Section: Anatomy

Original Research Article

THE ROLE OF PROBLEM-BASED LEARNING IN ENHANCING STUDENT ENGAGEMENT AND STRENGTHENING CLINICAL CORRELATION SKILLS IN GROSS ANATOMY

Rupali S. Kavitake[1], Sumedh Ganpat Sonavane[2], Santosh Waghmode[3]

[1]Assistant Professor, Government Medical College, Alibag, District Raigad, Maharashtra, India.
[2]Associate Professor, Department of Anatomy, Topiwala National Medical College and B. Y. L. Nair Charitable Hospital, Mumbai, India.
[3]Associate Professor, Government Medical College, Alibag, District Raigad, Maharashtra, India.

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Corresponding Author:
Dr. Rupali S. Kavitake,
Email: drrupallikhedu@gmail.com

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ABSTRACT

This study explores the limitations of traditional gross anatomy teaching, where passive learning often leads to student disengagement and poor retention of clinically relevant knowledge. The absence of interactive, real-world problem-solving restricts the development of essential clinical skills, holds back the effective application of anatomical concepts in clinical settings. The research examines the role of Problem-Based Learning (PBL) as an innovative approach to enhance student engagement and foster clinical skill development. The objective is to evaluate PBL's effectiveness in improving participation and practical understanding, ultimately preparing students for clinical practice. This study employs a quasi-experimental design comparing traditional lecture-based instruction with Problem-Based Learning (PBL) among 90 first-year medical students. The PBL group engages in case-based, small-group sessions focused on real clinical scenarios, promoting active learning and collaboration. Student engagement is assessed through pre- and post-course surveys, classroom observations, and reflection journals, measuring cognitive, emotional, and behavioural factors. Quantitative and qualitative analyses are conducted to determine PBL's effectiveness in enhancing engagement and clinical application of anatomical knowledge. The study found that Problem-Based Learning (PBL) significantly enhances student engagement and clinical correlation skill development in gross anatomy.

INTRODUCTION

Problem-based learning (P.BL) transforms gross anatomy education from rote memorization to active, case-based reasoning by using real-world clinical scenarios to engage students.[1] This pedagogical approach improves student engagement and develops grave clinical skills, such as problem-solving, critical thinking, and self-directed learning, by pushing students to apply their knowledge in a more interactive, student-centred environment than traditional lecture-based methods.[2-3] It bridges the gap between basic sciences and clinical practice, preparing students for their future professional roles by providing a more comprehensive and practical understanding of anatomy.[4] Traditional, lecture-based instruction in gross anatomy is often criticized for its passive, teacher-centric approach that highlights rote memorization over the practical, clinical application of knowledge.[5] This can lead to a gap between students' foundational anatomical knowledge and their capacity to effectively apply that knowledge in clinical situations.[6-7] Also, passive learning can result in lower student engagement and a perception that anatomy is disconnected from future medical practice, hindering the development of essential clinical reasoning and problem-solving skills.[8-9] The motivation for using problem-based learning (PBL) in gross anatomy stems from the limitations of traditional lecture-based methods and the need to produce more clinically competent, engaged, and independent medical professionals.[10]
Traditional methods frequently rely on rote memorization, which can lead to rapid knowledge decay and a poor understanding of how anatomical concepts apply to real clinical practice.[11-12]
Problem-based learning (PBL) enhances student engagement and develops clinical skills in gross anatomy by using real-world problems to motivate students, foster critical thinking, and connect anatomical concepts to clinical practice.[13-14] PBL helps students develop clinical reasoning and diagnostic skills, improve knowledge retention, and increase their ownership of learning, making it a

valuable alternative or supplement to traditional lecture-based methods.[15] A problem-based learning (PBL) solution for improving student engagement and clinical skills in gross anatomy includes creating a hybrid curriculum that uses clinically relevant scenarios and technology to guide students through the anatomical concepts.[16] This approach addresses the limitations of traditional lecture-based anatomy, which often relies on memorization and fails to connect basic science to practical clinical applications.[17] The objective is to investigate and compare the efficacy of a problem-based learning curriculum versus a traditional lecture-based approach in gross anatomy education.[18-19] It concludes the effect of problem-based learning on medical student's clinical skill development, their level of engagement in the learning process, and their acquisition and retention of factual anatomical knowledge.[20] The study also aims to evaluate students' perceptions and satisfaction with the problem-based learning method, while also examining its effect on fostering critical thinking, independent study habits, and collaborative teamwork skills, which are all essential for future clinical practice.

