Application of Digital Technology-Assisted PBL in Clinical Education of Trauma Orthopedics

Bobin Mi

Submitted to: JMIR Medical Education
on: March 27, 2025

Table of Contents

Application of Digital Technology-Assisted PBL in Clinical Education of Trauma Orthopedics

Bobin Mi[1]

[1]1277 Jiefang Avenue Wuhan Union Hospital Wuhan CN

Corresponding Author:
Bobin Mi
1277 Jiefang Avenue
Wuhan Union Hospital
1277 Jiefang Avenue
Wuhan
CN

Abstract

Background: Medical education has evolved significantly over the past few decades, with increasing emphasis on interactive and student-centered learning approaches. Traditional lecture-based learning (LBL), once the dominant method of instruction in medical schools, has faced criticism for its passive nature and limited engagement in developing clinical reasoning and problem-solving skills. In response, problem-based learning (PBL) has emerged as an alternative, placing students in more active roles, where they work through real-life clinical cases and collaboratively develop solutions. PBL has been shown to foster critical thinking and enhance long-term retention of medical knowledge compared to conventional methods.

Objective: This study aims to address the challenges commonly encountered in trauma orthopedic education, such as the complex morphology of fractures and the limited experience of novice learners. By integrating advanced digital technologies with Problem-Based Learning (PBL), the study seeks to enhance teaching effectiveness in this clinical setting.

Methods: The study included 50 clinical interns from the eight-year medical program at Tongji Medical College, Huazhong University of Science and Technology, who completed a one-week internship in the trauma orthopedic department of Union Hospital. Participants were randomly assigned to either a group utilizing a digital technology-assisted PBL model or a group following the traditional lecture-based learning (LBL) approach. The educational content focused on hip fractures, and the effectiveness of the teaching methods was evaluated through assessments of theoretical knowledge, clinical skills, and a satisfaction survey. Data were analyzed using SPSS 20.0 to determine the effectiveness of the digital technology-assisted PBL approach in improving clinical education outcomes.

Results: The use of 3D-printed models enhanced the visualization and practical application of anatomical structures, positively influencing students' engagement and fostering autonomous learning. The PBL method significantly promoted active learning, improving collaboration and communication skills among students. However, digital technologies presented certain limitations, including high costs and the inability to represent soft tissue structures, while the PBL approach posed challenges such as increased student workload and higher instructional demands on educators.

Conclusions: The integration of digital technology with PBL in trauma orthopedic education demonstrated significant pedagogical advantages, contributing to improved teaching quality and learning outcomes. This approach warrants further investigation and broader implementation in clinical education. Clinical Trial: none

(JMIR Preprints 27/03/2025:75051)
DOI: https://doi.org/10.2196/preprints.75051

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?
✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.

No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**

Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v

Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

No. Please do not make my accepted manuscript PDF available to anyone.

Original Manuscript

Application of Digital Technology-Assisted PBL in Clinical Education of Trauma Orthopedics

Lizhi Ouyang[1], Guohui Liu[1], Bobin Mi[1]

[1]Department of Orthopedics, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, 1277 Jiefang Avenue, Wuhan 430022, China

Correspondence: mibobin@hust.edu.cn

Abstract

Background: This study aims to address the challenges commonly encountered in trauma orthopedic education, such as the complex morphology of fractures and the limited experience of novice learners. By integrating advanced digital technologies with Problem-Based Learning (PBL), the study seeks to enhance teaching effectiveness in this clinical setting.

Methods: The study included 50 clinical interns from the eight-year medical program at Tongji Medical College, Huazhong University of Science and Technology, who completed a one-week internship in the trauma orthopedic department of Union Hospital. Participants were randomly assigned to either a group utilizing a digital technology-assisted PBL model or a group following the traditional lecture-based learning (LBL) approach. The educational content focused on hip fractures, and the effectiveness of the teaching methods was evaluated through assessments of theoretical knowledge, clinical skills, and a satisfaction survey. Data were analyzed using SPSS 20.0 to determine the effectiveness of the digital technology-assisted PBL approach in improving clinical education outcomes.

Results: The use of 3D-printed models enhanced the visualization and practical application of anatomical structures, positively influencing students' engagement and fostering autonomous learning. The PBL method significantly promoted active learning, improving collaboration and communication skills among students. However, digital technologies presented certain limitations, including high costs and the inability to represent soft tissue structures, while the PBL approach posed challenges such as increased student workload and higher instructional demands on educators.

Conclusion: The integration of digital technology with PBL in trauma orthopedic education demonstrated significant pedagogical advantages, contributing to improved teaching quality and learning outcomes. This approach warrants further investigation and broader implementation in clinical education.

