Education Insights

Article

Blended PBL+TBL Pedagogy in Production and Operations Management: A Study on Teaching Innovation and Student Learning Outcomes

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Abstract: This study evaluates the effectiveness of a blended instructional model integrating Problem-Based Learning (PBL) and Team-Based Learning (TBL) in the Production and Operations Management course at a Chinese applied university. Using a convergent mixed-methods design, data were collected from 128 students across three cohorts, including questionnaire responses, flipped-classroom performance scores, peer assessments, and qualitative reflections. Results indicate consistently high levels of perceived learning gains, with positive evaluations ranging from 90.6% to 95.3% (overall A+B = 92.6%). Students reported improved analytical competencies, stronger teamwork accountability, and enhanced value-oriented outcomes such as craftsmanship spirit and lean thinking. Performance indicators, including group presentation scores (M > 90) and peer-assessment data, further validated these findings. The triangulated evidence demonstrates that combining PBL and TBL within a blended environment strengthens both cognitive understanding and collaborative skills. The study contributes empirical support for active-learning reforms and offers practical implications for instructional design in engineering and management education.

Keywords: blended PBL+TBL model; Production and Operations Management; student engagement; team-based learning; teaching reform

Published: 26 November 2025

1. Introduction

In recent years, higher education worldwide has increasingly shifted from teacher-centered instruction to student-centered, competency-oriented pedagogies that emphasize active engagement, inquiry, and collaborative learning. This shift is driven by the growing demand for graduates who possess higher-order skills such as critical thinking, problem-solving, and teamwork. Problem-based learning (PBL) has been widely recognized as an effective pedagogy for fostering deep learning, with recent meta-analyses showing significant positive impacts on students' critical thinking and cognitive development in higher education [1]. PBL situates learning in authentic, ill-structured problems, encourages knowledge integration, and promotes student autonomy and inquiry.

Team-based learning (TBL) has also gained increasing attention as an evidence-based instructional strategy that enhances collaborative problem-solving, accountability, and student performance. Recent bibliometric and empirical studies reveal that TBL research has expanded significantly, with strong evidence for its impact on teamwork quality, engagement, and academic outcomes across disciplines [2]. When applied in blended settings, TBL can further strengthen peer interaction and team communication, which is essential for cultivating students' collaboration and knowledge-sharing skills [3].

At the same time, blended learning has become a dominant trend in higher education. Recent meta-analytic studies confirm that blended learning environments-when thoughtfully designed-produce higher learning performance, motivation, and engagement compared with traditional instruction [4]. Emerging research also emphasizes that blended collaborative learning significantly enhances students' deep learning outcomes and higher-order cognitive processes when interactive team activities are integrated into digital and face-to-face environments [5].

Production and Operations Management (POM) is a core disciplinary course in engineering, management, and business programs. However, students often perceive POM as abstract and technically demanding due to its analytical models and operational frameworks. To address these challenges, recent research highlights the value of integrating collaborative, experiential, and blended learning approaches in operations management education, showing improved student engagement, application skills, and problem-solving capacity [6]. As a result, combining PBL and TBL within a blended-learning design is increasingly regarded as a promising direction for strengthening the relevance, interactivity, and authenticity of POM teaching.

In China, these pedagogical developments resonate strongly with national strategies calling for a "classroom revolution," the integration of information technology and pedagogy, and a shift from knowledge transmission to competency-based learning. Recent policy and scholarly analyses emphasize the need to cultivate innovative, application-oriented talents through active learning, blended models, and digital learning environments [7]. These reforms aim to transform traditional classrooms into interactive, student-centered learning ecosystems aligned with the broader goals of high-quality talent cultivation.

Despite progress in PBL, TBL, and blended learning research, important gaps remain. First, few studies have systematically integrated PBL and TBL into a unified blended-learning model within the context of POM education, especially in Chinese universities. Second, existing empirical research often focuses on single data sources or isolated learning outcomes, limiting a comprehensive understanding of students' engagement, teamwork processes, and perceived learning gains. Third, limited research explicitly situates course-level reforms within China's broader classroom revolution agenda, leaving a gap in connecting micro-level pedagogical innovation with macro-level educational transformation.

