

Facilitator-Mediated Versus AI-Mediated Problem-Based Learning in Pharmacology Education: A Quasi-Experimental Study Among Second Year Medical Students

Padmaja Shetty

padmajashetty.cdsimer@dsu.edu.in

Dayananda Sagar University, Dr.Chandramma Dayananda Sagar Institute of Medical Education and research

Mangala Rao

St. John's National Academy of Health Sciences, St.John's Medical College

Research Article

Keywords: Problem Based learning, Critical thinking, Artificial intelligence, critical thinking

Posted Date: October 12th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10843600/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Problem-based learning (PBL) is a coordinated, multifaceted learner centred approach. Artificial intelligence has emerged as the most extensively used learning tool in medical education in the recent days. Hence, an attempt has been made here to integrate AI into PBL and to study and compare the effectiveness of facilitator and AI mediated PBL.

Materials & methods

This quasi- experimental study was conducted on 150 second year medical students attending Pharmacology practical sessions, with PBL triggers discussed over a duration of 4 weeks. Pre and post MCQ tests, critical thinking and group assessment rubric were used to assess student performance and group dynamics. Semi-structured questionnaire based satisfaction surveys were collected as to check for the likeness for learning tools.

Result

Out of 150 students, 136 (Batch 1: $n = 68$ and Batch 2: $n = 68$) completed the study. In post test MCQ scores, positive scores- 63.2% in facilitator led PBL while 58.8% in AI led PBL. There was a significant difference ($p < 0.0001$) in pre ($M = 7.1$, $SD = 2.2$) and post ($M = 8.2$, $SD = 1$) tests within both groups.

Group assessment rubric of facilitator led PBL had a significantly ($p < 0.035$) better overall response especially in group/team based activity, response to feedback and problem solving. In this study, Independent T test of critical thinking rubric between the facilitator led PBL (14.75 ± 1.41) and AI led PBL (13.09 ± 1.70) shows a statistically significant difference ($p = < 0.001$).

Student satisfaction survey showed that students in AI led PBL had significantly ($p < 0.001$) better discussion and access to resources required in their learning. In faculty satisfaction survey on AI usage in medical education, with 12.2% new to PBL, around 50% were somewhat familiar to AI usage.

Conclusion

This study draws our attention towards a more positive impact of PBL in learner centred pedagogy. With AI emerging as an important resource tool for learning, the hybrid model of AI with facilitator guided PBL can be very effective tool in medical education.

Note: The study did not involve a clinical trial and therefore was not registered in a clinical trials registry.

Introduction

Medical education is a dynamic process which needs constant update and periodic refinement. During learning, students and teachers have to work mutually to make this knowledge sharing process

enjoyable and easier for comprehension.

In contrast to traditional medical education methods, problem-based learning (PBL) is a learner-centred pedagogy where students are required to develop multiple core competencies such as critical thinking, self directed and collaborative learning, knowledge integration and communication skills.¹ This ignites a “student-centred” learning environment that integrates practice and theory through clinical reasoning and team work thus positively changing the social and communication skills, real-world-problem solving and structured self directed learning.²

PBL is a methodology that fosters the acquisition of practical skills and explorative learning by diverting from rote memorization towards integration of knowledge for the resolution of clinical problems which is a quintessential point in medicine.³ PBL, as a teaching and learning strategy, engages students in group discussions to address complex and ambiguous clinical problems, group projects allow learners to develop their teamwork abilities, makes curriculum content relevant, facilitates learning the core topics and development of transferable skills. This process involves analysing problems, setting objectives, gathering information, summarizing ideas, receiving feedback and reflecting on problem-solving experiences.⁴

Problem based learning is designed as a highly structured session designed for 3–4 weeks duration with adequate gap in multiple sessions where triggers are provided as case scenarios, images, videos, clinical problems etc. Traditionally PBL sessions are guided by human facilitators who act as guides fostering critical thinking, team discussions, collaborations and empathy through open ended discussions.⁵ Despite the advantages of PBL, challenges for the facilitator are to engage all sessions, time and group management, development of good triggers, preparation and facilitation of multifaceted problem solving, assessment and feedback delivery.⁶

Several challenges in academic activities such as time restraint, pressure to adhere to timeline, unrestrained access to abundant information has diverted the attention of students towards newer technologies such as Artificial Intelligence (AI). Even with its pedagogical advantages, AI has its own set of challenges such as hallucination, cognitive deskilling, lack of restriction and refinement to the medical information along with knowledge gap between teachers/students and system designers. Medical educators may not be comfortable with students relying too much on artificial intelligence.⁷

While AI led PBL allows accessibility and scalability, its role still remains unclear in educational outcome and overall engagement level of learning in medical education. Hence this study aims to evaluate and compare the relative effectiveness of facilitator led and AI led PBL in learning Pharmacology subject among second year medical students.

Methodology

Study design:

This quasi- experimental study was conducted on 150 second year medical students attending Pharmacology practical sessions. They were divided into 2 batches - Batch 1:Facilitator led PBL (n = 75) and Batch 2: AI led PBL (n = 75). Each of these groups were further divided into 7 small groups comprising of 10–12 students each for the PBL sessions spanning over 4 weeks period. The study was conducted in accordance with the ethical principles of the 1964 Declaration of Helsinki and was approved by the Institutional Ethics Committee, reference no.-CDSIMER/MR/0237/IEC/2025. Written informed consent was obtained from all study participants prior to their enrolment in the study.

Study intervention:

Case based clinical problem triggers for the assigned pharmacology practical were prepared by the facilitator and validated by two experts in the subject. In the first session, both the batches were briefed about the PBL sessions, general instructions were given to the students of respective groups regarding the sequence of events, role of facilitator, role and prompts for AI over the next 4 weeks.

