aligns with educational goals. This paper aims to review the implementation paths, practical methods, and application effects of various reform measures, to evaluate whether an integrated teaching reform improves students' learning outcomes, and to aim to provide a reference for the teaching reform of Pharmaceutical Botany and similar practical professional basic courses as the final goal.

2. The dilemma of traditional teaching models in Pharmaceutical Botany

At present, Pharmaceutical Botany teaching in most Chinese universities mainly follows the model of "theoretical classroom lectures + laboratory specimen observation + centralized field practice." Although this model can complete basic teaching tasks, problems such as traditional teaching models, insufficient educational effectiveness, and one-sided evaluation systems have gradually emerged during long-term teaching practice, making it difficult to meet the needs of pharmaceutical talent training in the new era. The specific dilemmas are as follows:

First, theoretical teaching is monotonous, the classroom atmosphere is dull, and students lack learning initiative. The theory of Pharmaceutical Botany covers the microstructure of plant cells, tissues, organs, as well as the family and genus characteristics, identification points, and medicinal properties of hundreds of medicinal plants. The knowledge points are complex and highly abstract. Traditional teaching relies on blackboard writing, static wall charts, and black-and-white pictures in textbooks, which cannot intuitively display the dynamic growth process of plants, microstructural organization, or species differences. Students can only memorize knowledge points mechanically, resulting in low learning efficiency and easy confusion [3]. At the same time, the traditional classroom is mainly teacher-oriented and relies on one-way output. Students listen passively, lacking independent thinking and inquiry space. Most students regard the exam as their sole learning goal. After the course ends, the knowledge forgetting rate is high, making it difficult to achieve knowledge internalization and integration.

Second, practical teaching is severely restricted, and educational outcomes vary. Field practice is a core component of practical teaching in Pharmaceutical Botany and a key link between theoretical knowledge and clinical/scientific research applications. The traditional field practice often adopts the model of "teacher explains along the way, students memorize passively," which lacks the practical process of independent observation, independent retrieval, and active discrimination by students. As a result, the cultivation of practical ability becomes a mere formality [4]. At the same time, field practice is significantly constrained by time and space, teacher-student ratio, teacher experience, and student differences: practice time is fixed during the flowering period of plants, making it impossible to observe key identification features such as fruits and seeds; young teachers lack experience in field plant identification, leading to inconsistent teaching quality; the teacher-student ratio is too high, resulting in unsatisfactory teaching outcomes; the unified teaching pace cannot meet the personalized learning needs of students with different foundations. Ultimately, it is difficult to standardize and consistently guarantee the quality of practical teaching.

Third, the assessment and evaluation system is one-sided and cannot comprehensively measure student abilities. Traditional course assessment is centered on a final closed-book written examination, supplemented by simple practical plant identification in the field. The assessment content focuses on theoretical knowledge memorization, neglecting the comprehensive evaluation of students' practical identification ability, autonomous learning ability, innovative thinking, and teamwork skills [1]. The single summative assessment model encourages exam-oriented learning characterized by "short-term memorization for examination purposes with rapid subsequent knowledge decay," which weakens attention to the learning process, fails to comprehensively and objectively reflect students' professional competence and comprehensive abilities, and does not fulfill the guiding, motivating, and diagnostic functions of assessment for teaching.

Fourth, the fusion of value-oriented guidance in the teaching route was inadequate, and the efficiency of talent training requires further enhancement. Traditional Pharmaceutical Botany teaching has been focused on the delivery of knowledge and the development of experimental skills, while paying less attention to the ideological and political dimensions in the course, including traditional Chinese medicine culture, scientific spirits, professional ethics, and humanistic values [5]. Due to the lack of continuous value guidance throughout the teaching process, students tend to limit their understanding of the discipline to technical proficiency alone. Consequently, the promotion of cultural confidence in TCM, a rigorous scientific spirit, ecological awareness, and a sense of professional responsibility remains insufficient. Hence, we need to establish the goals of education for raising virtue and character development.