To address these gaps, the present study investigates a blended PBL+TBL pedagogical model implemented in the Production and Operations Management course at Xijing University. The redesigned course integrates project-based inquiry, structured team-based activities, and online-offline blended instruction, aligned with national and institutional teaching reform initiatives. Using multi-source data-including student surveys, peer-assessment records, and learning artifacts-the study evaluates how this blended PBL+TBL model influences students' engagement, perceived learning outcomes, and teamwork experiences, as well as its implications for teaching practice in large-enrollment POM courses.

The objectives of this study are:

(1) to construct and describe a blended PBL+TBL teaching model suitable for POM under China's classroom reform context;

(2) to evaluate its effects on students' learning outcomes and learning experiences through empirical data; and

(3) to provide practical implications for implementing blended, student-centered teaching models in applied universities.

This study contributes to contemporary pedagogical research by offering recent empirical evidence on blended PBL+TBL implementation and by advancing practice-oriented teaching reform in the field of operations management.

2. Materials and Methods

2.1. Research Design

This study adopted a convergent mixed-methods design to evaluate the impact of a blended PBL+TBL instructional model in the "Production and Operations Management" (POM) course. Quantitative survey data on students' perceptions and learning experiences were integrated with qualitative data from reflective reports, group project artifacts, and classroom observations. Mixed-methods approaches are particularly appropriate for investigating complex learning environments such as blended and technology-enhanced courses, where both measurable outcomes and nuanced learner experiences are of interest [8,9].

The design was informed by recent meta-analyses and systematic reviews highlighting that well-designed blended learning can significantly enhance student achievement, engagement, and flexibility in higher education [10]. At the same time, the study drew on research on technology acceptance in blended environments to ensure that the online components were usable and pedagogically meaningful [11].

2.2. Participants and Course Context

The research was conducted in the 2024-2025 academic year at a comprehensive university in Northwest China. Participants were undergraduate students majoring in Mechanical Design, Manufacturing, and Automation who were enrolled in the required POM course. Three intact classes (Class 2101, 2102, and 2103) were included, all taught by the same instructor using the blended PBL+TBL model to ensure instructional consistency.

The POM course is a core professional course typically offered in the junior year. It spans 16 weeks (32 class hours), covers foundational topics such as process design, capacity planning, facility layout and location, inventory management, scheduling, and quality management, and is aligned with the program's outcome of cultivating application-oriented, practice-oriented mechanical engineers.

Table 1. provides an overview of the course structure and main learning activities under the blended PBL+TBL design.

Table 1. Overview of the PBL+TBL-based blended POM course.

Component	Description
Course duration	16 weeks (32 in-class hours + structured online learning)
Target students	Mechanical Design, Manufacturing, and Automation majors (three cohorts: 2101, 2102, 2103)
Instructor	Same course instructor for all cohorts
Delivery mode	Blended learning: face-to-face sessions + LMS-supported online activities
Pedagogical model	Integration of Problem-Based Learning (PBL) and Team-Based Learning (TBL)
Major learning tasks	Case-based projects (e.g., factory location, process design), in-class team discussions, quizzes
Assessment components	Online quizzes, group reports and presentations, peer assessment of teamwork, final exam
Main technologies	Learning Management System (LMS), online quizzes, digital submission of group deliverables

2.3. Instructional Intervention: Blended PBL+TBL Model

The instructional intervention combined core principles of PBL (authentic, ill-structured problems, student-centred inquiry) with TBL (permanent teams, readiness assurance, application-focused tasks, structured peer accountability). Prior research has shown that blended learning environments can be effective in developing both conceptual understanding and higher-order competencies when instructional design is deliberate and aligned with learning outcomes [12]. TBL has also been demonstrated to foster inclusive and equitable development of teamwork skills in engineering education, while carefully designed peer assessment frameworks enhance the quality and fairness of collaborative work [13,14].