Literature Survey

Problem-Based Learning (PBL) enhances student engagement through active, collaborative, and self-directed learning centred on complex problems, which promotes critical thinking and knowledge retention. Research indicates PBL is effective in evolving clinical skills, with students often scoring comparably or better on clinical skills assessments than those in traditional programs, as it integrates knowledge directly into a clinical context. Ogut et al,[21] evaluated the effectiveness of Special Study Modules (SSMs) in Cross-Sectional Anatomy. These modules offer students the opportunity to develop their learning skills and foster specific academic interests. The findings demonstrate that cross-sectional anatomical SSMs play a crucial role in bridging theoretical knowledge and clinical practice. By enhancing radiological interpretation skills, fostering professional decision-making, and improving presentation abilities, these modules significantly contribute to medical education. The integration of anatomical and radiological learning has been demonstrated to be a critical component of the module, with students expressing high levels of satisfaction and identifying the relevance of this approach to their future medical careers. Yu et al,[22] compared the daily and final exam scores of students who did not undergo systematic educational reforms with those who embraced the systematic educational reforms. The findings indicate that this curriculum reform not only enhances students' understanding and proficiency in anatomy but also directly enhances their performance in anatomy courses. In the future, it is need to expand the research populations, involve more students in this teaching method, and conduct evaluations of long-term effects. Barut et al,[23] highlighted significant variations in study preferences and durations across diverse regions and academic years, highlighting the necessity of tailored educational approaches. Significant differences in study methods and resource preferences were witnessed across academic years, with 78% of second-year, 69.4% of first-year, and 73% of third-year students preferring individual studies ($X2 = 15.694$; $p = 0.003$). Regular repetition was predominant in Southeastern Anatolia (27.4%) and Central Anatolia (24.4%); encoding for memorization was predominant in the Aegean region (20.9%); and correlation of structures with relations was predominant in the Mediterranean (20.5%) and Southeastern Anatolia (21.9%) regions ($X2 = 90.745$; $p < 0.05$). Finally, understanding and responding to the evolving preferences and needs of medical students can enable educators to create an enriched learning environment that empowers future healthcare professionals in Turkey and beyond. Ahmed et al,[24] demonstrated that integrating active learning strategies through AR methodology can significantly enhance dental students' learning experience and achievement. The findings establish the significance of careful implementation and student support while having an active teaching–learning strategy to be applied. Higher-order thinking fostered through group discussions is key to the success of the flipped classroom approach. This method contrasts with traditional lecture-based learning, which primarily involves lower-order thinking. Future studies that incorporate multiple institutions to increase sample size and diversity. Longitudinal studies would be valuable to evaluate the sustained impact of active learning strategies on clinical performance.

MATERIALS AND METHODS

Research Proposed Methodology

The methodology follows a quasi-experimental design involving two parallel groups: a control group receiving traditional lecture-based instruction and an experimental group exposed to Problem-Based Learning (PBL). First-year medical students of the batch 2025 of Government Medical College Alibag are selected through stratified random sampling, ensuring balanced representation across demographics and academic backgrounds. The experimental group participates in case-based sessions, where real clinical problems drive collaborative discussion and anatomical reasoning. Engagement is assessed using pre- and post-course surveys focusing on cognitive, emotional, and behavioural dimensions. Observations and student reflection journals offer qualitative data. Quantitative and qualitative data are analyzed using appropriate statistical and thematic coding methods. This mixed-methods approach enables a comprehensive understanding of PBL's role in enhancing engagement and clinical competency.