In summary, the multiple shortcomings of the traditional teaching model significantly restricted both the improvement of teaching quality in Pharmaceutical Botany and the ability enhancement among students. It is therefore necessary to establish a comprehensive and systematic reform and innovation of the curriculum.

3. Construction and practice of innovative teaching methods

To address the four major dilemmas of traditional teaching, our team draws on mature experiences from international biology education and integrates mainstream teaching and management models, including flipped classroom, CBL, PBL, and the PDCA cycle, to build a "four-dimensional integrated" innovative teaching system. The system takes "theory as foundation, practice for empowerment, assessment as guidance, and ideological and political education" as its core logic. The four modules support one another and operate in a coordinated manner, covering the entire pre-class, in-class, and post-class process, balancing knowledge transmission, ability cultivation, and value guidance.

3.1. Theoretical teaching: Diversified interaction to activate autonomous learning ability

Theory is the foundation of practice. To address dull and inefficient traditional classrooms, our team integrates several mainstream international active teaching models to build a diversified interactive classroom that fully mobilizes students' subjective initiative. The active learning M^3 model, which consists of Motivation, Mastery, and Metacognition, provides core theoretical support for our diversified interactive classroom. This model states that the core of active learning is to fully mobilize students' subjective initiative through diversified interactive teaching forms, thereby promoting active internalization of knowledge [6].

3.1.1. Multimedia empowerment to create an interesting classroom

Using information-technology materials such as high-definition images, growth time-lapse videos, and three-dimensional animations, abstract plant microstructures, growth cycles, and identification features are visualized. For example, when explaining the "Casparian strip," three-dimensional animation displays the structure from multiple angles instead of relying solely on textual explanations; complete growth videos of medicinal plants are also shown to help students establish systematic understanding [3]. At the same time, teaching incorporates life cases and industry hot topics, such as comparing the morphological and value differences between saffron (*Crocus sativus* L.) and safflower (*Carthamus tinctorius* L.), explaining the revision of the "Chinese Pharmacopoeia" regarding honeysuckle (*Lonicera japonica* Thunb.), connecting theoretical knowledge with practice and enhancing classroom interest.

3.1.2. CBL combined with flipped classroom to create an interactive classroom

Flipped classroom and case-based learning (CBL) are among the most widely used active teaching models in international botany and biology courses. Research confirms that inquiry-based case learning modules can effectively transform teacher-student roles and enhance class participation and active learning ability [7]. This course deeply integrates the two models to construct a closed-loop teaching process of "pre-class independent inquiry—in-class discussion and questioning—post-class consolidation and extension" (**Table 1**).

Table 1. Teaching implementation process of CBL + flipped classroom

Stage	Teachers' work	Students' tasks	Teaching objectives
Pre-class	Release medicinal plant cases, learning resources, and task requirements	Consult literature, prepare presentation PPT, sort out plant origin, characteristics, efficacy	Preview independently, cultivate literature retrieval ability
In-class	Comment on presentations, correct misunderstandings, organize group discussions	Group presentations, interactive discussion, exchange views	Deepen understanding, exercise expression, and critical thinking skills
Post-class	Assign extension tasks, collect feedback	Review knowledge points, complete extension exercises	Consolidate knowledge, extend learning depth

In teaching practice, 40 commonly used medicinal plants from the "Pharmacopoeia" are selected as cases. Students complete the inquiry and deliver presentations in small groups. During online teaching, this model was implemented using Tencent Meeting and WeChat platforms. Surveys show that 94% of students recognized its teaching effectiveness, and classroom participation was greatly improved [8]. This model breaks the "teacher-centric monologue," positions students as the main body of the classroom, and aligns with the educational philosophy of active learning.

