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# Enhancing medical education in Nepal through problem-based learning (PBL) and collaborative action research strategies

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## Abstract

**Background** Teamwork and collaboration among students are essential for successful problem-based learning (PBL) implementation; however, many medical colleges in Nepal face obstacles to implementing successful PBL sessions. This action research explored elements affecting teamwork during PBL sessions at Lumbini Medical College in Nepal and developed interventions that could readily be applied to enhance student collaboration.

**Methods** The study employed qualitative methods, collecting data through online open-ended questionnaires from second-year and first-year medical students. Initial data from second-year students identified teamwork challenges, while feedback from first-year students evaluated interventions. Specific interventions were implemented with first-year students, including improved internet connectivity, systematic textbook availability in PBL rooms, structured presentation formats (PechaKucha), and clear role assignments, as second-year students had completed their preclinical phase. The effectiveness of these interventions was evaluated through first-year students' feedback.

**Results** Thematic analysis revealed three key challenges: communication barriers (including language and technical issues), discrepancies in participation, and differing levels of preparation. Positive feedback from first-year students confirmed that the implemented interventions were successful in improving team dynamics, facilitating more active participation, and enhancing resource utilization.

**Conclusions** Successful implementation of PBL necessitates not only infrastructural support (internet and access to the resources needed to learn) but also pedagogical structure (e.g. clearly defined roles within groups, systematic structures of participation). These findings offer practical guidance for medical educators seeking to enhance PBL effectiveness, particularly in resource-limited settings.

**Clinical trial number** Not applicable.

**Keywords** Problem-based learning, Medical education, Teamwork, Action research, Nepal

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## Background

Problem-based learning (PBL) has become one of the most highly recommended pedagogical approaches in medical education and in many other fields, allowing active learning and development of student's critical thinking, problem-solving, and teamwork skills by applying theoretical knowledge to clinical scenarios [1].

First introduced in medical education in 1969 by McMaster University in Canada, this approach has been widely adopted at universities worldwide over the past 50 years [2, 3]. In Nepal, the journey of integrating PBL into medical education began with the establishment of the first medical college at the Institute of Medicine (IOM) under Tribhuvan University in 1978 [4, 5]. The IOM's MBBS curriculum was designed as an organ system-based, integrated, and community-oriented program, with PBL introduced as a component of its teaching methodology from the outset [4, 5]. However, it was not until 1998, two decades later, that PBL was formally structured within the IOM's program, though it remained a partial implementation, serving more as a familiarization tool rather than a fully transformative pedagogical shift [4].

Following IOM, PBL was partially introduced into the MBBS course at the BP Koirala Institute of Health Sciences (BPKIHS) in Dharan in 1999, complementing the existing organ-system approach [4]. A significant milestone occurred in 2001 when the Kathmandu University School of Medical Sciences, with support from Harvard University, launched its MBBS program, marking the first effective and structured PBL sessions in a Nepali medical college [4, 5]. Subsequently, PBL was implemented into the undergraduate medical curriculum across Kathmandu University-affiliated medical colleges [4]. The Patan Academy of Health Sciences (PAHS) later adopted PBL in its MBBS course, further embedding this approach within Nepal's medical education landscape [4, 5]. However, PBL has not been implemented with the fidelity that was looked forward to, and its existence in medical colleges seems to be waning [6]. No institution in Nepal has fully replaced traditional teaching methods with PBL; instead, a hybrid model persists, blending organ-system approaches and community orientation to varying degrees across universities and deemed universities [4]. This is ascribed to inadequately trained tutors/facilitators in facilitation skills, poorly equipped tutorial rooms, and an incompletely stocked library facility [6]. Effective PBL hinges on good teamwork within student groups [7, 8]. When groups fail to work together well, certainly, the students in those groups are not reaping the benefits of PBL [9]. The attitude and preference for PBL are associated not only with the individual personality traits of medical students but also with the socio-cultural background [9]. This poses a particular challenge for freshmen in Nepal, who face a steep transition from traditional learning to PBL's self-directed, collaborative approach, shaped by their socio-cultural backgrounds and prior educational experiences [9, 10].