Keywords: Digitalization; PBL (Problem-Based Learning); Trauma Orthopedics; Teaching Methods; Clinical Internship

1. Background

Medical education has evolved significantly over the past few decades, with increasing emphasis on interactive and student-centered learning approaches. Traditional lecture-based learning (LBL), once the dominant method of instruction in medical schools, has faced criticism for its passive nature and limited engagement in developing clinical reasoning and problem-solving skills. In response, problem-based learning (PBL) has emerged as an alternative, placing students in more active roles, where they work through real-life clinical cases and collaboratively develop solutions. PBL has been shown to foster critical thinking and enhance long-term retention of medical knowledge compared to conventional methods.[1-3]

In recent years, technological advancements have opened up new opportunities to integrate digital tools into medical education. Virtual simulations, 3D models, and digital imaging technologies offer immersive experiences that can improve students' understanding of complex anatomical structures and clinical procedures.[4-6] These technologies, when combined with PBL, have the potential to revolutionize clinical teaching by providing more hands-on, interactive learning environments, allowing students to better bridge the gap between theoretical knowledge and clinical practice.

Orthopedic education, in particular, can benefit greatly from this integration of digital tools and PBL. Understanding the intricacies of bone fractures, surgical techniques, and related anatomical structures is critical for medical students, yet traditional teaching methods may not fully capture these complexities.[7] The use of 3D models and virtual simulations provides students with opportunities to visualize and interact with anatomical structures in ways that standard textbooks and lectures cannot. This study aims to compare the effectiveness of a digital-assisted, PBL-based teaching approach with the traditional LBL model in the context of orthopedic clinical education. [8, 9]

By comparing the learning outcomes and satisfaction levels of medical students exposed to these two different teaching models, this study seeks to provide insights into the potential benefits of incorporating digital tools into problem-based learning for clinical training. It will also explore whether such approaches better prepare students for the practical demands of orthopedic surgery and patient care.

2. Methods

2.1 Participants

This study involved 50 clinical interns enrolled in the eight-year medical program at Tongji Medical College, Huazhong University of Science and Technology, who completed a one-week trauma orthopedic internship at Union Hospital between September 2022 and June 2023. All participants were undergoing their first clinical rotation in trauma orthopedics, and informed consent was obtained from each participant.

2.2 Study Design

The study employed an experimental control design. The 50 students were randomly assigned to two groups, each consisting of 25 participants. The experimental group received instruction using a digital technology-assisted PBL model, while the control group followed the traditional LBL approach. Both groups were taught by associate chief physicians, and the clinical teaching content focused on femoral fractures. A comparison of basic demographic information (e.g., prior academic performance, gender, and age) between the groups revealed no significant differences ($P > 0.05$).

2.3 Teaching Implementation

2.3.1 Experimental Group (PBL Model)

Problem Presentation: Teaching was centered around typical clinical cases of hip fractures, such as femoral neck, femoral head, intertrochanteric, and acetabular fractures. Instructors guided students in collecting clinical case data, providing detailed explanations of key concepts, and posing questions to stimulate critical thinking.

Data Retrieval: Students were tasked with addressing clinical case questions by consulting textbooks and conducting literature searches in databases such as PubMed, CNKI, Wanfang, and VIP. The collected data were then summarized, compared, and analyzed.

Digital Technology Support: Students used specialized 3D software to manipulate fracture models and simulate virtual surgeries, deepening their understanding of fracture types and reduction techniques. CT data from clinical cases were reconstructed into 3D models, and realistic 3D-printed models of patient injuries were produced to enhance the students' spatial awareness of surrounding anatomical structures (Figure 1).

