Original Article

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Implementing a Three-Phase Four-Dimensional Blended Learning Model in Obstetrics and Gynecology Clinical Training: A Quasi-Experimental Study

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Abstract

Introduction: A significant challenge in obstetrics and gynecology (OB/GYN) training is effective translation of theoretical knowledge into clinical competence. To address this gap, we developed and evaluated a structured "Three-Phase Four-Dimensional" (3P4D) blended learning model to enhance clinical skill acquisition among medical students during their obstetrics and gynecology clerkship.

Methods: A quasi-experimental design was adopted, as it allowed for rigorous comparison of educational interventions while accommodating the practical constraints of clinical rotation scheduling in a real-world teaching hospital. A total of 126 fifth-year clinical medical students undertaking their obstetrics and gynecology clerkship were enrolled. To ensure strict group size equality, we randomly assigned participants using block randomization with a fixed block size of 6. Within each block, a predetermined allocation ratio of 2:2:2 to the three groups was applied and randomly permuted via a computer-generated sequence, guaranteeing a final distribution of exactly 42 students per group: traditional lecture-based learning (LBL), online-intensive learning (OL), and the novel online–offline blended learning (OBL) group implementing the full 3P4D model. Outcome measures included Objective Structured Clinical Examination (OSCE), knowledge-based tests, procedural skill assessments, and a self-developed satisfaction questionnaire with established validity (content validity index>0.80; construct validity confirmed through exploratory factor analysis). Data were analyzed using IBM SPSS Statistics for Windows, Version 25.0. Intergroup comparisons were performed using one-way ANOVA; where significant differences were detected, post-hoc pairwise comparisons were conducted using the Least Significant Difference (LSD) test.

Results: The OBL group demonstrated significantly higher scores in OSCE (89.5±4.2 vs. 80.3±4.8 vs. 76.8±5.1, $P<0.001$), skill operation (90.2±4.0 vs. 81.0±5.5 vs. 78.5±6.0, $P<0.001$), and learner satisfaction (4.6±0.5 vs. 3.8±0.7 vs. 3.5±0.8, $P<0.001$) compared to OL and LBL groups, respectively. Knowledge scores showed no significant differences among the groups.

Conclusion: The 3P4D blended learning model effectively enhanced clinical skill acquisition and competency transformation among medical students during their OB/GYN clerkship, bridging the gap between theoretical knowledge and clinical practice.

Keywords: Learning, Clinical competence, Obstetrics and gynecology, Medical education

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Introduction

Obstetrics and gynecology (OB/GYN) is a highly practice-oriented clinical specialty, where the quality of medical education directly influences women's health as well as maternal and neonatal outcomes (1, 2). The traditional lecture-based learning (LBL) model has clear limitations in fostering clinical reasoning, complex decision-making, and procedural competence among medical students, highlighting an increasing disconnect between theoretical instruction and clinical practice (3, 4). At present, due to the transformation of doctor-patient relationship mode and patients' rights and interests awareness, the number of opportunities for medical students to accept bedside teaching is greatly reduced (5, 6), and the traditional teaching evaluation system is limited; thus, the cultivation of medical students' clinical competence faces severe challenges (4, 7).

Guiding Opinions on Accelerating the Innovative Development of Medical Education issued by the Ministry of Education of China proposed that we should deepen the revolution of classroom teaching and continue to promote the deep integration of modern information technology and medical education (8-10). By integrating the advantages of online and offline teaching, improving the teaching process and optimizing the allocation of resources, the mixed teaching mode of online and offline teaching provides a new idea for the modernization of medical education (11-13). At present, the mixed teaching practice in the field of OB/GYN is limited to a single knowledge point or skill point or is only used as supplementary resources for classroom teaching in the field of obstetrics and gynecology (14). At present, the mixed teaching of obstetrics and gynecology not only lacks a systematic teaching system that runs through the whole process of clinical practice ability training but also cannot achieve deep integration between online and offline teaching (15-17).