Literature suggests that until the 1990s, studies were focused on the question "Does PBL work?", however by the mid-2000s the focus shifted towards "How does PBL work?" which allowed for a deeper understanding of the conditions and influences for effective PBL sessions [11].

The positive aspects of PBL are problem-solving ability, acquiring self-learning skills, raising motivation to learn, acquiring logical thinking, and enhancing the ability to discuss and collaborate which encourages memorable learning and deep understanding [12]. Furthermore, PBL promotes a positive attitude towards learning in the student [12].

While the benefits of PBL in medical education are well-documented, our experience at Lumbini Medical College revealed challenges in implementing effective teamwork and collaboration during PBL sessions. These observations prompted us to undertake an action research study to systematically understand and address these challenges.

## Aim

This study aims to investigate the important factors that hinder or facilitate effective teamwork and collaboration among students during the PBL session and develop practical enhancement strategies through action research.

## Methods

The issue was the lack of effective teamwork and collaboration among students during PBL sessions. The symptoms observed were students struggling to work cohesively as a team; a lack of equal participation or contribution from all the team members; and there was difficulty noted in effective communication, coordination, and sharing of ideas and perspectives. As a result, some potential losses for the students identified were listed below.

i. Diminished learning experience and outcomes for students.
ii. Missed opportunities for developing essential teamwork and collaboration skills.
iii. Ineffective problem-solving and decision-making processes within teams.
iv. Negative impact on student engagement, motivation, and satisfaction with the PBL approach.

These symptoms, such as unequal participation and communication difficulties, may also reflect challenges in tutor facilitation, as noted in the literature [13, 14],

though this study prioritized student's perspectives as an entry point for action research. At Lumbini Medical College, PBL sessions are formatively assessed by tutors/facilitators for participation and content understanding, however, there is no standardized evaluation or consequences for lacking soft skills such as collaboration or communication, nor are there direct consequences for deficiencies, which may exacerbate these issues. As the issue was identified, some questions needed to be addressed:

a. What are the key elements that contribute to or hinder effective teamwork and collaboration?
b. How can team-building activities, collaborative learning tasks, or structured team roles enhance teamwork and collaboration?
c. What strategies can be employed to promote active participation, communication, and coordination among team members?

To further explore the issue for possible solutions a focus group discussion session with students was planned. Lumbini Medical College enrolls a hundred students per year in the undergraduate medical program. Students in each year are randomly divided into groups of ten. PBL team members are selected in a way that there are equal numbers of male and female students, who are from diverse backgrounds, ethnicity, and also nationality. Each PBL group was similar to a focus group representing the entire class. PBL is compulsory for pre-clinical science students studying in the first and second year. A PBL session is conducted three days a week. PBL tutors/facilitators are faculty members with either MD/MS or MSc degrees from pre-clinical departments, who receive basic PBL facilitation training during faculty orientation, though it may not cover advanced group dynamics. A sample PBL session is depicted in Fig. 1.

We iteratively developed nine open-ended questions (Supplementary file 1) consistent with Braun & Clarke's flexible thematic analysis (TA) framework. These were based on observed PBL issues and action research goals prioritizing practical relevance over formal validity, with input from the team's educational expertise rather than a dedicated qualitative expert. The questions were then sent to the respective PBL group (1st author-facilitator) in the online platform of the second-year students, and their responses formed the basis for developing targeted interventions implemented with first-year students. Although initially, it was planned to interview students in a group, we thought of distributing the questions via the online platform. It was so decided because we assumed that being in a group the introverted students would not open up and only the active members would answer the questions and provide suggestions. The other drawback of face-to-face interviews was, that the students would not provide heartfelt negative comments as they might think they would offend the facilitator, which would ultimately hamper the academic grades. Online questionnaires were chosen over in-depth interviews to ensure broader participation and candidness, though this may