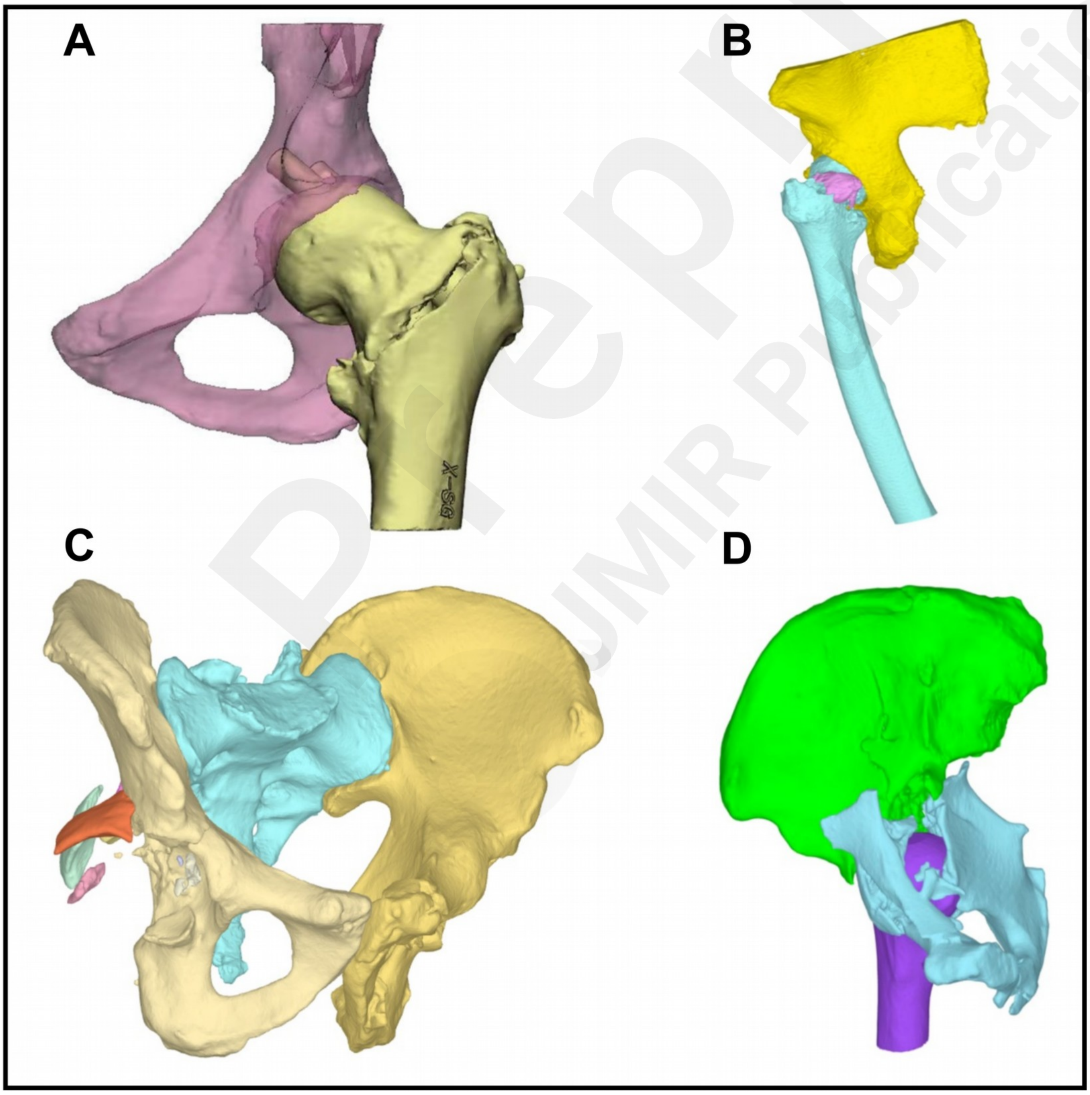

Figure 1. 3D-printed models used in clinical instruction: A, B: femoral neck fractures; C, D:

pelvic and acetabular fractures

Group Discussions: Students were randomly divided into five groups, each comprising five members. They engaged in group presentations, reporting, and discussions. The instructor evaluated the quality of the students' discussions, the evidence they gathered, and the clinical plans they proposed. Best practices were identified, and students were guided in simulating surgical procedures on the 3D models.

2.3.2 Control Group (LBL Model)

The control group followed a traditional LBL model, where the instructor delivered structured lectures and demonstrations. The instructor explained the clinical presentation, radiological features, and treatment plans of the selected cases, utilizing standard pelvic models and imaging data. No 3D reconstruction or 3D-printed models were used in this group.

2.4 Evaluation of Teaching Effectiveness

2.4.1 Examination Performance

At the end of the trauma orthopedic rotation, both groups underwent exit assessments, which included theoretical knowledge and clinical skill evaluations, each scored out of 100 points. The theoretical examination covered topics such as pelvic and femoral anatomy, fracture classification, common surgical approaches, advantages and limitations of different procedures, and surgical indications. The practical assessment required students, under instructor supervision, to perform medical history collection, physical examinations, preoperative analysis, selection of appropriate fixation methods, and surgical plan design for a femoral fracture case.