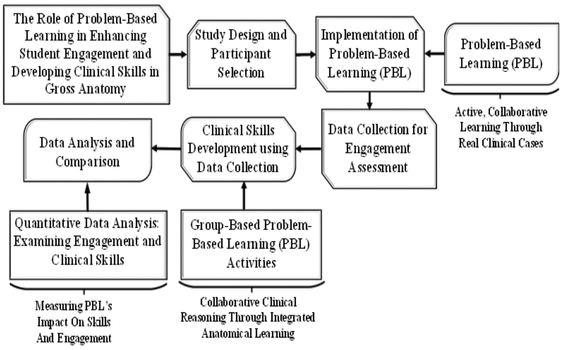

Figure 1: Block Diagram of the Proposed Work

Figure 1 outlines a study investigating the Role of Problem-Based Learning (PBL) in Enhancing Student Engagement and Developing Clinical correlation Skills in Gross Anatomy. The process began with Study Design and Participant Selection, followed by the Implementation of PBL. PBL is defined as Active, Collaborative Learning Through Real Clinical Cases. Data was then collected to assess engagement. The practical component involved Group-Based PBL Activities, which facilitate Collaborative Clinical Reasoning through Integrated Anatomical Learning. Subsequent steps included Quantitative Data Analysis: Examining Engagement and Clinical correlation Skills, which focuses on Measuring PBL's Impact on Skills and Engagement. Finally, this concluded in a Data Analysis and Comparison phase. The entire cycle demonstrates the investigation of PBL's effects on students correlation skills and engagement.

Study Design and Participant Selection

The study uses a quasi-experimental design with two groups: a control group that follows traditional lecture-based instruction and an experimental group that engages in Problem-Based Learning (PBL). First-year medical students are selected based on their willingness to participate and their completion of preliminary assessments. A sample of at least 90 students is chosen to ensure sufficient statistical power for the analysis. This step ensures a clear comparison between the two instructional methods and provides a foundation for analyzing their impact on student engagement and clinical skills development.

A total of 90 first-year medical students were separated into two groups: an experimental group receiving PBL instruction and a control group taught through traditional lectures. Participants were selected using stratified random sampling to allow balanced depiction by gender, age, and academic background. Inclusion of important enrollment in the gross anatomy course and completion of a basic anatomy pre-test, authorizing baseline knowledge comparability. This design is acceptable for an organized comparison between teaching methods, aiming to estimate whether the PBL method more efficiently fosters active learning and practical skill development in early medical education.

Study Design and Participant Selection

This study employs a quasi-experimental design to compare the impact of two teaching methods on medical students' anatomical knowledge and clinical correlation skills. The control group receives traditional lectures characterized by passive, instructor-led learning, while the experimental group participates in student-centred Problem-Based Learning (PBL), involving active critical thinking and collaborative problem-solving with real clinical cases. The design suits educational settings where random assignment is impractical but still allows meaningful comparison. First-year medical students meeting eligibility criteria, including preliminary assessment and consent, are recruited, totalling at least 90 participants evenly split between groups. Group assignment aims to minimize selection bias by matching students based on academic performance and demographics. These methodological controls enhance validity, ensuring observed outcomes can be attributed to the teaching methods rather than confounding factors. This approach effectively investigates PBL's influence on student engagement and clinical skill development within medical education.

Implementation of Problem-Based Learning (PBL)

PBL is implemented in the experimental group through case-based learning sessions. These sessions focus on real clinical cases requiring anatomical knowledge, encouraging students to work in small groups. They collaboratively solve problems, discuss anatomical structures, and apply their learning to simulated clinical scenarios. Instructors facilitate the process but allow students to take the lead in exploring solutions. This approach fosters active learning, critical thinking, and collaboration to improve both engagement and the ability to apply anatomical knowledge in clinical settings.

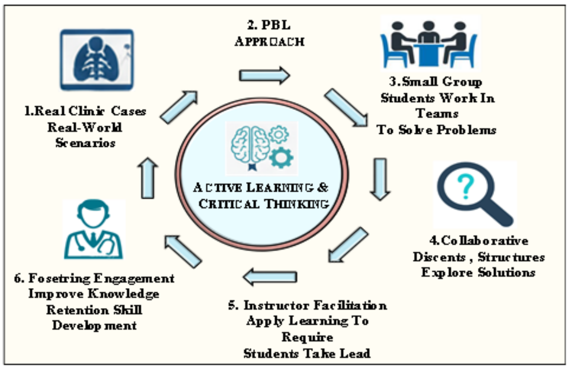

Figure 2: Problem-Based Learning Cycle for Medical Students

Figure 2 illustrates the Problem-Based Learning (PBL) cycle implemented in medical education. It begins with real clinical cases to simulate real-world scenarios, encouraging students to work in small teams. Collaborative discussions enable exploration of solutions and a deeper understanding of anatomical structures. Instructors facilitate the process, guiding students while encouraging them to take the lead. The approach fosters active learning, critical thinking, and engagement. The cycle culminates in improved knowledge retention and clinical correlation skill development, enhancing students ability to apply anatomical concepts in clinical practice effectively.

