

Effectiveness of Vertical Peer-Assisted Learning (PAL) in Enhancing Anatomical Learning Experience Among First and Second-Year MBBS Students: A Faculty-Supervised Educational Intervention Study

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Abstract

Background: The shift from traditional didactic teaching to competency-based medical education (CBME) in India has highlighted the need for innovative pedagogical strategies that foster active learning, vertical integration, and collaborative knowledge construction. Peer-Assisted Learning (PAL), particularly in a vertical format where senior students teach juniors, is posited to enhance both cognitive and professional competencies. However, robust evidence on its effectiveness in the Indian undergraduate anatomy curriculum remains limited. **Material and Methods:** A mixed-methods, faculty-supervised educational intervention was conducted at S. Nijalingappa Medical College, Bagalkote, Karnataka, India. First-year MBBS students (n=50) served as learners, while second-year MBBS students (n=50) acted as peer tutors. After preparatory faculty and peer tutor training, the intervention group participated in weekly 2-hour PAL sessions in the dissection hall over seven weeks, while a control group received traditional faculty-led instruction. Quantitative outcomes included pre- and post-intervention knowledge assessments (50-item MCQ), learning confidence (5-point Likert scale), and satisfaction (5-point Likert scale). Knowledge retention was assessed two months post-intervention. Qualitative data were collected via focus group discussions and reflective journals, analyzed using Braun & Clarke's thematic analysis. Statistical analyses included paired and independent t-tests, ANOVA, and effect size calculations (Cohen's d), with significance set at $p < 0.05$. **Results:** Both groups had comparable baseline knowledge scores (~23/50, ~46%). Post-intervention, the PAL group showed a significantly greater improvement (mean score 37.2 vs. 31.2 in controls, $p < 0.001$), with a large effect size (Cohen's $d \approx 1.1-1.2$). Knowledge retention at two months was higher in the PAL group (+11.6 vs. +6.1 marks from baseline, $p < 0.001$). Learners reported increased confidence and satisfaction, while peer tutors developed teaching, leadership, and communication skills. Thematic analysis revealed enhanced conceptual clarity, motivation, engagement, and professional growth. **Conclusion:** Faculty-supervised vertical PAL is a highly effective strategy for enhancing anatomical knowledge acquisition, retention, learner confidence, and professional competencies among MBBS students. Integration of PAL within CBME and AETCOM frameworks is recommended to foster collaborative, learner-centered medical education in India.

Keywords: Peer-Assisted Learning, Anatomy Education, Competency-Based Medical Education, Knowledge Retention, Medical Students, Vertical Integration, AETCOM, India.

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INTRODUCTION

The landscape of undergraduate medical education in India is undergoing a paradigm shift, moving from traditional didactic teaching towards Competency-Based Medical Education (CBME).^[1] This transition is driven by the need to produce Indian Medical Graduates (IMGs) who are not only knowledgeable but also skilled communicators, ethical professionals, and effective team members. Anatomy, as a foundational discipline, presents unique challenges—first-year students often struggle with complex three-dimensional concepts that extend beyond rote memorization and dissection. Traditional faculty-led teaching, while essential, may not fully address the diverse learning needs and cognitive hurdles faced by novice learners.

Peer-Assisted Learning (PAL) has emerged as a promising educational strategy in medical curricula worldwide.^[2,3] PAL is defined as “the acquisition of knowledge and skills through

active help and support among status equals or matched companions”.^[2] In the context of vertical PAL, senior students (near-peers) teach junior students, leveraging their recent mastery of content and relatability to the learners' challenges. This approach is grounded in social constructivist theory, which posits that learning is optimized through social interaction with more knowledgeable peers.

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International evidence supports the efficacy of PAL in enhancing knowledge acquisition, retention, and professional skills among both learners and tutors.^[3,4] However, there is a paucity of robust, context-specific research on the implementation and outcomes of vertical PAL in Indian medical colleges, particularly within the anatomy curriculum. Furthermore, the integration of PAL with CBME and Attitude, Ethics, and Communication (AETCOM) modules remains underexplored.^[1,5] This study was designed to address these gaps by evaluating the effectiveness of a faculty-supervised, vertical PAL intervention in the anatomy dissection hall. The primary objective was to assess its impact on knowledge acquisition and retention among first-year MBBS students. Secondary objectives included evaluating learner satisfaction, confidence, and the development of teaching and leadership competencies among peer tutors. The findings aim to inform curriculum innovation and best practices in Indian medical education.