A 10-item based MCQ tests were conducted at the time of initiation and at the end of the PBL. Each trigger was given weekly at the initiation of the session to respective groups. This spanned over the next 4 weeks allowing a week's gap for team collaboration, discussion and critical thinking. Facilitator guided the students in their discussion and moderated the session in batch 1 while batch 2 who used AI had a team based discussion as the class convened.

Critical thinking was assessed using an adapted Critical Thinking Rubric based on the Association of American Colleges and Universities (AAC&U) Critical Thinking VALUE Rubric.^{8,9} The rubric was contextualized to the pharmacology PBL activities and learning objectives comprising of 5 items and validated with 2 subject experts with scores 4 to 1. The English version of the rubric is provided as supplementary file 1.

Framework from AAC&U, 2009 was used to compose group assessment rubric to measure collaborative dynamics comprising of 8 items graded from distinguished (4) to beginner (1) as per the study needs.¹⁰ This rubric was standardized and validated by 2 subject experts and given to team members of the 7 groups. During the sessions, team collaboration and critical thinking were assessed by 8 subject experts using these rubrics. The English version of group assessment rubric is provided as supplementary file 1.

And at the end of 4 weeks on completion of PBL, student satisfaction survey and faculty satisfaction survey were collected by semi -structured interviews. A structured questionnaire was developed by the investigators to assess students' perceptions and satisfaction regarding facilitator-led and AI-led PBL. The questionnaire comprised 12 items rated on a four-point Likert scale ranging from 1 (Strongly Disagree) to 4 (Strongly Agree). The complete English-language version of the questionnaire is provided as Supplementary File 1.

While faculty satisfaction survey was prepared, standardised and validated by 2 subject experts. It comprises of three part-First section covered faculty age and their experiences with PBL and AI usage, Part 2 covered faculty perception on AI usage by students in their learning and part 3 was a 6 item based questionnaire based on a Likert scale scoring from 1(strongly disagree) to 5(strongly agree) on faculty satisfaction of AI usage by students for PBL. ¹²All the data including pre and post test MCQs, satisfaction surveys (student and faculty) were collected on google form. The complete English-language version of the questionnaire is provided as Supplementary File 1.

Statistical analysis

Microsoft Excel and the SPSS version 27 was used to analyze the data. Descriptive statistics such as frequency and percentages were used for assessing the satisfaction surveys and comparison between groups are done by using Independent t test. Paired t-tests was used for comparing academic performance intra group and independent T test between groups. Independent T test was used to assess categorical or ordinal variables such as the critical thinking and group assessment rubrics. Mann Whitney U test was used to assess student satisfaction survey in both groups. Frequency and percentage was used to present faculty responses to AI usage in PBL by students.

Result

Out of 150 students, 136 (Batch 1: n = 68 and Batch 2: n = 68) completed the study and 14 students who did not complete the study and missed one or more sessions were considered as drop outs. In this study, second year medical students attending pharmacology practical included 62 males and 88 female and of age group 19–20 years. The study assessed the academic gains, group discussion dynamics, critical thinking, responses to feedback and satisfaction to the tools used for learning throughout this problem based learning in pharmacology practical.

Analysis of Academic Performance:

While assessing academic gains, comparison between pre and post session MCQ tests, facilitator led PBL showed positive scores: 63.2%, neutral: 11.7% and negative scores: 25% while in AI led PBL, positive scores:58.8%, neutral: n = 1.5% and negative scores: 25%.

Results of the paired-t test indicated that there is a significant difference($p < 0.0001$) between Pre ($M = 7.1$, $SD = 2.2$) and Post ($M = 8.2$, $SD = 1.7$), $t(65) = 4.1$ MCQ based tests in both groups (Table 1).

Table 1
Pre and post test result of facilitator led v/s AI led PBL

Facilitator led PBL Test scores	Test scores (Mean + SD)	Mean gains	P value
Pre Test	7.07 ± 2.1	1.00 ± 2.78	0.0001*
Post Test	8.12 ± 1.65		
AI led PBL test scores			
Pre test	7.49 ± 2.04	1.03 ± 2.52	0.000025*
Post test	8.52 ± 1.58		

Further on, between group comparison with Independent T test showed that the difference between the two groups is NOT statistically significant (p = 0.474).

Analysis of Group assessment Rubric:

In this study, Independent T test of group assessment rubric showed that Facilitator led PBL had a significantly better group/team based activity, response to feedback and problem solving with an overall response (p < 0.035) in comparison to AI led PBL(Table 2).

Table 2
Analysis of Group assessment rubric analysis

Metric	Mean ± SD (Group A)	Mean ± SD (Group B)	p-value	Effect Size (Cohen's d)
Individual Contribution	3.34 ± 0.73	3.19 ± 0.71	0.244	0.20 (Small)
Collaboration & Teamwork	3.35 ± 0.71	3.06 ± 0.76	0.021	0.40 (Medium)
Leadership	3.10 ± 0.83	2.83 ± 0.91	0.065	0.32 (Small)
Communication	3.38 ± 0.71	3.19 ± 0.91	0.168	0.24 (Small)
Listening	3.50 ± 0.70	3.42 ± 0.72	0.511	0.11 (Negligible)
Feedback	3.29 ± 0.62	2.91 ± 0.85	0.003**	0.51 (Medium)
Problem Solving	3.24 ± 0.76	2.97 ± 0.75	0.041*	0.35 (Small)
Reflection & Improvement	3.40 ± 0.72	3.17 ± 0.89	0.108	0.28 (Small)
OVERALL TOTAL	26.51 ± 4.63	24.74 ± 5.11	0.035*	0.36 (Small)

Critical Thinking Rubric analysis:

In this study, Independent T test of critical thinking rubric between the facilitator led PBL (14.75 ± 1.41) and AI led PBL(13.09 ± 1.70) shows a statistically significant difference ($p = < 0.001$) (Bar Diagram 1). Critical thinking assessed with rubrics such as explanation of problem, description, collection of information and its interpretation, systematic investigation and analysis of information gathered, proposing a hypothesis and arriving at a conclusion was significantly($p < 0.0001$) better in facilitator led PBL in comparison to AI led PBL.