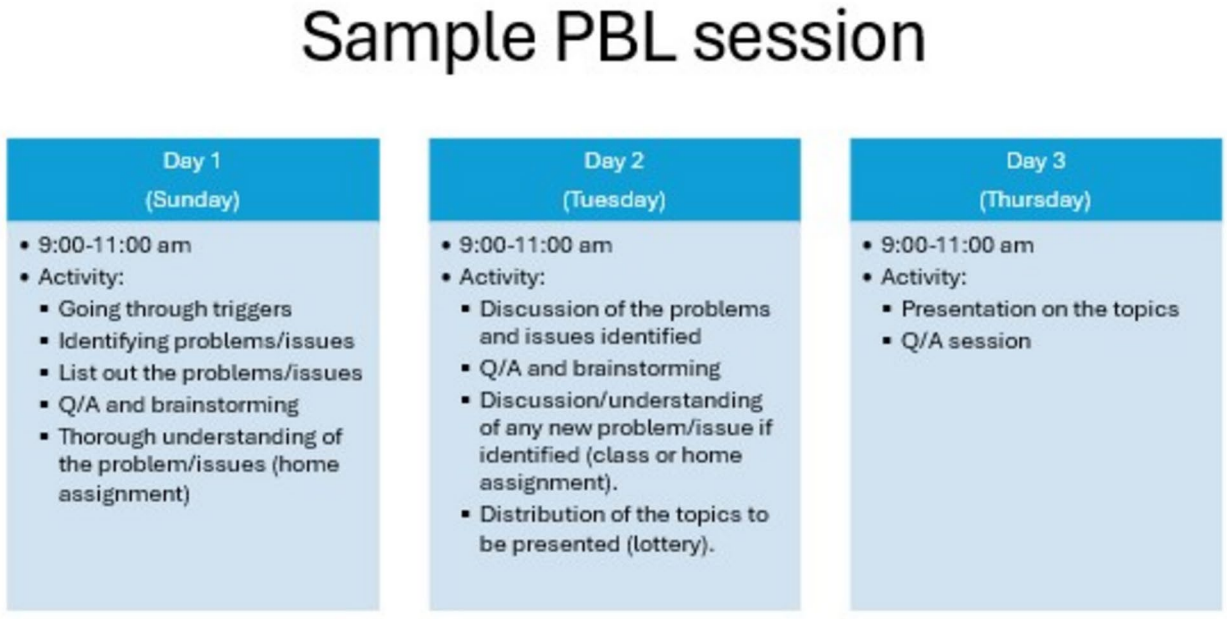


**Fig. 1** Sample PBL session, reflecting a locally adapted process akin to the 7-jump method, including problem identification, discussion, and wrap-up, tailored to resource availability

limit 'thick description'; the team's qualitative expertise guided this trade-off within the project's scope.

A week was allotted for the students, and a day was marked to collect the responses. We asked the students to write down the responses on a paper to be submitted to us. We received all responses from the consenting students, male and female (*II-MS/II-FS*). The responses thus collected were then typed into an Excel sheet. Qualitative data from both second-year students (to identify teamwork challenges) and first-year students (to access intervention effectiveness) were analyzed using thematic analysis following Braun and Clarke's flexible framework [15], with initial coding accelerated by Claude 3.5 Sonnet software. All codes and themes were reviewed and refined by the research team to ensure interpretive depth, aligning with emerging practices in qualitative research efficiency [16, 17].

#### Ethical considerations:

This study was conducted as part of a social science project for the partial fulfilment of the degree of Masters in Higher Education under Kathmandu University School of Education (KUSOED). Ethical approval for this study was obtained from the Research Committee of KUSOED via letter reference number KUSOED-241,111 on 11 November 2024. As the study site was Lumbini Medical College, Palpa, written permission was obtained from the Principal of the institution for data collection. Informed consent was obtained from all participants prior to their involvement in the study. The study posed no risk to the participants, who were required to provide critical feedback and reflections to enhance the quality of the PBL sessions. The anonymity of the participants was maintained throughout data collection and analysis. The study was conducted in accordance with ethical principles outlined in the Declaration of Helsinki.