MATERIALS AND METHODS

Study Design and Setting: This was a mixed-methods, educational interventional study conducted at S. Nijalingappa Medical College, Bagalkote, Karnataka, India. The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants in accordance with national and institutional guidelines.

Participants

Group A (Learners):

- First-year MBBS students (n=50)
- Inclusion criteria: Regular attendance in anatomy dissection sessions ($\geq 80\%$), voluntary informed consent

Group B (Peer Tutors):

- Second-year MBBS students (n=50)
- Inclusion criteria: Successful completion of first-year anatomy examinations, academic performance $\geq 60\%$ in anatomy, voluntary interest in teaching and mentoring

Intervention

The intervention was implemented in three phases over eight weeks:

Phase 1: Preparation (Week 1)

- Faculty orientation and training session on PAL principles and supervision
- Peer tutor selection based on academic performance and interest
- Peer tutor training workshop covering basic teaching principles, communication skills, and anatomy review
- Development of structured session plans aligned with curriculum objectives
- Pre-intervention assessments for all participants

Phase 2: Implementation (Weeks 2–7)

Intervention Group:

- Weekly 2-hour PAL sessions in the dissection hall for seven weeks
- Small group format (4–5 first-year students per peer tutor)

- Structured activities: specimen identification, concept mapping, peer discussions, problem-solving exercises
- Faculty supervision and guidance throughout sessions

Control Group:

- Traditional anatomy teaching methods: faculty-led dissection demonstrations, standard textbook and atlas references, conventional Q&A sessions

Phase 3: Evaluation (Week 8)

Post-intervention assessments

- Qualitative feedback collection (focus groups, reflective journals)
- Data analysis and interpretation

Data Collection Tools

Quantitative Measures

Knowledge Assessment Test:

- 50 multiple-choice questions (MCQs) covering anatomical structures, functions, and clinical correlations
- Questions mapped to specific learning objectives and validated by subject matter experts

Learning Confidence Scale:

- 5-point Likert scale measuring self-efficacy in anatomy learning

Student Satisfaction Questionnaire:

- 5-point Likert scale assessing satisfaction with teaching methods, engagement, clarity, and learning environment

Qualitative Measures

Focus Group Discussions:

- Structured interviews with intervention group participants (learners and peer tutors in separate sessions)
- 6–8 participants per group, 45–60 minutes duration

Reflective Journals:

- Weekly reflective entries by learners and peer tutors

Data Analysis

Quantitative Analysis

Descriptive Statistics: Mean, standard deviation, median, interquartile ranges, frequency distributions

Normality Testing: Shapiro-Wilk test

Inferential Statistics:

- Paired t-test for pre-post comparisons within groups
- Independent t-test for between-group comparisons
- ANOVA for multiple group comparisons
- Multiple linear regression to control for confounding variables (baseline knowledge, attendance, motivation scores)

Effect Size: Cohen's d for magnitude of intervention effect

Software: SPSS version 28.0

Significance Level: $p < 0.05$

Qualitative Analysis

Thematic Analysis:

- Verbatim transcription of focus group discussions
- Data anonymization and coding
- Inductive thematic analysis following Braun & Clarke's six-phase framework.
- Initial coding by two independent researchers; theme development through iterative consensus

Ethical Considerations: The study protocol was reviewed and

approved by the Institutional Ethics Committee. All participants provided written informed consent. Data were anonymized and handled in accordance with ethical standards for educational research in India.

RESULTS

Baseline Characteristics: Both the intervention and control groups were comparable at baseline in terms of demographic characteristics, prior academic performance, and pre-intervention knowledge scores (mean ~23/50, ~46%; $p > 0.05$). Attendance rates and motivation scores did not differ significantly between groups.