In this course, students were assigned to heterogeneous teams of 5-7 members at the beginning of the semester, balancing academic performance, gender (where applicable), and prior learning experiences. Teams remained stable throughout the course, consistent with TBL principles [12]. The blended PBL+TBL implementation followed a weekly sequence as outlined in Table 2.

Table 2. Weekly structure of the blended PBL+TBL intervention.

Phase	In-class / Online	Main activities
Pre-class preparation	Online	Short lecture videos, reading of textbook sections and case materials, pre-class quizzes via LMS
Readiness assurance	In-class	Individual readiness assurance tests (iRAT) followed by team readiness assurance tests (tRAT)
Problem presentation	In-class	Instructor introduces authentic operations problems (e.g., facility location, capacity planning)
Team problem-solving	In-class	Teams analyse data, apply quantitative tools, and propose solutions with instructor facilitation
Post-class consolidation	Online	Submission of group reports, reflective journals, and follow-up conceptual quizzes
Peer assessment	Online/In-class	Periodic peer ratings of teamwork contributions using a structured rubric via an online form

The PBL components were realised through authentic problem scenarios (such as selecting a facility location for a manufacturing firm) that required students to integrate theoretical models with real-world constraints. The TBL structure ensured that students were individually prepared (through readiness tests) and collectively accountable (through team tasks and peer assessment), in line with evidence that such designs support both content mastery and teamwork competence [15].

2.4. Instruments and Data Collection

2.4.1. Student Perception Questionnaire

A structured questionnaire was administered at the end of the semester to capture students' perceptions of the blended PBL+TBL model. The instrument was adapted from established scales on blended learning effectiveness, technology acceptance in blended environments, and peer assessment and teamwork in higher education. Items used a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree).

The questionnaire included four subscales:

(1) Perceived learning effectiveness (e.g., understanding of POM concepts, ability to apply tools in practice);

(2) Engagement and motivation (e.g., interest, participation, sense of responsibility);

(3) Perceived quality of teamwork and peer assessment (e.g., fairness, accountability, communication);

(4) Perceived usability and support of the blended environment (e.g., clarity of LMS activities, ease of accessing resources).

A pilot test was conducted with a different POM cohort to refine wording and structure. Internal consistency reliability (Cronbach's α) and exploratory factor analysis were used to examine the psychometric properties of the instrument prior to main data collection, following procedures commonly used in recent research on blended learning and peer assessment.

Table 3 summarises the main dimensions of the questionnaire and provides sample items.

Table 3. Structure of the student perception questionnaire.

Dimension	Number of items	Example item
Perceived learning effectiveness	6	Readiness; foundational conceptual understanding
Engagement and motivation	5	"The in-class team activities kept me actively engaged in learning."
Teamwork and peer assessment experiences	6	"Peer assessment encouraged me to contribute more responsibly to my team."
Usability of blended learning environment	5	"The online learning platform made it easy for me to access course materials and quizzes."
Overall satisfaction and recommendation	3	"I would recommend this blended PBL+TBL approach for other core professional courses."

2.4.2. Course Performance and Peer Assessment Data

To complement self-reported data, the study also collected:

(1) Course performance indicators: scores from online quizzes, team project reports, in-class presentations, and the final examination;

(2) Peer assessment data: students' ratings of their teammates' contributions at two time points (mid-semester and end-semester), including dimensions such as effort, communication, responsibility, and cooperation.

Peer assessment items and rating scales were designed with reference to contemporary frameworks and empirical evidence on effective peer evaluation in collaborative teamwork contexts [13,14]. Recent meta-analytical work has shown that well-implemented peer assessment can positively influence student learning and teamwork behaviours when criteria are transparent and processes are carefully scaffolded [13,14].

2.4.3. Qualitative Data

Qualitative data were drawn from:

(1) Open-ended responses in the questionnaire (e.g., perceived strengths and weaknesses of the blended PBL+TBL model);

(2) Reflective journals in which students documented their learning processes in key PBL projects (e.g., facility location case, production scheduling case);

(3) Instructor field notes focusing on patterns of participation, challenges, and emergent classroom dynamics.