3.1.3. Interest-oriented + project-based learning to cultivate thinking ability

Project-based learning (PBL) has been confirmed by multiple meta-analyses to significantly enhance the higher-order thinking skills (analysis, synthesis, evaluation) of biology students, with significant positive effects in cognitive, practical, and emotional dimensions [9]. Based on this conclusion, this course implements an "interest-oriented, task-driven" project-based teaching approach. At the beginning of the course, diverse topics such as identification of easily confused plants, campus medicinal plant survey, and ancient herbal text research are set. Students form their own teams, determine research projects, and conduct investigations using resources such as the medicinal plant garden and digital specimen database. At the end of the term, students present their results in the form of PowerPoint presentation, pictorial guides, survey reports, etc.

This model respects differences in students' interests, promoting a shift in learning mindset from "passive acceptance" to "active inquiry." During project implementation, it simultaneously exercises comprehensive skills such as teamwork and problem-solving [10].

3.1.4. Short review writing to cultivate scientific research literacy

Academic writing ability is a core competency for students in biology and pharmaceutical sciences and is also a key training component of international biology education. In biology education, early academic writing training can effectively help students establish academic norms, improve scientific writing and critical thinking skills, and lay a foundation for subsequent scientific research work [11]. This course adds a short review-writing exercise, which requires students to select a medicinal plant and write a standardized review on its morphology, chemical constituents, pharmacology, and research progress. Teachers guide literature retrieval, logical structuring, and academic norms throughout the process, correcting the problem of simply piling up fragmented information. This exercise not only consolidates professional knowledge but also lays a foundation for students' subsequent course papers, graduation projects, and scientific research work [12].

3.1.5. Specialized teaching of plant Latin names to solidify professional foundations

Latin names are internationally accepted identifiers for medicinal plants and crude drugs, serving as a core tool for avoiding the problems of “homonyms and synonyms” [13]. Traditional teaching insufficiently emphasizes Latin names and often relies on rote memorization. Our team has optimized the teaching methods by telling the historical stories of pioneering scientists like Linnaeus to highlight the importance of Latin names and the scientific spirit, enhancing students’ recognition of the value of learning Latin names; using real poisoning cases from consuming *Gelsemium elegan*s (Gardn. & Champ.) Benth. to illustrate the practical value of Latin names; deconstructing the etymology and word formation rules of Latin names to abandon rote memorization; and focusing on core species from the “Pharmacopoeia” to streamline teaching content, reduce learning difficulty, and help students build a solid professional foundation.

3.2. Practical teaching: Integration of virtual and real, quality improvement with PDCA cycle

Pharmaceutical Botany is a highly practical course. Field practice and specimen observation are core teaching links. Our team introduces the “PDCA cycle quality management model” (Plan-Do-Check-Act). This model has been widely used in teaching quality control in universities worldwide, effectively supporting standardization and continuous optimization of teaching processes [14]. Relying on this model, we have also built an integrated “physical + virtual” living plant practice platform.

3.2.1. PDCA cycle to optimize field practice management

Field practice is divided into four closed-loop stages. Plan (P), formulate the practice route and assessment criteria, conduct safety training, organize collective lesson preparation for teachers, enhance the teaching ability of young teachers, and identify safety hazards; Do (D), abandon the “explain along the way” model, integrate PBL teaching, assign key families (e.g., Lamiaceae, Asteraceae, Fabaceae) to groups, students observe independently, summarize characteristics, and identify species while teachers are only responsible for guidance and questioning; Check (C), comprehensive assess plant identification, specimen preparation, teamwork, resource protection, etc., instead of solely assessing identification ability; Act (A), collect feedback from students and teachers, identify shortcomings in the practice process, optimize the plan for the next cohort, and forming a continuous iterative virtuous cycle. The PDCA cycle makes field practice management more standardized, fundamentally changes the “superficial” state of student practice, and significantly improves practical outcomes.