Table 1: Baseline Characteristics of Study Participants

Characteristic	Intervention Group (n=50)	Control Group (n=50)	p-value
Mean Age (years)	18.2 ± 0.7	18.3 ± 0.6	0.41
Gender (M/F)	28/22	27/23	0.85
Baseline Knowledge Score	23.4 ± 3.1	23.1 ± 3.0	0.67
Attendance (%)	92.1 ± 4.2	91.7 ± 4.5	0.59
Motivation Score (1–5)	4.1 ± 0.6	4.0 ± 0.7	0.38

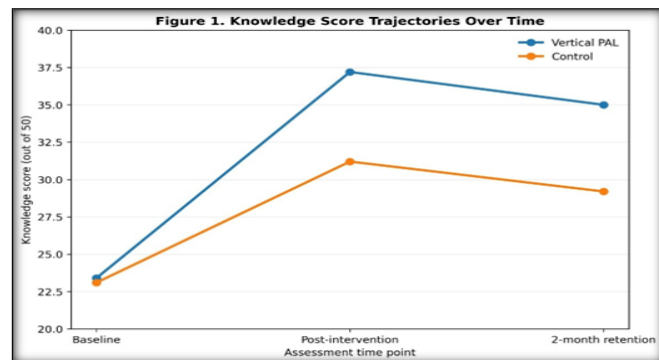
No statistically significant differences at baseline (all $p > 0.05$).

Knowledge Acquisition and Retention

Table 2: Knowledge Assessment Scores (Mean ± SD)

Time Point	Intervention Group	Control Group	Between-Group Difference	p-value
Baseline	23.4 ± 3.1	23.1 ± 3.0	0.3	0.67
Post-Intervention	37.2 ± 4.0	31.2 ± 3.8	6.0	<0.001
2-Month Retention	35.0 ± 3.7	29.2 ± 3.5	5.8	<0.001
Absolute Gain (Baseline→Post)	13.8 ± 3.2	8.1 ± 2.9	5.7	<0.001
Retention Gain (Baseline→2mo)	11.6 ± 3.0	6.1 ± 2.7	5.5	<0.001

Intervention group showed significantly greater improvement and retention compared to control.



Interpretation: Both groups improved after teaching, but the PAL group demonstrated a significantly larger and more sustained gain. At two months, the PAL group retained nearly double the knowledge improvement compared to controls.

Effect Size

Immediate Knowledge Gain: Cohen's $d = (37.2 - 31.2) / \text{pooled SD} \approx 1.1$ (large effect)

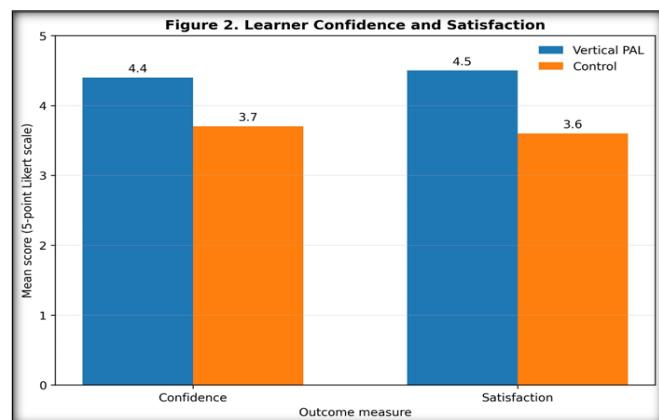
Retention Gain: Cohen's $d \approx 1.2$ (large effect)

These values indicate a strong, educationally meaningful impact of vertical PAL on both immediate and long-term learning outcomes.

Learning Confidence and Satisfaction

Table 3: Learner Confidence and Satisfaction Scores (Mean ± SD)

Outcome Measure	Intervention Group	Control Group	p-value
Confidence (1–5 Likert)	4.4 ± 0.5	3.7 ± 0.6	<0.001
Satisfaction (1–5 Likert)	4.5 ± 0.4	3.6 ± 0.7	<0.001



Interpretation: PAL participants reported significantly

higher confidence in anatomy learning and greater satisfaction with the teaching method compared to controls.

