A Blended Teaching Practice to Promote Students' Deep Learning: A Case Study in Pharmacology of Traditional Chinese Medicine

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Abstract: Deep learning represents an important pathway to fostering human development. China Education Modernization 2035 explicitly emphasizes the integration of intelligent technologies into all aspects of teaching and learning. In the era of Education Informatization 2.0, how to effectively achieve deep learning, particularly within technology-supported environments, has become a key issue in educational development. As a significant reform strategy in higher education, blended teaching provides broad opportunities for facilitating students' deep learning. To this end, this study takes the Pharmacology of Traditional Chinese Medicine (TCM) course as an example and employs Rain Classroom to implement blended teaching practices. Through classroom observation, questionnaires, and interviews with both teachers and students, we comparatively analyze the changes in students' deep learning abilities before and after the course, aiming to identify effective approaches for promoting deep learning. The results indicate that this teaching model significantly enhances higher-order thinking skills and affective learning experiences, while suggesting that assessment mechanisms and resource quality still require optimization. These findings provide useful implications for improving the teaching quality of TCM pharmacology and for cultivating innovative talents in the field of traditional Chinese medicine.

Keywords: Pharmacology of Traditional Chinese Medicine; Blended Teaching Model; Deep Learning; Outcome-Based Education; Rain Classroom

1. Introduction

China's rapid socio-economic development has intensified global complexity and specialization. Learners who remain at a surface learning level cannot meet the demands of future work [1]. To cultivate talents capable of adapting to dynamic contexts, scholars have emphasized the importance of fostering deep learning [2,3]. In the era of Education Informatization 2.0, how to effectively achieve deep learning, especially with the aid of information technology, has become a central issue in education [4].

The innovation-driven strategy and advances in artificial intelligence and big data are reshaping learning patterns and enabling new educational models [5]. Examples range from Khan Academy and flipped classrooms to micro-lectures, MOOCs, and platforms such as Chaoxing, Zhihuishu, Rain Classroom, and WeCom. These tools enrich traditional face-to-face instruction and support a shift from teacher-centered to student-centered pedagogy [6]. By integrating online and offline opportunities, blended teaching overcomes temporal and spatial limits, increases student engagement, and fosters the development of deep learning.

Although blended teaching adoption in higher education has grown rapidly, challenges remain. Effective integration of online and offline components, and their impact on student competencies and innovative talent cultivation, remain unresolved. Exploring blended teaching models that truly promote deep learning is therefore essential for improving teaching quality.

Research on deep learning in China has mainly focused on instructional design and applications within online, blended, flipped, or subject-based contexts [1-3, 7-9]. Similarly, studies on blended teaching emphasize model design, theory, and platform development, but rarely assess its impact on students' deep learning [9-11]. This study addresses this gap by focusing on affective experience and higher-order thinking. A blended teaching model oriented toward deep learning was designed to guide students through clear objectives and tasks, strengthen communication and feedback, and enhance overall competence.

In today's digital context, integrating online platforms into pedagogy is a pressing task for educational reform to improve deep learning and cultivate innovative talents. Blended teaching particularly highlights the student's central role. This study takes the course *Pharmacology of Traditional Chinese Medicine* as a case, applying Rain Classroom for blended instruction. The goal is to explore effective strategies for enhancing students' deep learning, and to provide empirical evidence for improving instructional effectiveness and talent cultivation.

2. Construction of a Blended Teaching Model for Pharmacology of Traditional Chinese Medicine (TCM) to Promote Deep Learning

2.1 Pre-Class Development of Teaching Resources

Teaching resources form the foundation of blended learning and consist of both offline and online materials. Offline resources mainly include standard textbooks and reference works, while online resources integrate course information, teaching content, and activity modules. Prior to course implementation, resources were organized according to students' learning levels, embedding the principle of student-centered learning. Specifically, resource development was guided by course objectives and emphasized the concurrent cultivation of knowledge, skills, and affective qualities. Offline resources relied on nationally adopted pharmacology of TCM textbooks. Online resources were designed following the cognitive principle of "from simple to complex, from isolated to integrative," and included micro-lecture videos, reading materials, and practice question banks. This dual approach not only contextualized abstract concepts and transcended the temporal and spatial limitations of traditional teaching but also stimulated students' interest and agency in learning.