2.4.2 Satisfaction Survey

An anonymous satisfaction survey was conducted after the completion of the rotation to objectively assess the teaching outcomes. The survey evaluated the effectiveness of the teaching methods in enhancing the understanding of hip fracture theory, stimulating learning interest, and improving teamwork skills. A 0-10 rating scale was used, with a maximum score of 10, allowing students to rate their experience based on personal perceptions.

2.5 Statistical Analysis

Statistical analysis was performed using SPSS 20.0. Continuous variables were expressed as mean ± standard deviation (x±s) and compared using the t-test. Categorical data were analyzed using the chi-square (χ^2) test. A significance level of $P < 0.05$ was considered statistically significant.

3. Results

3.1 Comparison of General Characteristics Between the Two Groups

Both groups consisted of the same number of students, with no significant differences in age, gender distribution, or previous academic performance in the "Diseases of the Musculoskeletal System" course. The detailed comparison is provided in Table 1.

Table 1: Comparison of General Characteristics Between the Two Groups [Mean ± SD]

Groups	Sex		Age (years)	Course Score
	Male	Female		
Experimental (n=25)	11	14	23.4±0.7	84.2±6.3
Control (n=25)	13	12	23.6±0.8	83.4±8.1
t or χ^2 value	0.321		0.636	0.264
P value	0.572		0.529	0.793

3.2 Comparison of Assessment Outcomes

The overall assessment scores of the experimental group were significantly higher than those of the control group ($P < 0.05$). Further analysis revealed that both theoretical knowledge and practical skills scores were notably higher in the experimental group, with statistically significant differences ($P < 0.001$). The detailed results are presented in Table 2.

Table 2: Comparison of Assessment Results Between the Two Groups [Mean ± SD]

Groups	Theoretical Knowledge	Practical Skills	Over score
Experimental (n=25)	89.7±3.4	90.6±2.9	180.3±5.5
Control (n=25)	85.3±4.0	84.2±4.7	169.5±6.4
t value	3.212	4.469	4.871
p value	0.003	0.000	0.000

3.3 Teaching Satisfaction Survey

A total of 50 questionnaires were distributed and returned, yielding a 100% valid response rate. The experimental group demonstrated significantly higher satisfaction levels in terms of understanding femoral fracture theory, increased interest in learning, and improved teamwork skills, compared to the control group ($P < 0.05$). The detailed survey results are shown in Table 3.

Table 3: Comparison of Teaching Satisfaction Between the Two Groups [Mean ± SD]

Groups	Theory Understanding	Learning Interest	Teamwork Skills	Satisfaction
Experimental (n=25)	8.78 ± 0.64	8.96 ± 0.71	9.15 ± 0.65	26.88 ± 1.57
Control (n=25)	7.65±1.19	5.26±1.35	4.31±1.17	18.06 ± 2.97
t value	3.238	9.812	11.37	11.77
p value	0.003	0.000	0.000	0.000

4. Discussion

This study evaluated the effectiveness of a digital-assisted, PBL model compared to traditional LBL in orthopedic clinical education. The results indicate that students in the PBL group, which utilized digital tools, achieved significantly higher scores in both theoretical knowledge and practical skills assessments than those in the LBL group. Additionally, the PBL group reported greater satisfaction with their learning experience, particularly in areas such as understanding of key concepts, increased interest in learning, and enhanced teamwork skills.

The superior performance of the PBL group suggests that integrating digital resources—such as 3D-printed models and virtual surgical simulations—significantly enhanced students' comprehension of complex orthopedic concepts.(Shaffer, 2004, 2005) The interactive nature of these tools provided students with a deeper understanding of anatomical structures, fracture types, and surgical procedures. In contrast, the LBL group, which relied on traditional teaching methods, may have lacked the hands-on engagement needed for a comprehensive grasp of these clinical topics.

Furthermore, the PBL model's focus on active problem-solving likely contributed to the greater intellectual engagement and motivation observed in the experimental group.[12, 13] By working through clinical case discussions and tackling real-world problems, students were encouraged to think critically and apply theoretical knowledge in practical scenarios. This approach aligns with existing research demonstrating that PBL enhances cognitive engagement and clinical reasoning skills, which are essential for medical students as they transition into clinical practice. The collaborative aspect of PBL, involving group discussions and presentations, also promoted the development of communication and teamwork abilities, which are critical in multidisciplinary healthcare settings.

The satisfaction survey results further support these findings. Students in the PBL group reported significantly higher satisfaction with their learning experience, particularly regarding their understanding of orthopedic principles, increased interest in the subject matter, and the development of teamwork skills.[14, 15] These outcomes suggest that the PBL approach, combined with digital learning tools, not only improves academic performance but also prepares students for the collaborative nature of clinical practice.

