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Beyond Content Delivery: Investigating the Impact of Blended Micro-Courses on Pharmaceutical Literature Retrieval Skill Acquisition and Competency Development in Vocational Education

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Abstract: Micro-courses offer a flexible and accessible mode of learning. The effectiveness of a blended micro-course on pharmaceutical literature retrieval skills was empirically evaluated. Data were obtained from 76 pharmaceutical students in a quasi-experimental, pre-test-post-test control group design. Participants were allocated to an experimental group (n = 39) receiving the blended micro-course intervention or a control group (n = 37) receiving traditional instruction. Statistical analyses were undertaken in SPSS. Analysis of covariance (ANCOVA) was employed to compare post-intervention outcomes while controlling for baseline scores. The ANCOVA results revealed a statistically significant difference in favor of the experimental group for both practical skill acquisition ($F(1, 73) = 60.677$, $p < .001$, partial $\eta^2 = .454$) and competency development, including information need identification, retrieval, critical thinking, and application. Furthermore, students in the experimental group reported high levels of satisfaction with the blended micro-course, particularly praising its course design (M=5.0, SD=0.6) and the seamless integration of online and offline learning (M=4.8, SD=0.7). The findings provide evidence that a well-designed blended micro-course model, which intentionally integrates cognitive, social, and teaching presences, can significantly outperform traditional methods in fostering practical skills and professional competencies in vocational education.

Keywords: Blended learning; Micro-course; Vocational education; Online inquiry-based micro-lectures; Offline supervised practice

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1. Introduction

Vocational education has undergone significant transformations in recent decades, driven by the advancement

of information technology and evolving pedagogical philosophies. The rapid evolution of global industries and the increasing demand for a "job-ready" workforce have placed unprecedented pressure on vocational education and training (VET) systems worldwide.[1] Traditional VET models, characterized by rigid schedules and a primary reliance on face-to-face instruction, are often challenged by the need for greater flexibility, scalability, and alignment with industry practices. Particularly in fields like pharmacy and nursing, the ability to integrate theoretical knowledge with practical application in scenarios is crucial for nurturing workforce-ready graduates [2].

In response, digital learning technologies have emerged as a powerful catalyst for pedagogical innovation. Among these, micro-courses—short, focused learning modules—have gained significant traction due to their potential to deliver flexible, accessible, and just-in-time learning experiences[3].

Micro-courses, a fundamental component of blended learning, have evolved significantly over time. The initial phase, referred to as "Micro-Course 1.0," focused on short online lectures designed to deliver content in a concise format. However, the proliferation of micro-courses in vocational education and training (VET) has often been accompanied by a critical pedagogical flaw:Many micro-courses are designed as simple repositories of video lectures and reading materials, reducing learning to a passive act of information consumption.[4] This approach is particularly problematic in vocational education, where the ultimate goal is not merely knowledge acquisition but the development of tangible practical skills and multifaceted professional competencies[5].

In "Micro-Course 2.0", these resources started incorporating interactive elements and immediate feedback mechanisms, making them more engaging for learners. The current phase, "Micro-Course 3.0," emphasizes inquiry-based tasks and collaborative learning, prioritizing personalized learning and the development of higher-order skills beyond rote memorization.[6] This evolution highlights the potential for micro-courses to serve not only as content delivery mechanisms but also as tools for promoting active inquiry and collaborative problem-solving.

The critical question remains: How can micro-courses be designed to move "beyond content delivery" to become effective catalysts for applied learning and skill development? Blended learning, which strategically combines online and offline learning modalities, offers a promising solution. This approach allows theoretical knowledge to be delivered and assimilated online via micro-courses, freeing up valuable face-to-face time for hands-on practice, personalized feedback, and collaborative problem-solving.[7] This study posits that an intentionally designed blended micro-course, grounded in robust learning theory, can create a powerful ecosystem for vocational learning.