Data Collection for Engagement Assessment

Student engagement is measured through a combination of surveys and observational assessments. A validated Student Engagement Survey is administered before and after the course to measure cognitive, emotional, and behavioural engagement. Additionally, classroom observations are conducted to record participation levels, attentiveness, and interaction. These observations focus on behaviours like group discussions, student-driven activities, and the quality of engagement during lectures and PBL sessions. Individual reflection journals further capture students' personal engagement experiences and insights, providing a deeper understanding of their learning processes and attitudes toward the course.

Table 1: Sample Overview and Survey Factors (90Respondents)

Factor	Description	Value/Parameter
Sample Size	Total number of respondents	90 students (45 experimental, 45 control)
Study Design	Type of experimental approach	Quasi-experimental (control vs. PBL group)
Control Group	Group using traditional teaching methods	45 students are receiving lecture-based instruction
Experimental Group	Group using Problem-Based Learning (PBL)	45 students engaged in case-based learning sessions
Survey Method	Mode of survey distribution	Online survey platform (e.g., Google Forms, Qualtrics)
Survey Domains	Areas assessed by the survey	Cognitive, emotional, behavioural engagement
Survey Timing	When the survey is administered	Pre- and post-course MCQ test
Engagement Indicators	Key metrics of engagement assessed	Participation frequency, attention level, and group interaction
Reflection Journals	Qualitative assessment of student reflections	Random sample of 20 students per group (10% of total)

Table 1 outlines key data collection elements measuring student engagement in a study comparing Problem-Based Learning (PBL) and traditional lectures with 90 first-year medical students (45 per group). Engagement was assessed through online surveys before and after the course, addressing cognitive, emotional, and behavioural domains through 25 Likert-scale and open-ended questions. Observations of participation, attention, and group interaction were recorded. Reflection journals from 10% of each group provided qualitative insights. This mixed-method approach captured the depth and impact of PBL on engagement and clinical skill development.

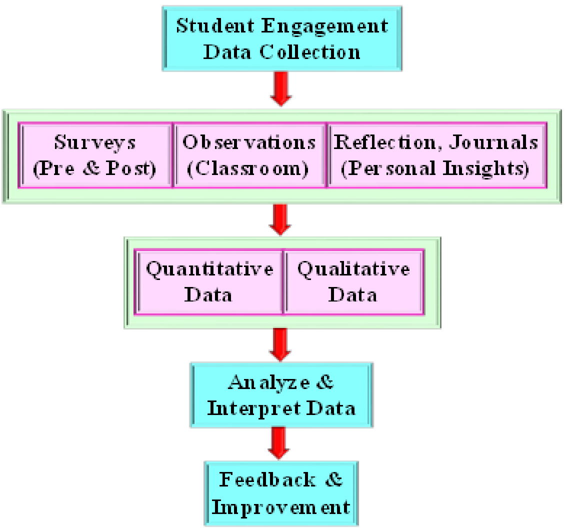

Figure 3: Student Engagement Data Collection and Analysis Framework

Figure 3 illustrates the framework for collecting and analyzing student engagement data. It includes multiple methods such as pre- and post-course surveys, classroom observations focusing on participation and attentiveness, and individual reflection journals capturing personal insights. These data sources are categorized into quantitative and qualitative data, which are then analyzed to assess engagement levels. The outcomes of this analysis provide valuable feedback for course improvement and tailored student support. This comprehensive approach enables a deeper understanding of student involvement and informs strategies to enhance learning experiences.

Group-Based Problem-Based Learning (PBL) Activities

Group-based PBL sessions complement individual evaluations by fostering the development of clinical correlation skills through collaboration and interactivity. Students tackle complex, multi-layered clinical cases that require integrating anatomy with physiology, pathology, and clinical practice. Working in groups, they analyze patient presentations, debate diagnoses, and propose management plans, highlighting how anatomical knowledge interacts with broader medical concepts. This cooperative problem-solving mirrors the multidisciplinary teamwork essential in healthcare, emphasizing the value of diverse perspectives. Educators gain insights into students' communication and interpersonal skills, crucial for effective clinical practice, by observing group dynamics. Facilitators assess clarity in expressing anatomical concepts, active listening, idea contribution, leadership, conflict resolution, and collective reasoning. These evaluations reveal student's readiness to function within healthcare teams and apply anatomical knowledge to clinical reasoning and patient care. Additionally, PBL encourages lifelong learning through self-directed inquiry and peer teaching, essential for ongoing professional growth.