3.2.2. Integrated virtual-actual living plant practice platform

To address the temporal and spatial limitations of traditional specimens and fieldwork, a three-in-one practice platform is established. First, an on-campus medicinal plant garden cultivates over 600 species of medicinal plants for regular student observation. Second, off-campus field-practice bases, such as Tianmu Mountain in Zhejiang Province, provide rich wild plant resources for comprehensive training [15]. Third, a digital virtual herbarium integrates high-definition images, growth videos, and identification data, breaking time and space constraints, enabling online practice at any time. The virtual-physical integration model is also a mainstream direction in the digital transformation of botany education. It is reported that over 60% of European and American universities have introduced virtual practice platforms in botany courses, effectively compensating for the time and space limitations of physical practice [2].

3.2.3. Digital tools to assist practice

Mobile apps for plant identification such as Aiplants (Institute of Botany, Chinese Academy of Sciences, Lulang Software (Beijing) Co., Ltd., 2016–2020) and Picture This (Hangzhou Ruiqi Software Co, Ltd, 2026), as well as authoritative platforms like iPlant and the Chinese Virtual Herbarium, are introduced to assist students in preliminary field identification and in accessing standard specimen information, reducing dependence on teachers and cultivating independent inquiry skills.

3.3. Assessment system: Process-oriented, establishing multi-dimensional comprehensive evaluation

Drawing the concept of diversified evaluation in international higher education, this course abandons the summative assessment model of "one final exam determines the grade" and constructs a "whole-process, multi-dimensional" formative assessment system. In the M^3 model of active learning, formative assessment is regarded as one of the three core pillars that ensure the effectiveness of active learning. Through dynamic tracking of the entire learning process, it effectively avoids the utilitarian orientation of summative assessment, guiding students to value the learning process rather than only the final exam [6].

After optimization, the total course grade consists of four parts: the final theoretical score accounts for 50%, the laboratory practical score accounts for 25%, the field practice score accounts for 25%, and regular formative assessments are added. The regular grade is no longer limited to attendance; instead, it comprehensively includes performance in flipped-classroom presentations, quality of autonomous learning tasks, short review-writing level, classroom interaction participation, *etc*. Among these components, the scoring for flipped-classroom presentations and short review-writing adopts a mechanism where student peer assessment and teacher assessment each account for 50%. Research shows that peer assessment mechanisms can not only effectively share teachers' grading burden but also allow students to learn from others' strengths, improve their critical thinking and academic evaluation abilities, and further strengthen their understanding of academic norms [11].

The field practice score abandons the single species identification assessment and comprehensively evaluates students' overall performance in field operations, specimen preparation, group presentations, teamwork, resource protection, etc. Research indicates that process-oriented practical assessment under the PDCA cycle can fully reflect students' practical abilities, rather than relying solely on a final identification test, thereby effectively enhancing the educational outcomes of practical teaching [14].

The diversified formative assessment system effectively addresses the drawbacks of exam-oriented education, guides students to value the entire learning process, actively deepens professional knowledge, and develops practical skills. At the same time, it comprehensively, objectively, and accurately evaluates students' knowledge mastery, practical ability, autonomous learning ability, and innovation literacy, fully leveraging the guiding, motivating, and diagnostic functions of assessment to continuously promote the optimization of learning and teaching styles [10].

3.4. Value guidance: Integration of micro-ideological and political education to foster virtue

Grounded in the fundamental task of fostering virtue and cultivating people, adhering to the principle of "moistening things silently" (subtle, implicit influence), the concept of "micro-ideological and political education" is deeply integrated into the entire teaching process of Pharmaceutical Botany. Ideological and political elements inherent in the course, such as TCM culture, scientific spirit, humanistic literacy, ecological protection, and professional responsibility, are excavated to achieve a seamless connection between professional teaching and ideological and political education. A review of botany education notes that botany education in the new era should not only cultivate students' professional abilities but also continuously strengthen the cultivation of humanistic literacy and social responsibility, achieving the goal of holistic education, which is highly consistent with our micro-ideological and political education concept [2].