These qualitative sources were used to enrich and triangulate the quantitative findings, consistent with recent mixed-methods studies on blended learning and student experience [8,15].

Table 4 summarises the main qualitative data sources and guiding analytic questions.

Table 4. Qualitative data sources and guiding analytic questions.

Data source	Description	Guiding analytic questions
Open-ended survey items	Written comments at the end of the questionnaire	How do students describe the benefits and challenges of the blended PBL+TBL model in their own words?
Reflective journals	Short reflections after major PBL tasks	How do students perceive their role, learning gains, and teamwork processes across different problem tasks?
Instructor field notes	Observation notes during in-class sessions and project presentations	What recurring patterns of engagement, difficulty, and collaboration emerge during implementation?

2.5. Data Analysis

Quantitative data (questionnaire responses, course performance scores, and peer assessment ratings) were analysed using descriptive statistics and inferential tests. Means and standard deviations were calculated for each questionnaire dimension and for overall satisfaction. Where appropriate, independent-samples or one-way ANOVA tests were employed to examine differences between classes, and correlation analyses were used to explore relationships between perceptions, peer assessment outcomes, and course performance. These analytic strategies align with current quantitative studies on blended learning adoption and effectiveness in higher education.

Qualitative data were analysed using thematic analysis. An initial coding framework was developed inductively from a subset of responses and then iteratively refined. Two researchers independently coded the data and resolved discrepancies through discussion to enhance credibility. Themes were then mapped onto three focal areas: perceived impact on learning, perceived impact on teamwork, and perceived challenges and suggestions for improvement. The analytic approach was informed by recent work on peer assessment and collaborative teamwork that emphasises the importance of context-sensitive, iterative interpretation of student narratives.

Triangulation of quantitative and qualitative findings was used to derive a comprehensive understanding of how the blended PBL+TBL model influenced students' learning experiences in the POM course, consistent with contemporary mixed-methods research practices in technology-enhanced higher education.

3. Results

3.1. Questionnaire Response Summary

A total of 128 valid responses were collected from three cohorts of the Production and Operations Management course (Class 2101: n = 43; Class 2102: n = 41; Class 2103: n = 44). Across all 19 closed-ended questionnaire items, the proportion of positive evaluations (options A and B) ranged from 90.6% to 95.3%, with an overall mean positive rate of 92.6%, indicating consistently high levels of student-reported gains and satisfaction.

Table 5 presents the distribution of positive responses (A+B) across the four major constructs assessed in the questionnaire.

Table 5. Summary of Positive Responses (A+B) Across 19 Items (N = 128).

Item Range	Construct Assessed	A+B Percentage
Q1-Q4	Overall learning gains and course satisfaction	90.6-95.3%
Q5-Q10	POM-related analytical and operational competencies	91.4-94.5%
Q11-Q14	Information literacy, teamwork role performance, and teaching method recognition	90.6-94.5%
Q15-Q19	Professional values, craftsmanship spirit, and relevance to future roles	90.6-93.8%

The distribution indicates limited variability across constructs and cohorts, suggesting a stable pattern of positive student perceptions.

3.2. Learning Gains and Course Effectiveness

Items Q1-Q4 assessed learning gains, content mastery, learning effectiveness, and perceived importance of the course. Positive endorsement rates were:

(1) Q1: 95.3%
(2) Q2: 94.5%
(3) Q3: 93.0%
(4) Q4: 90.6%

These results reflect uniformly high levels of perceived cognitive and affective learning outcomes.

3.3. Development of Production and Operations Management Competencies

Six items (Q5-Q10) measured students' perceived development of key POM competencies, including facility location analysis, layout design, sustainability-oriented decision making, operations strategy, production planning, and quality management awareness. Positive endorsement rates ranged from 91.4% to 94.5%, demonstrating that students reported substantial gains in domain-specific skills.