## Results

Thematic analysis was conducted with initial coding supported by Claude 3.5 Sonnet, with all findings validated and interpreted by the research team to ensure fidelity to participant responses. The responses of the students were read carefully, and the data were analyzed based on the aim and the questions of the study. Common themes, patterns, and insights were identified and organized to address the three research questions explicitly.

### Key elements contributing to or hindering effective teamwork and collaboration

This section addresses the first research question: *What are the key elements that contribute to or hinder effective teamwork and collaboration?* Thematic analysis identified several critical factors influencing teamwork dynamics during PBL sessions:

- **Positive Elements Supporting Teamwork**: Students indicated that effective communication relies on mutual respect, strong communication, and genuine feedback. For example, one student stated, *"A good collaboration would include mutual respect and understanding, genuine feedback, good communication & lastly a unanimous conclusion." (II-MS1)*. Successful teamwork was also linked to external motivators like deadlines or tutor oversight, as noted: *"Our team works good under pressure, when there's a deadline or Q&A sessions after our discussion by teacher. Getting tasks helped us most of the times as well as I would like to mention under teacher's strict surveillance it was more successful." (II-MS3).* Another student recalled, *"A moment I recall where my team worked really together is the first case we got under you as a tutor.... it was a completely new way of problem solving and no doubt the most interesting way to exist in this college.... so were all fascinated and we worked together really well." (II-FS5)*, highlighting how engagement and novelty fostered collaboration.
- **Barriers Hindering Teamwork**: Key challenges included communication barriers (e.g., language differences and technical issues), unequal participation, and poor preparation. Students noted, *"In my observation, the major challenge as of now is the language barrier among the diverse students." (II-MS1)* and *"Sometimes due to slow internet, messages fail to get delivered." (II-FS2)*, indicating communication gaps. Unequal participation was evident in comments like, *"Not all members contributed equally or fulfilled their responsibilities effectively." (II-MS2)* and *"Lack of equal participation and during discussion some of us seemed to be disconnected, and they were busy doing their own stuff." (II-FS4)*. Preparation challenges were also significant: *"The challenge I faced was I could not study my assigned topics because of lack of time to prepare so many topics. So every week I knew only little things or sometimes more than little things." (II-FS3)* and *"It was challenging for me to study all the topics for 2nd day from different resources and was always frightful of the questions that Sir asked randomly during sessions." (II-MS2)*. Absenteeism and time constraints further hindered collaboration, as one student described, *"Our team struggled to collaborate effectively once when many were absent. It wasn't productive at all..." (II-FS5)*, and another noted, *"I think in almost every PBL session we struggled to collaborate because our pattern was really different and difficult too." (II-MS2)*.
- **General Perceptions**: Students generally valued PBL for fostering critical thinking and communication

skills but faced challenges adapting to its demands. Positive experiences included, *"Overall my experience working as a team in my allotted PBL group was very fruitful." (II-MS1)*, *"Working as a team in PBL has been significant aspect for my personal and academic growth." (II-FS1)*, and *"Working in a PBL team has helped me to be more confident about speaking my views and has helped me immensely with communication." (II-FS2)*. The engaging nature of PBL was also appreciated: *"Every time I attended PBL classes it is never boring or text limited because wide coverage of content is done so I feel like attending PBL classes." (II-FS3)*.

#### Enhancing teamwork through Team-Building, collaborative tasks, or structured roles

This section addresses the second research question: *How can team-building activities, collaborative learning tasks, or structured team roles enhance teamwork and collaboration?* The analysis highlighted specific practices that improved team dynamics and collaboration:

- **Collaborative Learning Tasks and Structured Roles**: Assigning tasks and roles, such as presentations or topic discussions, enhanced accountability and engagement. A student noted, *"…. We did well because, Sir was really upset about the previous sessions. So we really had to give our best, studied all topics from Sir recommended resources, and next day, we presented too. I think that was because of unity and sincerity…" (II-MS2)*, indicating that structured tasks under pressure fostered unity. Another example of successful collaboration was, *"Our team works good under pressure, when there's a deadline or Q&A sessions after our discussion by teacher. Getting tasks helped us most of the times as well as I would like to mention under teacher's strict surveillance it was more successful." (II-MS3)*, emphasizing the role of deadlines and oversight.
- **Team-Building through Mutual Respect and Feedback**: Collaborative environment thrived when mutual respect and constructive feedback were prioritized. A student recalled, *"A moment I recall where my team worked really together is the first case we got under you as a tutor…. It was a completely new way of problem solving and no doubt the most interesting way to exist in this college…. So we were all fascinated and we worked together really well." (II-FS5)*. Conflict resolution through discussion also supported teamwork, as one student explained, *"Conflicts were usually resolved through discussion, research, and finding a consensus, though sometimes personal issues caused conflicts." (II-FS4)*.
- **Challenges in Implementation**: Despite successes, some groups struggled with collaboration due to differing work patterns or misunderstandings. For instance, *"Yes, there was one time such situation had occurred and it was completely out of misunderstanding among the members." (II-FS1)* and *"The time when we struggle is sometimes 2 or 3 students work whole night and come prepared but the one who couldnot cover up has to remqin silent and nod." (II-FS3)* highlighted how uneven effort or miscommunication undermined team-building efforts.

#### Strategies to promote active participation, communication, and coordination

This section addresses the third research question: *What strategies can be employed to promote active participation, communication, and coordination among team members?* Students suggested and demonstrated strategies that enhanced these aspects of PBL sessions:

- **Promoting Active Participation**: Students emphasized clear role distribution and active engagement as key to participation. One suggestion was, *"Better communication, active participation, and clear role distribution are suggested for improving teamwork." (II-FS3)*. Essential skills for participation included, *"Communication, active listening, responsibility, and a positive attitude are crucial for successful teamwork." (II-FS4)*. Structured tasks, like presentations, also encouraged involvement, as seen in successful cases driven by tutor expectations or deadlines.
- **Enhancing Communication**: Digital tools like Viber groups and phone calls were effective for communication outside sessions, despite challenges. Students noted, *"We used to communicate and share information online through Viber groups, and sometimes we also used to set up meetings for certain difficult topics during our spare time apart from the formal PBL sessions." (II-FS1)* and *"By talking with each other or just sharing information in the group, any new ideas or information we get regarding related topics we share in the group so everyone can see and learn it." (II-MS4)*. However, barriers persisted: *"We usually communicate with each other outside the PBL session through the social media, phone calls and rarely have meet ups. But all of us are not always available everytime in those social medias so that makes it difficult to communicate sometimes." (II-FS4)*.
- **Improving Coordination**: Strategies to improve coordination included leveraging digital platforms and ensuring inclusive discussions. Students

**Table 1** Patterns and trends in themes related to teamwork and collaboration in PBL sessions

| **Pattern across themes** | | |
|---|---|---|
| **Communication issues** | **Recurrent mention** | "overall experience," "collaboration and teamwork," "communication and information sharing," and "handling conflicts and disagreements". |
| | **Impact** | "affect teamwork", "information sharing", and "conflict resolution". |
| **Unequal participation** | **Common barrier** | "collaboration and teamwork," "team dynamics and contribution," and "examples of struggles in collaboration" |
| | **Root cause** | "lack of preparation", "absenteeism", and "individual disengagement". |
| **Effective strategies** | **Successful practice** | "examples of successful collaboration" and "suggestions for improvement" pointed out effective strategies like clear role distribution, mutual respect, and external motivators (e.g., deadlines, tutor presence). |
| **Pattern within themes** | | |
| **Collaboration and teamwork** | **Positive dynamics** | Those groups that experienced mutual respect and genuine feedback performed better. |
| | **Negative dynamics** | Lack of responsibility and conflicting ideas hindered teamwork. |
| **Communication and information sharing** | **Preferred methods** | Digital communication- social media and phone calls |
| | **Barriers** | Language issues and internet availability |

suggested addressing barriers like language and internet issues to enhance coordination, aligning with their experiences of using social media for group updates. The emphasis on mutual respect and consensus-building, as in *"Conflicts were usually resolved through discussion, research, and finding a consensus, though sometimes personal issues caused conflicts." (II-FS4)*, also supported better coordination.