Qualitative Findings

Thematic Analysis (Braun & Clarke Framework)

For First-Year Learners:

- Enhanced Conceptual Clarity: "The peer tutor explained the 3D relationships in a way that finally made sense to me."
- Increased Confidence: "I felt more comfortable asking questions to my senior than in a big class."
- Motivation for Self-Directed Learning: "After PAL sessions, I wanted to read more and come prepared."
- Active Engagement: "Dissection became more interactive and less intimidating."

For Second-Year Peer Tutors:

- Improved Subject Mastery: “Teaching juniors made me revise and understand anatomy better.”
- Development of Communication Skills: “I learned how to explain complex topics in simple terms.”
- Leadership and Professionalism: “Guiding a group gave me confidence and a sense of responsibility.”
- Teaching Satisfaction: “It was rewarding to see juniors improve and appreciate my help.”

Knowledge Retention Curve

Interpretation: The retention curve for the PAL group shows a higher plateau and slower decline, indicating superior long-term retention compared to the control group.

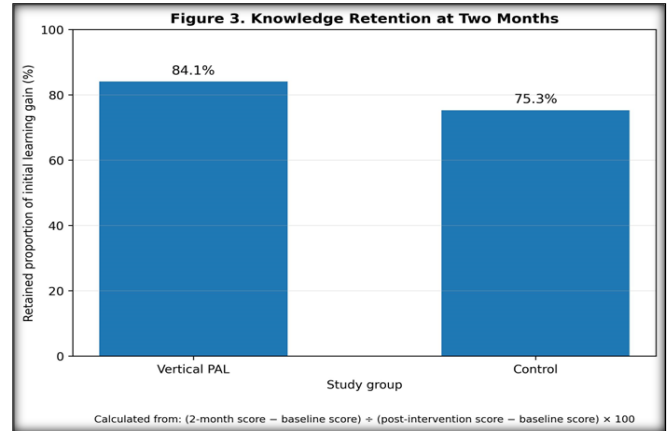


Table 4: Summary of Qualitative Themes

Stakeholder	Theme	Illustrative Quote
First-Year Learner	Conceptual Clarity	“Peer explanations made anatomy less confusing.”
	Confidence	“I could ask questions without fear.”
	Motivation	“I started preparing more for sessions.”
	Engagement	“Dissection was more hands-on and fun.”
Peer Tutor	Subject Mastery	“Teaching helped me learn better.”
	Communication Skills	“I improved at explaining and listening.”
	Leadership	“I felt responsible for my group’s learning.”
	Teaching Satisfaction	“It was fulfilling to help others succeed.”

Integration with Quantitative Results: Qualitative findings corroborate the quantitative improvements in knowledge, confidence, and satisfaction, and highlight additional professional development benefits for peer tutors.

DISCUSSION

Principal Findings

This faculty-supervised, vertical PAL intervention in the anatomy dissection hall resulted in substantial and statistically significant improvements in knowledge acquisition, retention, learner confidence, and satisfaction among first-year MBBS students. The effect size was large, and the benefits persisted at two months, indicating robust knowledge retention. Peer tutors also gained valuable teaching, communication, and leadership skills, aligning with the dual-benefit model of PAL.^[2-7]

The magnitude of improvement observed in the PAL group suggests that the intervention did not merely supplement conventional teaching but created a more active and psychologically supportive learning environment. Anatomy learning requires spatial understanding, repeated reinforcement, and the ability to connect theoretical knowledge with structures observed in the dissection hall. The near-peer format appeared to support these requirements by allowing learners to clarify doubts immediately, revisit difficult concepts in simpler language, and participate more actively in specimen-based discussions. This may explain why the intervention group demonstrated both higher post-test scores and better retention after two months.