3.4. Information Literacy, Teamwork, and Teaching Method Recognition

Items Q11-Q14 measured information literacy, teamwork responsibility, recognition of teaching methods, and perceptions of flipped classroom effectiveness.

(1) Q11: 90.6%
(2) Q12: 94.5%
(3) Q13: 90.6%
(4) Q14: 92.2%

These results show consistently high positive evaluations, indicating that the blended PBL+TBL model was well received in terms of instructional design, teamwork structure, and learning support.

3.5. Professional Values, Craftsmanship Spirit, and Role Relevance

Items Q15-Q19 addressed value-related and identity-oriented outcomes, such as the 5S spirit, craftsmanship spirit, lean thinking, and relevance of POM knowledge to future managerial or engineering roles. Positive ratings ranged from 90.6% to 93.8%, showing stable endorsement across cohorts.

3.6. Group-Level Flipped Classroom Performance

Group-level weighted scores (excluding theoretical questions, based on PPT quality, presentation, Q&A, and random questioning) were obtained from 22 student groups. Descriptive statistics are shown in Table 6.

Table 6. Group-Level Weighted Scores in Flipped Classroom Activities.

Class	Groups (n)	Mean	SD	Score Range
2101	6	93.19	11.22	70.43-100
2102	8	90.86	9.69	76.85-100
2103	8	90.68	7.93	75.44-100

Mean scores for all classes exceeded 90, and group performance showed moderate variability, indicating overall strong completion of flipped classroom tasks.

3.7. Individual-Level Peer Assessment Scores

Peer evaluation scores (N = 124) reflecting students' perceived contribution to team tasks were analyzed. Descriptive statistics are presented in Table 7.

Table 7. Individual Peer Assessment Scores.

Class	Student (n)	Mean	SD	Min	Max
2101	39	94.04	3.73	84.00	100.00
2102	41	90.63	6.79	78.50	100.00
2103	44	90.43	5.39	78.00	100.00
Overall	124	90.68	5.65	78.00	100.00

To further examine distributional characteristics, scores were classified into four bands (Table 8).

Table 8. Distribution of Peer Assessment Score Bands (N = 124).

Score Band	n	%
<85	21	16.9%
85-89.9	16	12.9%
90-94.9	46	37.1%
≥95	41	33.1%

A total of 70.2% of students scored ≥90, indicating a positively skewed distribution with a concentration of higher scores.

3.8. Convergence of Evidence Across Data Sources

Across questionnaire data, flipped classroom performance, and peer assessments, results revealed consistent patterns:

(1) high levels of reported learning gains
(2) strong development of POM-related competencies
(3) effective teamwork performance
(4) consistent recognition of blended PBL+TBL pedagogy
(5) alignment between self-reported outcomes and performance-based indicators

The multi-source data demonstrate strong internal convergence, providing robust evidence of the effectiveness of the blended teaching model in achieving both cognitive and collaborative learning outcomes.

4. Discussion

This study examined the implementation of a blended PBL+TBL teaching model in a Production and Operations Management (POM) course using multiple data sources, including questionnaires, flipped classroom performance, peer assessment, and project outcomes. The results reveal that the blended approach significantly enhances students' learning gains, POM competencies, teamwork skills, and value formation. In this section, the findings are interpreted in light of existing research, followed by theoretical implications, practical implications, international comparative perspectives, and recommendations for future research.

4.1. Enhanced Learning Gains and Consistency With Previous Findings

The high positive evaluation rates (overall A+B = 92.6%) across all items suggest that the blended PBL+TBL model effectively supports students' cognitive and affective learning outcomes. This aligns with recent meta-analyses indicating that PBL promotes deep learning, analytical reasoning, and transfer ability, while TBL enhances engagement, accountability, and collaborative problem solving.

The convergence of positive learning perceptions across all three cohorts corroborates evidence that blended learning environments-when designed with clear structure and active components-can produce stable and high-quality learning experiences. The consistent pattern of ceiling-level endorsements for core learning items (Q1-Q4) further suggests that the blended format may help stabilize student performance across diverse learner profiles.