In the following steps, we identified the recurring patterns and trends in the themes for a more comprehensive analysis of the findings (Table 1).

### Patterns and trends

Key insights, derived from team consensus after large language model (LLM)-assisted coding and analysis of pattern and trends, were as follows:

1. Effective communication is essential for successful PBL sessions. This could be achieved by addressing communication barriers which would enhance information sharing and overall teamwork.
2. To address unequal participation, targeted strategies are needed, such as clear role assignments and better preparation practices, so as to ensure all members contribute effectively in each session.
3. Mutual respect and constructive feedback are fundamental for positive team dynamics and successful collaboration.

### Strategies developed to enhance PBL teamwork

1. Implementing structured communication protocols would address language barriers and ensure all members are informed and engaged.
2. Introducing regular team-building activities and workshops on effective communication and active listening skills would prepare the students for active participation in PBL sessions.
3. Assigning clear roles and responsibilities within PBL groups would promote accountability and equal participation.
4. Utilizing digital tools and platforms would facilitate better information sharing and collaboration outside of scheduled sessions. This aligns with Maharjan et al., who noted the potential of digital enhancements in Nepali PBL settings [7].
5. Encouraging tutors to monitor group dynamics closely and provide timely feedback and guidance to resolve conflicts and improve teamwork.
6. Promoting peer-led facilitation and role rotations to enhance teamwork and participation, leveraging student resources in settings where infrastructure upgrades are not feasible.

### Application of interventions in PBL sessions

Based on the strategies developed, the following interventions were applied for the first-year students (*I-MS/I-FS*) of the respective PBL group (1st author-facilitator), as second-year students had completed their preclinical phase and were no longer available for PBL sessions to assess their effectiveness:

1. **Internet Connectivity**: A new wireless router was installed in the PBL room for an uninterrupted internet connection. It was required to facilitate the students to broaden their access to the study materials.
2. **Textbook Availability**: The PBL classroom did not have textbooks available which could be referred to once the problem or learning objective was identified. It would have been a heavy weight if every

student brought all of their course books to the PBL sessions. For the same reason, we planned for each of the ten students to bring a textbook to the PBL sessions so that we had 10 different textbooks of 10 different subjects, such as Anatomy, Embryology, Histology, Physiology, Biochemistry, Microbiology, Pathology, Pharmacology, Clinical Examination and Clinical Methods. Previously, the students had to either go to the library or their rooms to look up the problem. However, with the availability of the books in the classroom, it was possible to access the content without a waste of time.

3. **Mutual Respect**: Not all students in the classroom were of the same intellect. For the same reason, there was an open discussion of the topics and the doubts were cleared so that all the students were on the same track at the end of the day. This built trust and respect for the students and also the students felt they were taken care of.
4. **Clear Role Assignments**: All the students actively participated in the PBL sessions to identify the problem and learn the key learning objectives. In the second PBL session once all the problems and the key learning topics had been covered, a wrap-up session was conducted where the students gave a PowerPoint presentation on the topic. Choosing the topic was by a lottery system and the individual assigned prepared a presentation slide for 10 min. Initially, the students were not able to complete the presentations in the 10 min time frame as their content was lengthy. For the same reason, a PechaKucha presentation was employed later which was effective in managing time, and also the students started to learn to make effective presentations in a limited time period.