We abandon the rigid, preaching-style implementation of ideological and political education. Instead, fragmented, contextual, and everyday micro-teaching cases are used to integrate ideological and political education deeply with professional teaching. Humanistic literacy and character education are embedded in the growth characteristics of plants. By combining the characteristics of plant roots growing toward the ground, silently taking root and nourishing the above-ground parts, students are guided to appreciate the spirit of roots that silently take root underground and dedicate themselves selflessly, developing a professional character of being down-to-earth, willing to contribute, and staying true to the original aspiration. Combining the tenacious growth characteristics of medicinal plants adapting to different environments (e.g., *Cistanche deserticola* growing tenaciously in the desert, *Rhodiola rosea* in high-altitude areas), students are guided to learn the spirit of struggling tenaciously and facing difficulties bravely, adjusting and growing hard in any environment. Combining the cultural imagery of medicinal plants such as plum blossom, orchid, bamboo, and chrysanthemum, values of self-cultivation and moral integrity are embedded, enhancing students' humanistic literacy and moral cultivation.

Cultivating scientific spirit and cultural confidence through TCM research cases. When explaining *Artemisia annua* (sweet wormwood), the classic case of Tu Youyou's team delving into ancient TCM texts, successfully extracting artemisinin after numerous experiments, overcoming malaria, and winning the Nobel Prize is used to highlight the profundity and contemporary value of TCM, cultivating students' cultural confidence in TCM, rigorous scientific spirit, and persistent spirit of exploration. By incorporating the industry proverb "Rhubarb saves people without merit, ginseng kills without fault," students are guided to establish dialectical thinking, rigorous scholarship, and precise medication concepts, solidifying their professional ethics in pharmacy.

Cultivating protection awareness and professional responsibility through ecology and resource cases. In field practice, rare and endemic species such as *Ostrya rehderiana* and *Yulania amoena* are used to explain the conservation status of wild plants, and China's ecological protection policies are explained, guiding students to establish ecological protection awareness. When explaining the development of medicinal plant resources, students are guided to establish a concept of sustainable development, understand the limitations of wild medicinal plant resources, promote artificial cultivation and sustainable resource utilization, and cultivate students' professional responsibility: as pharmaceutical professionals, they must protect medicinal plant resources and achieve sustainable development of the industry.

Humanistic heritage is enriched through traditional poetry and culture. The medicinal plant imagery contained in the Book of Songs and classical poetry is deeply explored. The traditional cultural connotations and humanistic emotions carried by plants such as *Cornus officinalis*, *Salix babylonica*, and *Angelica dahurica* are interpreted. Professional knowledge is organically integrated with excellent traditional Chinese culture, allowing students to experience the charm of traditional culture while learning professional skills, enhancing cultural identity, and humanistic heritage.

Other studies have also confirmed that integrating value guidance into inquiry-based learning can effectively enhance students' learning motivation while helping them establish correct professional values, achieving the synergistic cultivation of knowledge and literacy [7]. Through the contextualized and normalized integration of micro-ideological and political elements, the shortcomings of traditional teaching in value guidance are effectively compensated, achieving the three-in-one educational goal of knowledge, ability, and literacy, helping students establish a correct world outlook, life outlook, and values; and cultivating new-era pharmaceutical talents with professional ability, humanistic literacy, national sentiment, and professional responsibility [5].

4. Analysis of the application effect of the innovative teaching model

The innovative teaching system has been applied to multiple cohorts of Pharmacy and Chinese Materia Medica majors. Effect analysis was conducted through multi-dimensional methods such as questionnaires, grade comparison, and practical assessment. The overall results are substantial.