Bar Diagram 1: : Analysis of Critical thinking rubric score (Mean $\pm$ SD)

Result of Student satisfaction survey:

Student satisfaction survey questionnaires with a good Cronbach's alpha reliability score of 0.874 was used to assess student's satisfaction with problem based learning in the 2 respective groups.

Mann-Whitney U test of the survey showed that student satisfaction scores were generally high in both groups. The mean overall satisfaction score was 49.46 ± 4.87 in the facilitator-led PBL group and 50.50 ± 3.33 in the AI-led PBL group (Table 3). There was no statistically significant difference in overall satisfaction between the two groups ($U = 2016.5$, $p = 0.243$) (Fig. 1). At the individual-item level, Item 5 showed a nominally significant difference ($p = 0.046$), with higher scores in the AI-led PBL group (Table 3).

Table 3
Analysis of Student satisfaction survey scores

Criteria	Facilitator led PBL (mean + SD)	AI led PBL (mean + SD)	Mann Whitney U test (P value)
1.Course materials were organised and helpful	4.09 ± 0.51	4.21 ± 0.59	0.118
2. I actively participated in the discussion	4.28 ± 0.54	4.29 ± 0.55	0.861
3. There were enough opportunities to find out if I clearly understood the topic	4.29 ± 0.62	4.29 ± 0.46	0.643
4. I learnt from the comments made by the teacher before, during or after the session	4.33 ± 0.64	4.35 ± 0.57	0.913
5. Sufficient learning materials studied and discussed with peers for discussion	4.06 ± 0.64	4.26 ± 0.54	0.046
6. I received cues from every trigger discussed during PBL	4.16 ± 0.48	4.31 ± 0.47	0.090
7. The instructor was able to respond to individual needs of learners during PBL	4.24 ± 0.52	4.29 ± 0.46	0.612
8. Discussion with other students has been very productive and challenging	4.22 ± 0.73	4.421 ± 0.51	0.424
9. Assessments (tests, assignments) reflect what was taught.	4.18 ± 0.65	4.31 ± 0.47	0.352
10. Using PBL without AI made my learning more productive	3.60 ± 1.07	3.72 ± 1.03	0.490
11. Using PBL with AI made my learning more productive	3.82 ± 0.98	4.03 ± 0.75	0.282
12. I am satisfied with the assessment methods	4.21 ± 0.59	4.22 ± 0.42	0.810

Box plot showing the distribution of overall student satisfaction scores between facilitator-led and AI-led PBL groups. The median satisfaction score was 49 in the facilitator-led PBL group and 50 in the AI-led PBL group, with substantial overlap in the score distributions. The difference between the groups was not statistically significant (Mann–Whitney U = 2016.5, $p = 0.243$).

Analysis of faculty satisfaction survey:

In faculty satisfaction survey on AI usage in medical education, out of the 57 responses obtained, 38.5% had 0–5 years, 31.5% with 6–10 years, 26.3% with 11–20 years and 3.5% with > 20 years teaching

experience. Out of these responses, 12.2% were new to PBL, 40.3% had 1–3 years experience, 43.8%: 4–7 years experience and 3.5% : more than 8 years experience. With reference to AI usage, 22.8% were very familiar, 57.8%-somewhat familiar, 12.2%- not very familiar and 7.01% were not familiar at all to usage of artificial intelligence.

Further the pattern of AI usage by students during academic activities (Table 4) and concerns regarding the same is represented below (Table 5). The awareness about AI usage, its benefits and readiness among faculty to include AI in learning and teaching is a represented in Table 5. Mean satisfaction scores of faculty responses showed a mixed response such that faculty feel students used AI to a considerable extent during PBL sessions which faculty feels might improve the discussion and outputs while may also undermine the purpose of PBL (Bar Diagram 2).

Table 4
Faculty-Reported Patterns of Artificial Intelligence Use by Students in Medical Education

Do your students use AI tools during academic activities?	
Yes	37(64.9%)
No	11(19.2%)
Not Sure	9(15.7%)
To your knowledge, which AI tools do students commonly use?	
ChatGPT	29(50.8%)
Grammarly	11(19.2%)
Notion AI	0
Bing AI/Copilot	0
Other (please specify): _____	6(10.5)
I'm not sure	11(19.2%)
In what ways do students use AI in medical education?	
Brainstorming ideas	10(1.75%)
Writing problem scenarios	15(26.3%)
Summarizing texts or research	17(29.8%)
Generating answers	41(71.9%)
Creating presentations	38((66.6%)
Peer feedback or editing	0
Other: _____	2(3.5%)

Table 5

Faculty Concerns, Confidence, and Preparedness Regarding Student Use of Artificial Intelligence in PBL

What concerns do you have about student use of AI in PBL?	
Over-reliance on AI	53(92.9%)
Plagiarism or lack of academic integrity	55(96.5%)
Reduced critical thinking	47(82.4%)
Lack of transparency in AI use	50(87.7%)
Inconsistent skill development among students	33(57.9%)
Other: _____	
I have no concerns	
How confident are you in identifying when AI has been used in student submissions?	
Very confident	0
Somewhat confident	26(45.6%)
Not confident	17(29.8%)
Not sure	14(24.5%)
Have you addressed student AI use in your class policies or instructions?	
Yes	9(15.8%)
No	43(75.4%)
Planning to	5(8.7%)
Not applicable	