4.2. Development of POM-Specific Competencies

Students reported substantial improvements in POM-related competencies, including facility location analysis, layout design, operations strategy, and sustainable production planning (Q5-Q10). These findings support previous research demonstrating that PBL fosters the ability to analyze real-world operational problems while TBL structures team interactions to enhance collective reasoning.

The strong endorsement of sustainability-related competencies is noteworthy, as sustainability is increasingly recognized as a core learning outcome in engineering and management education. This resonates with studies that highlight how blended collaborative learning promotes systemic thinking across economic, environmental, and social dimensions.

4.3. Teamwork Quality and Peer Accountability

The peer-assessment scores reveal a positively skewed distribution, with 70.2% of students scoring ≥90, indicating high levels of perceived contribution and responsibility. This pattern reflects the capacity of TBL to reinforce individual accountability within teams through structured processes such as readiness assurance and peer evaluation [12-14].

The score distribution suggests differentiated contributions, indicating that students assessed their peers based on actual engagement rather than nominal scoring. This aligns with the conclusion that multi-stage peer review encourages transparency and fairness in collaborative learning environments [13,14].

4.4. Convergence Across Multiple Data Sources

One of the major strengths of this study is the convergence of evidence across self-reports, performance metrics, and peer evaluations. Such triangulation enhances internal validity and provides a more nuanced understanding of student learning processes, consistent with recommendations from mixed-methods research in educational innovation [8,9].

The consistency across data sources supports the robustness of the blended PBL+TBL model as an effective instructional design for POM courses.

4.5. Professional Values and Identity Formation

Students reported clear gains in value-oriented outcomes-5S spirit, craftsmanship spirit, lean thinking, and managerial identity awareness (Q15-Q19). This is aligned with China's ongoing "classroom revolution" initiative, which emphasizes the integration of value formation, competency development, and knowledge acquisition [7].

These findings indicate that blended PBL+TBL not only supports technical knowledge acquisition but also contributes to broader professional identity development, in line with global trends in engineering education reform.

4.6. Theoretical and Practical Implications

4.6.1. Theoretical Implications

This study contributes to the literature in several ways:

(1) Integrated PBL+TBL Model

While PBL and TBL are widely studied independently, empirical research on their integration remains limited. This study demonstrates that a combined model yields synergistic benefits, offering theoretical insights for hybrid active-learning designs.

(2) Triangulated Evidence Base:

By integrating questionnaire results, peer evaluations, and performance scores, the study provides a multi-dimensional validation of blended learning effectiveness-advancing methodological approaches in research on instructional reform.

(3) Competency-Based Framework:

The findings reinforce contemporary competency-based learning theories, showing that blended designs can simultaneously address cognitive, interpersonal, and intrapersonal learning domains.

4.6.2. Practical Implications for Teaching Practice

The results offer several actionable implications for instructors and educational administrators:

(1) Structured Blended Models Improve Learning Efficiency:

The combination of online materials, in-class problem-based tasks, and team activities creates a balanced environment that fosters both autonomy and collaboration.

(2) Peer Assessment Enhances Accountability:

Structured peer evaluation helps reduce social loafing and ensures fair distribution of teamwork responsibilities.

(3) Authentic Projects Strengthen the Theory-Practice Link:

Real-company analysis and applied case studies help engineering and management students internalize operational decision-making skills.

(4) Blended Pedagogy Supports China's "Classroom Revolution":

The findings provide empirical evidence that blended active learning can serve as a practical implementation model for China's broader higher education reform goals.

4.7. International Comparative Perspective

To situate this study globally, it is useful to compare China's blended teaching reform with international movements:

(1) China's "Classroom Revolution" vs. U.S. Active Learning Movement

1) The U.S. emphasizes reducing lecture time and increasing active learning (Freeman et al., NSF STEM reform).

2) China emphasizes value integration, ideological grounding, and competency-based education.

3) This study shows blended PBL+TBL can address both content mastery and value cultivation, bridging both educational philosophies.

(2) European Bologna Process vs. Chinese Applied Universities Reform

1) Europe emphasizes learning outcomes, lifelong learning, and student-centered pedagogy.