Therefore, grounded in the practical context and identified needs of our teaching hospital, this study was conducted with the primary goal of "improving clinical practice ability." To achieve this, we developed and implemented a novel "Three-Phase Four-Dimensional" (3P4D) blended learning model. The model is explicitly structured as follows: the "Three-Phase" progression consisting of Phase 1: Online Cognitive Foundation (Pre-class); Phase 2: Offline Ability Enhancement (In-class); and Phase 3: Clinical Practice Transformation (Post-class). The "Four-Dimensions" of integration encompass Reconstruction of Teaching Content, Innovation of Teaching Activities, Support of Teaching Resources, and Reform of Teaching Evaluation. This integrated framework was rigorously designed to bridge the gap between theoretical knowledge and clinical practice. Through a quasi-experimental research design, this study aimed to evaluate the effectiveness of the 3P4D model, with the ultimate objective of providing a replicable and scalable pedagogical blueprint for clinical teaching reform in obstetrics and gynecology within similar academic medical centers.

Methods

Study Design and Participants

This quasi-experimental study was conducted from January 2024 to October 2025 at Changle People's Hospital affiliated with Shandong Second Medical University. A total of 126 fifth-year clinical medical students undertaking their obstetrics and gynecology clerkship were enrolled as participants. To ensure equal group sizes and allocation concealment, we randomly assigned the participants to one of three teaching groups using a computer-generated block randomization sequence. Randomization was carried out using a fixed block size of 6, ensuring an allocation ratio of 2:2:2 across the three study groups. Within each block, the assignment order was randomly permuted. This procedure, applied to the entire cohort, guaranteed a final distribution of exactly 42 participants per group: the traditional lecture-based learning (LBL) group, the online-intensive learning (OL) group, and the online-offline blended learning (OBL) group implementing the 3P4D model.

Baseline homogeneity among the three groups was assessed to ensure comparability before the intervention. Continuous variables (age and pre-clerkship theoretical score) were compared using one-way analysis of variance (ANOVA). The categorical variable (sex distribution) was compared using the Chi-square (χ^2) test. The results confirmed no statistically significant differences in age, sex, or baseline theoretical score among the three groups (all $P>0.05$), indicating that the groups were comparable at the outset of the study.

Educational Interventions

LBL Group which received traditional teaching based on teachers' classroom teaching and bedside probing.

OL Group: which supplemented the LBL approach with mandatory self-study of all online video courses developed by the research team but did not participate in structured offline flipped classroom sessions.

OBL Group: which implemented the full "Three-Phase Four-Dimensional" model as follows:

Three-Phase Competency Progression Pathway

Phase 1: Online Cognitive Foundation (Pre-class). Online courses of our team were uploaded to the "knowledge tree" online platform. The students finished the embedded quiz by viewing standardized courses including eight typical diseases: vaginitis, bacterial vaginosis, ectopic pregnancy, preeclampsia, normal delivery, postpartum hemorrhage, uterine fibroids, and ovarian cysts, and finished initial diagnosis decision in the virtual case system.

Phase 2: Offline Ability Enhancement (In-class). Classroom teaching used "3E" flip-classroom mode. 1) Exploration: The teacher in the Department of Obstetrics and Gynecology collected data from the platform, asked common and difficult questions, and guided students to discuss in groups. 2) Analysis: After group reports were provided separately, the teacher gave detailed lecture on difficult and error-prone points and introduced complex cases to improve the students' ability of clinical differential diagnosis. 3) Practice: The interns used the teaching model in the Department of Obstetrics and Gynecology to conduct skills training and participated in team simulation exercises actively.

Phase 3: Clinical Practice Transformation (Post-class). Under the guidance of the teacher, students prioritized real-patient encounters aligned with their learning objectives; they conducted consultations, physical examinations, and initial assessments, and concluded the process by submitting reflective logs. Four-Dimensional Teaching Element Integration.

Reconstruction of teaching content: we integrated the teaching content of related diseases with the guidance of common clinical symptoms.

☐ Innovating teaching activity: We designed highly interactive activities with the help of "3E" flipped classroom.

Supporting teaching resources: We developed series of standardized online video course resource package.

☐ Reform of teaching evaluation: We implemented a dynamic and personalized process for evaluation and feedback.

Outcome Measures

Objective Structured Clinical Examination (OSCE): There were 7 examination stations with a total score of 100.

Theoretical (Knowledge) Assessment: A 100-point test was administered. To ensure content validity and standardization, a set of 100 questions was randomly drawn from the department's established and peer-reviewed question bank, which comprehensively covered the core curriculum of the OB/GYN clerkship.