Bar diagram 2: Mean Satisfaction scores on AI use in PBL

Discussion

Problem-based learning (PBL) is a learner centred pedagogy that utilizes the principles of collaborative, constructive, self- directed and contextual learning in small groups. This constructive learning experience helps students integrate prior information on a topic with newer understanding which enhances their knowledge. By planning, monitoring, evaluating, discussing, sharing knowledge, obtaining feedback leads to a well coordinated, organised problem solving. One of the most characteristic feature of PBL is the guidance by the facilitators in encouraging and guiding the discussion to arrive at an appropriate level of understanding among students.¹³

With recent widespread use of artificial intelligence in medical education by the students to facilitate learning, AI-supported PBL assists to incorporate intelligent tutoring, personalized instruction, and real-time feedback. In order to personalize learning, collaboration, critical thinking and to foster deeper learning engagement, the use of AI PBL in medical education has evolved from basic automation to intelligent, adaptive, learner centred ecosystems.¹⁴

In the present study, second year undergraduate medical students attending pharmacology practical participated in facilitator and AI guided problem based learning on pharmacokinetics and pharmacodynamic concepts over a duration of 4 weeks with 3 triggers in the form of clinical problems.

On analyzing MCQ pre/post test result, there was significant improvement ($P < 0.0001$) post test in both facilitator led and AI led PBL while between the 2 groups, there was no significant difference. This is similar to study by Shogo Hayashi et al where there was no significant difference in written examination scores between tutored 67.83 ± 11.11 and tutorless (and 65.82 ± 13.42) groups in problem based learning.¹⁵ This suggests that both modalities of treatment are quite effective in facilitating learning.

While assessing group assessment rubric, it was observed that overall facilitator led PBL received significantly better result when compared to AI led PBL. Collaboration and teamwork ($p < 0.021$), feedback ($p < 0.003$) and problem solving ($p < 0.041$) were significantly better in facilitator led group thus strengthening the role of facilitators in learning. This can also be seen in a study by Lestari E et al which showed better collaboration and feedback among students in interprofessional student tutorials.¹⁶

One more rubric used was the assessment of critical thinking during PBL which showed that the parameters such as explanation, description, collection of information and its interpretation, systematic investigation and analysis of information gathered, proposing a hypothesis and arriving at a conclusion were significantly ($p < 0.0001$) better in facilitator led PBL in comparison to AI led PBL. This is substantiated by a study by Ling Lu et al which states that critical thinking is an important aspect in PBL to solve complex clinical problems. Critical thinking oriented PBL is very important for the development of metacognitive, all round skills.¹⁷

Out of 150 second year medical students, AI led group showed a significantly ($p < 0.05$) productive and challenging interaction, discussion and that AI usage in PBL made learning more interesting and productive. In AI led PBL, extensive collection of study materials and the discussion undertaken was better than in the facilitator led PBL. The most commonly used platforms to collect study materials were Chat GPT- 50.8% used Chat GPT while the rest used google Gemini, Notion AI etc. Maximum students used AI to generate answers (71.9%) and to develop presentations (66.6%).

This is similar to study by Hui Z which showed that students shared a positive feedback for Chat GPT based PBL.¹⁸ A study by Bokan R R et al showed that $\sim 91.6\%$ reported using AI tools for academic purposes, with ChatGPT being the most commonly used platform (96%) and overall, 69.4% favouring structured incorporation of AI in learning.¹⁹ Another study by Abouammoh N et al., showed that Chat GPT

was more time saving and provided rapid access to information among both faculty and students. Here it was observed that faculty used it to prepare academic materials preparation and test questions and student used it for academic assignments.²⁰

Further on, faculty satisfaction survey showed that with 87.3% faculty with knowledge about PBL, 80.6% were familiar with AI usage in PBL though not completely. With their view on students' use of AI, faculty feel that 64.9% students use AI for their academic works.

With 45.6% of faculty somewhat confident identifying AI use in student assignments with main concerns being plagiarism (96.5%) and over reliance on AI for academic activities(92.9%). In this survey, it was observed by faculty that student use of AI enhances quality of PBL discussion and outputs (3.63 ± 0.94) but undermines the goal of problem based learning. This is also seen in study by Ruiz et al, challenges, concerns, and areas for caution have been the risk of over-reliance on AI systems, which cannot replace the human interaction crucial for pupils' overall development and the promotion of soft skills such as empathy and teamwork. On further comparing and assessing the satisfaction surveys among students and faculty, there was a significant overall satisfaction ($p < 0.001$) and faculty guidance/ instructions produced more positive response in learning($p < 0.01$).²¹

Another study by Almisad B et al showed that faculty members had positive perceptions of AI in supporting research, collecting resource materials, reducing administrative tasks, enhancing online learning and solving clinical problems though the challenges include potential for plagiarism, over-reliance, lack of real-time clinical knowledge, misleading or incorrect information, over-dependence on technology, and ethical implications.²²

Artificial intelligence (AI) includes a diverse range of computational approaches such as analytics, prediction systems, generative models, personalization engines, that collectively influence how learning is adapted and upgraded. Analysing the behavioural and performance data, machine learning algorithms, and recognising pattern help identify learners' needs, progress and preferences. And this AI-driven personalization is widely regarded as a very important pedagogical innovation of the advanced technology.^{23,24,25}

Compared with the traditional classroom teaching, learners' satisfaction with problem based learning mediated by facilitators and technological assistance like AI indicates a changing phase in medical education. It is therefore important to devise an effective strategy for building an AI integrated facilitator led PBL.²⁶

AI contributes by reducing cognitive, technical, and temporal barriers through adaptive content delivery, interactive environments, and intelligent feedback. These technologies support self-directed learning, simplify complex concepts, and expand access to educational resources.