Data Analysis and Comparison

The collected data is analyzed using both quantitative and qualitative methods. Quantitative data includes pre- and post-survey engagement scores. Statistical tests like paired t-tests are used to compare the two groups and determine the effectiveness of PBL. Qualitative data from student journals and group discussions are coded and analyzed thematically to identify key patterns or insights related to engagement and clinical correlation skills development. This mixed-methods approach allows for a comprehensive evaluation of how PBL influences both student participation and the practical application of anatomical knowledge.

Quantitative Data Analysis: Examining Engagement and Clinical Skills

Quantitative data is crucial for objectively measuring PBL's impact on student engagement and clinical skills development. Engagement scores from pre- and post-survey often based on Theory Multiple Choice Questions and Likert scales, quantify changes in interest, motivation, and participation over time, enabling observation of engagement trends. Comparing scores between PBL and non-PBL groups helps determine if PBL enhances exam performance, validating its effectiveness in preparing students for real-world challenges. Statistical methods like paired t-tests and ANOVA analyze the data, testing whether observed differences in pre- and post-intervention scores are statistically significant rather than due to chance. These analyses offer robust empirical support for the relative success of PBL compared to traditional methods, informing curriculum decisions by illustrating its benefits in fostering clinical competence and student engagement.

Qualitative Data Analysis: Thematic Coding of Student Reflections and Group Discussions

Qualitative data provides rich insights into student experiences and perspectives, complementing quantitative measures. This data is often gathered from journals, reflective essays, and group discussion transcripts during PBL sessions, revealing emotional engagement, challenges, collaboration, and clinical reasoning that are difficult to quantify. It also highlights how students assimilate anatomical knowledge and factors influencing their motivation. Thematic coding is commonly used to analyze this data, involving a detailed review and assignment of codes to significant information units like confidence, frustration, teamwork, or knowledge application. These codes are then grouped into broader themes such as improved clinical reasoning, communication skills, or self-directed learning. This approach helps interpret complex data and supports quantitative findings. Qualitative analysis enhances understanding of PBL's impact, identifies areas for teaching improvement, and ensures curriculum decisions reflect student perspectives, promoting a learner-centred approach. Together, qualitative and quantitative data provide a comprehensive evaluation of PBL's effectiveness across multiple dimensions.

RESULTS

EXPERIMENTATION RESULTS

Results indicate a significant increase in student engagement and clinical correlation skill development in the experimental group. Survey data show higher scores in cognitive involvement, emotional investment, and behavioural participation among PBL participants compared to the control group. Observation reports highlight more active classroom participation, frequent peer interaction, and increased attentiveness during sessions. Reflection journals from the experimental group underscore deeper interest in the subject and improved self-directed learning habits. In clinical assessments, students using PBL demonstrate greater exam scores. Their responses indicate a clearer connection between anatomical concepts and clinical relevance. Thematic analysis of qualitative data supports the quantitative trends, revealing enhanced critical thinking, collaboration, and confidence in applying anatomical knowledge. Overall, PBL appears to promote a more interactive and clinically focused learning environment, aligning educational outcomes with real-world medical practice demands.

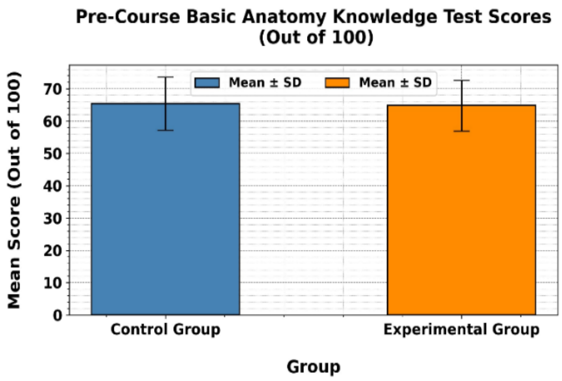

Figure 4: Pre-Course Basic Anatomy Knowledge Test Scores

Figure 4 displays pre-course basic anatomy knowledge test scores for Control and Experimental Groups, with mean scores of 65.4 and 64.8 out of 100, and similar standard deviations (8.2 and 7.9). These results indicate that both groups had nearly equal baseline anatomy knowledge before the intervention. Establishing this equivalence is crucial for attributing any subsequent differences in learning outcomes to Problem-Based Learning (PBL) rather than pre-existing knowledge gaps. This baseline enables a clearer assessment of PBL's impact on student engagement and clinical correlation skill development in anatomy education.