Blended learning is not simply a mix of technologies and traditional methods; it is a fundamental redesign of the instructional model to optimize the strengths of both environments.[8] In VET, its value lies in its ability to support the dual goals of knowledge construction and skill application. The online component can provide standardized, high-quality theoretical instruction through micro-courses, which students can access at their own pace. This prepares them for the offline component, where they can engage in intensive, supervised practice in labs or workshops, transforming theoretical understanding into practical proficiency.[9]However, the success of this model hinges on the seamless and purposeful integration of both components.

This research, situated within a leading pharmaceutical vocational college in China, investigates the impact of such a blended micro-course model. By employing a quasi-experimental design, this study aims to provide empirical evidence on the effectiveness of this approach compared to traditional teaching methods. The primary objective is to evaluate its influence on two core outcomes of vocational education: the acquisition of practical, hands-on skills and the development of broader professional competencies, such as information literacy and critical thinking, which are consistently identified as essential for success in the 21st-century workforce.[10]

Despite the widespread adoption of blended learning in Vocational Education and Training (VET), there is a scarcity of research that systematically explores pedagogical designs capable of moving beyond mere knowledge transmission to effectively foster complex applied competencies. This study addresses this crucial gap by applying the Community of Inquiry (CoI) framework.

2. Materials and Methods

2.1. Study design

The present study was a quasi-experimental, non-equivalent control group pre-test-post-test design study. It was conducted at Jiangsu Pharmaceutical Vocational College.

2.2. Ethical statement

Our study was approved by the Ethics Committee of the Jiangsu Pharmaceutical Vocational College under Approval ID TA_CACM_2023010 and SCX23086. The participants consented to participate in the study before completing the first questionnaire.

2.3. Participants and eligibility criteria

The participants were 76 second-year students enrolled in the Traditional Chinese Medicine program, distributed across two parallel classes. The experimental group comprised 39 students (33 female, 6 male; mean age = 19.2 years), while the control group consisted of 37 students (33 female, 4 male; mean age = 19.1 years). Independent t-tests and Chi-square tests confirmed that there were no statistically significant differences between the two groups at baseline regarding their college entrance scores, gender distribution, or age, ensuring group comparability.

2.4. Questionnaire

Adapt the existing ACRL (Association of College and Research Libraries) Information Literacy Framework for Higher Education and develop a scale for pharmaceutical information literacy and application capabilities, tailored to the specific scenarios of the pharmaceutical profession. Ten experts evaluated the relevance, clarity, and simplicity of the assessment and questionnaire which are available in full in Supplementary File 1, 2. The learning satisfaction questionnaire focuses on the design elements of blended micro-lessons, learning experience, interactivity, and their support for practical learning[11] .

2.5. Educational intervention

Week 1: A pre-test was administered to all students in both the experimental and control groups to collect baseline data on their operational skills and data from the self-assessment scale of their abilities.

Weeks 2 to 9 (8 weeks): This eight-week period was defined as the duration of the intervention, covering the core skill modules of the “Pharmaceutical Literature Retrieval” course.

Experimental Group: This group received the innovative blended micro-course intervention for the “Pharmaceutical Information Retrieval” module. The intervention was structured as follows:

Online Guided Learning: Students watched inquiry-driven micro-course videos, which included problem-based scenarios and interactive quizzes.

Offline Supervised Practice: In scheduled lab sessions, students applied the knowledge gained online to

perform practical tasks (e.g., database searching, literature analysis) under the guidance of an instructor who provided real-time feedback.

Online Reflection and Collaboration: Following the practice session, students completed reflective journals and participated in online discussion forums to solve complex problems collaboratively.

Control Group: This group received traditional instruction for the same module. This involved standard classroom lectures covering theoretical concepts, followed by conventional offline practice sessions where students completed assigned tasks with limited interactive guidance.

Week 10: A post-test was administered to students in both groups, using the exact same instruments as the pre-test. Concurrently, a learning satisfaction questionnaire was distributed to the students in the experimental group.