2.2 Integration of Online and Offline Teaching during Class

During instruction, course content was modularized and aligned with specific learning objectives at both chapter and topic levels. Therefore, a blended mode combining online and offline methods, theory and practice, lectures and discussions, as well as case-based and problem-based learning was adopted to increase student engagement. For introductory chapters—such as pharmacodynamics, pharmacokinetics, and modern research on TCM drug theory—lectures were primarily conducted offline, supplemented by curated online resources to facilitate comprehension. By contrast, in specialized sections on pharmacological actions of individual Chinese medicines, pre-class micro-videos via Rain Classroom were provided online, followed by in-class discussions where students analyzed challenging questions and extended learning through group interaction. In addition, multiple instructional approaches were implemented, including flipped classrooms, thematic discussions on TCM literature, virtual simulation practices through the national experimental platform, and group-based experimental design projects. These diverse strategies collectively fostered deeper knowledge construction and higher-order thinking.

2.3 Post-class Multidimensional Evaluation and Continuous Improvement

In the blended teaching model, assessment integrated online and offline components, shifting from reliance on traditional written examinations to multidimensional evaluation. Final course grades combined three elements: online platform performance, in-class participation, and final written exams. Online assessment further encompassed pre-class preparation, in-class engagement, quizzes, and post-class exercises, while offline evaluation included flipped classroom participation and group collaboration. This process-oriented assessment system significantly improved students' awareness of their learning attitudes and behaviors. Moreover, Rain Classroom provided real-time data on student participation and task completion, enabling instructors to identify issues and adjust instruction accordingly. Through a cycle of pre-class preparation, in-class questioning, post-class practice, extended learning, and teacher-student interactions, students could continuously monitor and refine their learning process, thereby achieving sustained deep learning.

3. Effectiveness Analysis of a Blended Teaching Approach for Enhancing Students' Deep Learning

3.1 Participants

This study involved 55 third-year students majoring in Chinese Medicinal Resources and Development (Class of XX) and two instructors from the School of Life Sciences, XX Normal University. The research focused on constructing a blended teaching model for the *Pharmacology of Traditional Chinese Medicine* (TCM) course and implementing a practical teaching intervention to examine the effectiveness of this self-designed blended model in promoting students' deep learning.

3.2 Methods

Initially, literature on deep learning and blended education was collected, integrated, and analyzed to clarify the current state of blended learning in China and to establish the theoretical foundation for this study. Based on this, a blended teaching model for the Pharmacology of TCM course was developed and applied in an empirical study.

The research employed longitudinal classroom observations and case studies to record and analyze teaching activities, enabling an in-depth understanding of the teaching process and students' learning behaviors. This approach facilitated the identification of instructional challenges and student performance gaps, providing insights for subsequent instructional refinements. In addition, semi-structured interviews were conducted with both students and instructors to capture perceptions of the blended model's application and its impact on deep learning.

A questionnaire survey was administered via Tencent Questionnaire to evaluate both the implementation of the blended model and its effectiveness in fostering deep learning. The reliability of the surveys was assessed using Cronbach's alpha in SPSS (Table 1). Results showed that the Deep Learning Process Questionnaire had an overall reliability coefficient of 0.810, with sub-dimensions as follows: learning motivation (0.766), learning engagement (0.822), and deep learning strategies (0.841).

All exceeded the 0.7 threshold, indicating good reliability. Similarly, the Deep Learning Level Questionnaire exhibited an overall reliability of 0.779, with the following sub-dimension coefficients: knowledge transfer (0.851), teamwork (0.791), learning-to-learn ability (0.755), innovation (0.784), and critical thinking (0.712), again surpassing the 0.7 benchmark (see Table 2).