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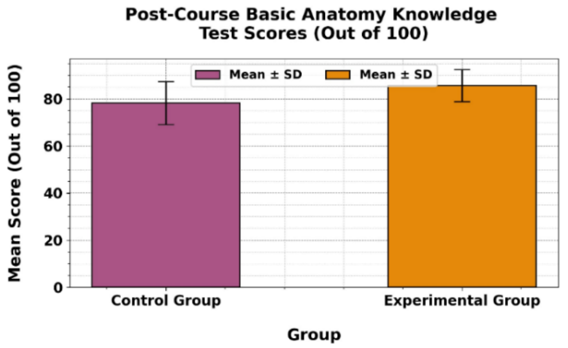

Figure 5: Post-Course Basic Anatomy Knowledge Test Scores

Figure 5shows post-course anatomy knowledge scores for the Control and Experimental Groups. The Experimental Group, likely using Problem-Based Learning (PBL), scored higher (mean 85.6) than the Control Group (78.2) with less variability (SD 6.8 vs. 9.1). This improvement suggests PBL enhances understanding and retention of gross anatomy compared to traditional methods. Higher, more consistent scores indicate better knowledge preservation and learning outcomes. These findings support PBL's role in promoting student engagement, critical thinking, and practical skills, making it an effective approach for improving academic performance and clinical competence in anatomy education.

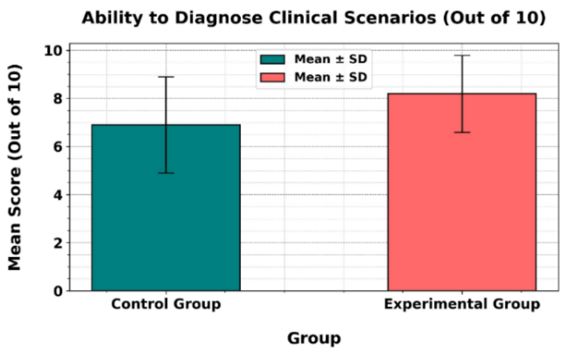

Figure 6: Ability to Diagnose Clinical Scenarios (Out of 10)

Figure 6 presents the ability to diagnose clinical scenarios for the Control and Experimental Groups, with scores out of 10. The Experimental Group, which qualified for Problem-Based Learning (PBL), proficient a higher mean score of 8.2 compared to 6.9 for the Control Group. The Experimental Group also exhibited less variability in scores, with a standard deviation of 1.6 versus 2.0 in the Control Group. This proposes that PBL not only advances diagnostic accuracy but also endorses more reliable clinical reasoning skills among students. The improved performance reflects PBL's efficiency in actively engaging students with real-world problems, developing critical thinking and application of anatomical knowledge. Consequently, PBL plays a vital role in emerging clinical skills important for accurate diagnosis, reinforcing its value in gross anatomy education by bridging theoretical learning and practical clinical competence.

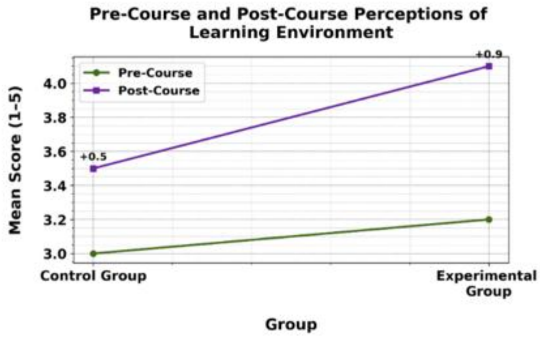

Figure 7: Pre-Course and Post-Course Perceptions of Learning Environment

Figure 7 compares pre-course and post-course perceptions of the learning environment between the Control and Experimental Groups, rated on a Likert scale from 1 to 5. Primarily, both groups had related perceptions, with means of 3.0 for the Control Group and 3.2 for the Experimental Group. After the course, perceptions developed in both groups, but the Experimental Group showed a greater increase, increasing to 4.1, related to the Control Group's 3.5. The mean alteration further highlights this difference: +0.9 for the Experimental Group versus +0.5 for the Control. These results support that Problem-Based Learning (PBL) generates a more positive and appealing learning environment. Enhanced perceptions likely reflect increased student contribution, motivation, and satisfaction, which are crucial for fostering engagement and emerging clinical skills in gross anatomy education.

