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Effectiveness of Student-Facilitated Problem-Based Learning in Integrated Basic Medical Sciences: A Retrospective Quantitative Analysis of Academic Records

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ABSTRACT

Introduction

Problem-based learning (PBL) is considered as a historic innovation in medical education. However, shortage of experienced faculty tutors for PBL is a major challenge in resource-limited settings. We aimed to assess effectiveness of student-facilitated PBL in content knowledge at a medical college of Nepal.

Methods

This observational study analyzed the outcome and experience of the PBL modules. This article reports the quantitative analysis which compared pretest and posttest results of the students on multiple-choice questions to assess content knowledge. The maximum possible score was 30 for each test and pass score was set as per modified Angoff method.

Results

Pretest and posttest results of 53 medical students were analyzed. The results showed that 39 (74%) students passed the pretest and 48 (91%) passed the posttest. This improvement was statistically significant (McNemar's chi-squared=4.27, p=0.04). The median (interquartile range) of the pretest scores was 19 (17-21) and that of the posttest scores was 23 (21-25) with a significant increase after the PBL module (Wilcoxon signed rank test, p<0.001, effect size=0.67). The posttest scores of the first year students were comparable to the posttest scores of the second year students (Wilcoxon rank sum test, p=0.40).

Conclusion

The student-facilitated PBL module was effective for improving content knowledge. Future, prospective experimental design with control group may rule out the role of other extraneous variables.

Keywords

Faculty, peer tutor, problem-based learning, test scores

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INTRODUCTION

Problem-based learning (PBL) is considered as a historic innovation in medical education,[1] and it has been incorporated in the medical curricula in Nepal for about three decades.[2-3] It is believed that this model of teaching-learning resembles real life scenarios and enhances higher order cognitive and social skills.[4-6] Theories of adult learning also support this approach of self-directed learning[7]. However, its implementation cost is high in terms of the human resources required to facilitate the PBL sessions and other logistics.[5] It is even more challenging in the remote areas where there is a pressing shortage of faculty members and other health education professionals.[6] Alternative models such as conduction of PBL sessions by facilitation by a peer/near peer have been tried globally with varying reports; mostly positive.[8] For instance, a study in Bahrain showed that the test scores when facilitated by students were comparable to those when facilitated by faculty tutors.[9] Another study from Japan reported that there was greater variability in the scores of students of tutorless group.[10]

To our knowledge, there is a mention of positive experience with peer-tutored PBL sessions in the literature from Nepal,[11] and quantitative details are limited. This report aimed to assess the effectiveness of student-facilitated PBL modules in content knowledge in the context of a remote area of Nepal.

METHODS

An observational study was conducted in Karnali Academy of Health Sciences, Jumla using both quantitative approach to assess pretest and posttest scores and qualitative approach to determine the perception or subjective experience of the stakeholders. This article reports the quantitative component; the qualitative analysis has been presented in a separate paper due to word limits per article.[12] The pretest and the posttest answer sheets to multiple choice questions of the students of the MBBS first year (50 students) and the second years (30 students) i.e. a total of 80 students were retrieved from PBL records. Students who were absent during PBL sessions more than one PBL day (out of 4 discussion/presentation days) or during the pretest or posttest were excluded from the analysis.

Approval from the Office of the Dean was obtained for conducting the study and ethics approval was obtained from the Institutional Review Committee of the Karnali Academy of Health Sciences (Ref: 081/082/01). Consent from the study participants was not applicable as we analyzed the academic records retrospectively during September of 2024. Confidentiality of the data and de-identification of the participants in publishable reports was ensured.

Karnali Academy of Health Sciences trains MBBS students during the first two years adopting lecture methods blended with hospital posting, community field visits and PBL is usually facilitated by faculty members. During March and April of 2024, at a time of shortage of faculty, a self-facilitated PBL module for the MBBS first and the second year on one case scenario for each year was conducted. . This article resulted from retrospective analysis of the PBL records by the faculty members involved in the implementation and evaluation of the student-facilitated PBL.

The student-facilitated PBL modules were supervised by PBL coordinator (LRJ) and the MBBS Phase-I coordinator (KA) without providing inputs in the role of a tutor. The student leaders facilitated the PBL sessions using PBL triggers and facilitator guide prepared by experienced faculty members from basic medical sciences and community health sciences. MBBS second year students had a prior experience of faculty tutor-facilitated PBL while PBL method was new to the first year students. Orientation sessions and pretest were conducted before the PBL sessions.

Maastricht seven-step-model of PBL was followed.[13] A PBL module was completed over duration of one week with group meetings (two hours each) on three alternate days interspersed with a self-study day (two hours each) in between. A wrap-up seminar was organized on the final day for each batch to share learning, and posttests were conducted after the PBL modules.

Different sets of single-response-MCQs were used for pretest and posttest for each batch so that the posttest would not be easier merely due to seen questions. Equivalence of the contents of pretest and posttest question sets was ensured by the question setters by matching the questions content-wise while preparing the questions. The questions were prepared including contents from various basic medical sciences; community health sciences; and introduction to clinical medicine, medical humanities and ethics. Each pretest and posttest MCQ set comprised of 30 questions (30 marks) for MBBS second year and 25 questions (25 marks) for MBBS first year. The scores obtained out of 25 marks were converted by unitary method to obtain the scores out of 30 for uniformity. Each calculated score in fraction was rounded to the nearest whole number.