Table 1. Reliability Analysis of the Questionnaire (Deep Learning Process)

Sub-factor	Item(s)	Number of Items	Cronbach's α (All Items)	Cronbach's α
Learning motivation	1, 2, 3, 4	4	0.773	0.766
Learning engagement	5, 6, 7, 9, 15, 17	6	0.858	0.822
Deep learning strategies	8, 10, 11, 12, 13, 14, 16	7	0.702	0.841
Deep learning process (total)	1–17	17	0.778	0.810

Table 2. Reliability Analysis of the Questionnaire (Deep Learning Level)

Sub-factor	Item(s)	Number of Items	Cronbach's α(All Items)	Cronbach's α
Knowledge transfer	1, 5, 6	3	0.882	0.851
Teamwork	2, 3, 4	3	0.761	0.791
Learning to learn	8, 9, 14	3	0.843	0.755
Innovation ability	10, 11, 13	3	0.900	0.784
Critical thinking	7, 12	2	0.731	0.712
Deep learning level (total)	1–14	14	0.823	0.779

The Deep Learning Process Questionnaire achieved a KMO value of 0.899 with a Sig. = 0.000 (< 0.05), suggesting strong structural validity. The Deep Learning Level Questionnaire had a KMO of 0.751 with Sig. = 0.000, also confirming good structural validity. Hence, both instruments demonstrated satisfactory reliability and validity, supporting their suitability for the study.

Questionnaire design targeted three dimensions: (1) the Deep Learning Process Questionnaire assessed aspects such as personal learning satisfaction, self-assessment, and reflective capacity; (2) the Deep Learning Level Questionnaire explored classroom discussion quality, innovative problem-solving, teamwork, analytical skills, and autonomous learning capacity.

3.3 Effectiveness Analysis of the Blended Teaching Model

3.3.1 Analysis of deep learning process outcomes

The study examined changes in each dimension of students' deep learning process before and after the implementation of the blended teaching model. As shown in Table 3, prior to the intervention, the ranking of mean scores was: learning motivation > overall deep learning process > deep learning strategies > learning engagement. Post-intervention, the same pattern was observed. Statistical analysis revealed no significant difference in the overall deep learning process, with a slight decline in total scores. This suggests that the model had limited impact on process-level engagement, potentially due to factors such as an intensive course schedule and high online workload.

Table 3. Differences in Students' Deep Learning Process Before and After Blended Teaching Practice

Dimension	Before Blended Teaching Practice (Mean±SD)	After Blended Teaching Practice (Mean±SD)	p-value	t
Learning motivation	4.05 ± 0.73	3.95 ± 0.80	0.92	-0.09
Learning engagement	3.72 ± 0.89	3.73 ± 0.80	0.65	-0.46
Deep learning strategies	3.83 ± 0.86	3.74 ± 0.87	0.56	0.59
Deep learning process (total)	3.87 ± 0.83	3.81 ± 0.82	0.99	0.01

3.3.2 Analysis of deep learning level outcomes

Peer and external assessments were used to evaluate changes in students' deep learning levels. As presented in Table 4, significant improvements ($p < 0.05$) were observed in knowledge transfer, teamwork, and overall deep learning level after the adoption of the blended model. Before implementation, the ranking of dimensions was: critical thinking > learning-to-learn ability > overall deep learning level > innovation > knowledge transfer > teamwork. After implementation, the order shifted to: learning-to-learn ability > critical thinking > knowledge transfer > overall deep learning level > innovation > teamwork.

Overall, the model effectively enhanced several dimensions, particularly knowledge transfer, teamwork, and metacognitive "learning-to-learn" skills. However, gains in higher-order critical thinking were not statistically significant, indicating the need for targeted instructional strategies to strengthen this area.