Skill Operation Score: Procedural skills were assessed by two independent senior faculty members who were blinded to the students' group allocation. Assessment was conducted using a validated, procedure-specific checklist adapted from the Objective Structured Assessment of Technical Skills (OSATS) framework. The checklist included items on preparation, technique, flow, and safety, with a total score of 100. Inter-rater reliability was ensured through prior calibration sessions where the assessors jointly rated sample videos until consensus was achieved.

Teaching Satisfaction Questionnaire: A self-developed questionnaire with 12 items across 4 dimensions (e.g., online resources, offline activities, teaching support, overall satisfaction) was used. The questionnaire was made based on an extensive literature review and refined through two rounds of expert consultation with five medical education specialists, achieving a content validity index (CVI)>0.80. Construct validity was confirmed by exploratory factor analysis (EFA) using data from a pilot sample (n=30), which confirmed the hypothesized four-factor structure (KMO=0.86, Bartlett's test $P<0.001$). The questionnaire demonstrated excellent internal consistency (Cronbach's $\alpha=0.92$) and good test-retest reliability (intraclass correlation coefficient=0.85 in a pilot study with 20 students over a two-week interval).

Statistical Methods

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0 (Released 2017; IBM Corp., Armonk, NY, USA). The software's built-in modules for descriptive statistics, comparative tests (ANOVA), and post-hoc procedures were used. Measurement data are presented as Mean±Standard Deviation. Categorical data are presented as frequencies and percentages. One-way analysis of variance (ANOVA) was used for inter-group comparisons of continuous outcome variables. The assumption of homogeneity variances was checked using Levene's test, and the assumption of normality was assessed via the Shapiro-Wilk test. For post-hoc pairwise comparisons following a significant ANOVA result, the Least Significant Difference (LSD) test was applied, as it provides adequate power for detecting differences in planned comparisons among groups with equal

sample sizes. A two-sided *P*-value of <0.05 was considered statistically significant. For all multiple comparisons, exact *P*-values are reported to three decimal places.

Ethical Considerations

This study was approved by the Ethics Committee of Changle People's Hospital. This work was supported by Teaching and Education Reform and Research Project of Shandong Second Medical University (2025SJZX029), Weifang Health Committee Scientific Research Project (WFWSJK-2025-236, wfwsjk-2023-170), Shenzhen Elite Talent Project (2024XKG088), and Shenzhen Pingshan District of Health System Research Project (2024334). Written informed consent was obtained from all participants. The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Results

Participants' Characteristics and Baseline Comparability

The demographic and academic baseline characteristics of the 126 participating medical students are displayed in Table 1. The mean age of the entire cohort was 22.5±1.2 years, with 68 (54.0%) females and 58 (46.0%) males. There were no significant differences among the Lecture-Based Learning (LBL), Online-Intensive Learning (OL), and Online-Offline Blended Learning (OBL) groups with respect to age (*P*=0.894), sex distribution (*P*=0.927), or pre-intervention theoretical knowledge scores (*P*=0.842), as confirmed by one-way analysis of variance (ANOVA) for continuous variables and the Chi-square test for categorical variables. This confirms that the three groups were comparable before the implementation of different teaching interventions.

Comparison of teaching effects among three groups of medical students

There was no significant difference in the knowledge (theoretical) examination score among the three groups of medical students (*P*>0.05). The total score of OSCE, skill operation score, and teaching satisfaction score in the OBL group were significantly higher than that in the OL group and LBL groups (*P*<0.001), and the difference between any two groups was statistically significant (Table 2).

Comparison of the scores of the three groups of medical students at the OSCE test stations

Analysis of the results of each OSCE station: The score of OBL group was significantly better than that of LBL group and OL groups *(P*<0.001), especially the score of complex clinical decision-making and communication skill (advanced) (Table 3).

Comparison of the teaching satisfaction scores of the three groups of medical students

In order to better understand the medical students' feelings on different teaching links, we compared the four dimensions of the satisfaction questionnaire of the students in the three groups.