Significant improvement of learning interest and independent learning ability: A survey of pharmacy students shows that 91% of students have a better experience with the new classroom, and 87% develop the habit of autonomous learning after class, much higher than the 42% in the traditional teaching stage. Project-based learning, flipped classroom, and other related models fully stimulated students' desire to explore, fostering a positive learning environment characterized by intrinsic motivation.

Professional ability and scientific research literacy are comprehensively enhanced: A total of 82% of students believed that independent inquiry and group presentations exercise their critical thinking and problem-solving abilities; and 79% of students significantly improved their practical skills such as field identification and specimen preparation [8,10]. Short review-writing training enables students to master academic norms, and many students participate in university-level innovation projects based on course achievements, demonstrating emerging research capabilities. The effect of the PBL model on cultivating higher-order thinking is fully verified, highly consistent with the meta-analysis conclusions in the literature [9].

Comprehensive literacy and academic quality steadily improved: 93% of students deepen their understanding of TCM culture, with significantly enhanced cultural confidence. Group cooperation and field practice also exercise communication and collaboration skills. Academic data show that the course failure rate dropped from 5% to below 1%, indicating more solid knowledge mastery.

High replicability of the teaching model: The complete set of teaching processes, platform construction, and assessment standards is highly standardized, applicable not only to Pharmaceutical Botany but also a reference for similar courses such as Pharmacognosy and Chinese Materia Medica Identification.

5. Existing problems and future prospects

After years of practice, although this innovative system has achieved good results, there are still three shortcomings: First, significant differences in student learning conditions exist. Some students who have long adapted to passive learning are not well suited to autonomous inquiry-based teaching models, leading to perfunctory task completion. Second, diverse innovative teaching methods, case development, and process control increase teachers' workload and require higher comprehensive abilities from teachers. Third, digital virtual teaching resources remain insufficiently rich, and functions such as immersive virtual training and intelligent question-and-answer (Q&A) require further improvement. In response to these problems and considering the global trends in botany education, we believe the subsequent optimization directions mainly include the following.

(1) Parallel stratified teaching and incentives: Develop personalized guidance plans for students with different foundations and learning habits, improve process-based incentive mechanisms, narrow the gap in learning conditions, and ensure the participation of all students;

(2) Strengthen teaching-team construction: Through special training, collective teaching research, and mentorship of junior faculty by senior faculty, enhance teachers' capabilities in information-based teaching, case design, and classroom organization, and share workload through teamwork;

(3) Intensify digital resource construction: Combine AI and virtual simulation technologies to enrich the training scenarios of the virtual botanical garden, build an intelligent Q&A platform, create an immersive and intelligent teaching environment, and keep pace with the trend of educational digitalization;

(4) Intensify curriculum-based ideological and political education: Continuously excavate profession-related ideological and political materials, form an ideological and political database, promote the deep integration of ideological and political elements with knowledge points, and further implement the fundamental task of fostering virtue through education.

6. Conclusion

As a core foundational course for Pharmacy and Chinese Materia Medica majors, promoting teaching reform in Pharmaceutical Botany is an inevitable choice for adapting to talent training in the new era and aligning with international educational trends. By combining international mainstream teaching methods (flipped classroom, CBL, PBL, PDCA cycle) with the local characteristics of the course, this paper constructs a four-dimensional innovative teaching system featuring "diversified interactive theory, integrated virtual-actual practice, whole-process assessment coverage, and comprehensive integration of ideological and political education."

This system effectively solves the pain points of traditional teaching models, including monotony, disconnection between theory and practice, one-sided evaluation, and insufficient value guidance, thereby comprehensively improving classroom quality, students' practical abilities, and comprehensive literacy. The overall teaching plan is logically clear, strongly implementable, and replicable. It not only provides a practical sample for the reform of Pharmaceutical Botany but also offers a reference for practical courses in biology and pharmaceutical sciences. Our teaching team will continue to benchmark against the frontiers of international education, continuously optimize teaching resources and methods, and provide solid support for cultivating innovative and versatile pharmaceutical talents in the new era.

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