### Assessment of intervention effectiveness

Following the application of interventions, an evaluation was conducted among the first-year PBL group and see the effectiveness and student response. The same methodology used for initial data collection was employed to ensure consistency. Some of the responses received are as follows:

#### *Open verbal sharing and collaborative decision making*

> *"Open verbal sharings, collaborative decision making, trust and reliability, Active tutor guidance, availability of research material (wifi), support and encouragement and team problem solving are dynamics of our PBL group. Every PBL week we are assigned with presentations to talk about. The PBL presentation appears in active presence of our PBL tutor who guides through hurdles we are facing every now and then. Somedays, in the absence of our tutor, our PBL leader guides everyone of us through the topics. Each one of members collaboratively obey his presence and participate actively." (I-FS1).*

#### *Teamwork and collaboration*

> *"A single situation might not do justification to brilliant teamwork we have accomplished till the date. First few PBLs were tough for members as we were new to everything and everyone. It was difficult at the beginning for us to interact and cooperate which led to tough disputes. By the time, we have worked through it as well and with every passing time, I have come to realize our teamwork is just getting stronger and resilient." (I-MS2).*

#### *Conflict resolution*

> *"Personally, I feel there were no huge conflicts between us. There may be misunderstanding between two parties or members. It did not need any effort to handle but we should be aware about that we should not do personal thing while learning which will create misunderstanding." (I-FS3).*

### Observed and reported impacts of interventions

Significant improvement in perceived and observed outcomes was evident when interventions were implemented in PBL sessions. As demonstrated by student quotes emphasizing cooperative decision-making and improved cooperation, students reported improved communication within their groups, more involvement through the PechaKucha presentation format, and improved team dynamics with better dispute resolution. These alleged advantages were supported by the tutor's observations of higher student participation in class discussions and presentations, more effective resource use due to better internet access and textbook availability, and an overall improvement in the learning process for students characterized by enhanced critical thinking and problem-solving abilities. The effectiveness of the interventions in fostering a more engaging and productive PBL environment for first-year medical students is demonstrated by the congruence between perceived and observed outcomes. Outcomes align with Kirkpatrick's model [18]: positive student reactions (Level 1), improved learning via participation (Level 2), and observed behavioral shifts in teamwork (Level 3), though long-term results (Level 4) remain unevaluated.

## Discussion

The findings of this action research study shed light on several vital aspects of teamwork and collaboration in PBL sessions within medical education. Our results align with existing literature while offering new insights into the dynamics of PBL implementation in the Nepali medical education context.

Studying as a team in a small group is an effective way to learn as it provides more engagement and participation [19]. A primary finding was the fundamental role of effective communication in successful PBL sessions. The communication challenges identified, particularly language barriers and technological constraints, echo findings by Maharjan et al. in their study of PBL implementation in Nepal [7]. However, our study extends beyond identifying these barriers by demonstrating how structured communication protocols and technological infrastructure improvements can effectively address these challenges. The successful implementation of wireless internet access and systematic textbook availability in PBL rooms exemplifies how institutional support can overcome practical barriers to effective communication and resource access.

The issue of unequal participation emerged as a significant challenge, consistent with Holen et al.'s observations about the influence of individual personality traits and socio-cultural backgrounds on PBL participation [9]. Our intervention in implementing PechaKucha presentations represents an innovative approach to addressing this challenge, forcing concise, time-bound contributions from all participants. This structured approach to participation appears to have particular value in the Nepali context, where hierarchical social structures and varying levels of academic confidence can inhibit open participation.

The importance of mutual respect and constructive feedback in fostering positive team dynamics emerged as a crucial theme. This finding aligns with Bate & Taylor's emphasis on the particular challenges faced by first-year students in forming academic identities and navigating collaborative work [10]. Our implementation of open discussion formats and systematic role rotation appears to have created a more equitable and respectful learning environment, addressing the concerns raised by Rimal et al. about PBL implementation fidelity in Nepal [6].

A Nepalese study revealed an overall satisfaction and active learning environment perceived by medical and dental students, who noted that PBL was more effective than traditional lectures [20].

A notable aspect of our findings was the effectiveness of blending traditional and digital approaches to PBL. While maintaining face-to-face interactions, the integration of digital tools for information sharing and collaboration outside scheduled sessions represents an adaptation to contemporary learning preferences. This hybrid approach appears to address some of the resource constraints identified in previous studies of PBL implementation in Nepal [4].