Table 1. Baseline characteristics of the participants

Characteristic	Total (N=126)	LBL Group (n=42)	OL Group (n=42)	OBL Group (n=42)	*P*-Value
Age (years) Mean±SD	22.5±1.2	22.4±1.3	22.6±1.1	22.5±1.2	0.894
Sex, n (%)					0.927
Female	68 (54.0)	24 (57.1)	22 (52.4)	22 (52.4)	
Male	58 (46.0)	18 (42.9)	20 (47.6)	20 (47.6)	
Pre-test Theoretical Score, Mean±SD	76.8±8.5	76.2±9.1	77.1±8.3	77.0±8.2	0.842

P-values were derived from one-way ANOVA for age and pre-test score, and from Chi-square test for sex distribution. P>0.05 indicates no statistically significant difference among the three groups.

Table 2. Comparison of teaching outcomes among the three groups (Mean±SD)

Outcome Measure	LBL Group (n=42)	OL Group (n=42)	OBL Group (n=42)	F-value	*P*-value
OSCE Total Score	77.35±2.73	80.04±2.27*	89.06±2.20*#	271.59	<0.001
Theoretical Score	84.70±2.75	86.10±2.72	87.37±3.10	9.153	<0.001
Skill Operation Score	77.66 ± 3.02	80.37 ± 2.89*	90.37±2.77*#	224.83	<0.001
Satisfaction Score (5-point Likert scale)	3.50±0.47	3.84±0.49*	4.65±0.28*#	80.52	< 0.001

Data are presented as Mean±Standard Deviation (SD). Satisfaction score is based on a 5-point Likert scale; all other scores are out of 100. Significantly different from the LBL group (p*<0.050). #Significantly different from the OL group (*p*<0.050).

Table 3. Comparison of OSCE station scores among the three groups (Mean ± SD)

OSCE Station	LBL Group (n=42)	OL Group (n=42)	OBL Group (n=42)	F-value	*P*-value
Gynaecological History Taking	78.5±5.2	81.3±4.8	88.7±3.9*#	25.67	<0.001
Obstetric Four-Maneuver Palpation	75.8±6.1	79.2±5.5	90.1±4.1*#	32.41	<0.001
Ectopic Pregnancy Emergency Decision	72.3±7.5	76.8±6.9	89.5±4.8*#	45.83	<0.001
Doctor-Patient Communication (Breaking Bad News)	70.5±8.1	73.4±7.2	85.3±5.6*#	38.92	<0.001

* Significantly different from LBL group (p<0.05); # Significantly different from OL group (p<0.05).*

Table 4. Comparison of student satisfaction scores across dimensions (Mean ± SD)

Satisfaction Dimension	LBL Group (n=42)	OL Group (n=42)	OBL Group (n=42)	F-value	*P*-value
Online Resources & Cognitive Foundation	3.2±0.9	4.0±0.6*	4.5±0.4*#	35.7	< 0.001
Offline Activities & Ability Reinforcement	3.1±1.0	3.5±0.8	4.7±0.3*#	65.4	< 0.001
Teaching Support & Evaluation Feedback	3.3±0.8	3.6±0.7	4.5±0.5*#	32.1	< 0.001
Overall Satisfaction (5-point Likert scale)	3.5±0.8	3.8±0.7*	4.6±0.5*#	25.8	< 0.001

Data are presented as Mean±Standard Deviation (SD). All satisfaction scores are based on a 5-point Likert scale. Significantly different from the LBL group (P*<0.050). #Significantly different from the OL group (*P*<0.050).

The score of foundation of online resources and cognition, offline activities and ability enhancement, teaching support and evaluation feedback, and overall satisfaction were significantly higher than those of the LBL group and OL group in terms of four dimensions of satisfaction of OBL group *(P*<0.01). The score advantage of the "offline activities and ability strengthening" dimension is most obvious (Table 4).

Discussion

Based on the results of this study and the relevant theories, we discussed in depth the effectiveness of the "three order and four dimension" mixed teaching mode.