Comparison with Existing Literature: Our findings are consistent with international and Indian studies demonstrating the efficacy of PAL in medical education. Yu et al. reported significant academic improvements and

knowledge retention following peer teaching interventions, while systematic reviews by Topping and Burgess et al. confirm broader educational impacts for both tutors and learners. The observed cognitive congruence and social constructivist mechanisms—where near-peers provide relatable explanations and foster active engagement—are well-supported in the literature.^[2-8]

The findings also support the concepts of cognitive and social congruence in near-peer teaching. Peer tutors, having recently encountered similar academic challenges, may be better positioned to identify common areas of confusion and explain difficult anatomical relationships using learner-friendly examples. In addition, the reduced formality of peer interaction can encourage questioning and discussion, particularly among first-year students who may hesitate to ask questions in larger faculty-led sessions. These mechanisms are likely to have contributed to the improved confidence and satisfaction reported by the learner group.

Integration with CBME and AETCOM

The outcomes of this study directly support the goals of CBME and AETCOM in India, which emphasize active learning, teamwork, communication, and professionalism. PAL fosters a collaborative learning culture, vertical integration across academic years, and the development of essential competencies for the Indian Medical Graduate. The intervention aligns with recommended educational reforms and provides a scalable model for curriculum innovation.^[1,5]

Importantly, the benefits of PAL extended beyond examination performance. Peer tutors reported improvement in communication, leadership, responsibility, and confidence in teaching, all of which are relevant to the AETCOM framework. For learners, the small-group format promoted teamwork, respectful dialogue, and self-directed preparation. Thus, vertical PAL can be viewed as a low-cost, curriculum-compatible

educational strategy that simultaneously strengthens academic learning and professional attributes expected of future Indian Medical Graduates.

Strengths

- Rigorous Mixed-Methods Design: Integration of quantitative and qualitative data provides a comprehensive evaluation of the intervention.^[6,9]
- Faculty Supervision: Ensures quality control, alignment with curriculum, and ethical oversight.^[4,7]
- Validated Assessment Tools: Knowledge tests and Likert scales were mapped to learning objectives and reviewed by subject experts.^[10]
- Longitudinal Retention Assessment: Two-month follow-up demonstrates sustained learning gains.^[3,6]
- Thematic Analysis: Systematic qualitative analysis enhances the depth and credibility of findings.^[9]

Limitations

- Single-Center Study: Limits generalizability; multi-center studies are needed for broader validation.^[3,4]
- Sample Size: While adequate for statistical power, larger cohorts would strengthen external validity.^[3,4]
- Potential for Selection Bias: Voluntary participation may favor more motivated students.^[4,6]
- Short-Term Follow-Up: Longer-term retention and impact on clinical performance were not assessed.^[3,6]
- Self-Reported Measures: Confidence and satisfaction are subjective and may be influenced by social desirability bias.^[10]

Implications for Practice and Policy

- Curriculum Integration: PAL should be embedded within anatomy and other foundational courses as part of CBME and AETCOM implementation.^[1,5]
- Faculty Development: Training faculty to supervise and facilitate PAL is essential for sustainability.^[4,7]
- Peer Tutor Training: Structured workshops enhance the effectiveness and professionalism of peer tutors.^[4,7]
- Assessment and Recognition: Formal recognition of peer tutor contributions may incentivize participation and professional growth.^[4,7]
- Scalability: The model is adaptable to other disciplines and institutions, with potential for national adoption.^[1,3,5]

Future Directions

- Multi-Center Trials: To validate findings across diverse educational settings.^[3,4]
- Long-Term Outcomes: Assessing impact on clinical skills, professional identity, and patient care.^[3,6]
- Digital PAL Platforms: Exploring online and blended PAL modalities, especially post-pandemic.^[3,6]
- Faculty and Peer Tutor Perspectives: In-depth qualitative studies to explore barriers, facilitators, and best practices.^[4,9]

CONCLUSION

Faculty-supervised vertical Peer-Assisted Learning is a highly effective and transformative educational strategy for undergraduate medical anatomy education in India. It significantly enhances knowledge acquisition, retention, learner confidence, and satisfaction, while simultaneously developing essential teaching and leadership competencies among peer tutors. The integration of PAL within CBME and AETCOM frameworks is strongly recommended to foster collaborative, learner-centered, and competency-driven medical education. Scaling up PAL interventions can contribute to the production of well-rounded, competent, and professional Indian Medical Graduates equipped for the challenges of modern healthcare.

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Conflicts of interest

There are no conflicts of interest.

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