The challenges of the PBL approach in learning are that the students are particularly focused on solving a particular problem or gaining a specific skill however, in real-world situations the medical students are not only responsible to their patients, but their decisions are paramount to the public health and the community at large. The challenges students face in the learning environment, their roles and responsibilities as a team, and reflecting on them for a possible solution is one way of making them responsible and insightful medical doctors. This action research has provided them an opportunity to reflect on their learning and responsibilities [21].

The success of our interventions, particularly among first-year students, indicates that implementing structured collaborative approaches at an early stage could be key to embedding effective PBL practices. While the implemented interventions (improved internet connectivity and systematic textbook availability) proved effective at Lumbini Medical College, we recognize that such solutions may not be universally feasible in all resource-limited settings due to infrastructural or budgetary constraints. These strategies were tailored to our institution, where minimal investment (e.g., a wireless router, reallocation of existing textbooks) was possible. To broaden applicability, our findings also suggest low-resource alternatives, such as structured peer-led discussions to enhance communication and role rotations to ensure equitable participation. These approaches leverage existing student capacities and require little to no additional infrastructure, offering practical options for settings with more severe resource limitations. Positive feedback from first-year students indicates that explicit role assignments, systematic access to resources, and structured formats for presentation can mitigate some common initial barriers to effective collaboration.

Our analysis has many ramifications for the practice in the medical education field. First of all, it indicates that effective PBL implementation relies on a systematic approach to meet both physical infrastructure needs such as the availability of the internet, textbooks, and feedback mechanism. Second, it suggests that these practices should be altered to appropriate local context as long as the foundation of collaborative learning is not undermined. Lastly, the study highlights the importance of continuous evaluation and adaptation of PBL practices with regard to student feedback and observed outcomes.

This study has some limitations, such as its emphasis on a single institution, and relatively brief duration for the interventions. Additionally, the interventions were applied only to first-year students because second-year

students had completed their pre-clinical course and were promoted to third year, limiting the ability to assess the interventions in them. Future research needs to be done to ensure that the design of such interventions has enduring applicability in diverse medical education contexts. Additionally, data saturation was not formally assessed due to the action research timeline, potentially limiting the depth of insights.

The revision of curriculum for effective pedagogy, and also the role of university for effective implementation of the curriculum, apart from affiliating medical colleges, should be prioritized [22]. Furthermore, the role of Medical Education Commission while accrediting standards and quality of medical education is already discussed and is beyond the scope of this study [22]. While this study focused on student-driven interventions, ineffective group dynamics may partly stem from limited tutor awareness of facilitation frameworks, such as Tuckman's model of group development (forming, storming, norming, performing, adjourning). At Lumbini Medical College, tutors/facilitators receive basic PBL training during orientation, but this may lack depth in managing group dynamics or fostering soft skills. This aligns with prior observations in Nepal [20, 23] and suggests that enhancing tutor training could amplify the effectiveness of PBL interventions. Future research should explore the impact of structured tutor facilitation on PBL outcomes.

## Conclusions

This action research study elucidates key challenges in implementing PBL within resource-constrained medical education settings. Enhanced internet accessibility, systematic textbook availability, defined roles, and structured presentations, such as PechaKucha, promoted better communication, improved team participation, and team dynamics at Lumbini Medical College. These context-appropriate interventions, which can be undertaken with minimal institutional support, adeptly overcame the identified barriers. In resource-limited settings, our findings further illustrate that cost-efficient strategies such as peer-led facilitation and role rotations can meaningfully achieve collaboration by empowering students, requiring minimal infrastructure. While these dual insights between context-tailored solutions and resource-efficient alternatives offer practical guidance for medical educators, the study's single-institution scope and brief duration call for broader contextual testing.

## Supplementary Information

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Supplementary Material 1

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**Author contributions**
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All data generated or analysed during this study are included in this published article.

## Declarations

**Ethics approval and consent to participate**
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**Consent for publication**
Not applicable.

**Competing interests**
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