2.6. Data collection

A standardized performance-based assessment was used to measure students' practical skills in pharmaceutical information retrieval. A self-developed "Pharmaceutical Information Literacy and Application Competency Scale" was used to measure students' competency development. A "Blended Micro-Course Learning Experience Satisfaction Questionnaire" was administered to the experimental group at the end of the intervention. The scale and questionnaire were adapted to an online format, with an informed consent form included at the beginning to comply with the personal information protection standards. To maintain confidentiality and encourage honest responses, no personal information, such as names or student numbers, was collected [12].

2.7. Statistical analysis

Quantitative data were analyzed using SPSS 26.0. Descriptive statistics (mean, standard deviation) were calculated for all variables. To determine the intervention's impact, a series of Analysis of Covariance (ANCOVA) tests were conducted. For each dependent variable (practical skill score and each competency dimension score), the post-test score was used as the outcome variable, the group allocation (experimental vs. control) as the fixed factor, and the corresponding pre-test score as the covariate. This method statistically controls for any pre-existing differences between the groups, providing a more accurate estimate of the intervention's true effect. The significance level was set at $\alpha = 0.05$.

3. Results

3.1. Literature Retrieval Knowledge and Skill Acquisition Score

The evaluation of pharmaceutical literature retrieval skills is conducted through a test with a maximum score of 100, which is conducted once before and after the teaching intervention, scored by senior teachers using the same standardized scoring scale.

Independent T tests were performed to identify if there were significant differences between different modalities for students in regard to their post-test scores. **Table 1** indicates that there was a significant difference between the learning modality for the students, in regard to their post-test scores, $t(74) = 8.116$, $p<.001$. Since the mean difference (MD) was 12.82 and the pooled standard deviation was approximately 6.88, $d = 1.86$, according to Cohen (1988) indicated the large effect size. Thus, students taking classes in the blended micro-course learning modality performed better than students taking classes in the traditional learning modality.

This section may be divided by subheadings. It should provide a concise and precise description of the

experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

Table 1. Independent samples test for literature retrieval knowledge and skill acquisition scores in post-test groups

Group	Post-test Mean	Post-test SD	t	df	p
Experimental Group	86.72	6.73	8.116	74	.000*
Control Group	73.90	7.03			

The results of the ANCOVA on practical skill scores are presented in **Table 2**. After controlling for the pre-test scores, there was a statistically significant difference in the adjusted post-test mean scores between the experimental and control groups, $F(1, 73) = 60.677$, $p < .001$. The effect size was large (partial $\eta^2 = .454$), indicating that the blended micro-course intervention had a substantial positive impact on students' practical skill development. The experimental group (Adjusted M = 86.6) significantly outperformed the control group (Adjusted M = 74.0).

Table 2. Descriptive statistics and ANCOVA results for practical skill scores

Group	N	Pre-test Mean(SD)	Post-test Mean(SD)	Adjusted Post-test Mean	F-value	p-value	Partial η^2
Experimental	39	45.5(9.7)	86.7(6.7)	86.6	60.677	<.001*	.454
Control	37	41.8(7.2)	73.9(7.0)	74.0			

3.2. Competency Development

A self-developed "Pharmaceutical Information Literacy and Application Competency Scale" was used to measure students' competency development. The scale contains several dimensions, including "Information Need Identification & Articulation", "Information Access & Retrieval", "Information Evaluation & Critical Thinking", "Information Integration & Application", "Information Ethics & Etiquette", and "Autonomous & Lifelong Learning". This scale was also administered as a pre-test and post-test.