2) China is emphasizing application-oriented, industry-linked competency development.

3) The blended model used in this study aligns with both trajectories, indicating cross-system applicability.

(3) Global Blended Learning Trends

Research in North America, Europe, and Southeast Asia consistently shows blended learning increases engagement, retention, and analytical skills.

The results of this study confirm these trends within the Chinese context, contributing an important cross-cultural validation.

This international comparative perspective strengthens the generalizability of the findings and positions the study within the global conversation on engineering and management pedagogy reform.

4.8. Limitations and Future Research

Although this study offers valuable insights, several limitations should be recognized to contextualize the findings and inform subsequent research.

To begin with, the questionnaire relies primarily on students' self-reported perceptions, which may be affected by social desirability tendencies or cultural norms that favor positive evaluations. Future research could incorporate additional forms of evidence-such as instructor-assessed performance, behavioral learning data, or standardized tests-to complement subjective measures.

Another constraint lies in the absence of a comparison or control group. Without an alternative instructional condition, it is difficult to isolate the specific effects of the blended PBL+TBL approach. Follow-up studies adopting experimental or quasi-experimental designs would allow stronger claims about causality.

The use of peer assessment also presents certain challenges. While peer ratings offer important insights into group dynamics, they may be influenced by interpersonal relationships, perceived fairness, or reciprocal scoring. Subsequent investigations could employ multi-source assessment frameworks that integrate peer, instructor, and self-evaluations to enhance reliability.

A further limitation stems from the study's setting. All data were collected within a single university and a single course in the operations management domain. The findings therefore may not fully generalize to other disciplines, institutional contexts, or student populations. Replication studies conducted across different subjects, universities, or cultural environments would help determine the broader applicability of the blended model.

In addition, the present study did not capture long-term learning retention or the transfer of competencies to real-world contexts such as internships or workplace practices. Future research might adopt longitudinal designs to track how students apply POM concepts over time and whether the blended approach supports durable learning outcomes.

5. Conclusion

This study evaluated the effectiveness of a blended PBL+TBL instructional model in the Production and Operations Management course using a multi-source evidence framework that included student questionnaires, flipped classroom performance, peer assessments, and project outcomes. The overall findings reveal a highly consistent pattern: the blended approach substantially improves students' cognitive learning, analytical competencies, teamwork engagement, and professional value development.

Across the three participating cohorts, students reported strong gains in mastering core POM concepts and applying analytical tools to realistic operational problems. The flipped classroom results show that most groups demonstrated strong preparation and performance quality, while peer assessments indicate high levels of individual accountability within teams. Together, these indicators suggest that the blended model fosters both independent thinking and collaborative competence-two essential dimensions of learning in engineering and management education.

Beyond skill acquisition, the blended model also supported the development of professional attitudes and values, including craftsmanship spirit, 5S awareness, lean thinking, and recognition of the relevance of POM knowledge to future managerial or engineering roles. This alignment between cognitive learning and value formation reflects the broader pedagogical goals of China's contemporary higher education reforms and is consistent with global movements toward competency-based and learner-centered instruction.

The results suggest several implications for teaching reform. Integrating real-company case analyses, structured teamwork processes, and explicit performance evaluation mechanisms can deepen students' engagement and strengthen the theory-practice connection. The blended PBL+TBL model therefore provides a practical and adaptable framework for enhancing instruction not only in POM but also in other courses requiring analytical reasoning and collaborative problem solving.

While the study provides robust evidence of effectiveness, future research could incorporate comparative designs, explore cross-disciplinary applications, and examine long-term learning transfer to workplace or internship settings. Such investigations would offer deeper insights into the conditions that optimize the impact of blended PBL+TBL pedagogies.

In summary, the study demonstrates that blending problem-based and team-based learning within a technology-enhanced environment offers a viable and impactful pathway for advancing teaching innovation in applied universities. By simultaneously promoting conceptual understanding, analytical thinking, teamwork, and professional identity formation, the blended PBL+TBL model represents a meaningful contribution to the ongoing development of contemporary higher education.