Table 4. Differences in Students' Deep Learning Level Before and After Blended Teaching Practice

Dimension	Before Blended Teaching Practice (Mean±SD)	After Blended Teaching Practice (Mean±SD)	*p*-value	t
Knowledge transfer	3.63 ± 0.79	3.77 ± 0.65	0.02	-2.14
Teamwork	3.53 ± 0.84	3.70 ± 0.73	0.03	-2.19
Learning to learn	3.68 ± 1.05	3.83 ± 0.65	0.10	-1.70
Innovation ability	3.63 ± 0.88	3.70 ± 0.72	0.35	-0.95
Critical thinking	3.80 ± 0.87	3.82 ± 0.72	0.74	-0.33
Deep learning level (total)	3.66 ± 0.89	3.76 ± 0.70	0.04	-1.81

3.3.3 Analysis of student and teacher interviews

Student interviews indicated that 75% preferred the blended model, citing its role in promoting deep learning, fostering autonomous learning, developing critical thinking, and enhancing teamwork and communication. Many students highlighted the novelty of the format, diversified content, and interactive classroom atmosphere as factors enhancing learning motivation. Furthermore, 50% reported that pre-class resources provided via the Rain Classroom platform improved comprehension during in-class sessions, expanded learning beyond textbook content, and exposed them to current developments and practical methods in the field.

Nevertheless, 25% expressed a preference for traditional teaching methods, citing established learning habits, discomfort with online learning via mobile devices, perceived lack of classroom immersion, and a mismatch between the blended learning pace and their own study rhythms.

Teacher interviews revealed that the blended model broke cognitive constraints inherent in traditional teaching, focusing more on the depth of students' internal knowledge construction. The integration of online delivery allowed teachers to provide multi-dimensional resources ahead of class, enabling face-to-face sessions to focus on problem-solving and clarifying misconceptions. Students engaged in collaborative inquiry with peers and instructors, forming a learning community that facilitated deeper understanding and multi-dimensional skill development. Moreover, the model emphasized both student-centered learning and the guiding role of instructors.

However, challenges remained. Less self-disciplined students often failed to complete pre-class preparation, undermining in-class activities. During pandemic restrictions, continuous online learning reduced opportunities for peer interaction, leading to disengagement. While platforms such as Rain Classroom ensured continuity of teaching under emergency conditions, further research is required to optimize both the efficiency and quality of instruction.

4. Discussion

The blended teaching model designed in this study showed limited effectiveness in facilitating students' deep learning processes. Specifically, both learning motivation and deep learning strategies slightly declined after implementation. This may be attributable to the prolonged reliance on online instruction and a possible mismatch between the quantity or complexity of assignments and students' acceptance levels. Online teaching is also vulnerable to external factors such as hardware limitations, network instability, and domestic or dormitory environments. Moreover, extended interaction via digital devices cannot replicate the nuanced communication of face-to-face instruction, where immediate feedback and in-person guidance often enhance the learning process.

In this course, many online–offline practices were conducted exclusively through digital platforms, which restricted authentic classroom exchanges and consequently hindered the development of critical strategies, such as argumentation and analytical reflection. Furthermore, the success of deep learning relies heavily on students' self-regulation and attentional control, which varied among participants. Taken together, these factors may explain why the blended model did not achieve the expected outcomes in terms of deep learning processes [9].

In addition, the blended model required students to engage in multiple tasks, including pre-class preparation, thematic discussions, literature reviews, group presentations, flipped classrooms, and review exercises. While such activities may stimulate learning motivation when well-received, they may also have adverse effects if perceived as excessive. Interviews confirmed this divergence: high-achieving students considered the tasks well-designed, engaging, and conducive to skill development; mid-level students acknowledged the benefits of online discussions and flipped classrooms but reported diminished enthusiasm due to heavy workload; lower-achieving students expressed difficulty in keeping pace, often requiring repeated viewing of course videos and preferring teacher-led reinforcement of key content. Therefore, differentiated task design-targeted at lower-, middle-, and higher-level learners-may better sustain learning motivation in future iterations.

Despite these challenges, the blended model did exert a positive influence on certain dimensions of students' deep learning abilities. Notably, significant improvements were observed in knowledge transfer and teamwork. These gains may be attributable to interactive components such as group discussions and flipped classroom sessions that required students to analyze core TCM prescriptions, examine the pharmacological mechanisms of artemisinin, or design research approaches for antipyretic drugs. Through such activities, students consolidated knowledge structures, practiced collaborative communication, and applied concepts across contexts. However, no significant improvements were observed in critical thinking. The cultivation of this higher-order skill necessitates more deliberate instructional design, including creating cognitive conflicts, fostering dialectical debate, and engaging students in activities such as structured debates or argument-backed group presentations. These strategies could better enable students to objectively analyze pharmacological effects of TCM and articulate independent viewpoints.