As shown in **Table 3**, the ANCOVA results consistently demonstrated the superiority of the blended micro-course across all measured dimensions of competency. Adjusted Post test Mean, refers to the average post test scores of each group after controlling for the influence of pre-test scores. This is one of the core outputs of ANCOVA, used to compare inter group differences more fairly. After adjusting for pre-test scores, the experimental group showed significantly higher post-test scores than the control group in areas such as Information Access & Retrieval ($F=28.963$, $p<.001$), Information Evaluation & Critical Thinking ($F=10.557$, $p<.001$), and Autonomous Learning & Lifelong Learning ($F=60.465$, $p<.001$). All effect sizes were moderate to large, confirming the intervention's robust effect on fostering holistic professional competencies.

Table 3. Comparison of competency development between two groups

Competency Dimension	Group	N	Pre-test Mean (SD)	Post-test Mean (SD)	Adjusted Post-test Mean	F-value	P-value	partial η^2
Information Need Identification & Articulation	Experimental	39	10.7 (0.7)	17.6 (1.0)	17.6	31.012	<.001	.298
	Control	37	10.6 (0.7)	16.4 (0.9)	16.5			
Information Access & Retrieval	Experimental	39	10.6 (0.6)	17.8 (1.3)	17.8	28.963	<.001	.284
	Control	37	10.6 (0.7)	16.4 (0.9)	16.5			
Information Evaluation & Critical Thinking	Experimental	39	9.2 (1.0)	16.0 (1.7)	16.0	10.557	<.001	.126
	Control	37	9.3 (0.9)	14.9 (1.3)	14.9			
Information Integration & Application	Experimental	39	10.7 (0.7)	18.8 (0.9)	18.8	42.881	<.001	.37
	Control	37	10.5 (0.6)	17.5 (0.9)	17.5			
Information Ethics & Etiquette	Experimental	39	9.4 (0.7)	14.9 (0.2)	14.9	26.967	<.001	.27
	Control	37	9.4 (0.8)	14.3 (0.7)	14.3			
Autonomous Learning & Lifelong Learning	Experimental	39	9.4 (0.7)	14.9 (0.3)	14.9	60.465	<.001	.453
	Control	37	9.5 (0.7)	13.9 (0.8)	13.9			

Through the visual presentation in **Figure 1**, the specific impact of blended micro-courses on students' competency development can be better illustrated. "Information Access & Retrieval" showed a significant upward trend in the experimental group, with the post-test average score increasing from 10.6 in the pre-test to 17.8. The experimental group also showed substantial increases in the two dimensions of "Information Evaluation & Critical Thinking" and "Autonomous Learning & Lifelong Learning", specifically reflected in students' strategy selection and sustained engagement when facing complex tasks. Combined with effect size analysis, the promoting effect of blended micro-courses on self-directed learning was particularly prominent (partial η^2 = .453), indicating that the cognitive conflict design and immediate feedback mechanisms in its teaching design effectively stimulated higher-order thinking activities.