Conclusion

To summarize, this study indicates the potential positive outcomes of both types of learning either facilitator led PBL or integration of AI into PBL while enhancing teacher- student learning experience. This study provides valuable insight on usage of newer technologies in problem based learning.

Digital transformation in medical education provides an accessible, flexible and inclusive learning opportunities. AI in PBL is helpful in facilitating self directed and adaptive learning thus students acquire both technical and overall skills. AI application in certain environments is limited by infrastructure and teacher training issues. Hence a hybrid approach of facilitator guided AI can be a more effective instructional practice that will foster and complement cognition, psychomotor skills and affective domains.

Limitation

As a quasi-experimental study design without random allocation, selection bias and baseline differences between the 2 groups can be considered as one of its limitation. Considering the limited study population and duration, the generalizability of the findings to a wider range of student population throughout the medical schools is not appropriate. The differences in students' learning with AI, digital literacy, learning preferences, and familiarity with PBL may also affect their performance and satisfaction. Responses to different elements may be very subjective and lead to bias. Faculty responses to interview has also been limited, thus diverting our attention to faculty awareness on AI usage in medical education. This warrants for a larger multicentric studies, longer follow-up, standardized AI exposure, and more elaborate objective measures of long-term learning and clinical reasoning.

Future Perspective

Larger, multicentric study of longer duration involving students from different medical colleges can improve generalizability involving areas such as knowledge retention, improved clinical reasoning, problem-solving skills, and academic performance. A hybrid model combining facilitator expertise with AI support, enhance the benefits of human guidance while utilizing the advantages of artificial intelligence. Future research should also evaluate the faculty workload, cost-effectiveness, student engagement, academic integrity, and the accuracy and reliability of AI-generated information. Development of institutional guidelines and faculty training programs for responsible and ethical integration of AI into PBL has to become a critical element in medical education.

Abbreviations

PBL-Problem based learning

AI-Artificial Intelligence

MCQ-Multiple choice question

AAC & U critical thinking & value rubric: Association of American colleges and universities critical thinking and value rubric

Declarations

The authors declare that this manuscript is original, has not been published previously, and is not under consideration for publication elsewhere. All authors have read and approved the final version of the manuscript and have agreed to its submission. The authors affirm that the work is their own and that all sources have been appropriately acknowledged.

Ethics approval:

The study was conducted after obtaining institutional ethics committee approval, ref no-CDSIMER/MR/0237/IEC/2025

Consent for publication:

Written informed consent taken from the study participants

Competing Interests:

The authors declare that they have no competing interests.

Funding Declaration:

No Funding was received for the submitted work

Author Contribution

Conceptualization: Dr.Padmaja Shetty K, Dr.Mangala Rao

Literature search and data curation: Dr.Padmaja Shetty K

Manuscript drafting: Dr.Padmaja Shetty K

Literature search and data curation, critical review: Dr.Padmaja Shetty K

All authors read and approved the final manuscript: Yes

Acknowledgement

I would like to thank Dr.Veena C N, Professor, Department of Physiology, Dr.Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University for her valuable input during conceptualisation of the project. I also thank my Department of Pharmacology, Dr.Chandramma Dayananda Sagar Institute of Medical Education and Research, Dayananda Sagar University for their contribution towards conduct of PBL sessions during pharmacology practical session.

Availability of data and materials :

The datasets generated and/or analyzed during the current study are not publicly available due to subject privacy and ethical restrictions but are available from the corresponding author on reasonable request, subject to approval from the Institutional Ethics Committee.

References

1. Chiu Y-P, Chen C-C. b > AI-Enhanced Problem-Based Learning: Differential Effects of AI Usage Patterns on Core Competency Development Through Psychological Mechanisms. *Int J Technol Educ Sci*. 2026;760–83. 10.46328/ijtes.5725.
2. de Andrade Gomes J, Braga LAM, Cabral BP, Lopes RM, Mota FB. Problem-Based Learning in Medical Education: A Global Research Landscape of the Last Ten Years (2013–2022). *Med Sci Educ*. 2024;34(3):551–60. 10.1007/s40670-024-02003-1. . PMID: 38887406; PMCID: PMC11180071.
3. Diciana Arévalo, Hugo M, Shakira B, Fernando G. PROBLEM-BASED LEARNING IN UNDERGRADUATE MEDICAL EDUCATION. *EPRA Int J Res Dev (IJRD)*. 2025;78–80. 10.36713/epra20168.
4. Ceker E, Ozdamli F. Features and characteristics of problem based learning. *Cypriot J Educational Sci*. 2021;11:195–202. 10.18844/cjes.v11i4.1296.
5. David JS. *Med Educ*. 2000;23–9. <https://web.mit.edu/jrankin/www/pbl/steele.pdf>
6. Mansor A, Ooi N, Jamalullail A, Mohamad S, Mohamed, Yusoff, Norhayati, Mohd, Rose, Amnah. Managing Problem-based Learning: Challenges and Solutions for Educational Practice. *Asian Social Sci*. 2015;11:259–259. 10.5539/ass.v11n4p259.
7. Abidin R, Fathurrohman M, Hendrayana A, Thaariq Z. AI-assisted problem-based learning: Effects on problem-solving abilities across learning styles. *Jurnal Inovasi dan Teknologi Pembelajaran*. 2025;12:162–72. 10.17977/um031v12i32025p162.
8. AAC&U. Critical Thinking VALUE Rubric. 2009.
9. Gleason et al. 2013;77(10):221. 10.5688/ajpe7710221
10. Ασσοcιaτιoν oφ Αμερικαν Collegeσ ανδ Univερsιtieσ. (2009). *Teαμωoρk VALUE ρυβρic*. aacu.org.
11. Kιμ MJ. Cтудентo' Cατισφαcτιoν ανδ Pερceπτιoν oφ Ppoβλεμ Bαceδ Leapvivg Evaluateδ βγ Queστιoνvαιpe. *Koσiv Meδ J*. 2015;30(2):149–57.