Overall, this study systematically examined the interplay between blended teaching practices and students' deep learning in the *Pharmacology of Traditional Chinese Medicine* course. The findings identified both benefits and challenges, highlighting the need to refine blended models toward deep learning goals. Although the study yielded meaningful insights for pedagogical design, several limitations remain. The relatively small sample size, confined to a single class, and the exclusive focus on one subject restrict the generalizability of findings. Future research should therefore expand to diverse disciplines, larger and more varied cohorts, and broader instructional contexts to further validate and optimize the blended teaching model.

5. Teaching Reflections and Directions for Improvement

5.1 Optimization of the Assessment System

The current assessment system lacks sufficient alignment with the instructional approach. Traditional single-dimensional evaluation models, such as examinations dominated by final written tests, tend to weaken students' learning motivation and reduce instructional effectiveness [10]. Although innovative course design has significantly enhanced students' independent inquiry abilities, the absence of a complementary evaluation mechanism has constrained the depth of teaching reform. Specifically, deficiencies remain in formative assessment dimensions and in the availability of quantitative indicators [11]. Based on action research, our team proposes the establishment of a "comprehensive traceable evaluation system." By refining formative assessment criteria and strengthening data-driven evidence, each stage of evaluation can be anchored to transparent and objective standards.

5.2 Innovation in Teaching Models

Against the backdrop of digital transformation in higher education, blended instruction and AI-empowered teaching have emerged as significant reform trends [12]. Our teaching practice revealed that the traditional flipped classroom carries notable limitations, particularly in cultivating higher-order thinking skills and in linking theoretical learning with practical application. To address these issues, the team plans to construct a "research project-driven, AI-assisted blended model" guided by the Outcome-Based Education (OBE) framework. Through layered instructional design, theory–practice integration can be reinforced. For high-achieving students, a "course theme–research project" conversion mechanism will be introduced, encouraging knowledge deepening through iterative project design. Meanwhile, a framework for cultivating innovation and entrepreneurship competencies will be implemented to strengthen the synergy between creative thinking and research practice.

5.3 Improvement of Teaching Video Quality

Longitudinal surveys conducted from 2022 to 2025 on students' viewing behaviors demonstrated that instructional videos—core resources for flipped classrooms—substantially affect learning outcomes. However, early recordings of 20–30 minutes produced cognitive overload. To address this, we propose a "micro-modular video design framework." Each segment will focus on a single knowledge node within 10 minutes and employ concept maps to illustrate logical connections across topics. Embedded formative quizzes (one after every two nodes) will reinforce cognitive processing. Furthermore, course materials will undergo dynamic updates, incorporating a "content annotation" mechanism—for example, QR-code links to frontier literature—with an update rate of no less than 20% each semester. Looking forward, we aim to develop a learning analytics-based intelligent recommendation system to provide personalized resource delivery and further enhance instructional efficiency.

6. Conclusion

In summary, the reflections and proposed strategies highlight three pivotal directions for advancing blended teaching practice: evaluation alignment, model innovation, and resource optimization. First, an improved assessment system that incorporates process-oriented and data-driven indicators is essential to ensure the long-term sustainability of teaching reform. Second, innovation in teaching models, particularly through integrating research project-driven mechanisms with AI-assisted blended approaches under the OBE framework, provides new opportunities for enhancing higher-order thinking, theory–practice integration, and innovation capacity. Third, the adoption of micro-modular video design, coupled with intelligent recommendation systems, offers a promising pathway for addressing cognitive overload and achieving personalized learning support.

Therefore, the synergy among these dimensions—comprehensive evaluation, innovative instructional design, and optimized digital resources—can collectively promote deeper learning, foster multidimensional competencies, and enhance overall instructional effectiveness. These reflections not only inform the continual refinement of the *Pharmacology of Traditional Chinese Medicine* course but also provide transferable insights for the broader implementation of blended and AI-empowered teaching in higher education.

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