Despite these positive results, the study has certain limitations. The short duration of the clinical rotation may have restricted the depth of skills and knowledge acquired by the students. Additionally, the study was conducted with a specific cohort of medical students, which may limit the generalizability of the findings. Future research should consider longer-term studies across diverse medical specialties and larger student populations to assess the broader applicability and impact of digital-assisted PBL.

In conclusion, this study demonstrates that the combination of digital tools with a problem-based learning model significantly improves students' theoretical knowledge and practical skills in orthopedic education. The digital-assisted PBL approach provides a more interactive and engaging learning environment compared to traditional methods. These findings suggest promising potential for its broader implementation in medical education, warranting further investigation in other clinical disciplines.[2, 14, 16, 17]

List of abbreviations

Abbreviation	Definition
PBL	Problem-Based Learning
LBL	Lecture-based learning

Acknowledgments

None are to be done.

Authors' contributions

OL: data gathering and analysis, writing, revising. GL: manuscript revising and approval. BM: conception, writing, revising and manuscript approval. All the authors have read the manuscript and agree in its submission to Medical Education Online and consent it is done.

Funding

Not availability.

Availability of data and materials

All data will become available if requested.

Ethics approval and consent to participate

This study has had an ethics committee approval, by the Institutional Review Board (IRB) at the Union Hospital, Tongji Medical College, Huazhong University of Science and Technology. All participants signed the informed consent before participating in the program.

Consent for publication

All data were obtained after written informed consent to answer and for data to be analyzed and published.

Competing interests

The authors have no conflicts of interest to disclose.

References:

[1] X. Ding, L. Zhao, H. Chu, N. Tong, C. Ni, Z. Hu, Z. Zhang, M. Wang, *Sci Rep* **2014**, *4*, 5126.
[2] X. Gao, S. Luo, D. Mu, Y. Xiong, L. Guanjian, C. Wan, *J Evid Based Med* **2016**, *9*, 136.
[3] G. Sangestani, M. Khatiban, *Nurse Educ Today* **2013**, *33*, 791.
[4] M. W. Cullen, J. B. Geske, N. S. Anavekar, J. A. McAdams, M. E. Beliveau, S. R. Ommen, R. A. Nishimura, *MAYO CLIN PROC* **2019**, *94*, 2501.
[5] S. Sandrone, L. D. Schneider, *NEURON* **2020**, *106*, 895.
[6] A. A. Sayiner, E. Ergonul, *Clin Microbiol Infect* **2021**, *27*, 1589.
[7] V. Yuenyongviwat, J. Bvonpanttarananon, *JMIR Med Educ* **2021**, *7*, e22992.
[8] J. Chen, B. Gao, K. Wang, Y. Lei, S. Zhang, S. Jin, W. Yang, Y. Zhuang, *BMC MED EDUC* **2023**, *23*, 322.
[9] T. Li, R. Song, W. Zhong, W. Liao, J. Hu, X. Liu, F. Wang, *BMC MED EDUC* **2024**, *24*, 253.
[10] K. Shaffer, *N Engl J Med* **2004**, *351*, 1279.
[11] K. Shaffer, *RADIOLOGY* **2005**, *235*, 359.
[12] H. Xie, L. Wang, Z. Pang, S. Chen, G. Xu, S. Wang, *Front Med (Lausanne)* **2022**, *9*, 985128.
[13] P. Yao, J. OuYang, C. Liu, S. Wang, X. Wang, S. Sun, *BURNS* **2020**, *46*, 647.
[14] J. Li, Q. L. Li, J. Li, M. L. Chen, H. F. Xie, Y. P. Li, X. Chen, *MED TEACH* **2013**, *35*, e963.
[15] M. Qu, Q. Hou, C. Yu, X. Li, J. Xia, Z. Dong, *Front Med (Lausanne)* **2024**, *11*, 1334919.
[16] S. A. Azer, *ANAT SCI EDUC* **2013**, *6*, 415.
[17] S. Stewart, B. Choudhury, *ANAT SCI EDUC* **2015**, *8*, 429.

□□□□

□□□□□□□□ [APA 7th]
□□□□□□□□□ 17 □□□ 8 □□□□□□□ 19 □□□□□□□□□
□ 0 □□□□□□□□□□□□□□□□
□□□□□□□□□
□□□□

□□□□□□□□ [Advanced Materials New]
□□□□□□□□□ 17 □□□ 8 □□□□□□□ 19 □□□□□□□□□
□ 0 □□□□□□□□□□□□□□□□
□□□□□□□□□