12. Ravi S, Κυρια Α, Ekka SC. et al. (January 15, 2025) Perception of Medical Students and Faculty Regarding the Use of Artificial Intelligence (AI) in Medical Education: A Cross-Sectional Study. *Cureus* 17(1): e77514. doi:10.7759/cureus.77514
13. Ghani ASA, Rahim AFA, Yusoff MSB, Hadie SNH. Effective Learning Behavior in Problem-Based Learning: a Scoping Review. *Med Sci Educ.* 2021;31(3):1199–211. 10.1007/s40670-021-01292-0. . PMID: 33903829; PMCID: PMC8059994.
14. Ayanwale MA. Christian Basil Omeh. AI-supported problem-based learning for enhancing computational thinking skills in STEM education, *Computers in Human Behavior: Artificial Humans*. Volume 7;2026,100263,ISSN 2949–8821. <https://doi.org/10.1016/j.chbah.2026.100263>. (<https://www.sciencedirect.com/science/article/pii/S2949882126000149>)
15. Hayashi S, Tsunekawa K, Inoue C, Fukuzawa Y. Comparison of tutored group with tutorless group in problem-based mixed learning sessions: a randomized cross-matched study. *BMC Med Educ.* 2013;13:158. 10.1186/1472-6920-13-158. PMID: 24289490; PMCID: PMC4220560.).
16. Lestari E, Stalmeijer RE, Widyandana D, Scherpbier A. Does PBL deliver constructive collaboration for students in interprofessional tutorial groups? *BMC Med Educ.* 2019;19(1):360. 10.1186/s12909-019-1802-9. . PMID: 31533721; PMCID: PMC6751883.
17. Yu L, Zin ZM. The critical thinking-oriented adaptations of problem-based learning models: a systematic review. *Front Educ.* 2023;8:1139987. 10.3389/feduc.2023.1139987.
18. Bokan RR, Malhotra R, Vatsa M, March 19. Artificial Intelligence in Undergraduate Medical Education: A Cross-Sectional Study of Utilization Patterns and Perceptions Among Medical Students. *Cureus.* 2026;18(3):e105503. 10.7759/cureus.105503.
19. Hui Z, Zewu Z, Jiao H, Yu C. Application of ChatGPT-assisted problem-based learning teaching method in clinical medical education. *BMC Med Educ.* 2025;25(1):50. 10.1186/s12909-024-06321-1. PMID: 39799356; PMCID: PMC11724493.
20. Abouammoh N, Alhasan K, Aljamaan F, Raina R, Malki KH, Altamimi I, Muaygil R, Wahabi H, Jamal A, Alhaboob A, Assiri RA, Al-Tawfiq JA, Al-Eyadhy A, Soliman M, Temsah MH. Perceptions and Earliest Experiences of Medical Students and Faculty With ChatGPT in Medical Education: Qualitative Study. *JMIR Med Educ.* 2025;11:e63400. 10.2196/63400.
21. Ruiz Viruel S, Sánchez Rivas E, Ruiz Palmero J. The Role of Artificial Intelligence in Project-Based Learning: Teacher Perceptions and Pedagogical Implications. *Educ Sci.* 2025;15(2):150. <https://doi.org/10.3390/educsci15020150>.
22. Almisad B, Aleidan A. Faculty perspectives on generative artificial intelligence: insights into awareness, benefits, concerns, and uses. *Front Educ.* 2025;10:1632742. 10.3389/feduc.2025.1632742.
23. Saki S, Zeinabadi H, Abbasian H, et al. Faculty perceptions of AI for personalized instruction and learning facilitation in higher education. *Sci Rep.* 2026;16:21888. <https://doi.org/10.1038/s41598-026-42980-4>).

24. Reynolds J, Carter S, Whitman A, Brooks M, Paul. Charles. (2023). Faculty Perceptions of Artificial Intelligence in Education.
25. Ayanwale MA. Christian Basil Omeh. AI-supported problem-based learning for enhancing computational thinking skills in STEM education. Computers in Human Behavior: Artificial Humans, Volume 7, 2026, 100263, ISSN 2949–8821. <https://doi.org/10.1016/j.chbah.2026.100263>. (<https://www.sciencedirect.com/science/article/pii/S2949882126000149>)
26. Ling Y, Jin Z, Li Y, Huang J. Learner satisfaction-based research on the application of artificial intelligence science popularization kits. Front Psychol., Ozdamli F. (2016). Features and characteristics of problem based learning. Cypriot Journal of Educational Science. 11(4), 195–202. 198 · PBL allows learners to take the responsibility of their own learning · Group projects allow learners to develop their adequacy in teamwork · Individual homework allows advanced students to display their highest performance, leadership attempts.