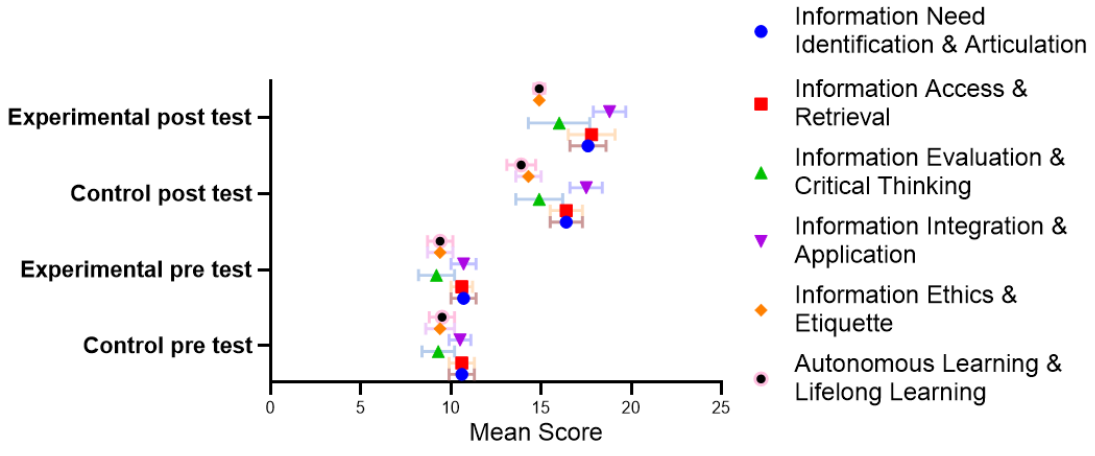

Figure 1. Changes in competency dimensions for experimental and control groups

3.3. Students' Learning Experience and Perceptions

The questionnaire data from the experimental group indicated a very positive reception of the blended micro-course. Students reported high satisfaction with the "Course Content & Design" (M=5.0, SD=0.6) and the "Learning Outcomes & Overall Experience" (M=5.0, SD=0.6). The dimension of "Online-Offline Integration & Practical Support" (M=4.8, SD=0.7) also received a high rating, suggesting that students perceived the blended model as a coherent and supportive learning journey rather than two disconnected parts.

3.4. Micro-Course Design Elements

To further analyze the content and structure of blended micro-courses, we established an analytical framework based on the Community of Inquiry framework and Mayer's Multimedia Learning Principles from the literature, and then examined whether the micro-courses contained these "beyond content delivery" elements one by one. The analysis results showed that the experimental group's micro-courses demonstrated certain manifestations in the three dimensions of Cognitive Presence, Social Presence, and Teaching Presence. The embedded questions, immediate feedback, and situational simulation tasks in the blended micro-course design enhanced learning engagement, enabling students to gain a stronger subjective experience in the knowledge construction process, thereby supporting the occurrence of deep learning. This student-centered design concept laid a solid foundation for subsequent autonomous learning. Interview data indicated that students generally believed that the question design in the micro-courses effectively guided them to think progressively in depth. The teacher's role has transformed from a knowledge transmitter to a learning facilitator, providing guidance at critical moments without replacing thinking. At the same time, this also verified the aforementioned student questionnaire results, indicating that the blended course model can significantly improve problem-solving abilities and critical thinking levels[13].

4. Discussion

The significantly higher practical skill scores of the experimental group (Table 1) demonstrate the power of the blended model. [14]Unlike traditional teaching, where class time is spent on lectures, the intervention "flipped" the learning. Students used online micro-courses to acquire foundational knowledge before the practical session. This allowed the precious offline time to be dedicated entirely to hands-on application, guided practice, and personalized feedback from the instructor. This aligns with the principles of experiential learning, where concrete experience and reflective observation are critical for skill development. The blended model created an effective bridge between "knowing" and "doing". The most significant finding was the experimental group's marked improvement in pharmaceutical literature retrieval skills ($F(1, 73) = 60.677$, $p < .001$). This result strongly suggests that the blended micro-course model is not merely an alternative to traditional instruction but a more effective pedagogical approach for procedural knowledge and practical skills.

The online inquiry-based micro-lectures allowed students to learn at their own pace, repeatedly viewing complex search strategies and database operations. This aligns with Cognitive Load Theory (CLT), which posits that breaking down complex information into smaller, manageable "micro" units can reduce extraneous cognitive load, thereby facilitating schema acquisition and transfer. This format is particularly suited for fostering self-regulated learning, as students can take control over the timing, pacing, and sequence of their learning activities. Unlike a traditional lecture where students have a single opportunity to grasp information, the on-demand nature of micro-courses empowers learners to master foundational knowledge before entering the hands-on practice session.

Subsequently, the offline supervised practice sessions provided a crucial scaffold for skill consolidation.