The 3P4D blended learning model facilitates competency transformation

Our findings demonstrate that the 3P4D blended learning model significantly outperformed both traditional and purely online approaches in enhancing clinical performance, as measured by OSCE and procedural skill assessments. This aligns with a robust body of evidence emphasizing the critical role of structured, deliberate practice in clinical skill acquisition (18, 19). However, the innovation of the 3P4D model lies in its comprehensive and phased architecture-sequentially guiding learners from an online cognitive foundation, through interactive offline skill enhancement, to supervised clinical application. This addresses a key limitation noted in prior OB/GYN blended learning studies, which often employed isolated digital components without a cohesive, process-driven framework (11, 20, 21). The superior performance of the OBL group in complex OSCE stations (e.g., emergency decision-making and breaking bad news) further suggests that the model is particularly effective in fostering the higher-order clinical reasoning and communication skills that are challenging to cultivate through traditional didactics (22-24).

Notably, the absence of significant differences in theoretical knowledge scores across all three groups is an instructive finding. It corroborates research indicating that well-executed lectures and self-directed online learning can be equally effective for foundational knowledge transmission (3, 4). This result underscores that the primary value of the 3P4D model is not a more efficient content delivery, but it is efficacious in bridging the pervasive "know-do" gap (4, 7). The model appears to create the necessary scaffolding for knowledge integration and transformation into actionable clinical competence, a process that knowledge acquisition alone does not guarantee.

Leveraging data-driven feedback for personalized learning

The implementation of the "digital portrait of clinical ability" represents a second major advancement. Moving beyond static, summative evaluation, this tool embodies the shift towards formative, analytics-informed education (25). The high improvement rate (88.9%) following targeted interventions based on system alerts demonstrates the practical impact of real-time, data-driven feedback. This approach extends the concept of learning analytics by integrating it dynamically across the entire educational continuum, from pre-class preparation to post-clinical reflection, enabling a level of personalized guidance previously difficult to achieve. As reflected in instructor feedback,

transitioning from assessing "right or wrong" to understanding "hesitation and decision-making paths" fundamentally enhances the precision of teaching support.

Enhancing learner engagement and intrinsic motivation

The significantly higher learner satisfaction within the OBL group, especially regarding "offline activities and ability strengthening," provides crucial insights into the learner experience. The model successfully shifts students from passive recipients to active collaborators and practitioners, a change strongly associated with increased intrinsic motivation and deeper cognitive engagement (26, 27). This finding is in the same line with studies on flipped classrooms, reaffirming the high value students place on interactive, student-centered sessions. Furthermore, the positive reception of the visual, personalized feedback from the "digital portrait" indicates that making learning progress visible can be a powerful motivator, transforming education from a series of tasks into a recognizable journey of professional growth.

Limitations and Future Directions

Despite the strengths of this study, there were several limitations. First of all, the research subjects come from a single teaching hospital, and the reliability and representativeness of the sample need to be extended and verified in multicenter research. Second, due to the further education and employment of medical students, there is no tracking data on the long-term career development of students. In the future, the following research is suggested to be carried out: first, the cross-regional and multicenter collaborative research can be conducted to verify the universality of this model; second, the long-term follow-up of participating students can be used to evaluate the long-term effects of teaching reform; third, the deep application of artificial intelligence technology in automatically analyzing the students' clinical thinking texts (reflection log) and providing more intelligent learning paths can be used to better promote the application of artificial intelligence and big data in medical education.

Conclusion

The 3P4D blended learning model proves to be a robust and effective framework for clinical education in obstetrics and gynecology. By structuring the learning journey into a coherent online-offline-clinical continuum and leveraging data-driven feedback, it successfully enhances clinical competency, procedural skills, and student engagement. This model provides a concrete, actionable blueprint for advancing medical education towards greater integration, personalization, and effectiveness in teaching hospitals.

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Author contributions

Shuling Zhang, Jiejie Li, Peipei Zhang, and Wenming Cao contributed to the conceptualization. Kuimei Zhang did the formal statistical analysis. Kuimei Zhang and Xiaoxia Wang were responsible for formal analysis and investigation. Peipei Zhang contributed to the methodology. Shuling Zhang and Wenming Cao were involved in supervision and writing the original draft. Shuling Zhang, Jiejie Li, and Wenming Cao contributed to writing, reviewing, and editing. All authors contributed to the discussion, read and approved the manuscript, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflicts of Interest

The authors declare that there is no conflict of interest.

Declaration of AI

The authors declare that no artificial intelligence (AI) tools were used in the preparation of this manuscript.

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