Figures

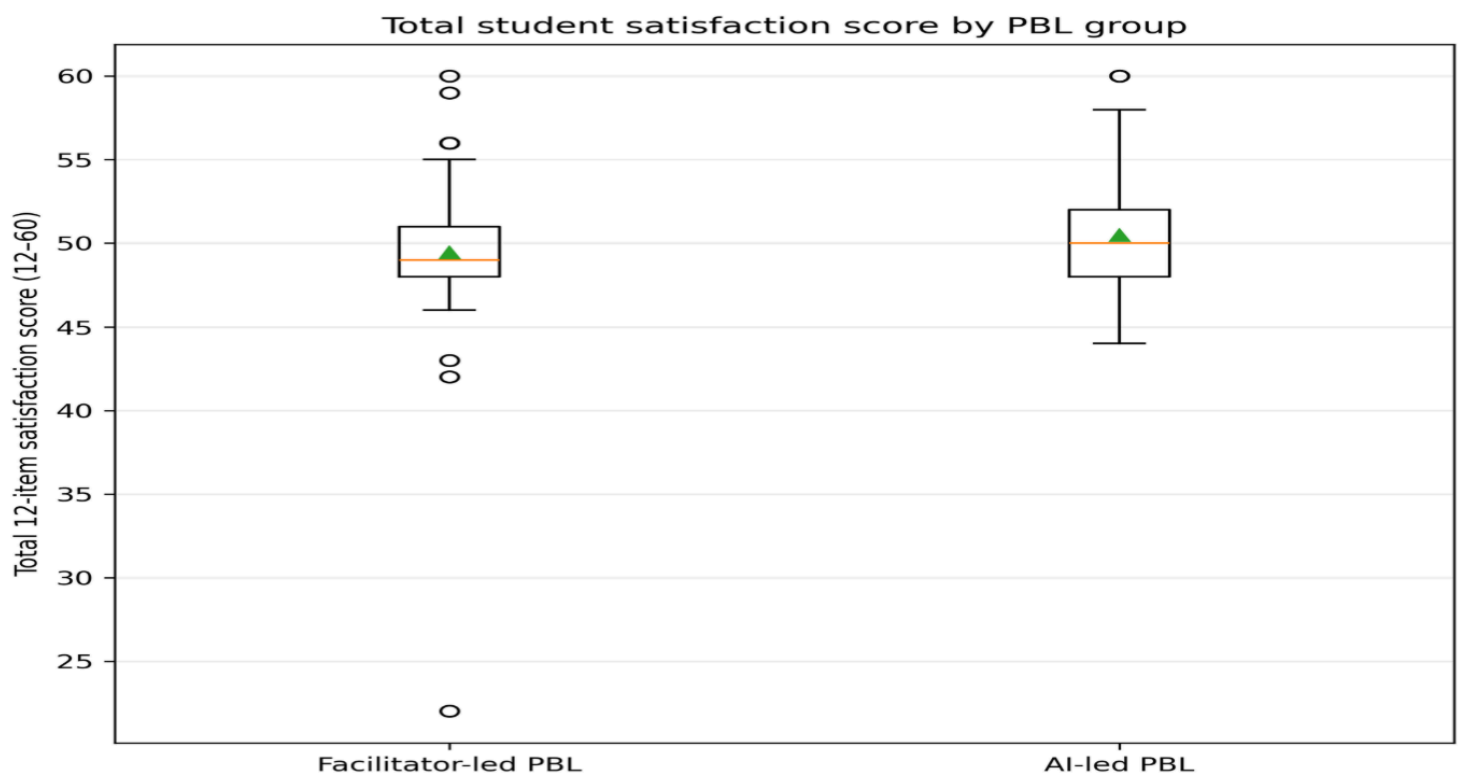


Figure 1

Box Plot for overall Student satisfaction

Box plot showing the distribution of overall student satisfaction scores between facilitator-led and AI-led PBL groups. The median satisfaction score was 49 in the facilitator-led PBL group and 50 in the AI-led PBL group, with substantial overlap in the score distributions. The difference between the groups was not statistically significant (Mann–Whitney $U = 2016.5$, $p = 0.243$).