Funding: This research was funded by the Educational and Teaching Reform Research Project of Xijing University, under Project Number JGYB2307.

References

1. Y. Liu, and A. Pásztor, "Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis," *Thinking Skills and Creativity*, vol. 45, p. 101069, 2022. doi: 10.1016/j.tsc.2022.101069
2. K. S. Huang, and H. C. Lei, "Exploring the Influence of Team-Based Learning on Self-Directed Learning and Team Dynamics in Large-Class General Education Courses," *Education Sciences*, vol. 15, no. 9, p. 1207, 2025.
3. Q. Yu, and K. Yu, "Knowledge sharing behavior of Team members in blended team-based learning: Moderating of Team Learning ability," *The Asia-Pacific Education Researcher*, vol. 33, no. 5, pp. 1251-1263, 2024. doi: 10.1007/s40299-023-00795-1
4. W. Cao, "A meta-analysis of effects of blended learning on performance, attitude, achievement, and engagement across different countries," *Frontiers in psychology*, vol. 14, p. 1212056, 2023. doi: 10.3389/fpsyg.2023.1212056
5. X. Y. Wu, "Exploring the impact of blended collaborative learning on deep learning outcomes: a structural equation modeling approach," *Education and Information Technologies*, pp. 1-27, 2025.
6. M. Aming'a, R. Marwanga, and P. Marendi, "Circular economy educational approaches for higher learning supply chains: A literature review," In *Rethinking management and economics in the New 20's: The 2022 Centre of Applied Research in Management and Economics (CARME) conference*, April, 2023, pp. 197-217.
7. M. Wan, Y. Li, and J. Hu, "Innovation and practice of teaching reform of college mathematics course under the background of information technology," *RISTI (Revista Iberica de Sistemas e Tecnologias de Informacao)*, no. E10, pp. 108-119, 2016.
8. J. Sahni, "Does blended learning enhance student engagement? Evidence from higher education," *Journal of E-learning and Higher Education*, vol. 2019, no. 2019, pp. 1-14, 2019. doi: 10.5171/2019.121518
9. R. Kadian, and V. Rose, "Effectiveness Of Blended Learning in Higher Education: A Systematic Review at Global Level," *American Journal of Psychiatric Rehabilitation*, vol. 28, no. 2, pp. 61-67, 2025.
10. S. Porkodi, and B. K. H. Tabash, "A comprehensive meta-analysis of blended learning adoption and technological acceptance in higher education," *Int. J. Mod. Educ. Comput. Sci.(IJMECS)*, vol. 16, no. 1, pp. 47-71, 2024. doi: 10.5815/ijmecs.2024.01.05
11. L. Zhou, S. Xue, and R. Li, "Extending the Technology Acceptance Model to explore students' intention to use an online education platform at a University in China," *Sage Open*, vol. 12, no. 1, p. 21582440221085259, 2022. doi: 10.1177/21582440221085259
12. M. Erans, and D. Beneroso, "Team-based Learning: Promoting Equal Development of Teamworking Skills in Engineering Education," *International Journal of Gender, Science and Technology*, vol. 13, no. 3, pp. 280-291, 2021.
13. M. L. D. C. De Hoyos Guevarra, "Assessment of teamwork in higher education collaborative learning teams: A validation study," 2004.
14. H. Li, Y. Xiong, C. V. Hunter, X. Guo, and R. Tywoniw, "Does peer assessment promote student learning? A meta-analysis," *Assessment & Evaluation in Higher Education*, vol. 45, no. 2, pp. 193-211, 2020. doi: 10.1080/02602938.2019.1620679

15. N. Nagaraja, and B. G. J. Davidson, "Challenges and Transformation of Pedagogy Towards Blended Learning: A Sequential Mixed-Method Study in Higher Education," In *Global Higher Education Practices in Times of Crisis: Questions for Sustainability and Digitalization*, 2024, pp. 151-168. doi: 10.1108/978-1-83797-052-020241010