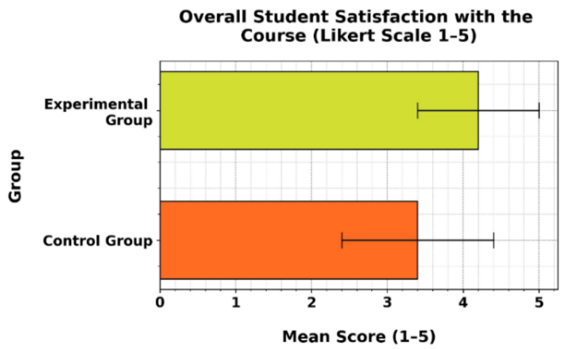

Figure 8: Overall Student Satisfaction with the Course

Figure 8 shows overall student satisfaction with the gross anatomy course, rated on a Likert scale from 1 to 5, relating to a Control Group and an Experimental Group. The Control Group, likely qualified using traditional methods, described a mean satisfaction score of 3.4 with a standard deviation of 1.0, representing moderate satisfaction with greater variation among students. In distinction, the Experimental Group, which qualified for Problem-Based Learning (PBL), displayed a higher mean satisfaction score of 4.2 and a smaller standard deviation of 0.8, indicating stronger and more reliable positive feedback. These consequences recommend that PBL significantly improves student satisfaction by fostering active engagement and practical skill development. The increased satisfaction supports PBL's role in improving motivation and learning experiences, supporting its efficiency in teaching gross anatomy and evolving clinical skills through more interactive and student-centred approaches.

DISCUSSION

The findings demonstrate that Problem-Based Learning (PBL) significantly improves student engagement and clinical skill development in gross anatomy compared to traditional lecture-based methods. Enhanced cognitive, emotional, and behavioural engagement suggests that PBL fosters deeper understanding and sustained interest in anatomical concepts. Active participation through case-based discussions promotes critical thinking and collaborative learning, essential skills for medical practice. The superior performance in clinical assessments reflects better application of anatomical knowledge to real-world scenarios, indicating that PBL effectively bridges the gap between theory and practice. These results align with existing literature supporting active learning strategies in medical education. The use of authentic clinical problems appears to motivate students by contextualizing their learning, thereby improving retention and practical competence. However, the quasi-experimental design limits control over extraneous variables, and the short-term nature of the study leaves long-term retention unclear. Future studies should explore the durability of these outcomes and investigate the integration of technological tools within PBL to further enhance engagement and skill acquisition.

Practical Application of the Study: In medical education, addressing the limitations of traditional passive learning methods. Through case-based, small-group PBL sessions, students actively engage with real clinical problems, promoting deeper understanding and retention of anatomical knowledge. Also, it fosters teamwork, problem-solving abilities, and self-directed learning, all vital for lifelong medical education and effective patient care.

CONCLUSION

Research Conclusion

This study concludes that Problem-Based Learning (PBL) is a valuable pedagogical approach in gross anatomy education, significantly enhancing student engagement and clinical skill development. By shifting the focus from passive reception of information to active problem-solving, PBL encourages meaningful interaction with anatomical content and fosters essential clinical reasoning abilities. Students exposed to PBL demonstrated higher engagement across cognitive, emotional, and behavioural dimensions, as well as improved performance in practical clinical assessments. These findings suggest that PBL better prepares students for clinical practice by promoting the integration of theoretical knowledge with real-world application. Incorporating PBL into gross anatomy curricula may therefore contribute to producing more competent and confident future healthcare professionals. Future investigations should focus on the long-term impact of PBL on knowledge retention and explore the integration of digital tools to enhance engagement and scalability within diverse educational settings.

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