In these sessions, students applied their online learning to authentic tasks under the real-time guidance of an instructor. This immediate, personalized feedback is critical for correcting misconceptions and refining practical techniques—a component often lacking in conventional, less interactive lab sessions. This finding resonates with research by Hattie and Timperley, which identifies timely and specific feedback as one of the most powerful influences on learning. The blended model, therefore, creates a powerful learning cycle: online modules build declarative knowledge, while offline practice transforms it into robust procedural skill

The success in fostering these competencies can be explained through the lens of the Community of Inquiry (CoI) framework. Our blended micro-course model was intentionally designed to foster all three core presences:

Cognitive Presence: The inquiry-based tasks embedded in the online modules and collaborative problem-solving in forums prompted students to move beyond simple information retrieval. They were required to evaluate the credibility of sources, synthesize findings, and apply information to solve complex problems, thereby engaging in higher levels of cognitive processing (i.e., integration and resolution). The progression from online foundational tasks to complex offline application reflects the structured development of cognitive presence, moving from exploration to the critical stages of integration and resolution[12].

Social Presence: The online discussion forums created a space for peer-to-peer interaction and collaborative learning. Students were not passive recipients of information but active co-constructors of knowledge. This aligns with Vygotsky's social constructivist theory (1978), which argues that learning is fundamentally a social process. By debating solutions and sharing insights, students developed communication skills and were exposed to diverse perspectives. This finding is consistent with research demonstrating that well-facilitated online discourse can serve as a powerful catalyst for collaborative inquiry and critical reflection, [13]which are essential for developing robust critical thinking.

Teaching Presence: The instructor's role was multifaceted, encompassing instructional design (creating the micro-courses and tasks), facilitation (guiding online discussions), and direct instruction (providing feedback during offline practice).[14] This active and continuous teaching presence ensured that students remained on track, received necessary support, and were consistently challenged to think critically. This integrated approach moves "beyond content delivery," transforming the learning environment into a dynamic ecosystem where students actively engage with content, peers, and instructors to build a comprehensive set of professional competencies[15].

This research provides empirical validation for the application of the CoI framework in the specific context of vocational education. It demonstrates that the three presences are not just relevant for online academic courses but are critical for designing blended learning that successfully cultivates applied skills and professional competencies[16] .

Despite the robust findings, this study has several limitations that suggest avenues for future research. First, its findings are based on a single institution and a specific subject area, which may limit generalizability. Future research should replicate this study across different vocational disciplines and institutional contexts. While the findings from this single-vocational-institution context are promising, they highlight the need for future multi-institutional and cross-cultural studies to test the model's robustness. Second, the study's duration was limited to one academic module; a longitudinal study would be beneficial to track the long-term retention of skills and the development of competencies. Finally, while ANCOVA controlled for pre-existing differences, the non-randomized nature of the quasi-experimental design cannot completely rule out other confounding variables[17].

5. Conclusions

This study set out to investigate whether a blended micro-course model could move beyond simple content delivery to foster meaningful skill acquisition and competency development in vocational education. By strategically integrating online micro-learning with offline hands-on practice within a theoretically grounded framework (CoI), the intervention not only significantly improved students' practical skills and professional competencies but also created a highly satisfactory learning experience. The results challenge VET institutions to rethink their approach to digital learning, shifting the focus from technological deployment to sophisticated pedagogical design. In an era demanding a versatile and highly skilled workforce capable of critical thinking and complex problem-solving, such innovative, blended models are not just an option but an imperative for the future of vocational education.

Author Contributions

Conceptualization, F.Q. and Y.T.; methodology, H.P.; software, C.H.; validation, L.Q., L.L. and P.D.; formal analysis, F.Q.; investigation, F.Q.; resources, Y.T.; data curation, Y.C.; writing—original draft preparation, F.Q.; writing—review and editing, F.Q.; visualization, Y.C.; supervision, C.H.; project administration, F.Q. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Jiangsu Pharmaceutical Vocational College under Approval ID TA_CACM_2023010 and SCX23086. The participants consented to participate in the study before completing the first questionnaire.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study

Data Availability Statement

Data are contained within the article.

Disclosure statement

The authors declare no conflicts of interest.

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