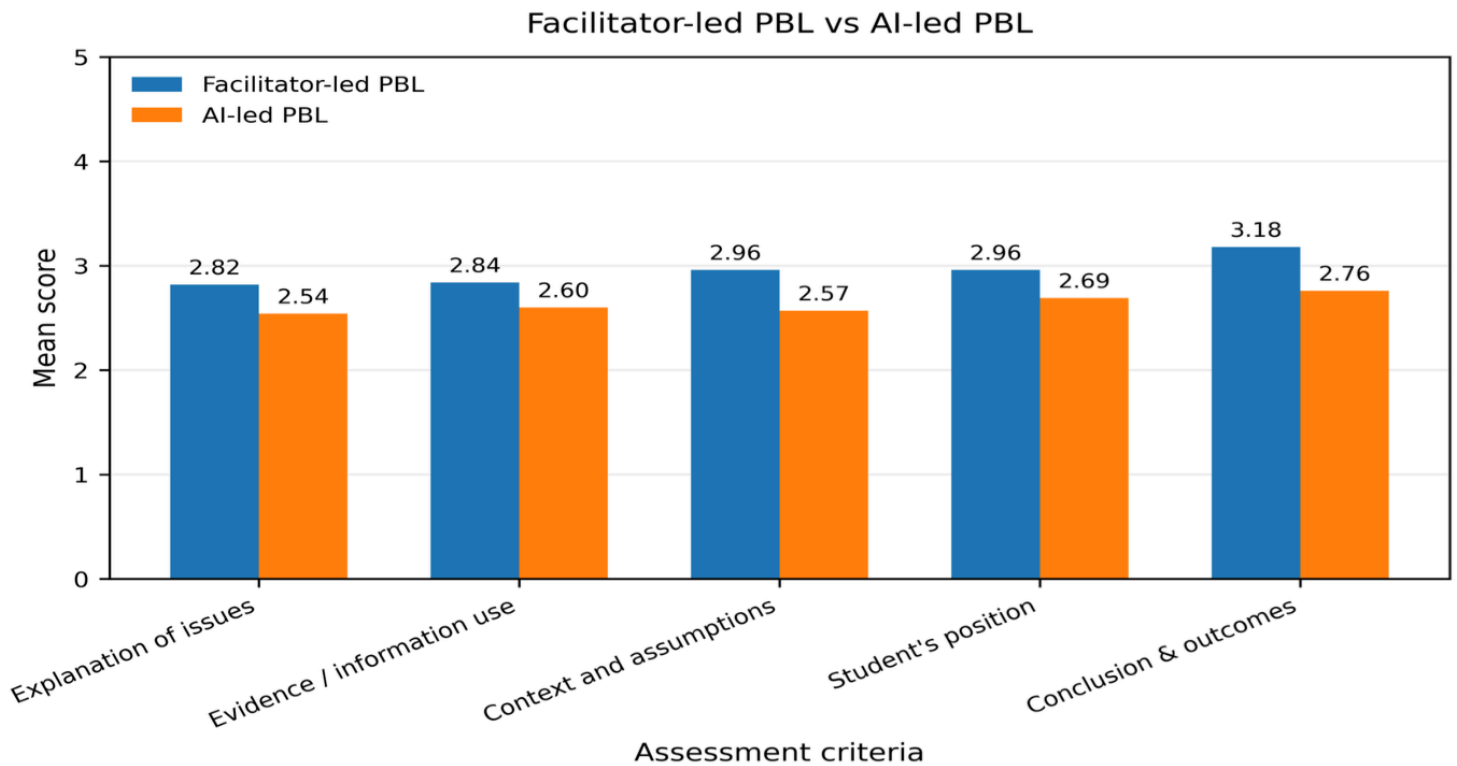


Figure 2

Bar Diagram 1: Analysis of Critical thinking rubric score (Mean $\pm$ SD)

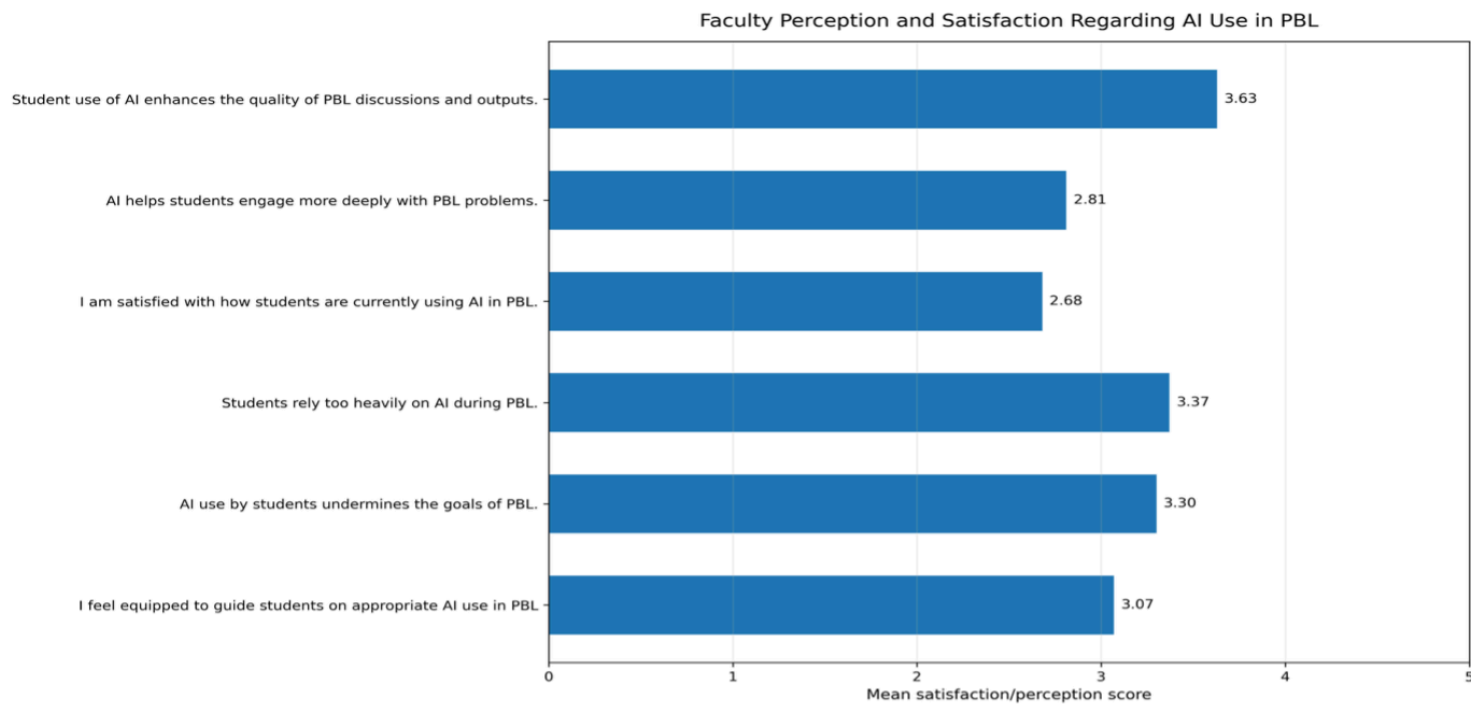


Figure 3

Bar diagram 2: Mean Satisfaction scores on AI use in PBL

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Supplementaryfile1Questionnaire.docx](#)