In order to determine the level of difficulty of the tests and to set the passing scores of the tests faculty meetings were held for standard setting using the modified Angoff method.[14] The team of five faculty members from various basic medical sciences scored and discussed the difficulty level of each question and the average score of the difficulty level of the set of questions was translated

to the pass marks for that set of questions. The modified Angoff method has established validity and reliability.[14] Inter-rater reliability of a team of faculty members for the determination of difficulty levels of the multiple choice question sets for both pretests and posttests of both batches was found to be good with the intra-class correlation coefficients (average of fixed raters) ranging from 0.73-0.87. The pass score, rounded to the nearest whole number, of the pretests of both years and of the posttest of the second year was found to be 18 (out of 30) and the pass score for the posttest of the first year was 19 (out of 30). The tests with different levels of difficulty were equated by mean equating method to enable comparison.[15] Since the posttest of the first year was one item easier than other tests, one mark was subtracted from the score of each of the first year students in the posttest in order to equate the test to other tests.

The data pertaining to the pretest and the posttest answers of the students to MCQs were entered into and initially processed using Microsoft Excel Spreadsheet. Further analysis was carried out using R (version 4.1.1) packages namely 'tidyverse' (2.0.0), 'magrittr' (2.0.3) and 'psych' (2.4.6.26) for quantitative analysis. McNemar's chi-squared test was applied for assessing association between categorical variables and Wilcoxon tests for continuous variables. The level of significance was set at 5%. Effectiveness of the PBL was expressed in terms of the difference between pretest and posttest scores.

RESULTS

Out of 80 eligible students (50 MBBS first year and 30 second year students) data from 53 students were included in the final analysis which represents 66% participation rate. The rest of the 27 students were excluded due to their absence during the pretest or the post test. There was less participation from the first year. (Table 1)

Since there was low participation rate from the first year in the posttest due to some event in the college, we compared the performance in the pretest of those who participated and those who did not in the posttest. The median (interquartile range) pretest score of those who did participate was 18(17-20) and the same of those who did not was 18(14-19) from the first year. No statistically significant difference between the two groups was found. (Wilcoxon rank sum test, W = 230.5, p = 0.17).

Table 1. *Characteristics of the participants (n=53)*

Characteristics	Number (%)
Gender	
Male	39
Female	14
Level	
MBBS first year	26
MBBS second year	27

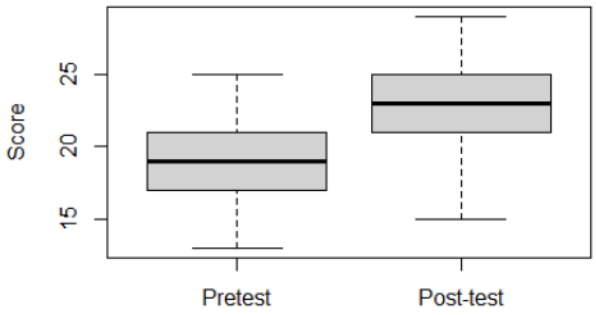

Figure 1. *Box plot showing pretest and posttest scores of the students*

Of the 53 students included in the final analysis, there was at least 50% representation from each PBL team except for one team which had only 20% representation. Taking the pass score of 18/30, 39 out of 53 students (74%) passed the pretest and 48 (91%) past the posttest. This improvement in the results was statistically significant (McNemar's chi-squared = 4.27, p-value = 0.04). Visual presentation of the pretest and posttest scores is given in Figure 1.

The first year students improved scores from the pretest to the post test significantly (Wilcoxon signed rank test, p<0.001, effect size=0.69) and similar was the case for the second year students (Wilcoxon signed rank test, p<0.001, effect size=0.66). Analysis of the results of both years (combined) also showed improved performance (Wilcoxon signed rank test, p<0.001, effect size=0.67) (Table 2).

Comparison of the pretest scores of the first and the second year students showed that the second year students had higher scores (Wilcoxon rank sum test, p=0.02) in the pretest. However, the posttest scores of the first year students were comparable to the posttest scores of the second year students (Wilcoxon rank sum test, W = 315.5, p=0.40).

DISCUSSION

There was significant improvement in the test result in terms of median score as well as pass percentage. The post-PBL scores of our study i.e. 23 out of 30 (77%) are comparable to the scores obtained by students after tutorless PBL sessions (66% and 74% by two separate groups) in a study by Hayashi et al. in a medical university in Japan among first year medical students.[10] These scores were also comparable to the scores obtained by

Table 2. Comparison of pretest and posttest scores

Group	Pretest score Median (IQR)	Posttest score Median (IQR)	p value*	Effect size*
First year	18 (17-20)	24 (20-25)	<0.001	0.69
Second year	20 (19-22)	23 (21-24)	<0.001	0.66
Combined	19 (17-21)	23 (21-25)	<0.001	0.67

faculty-tutored groups in their study. Compared to our study, test scores were relatively higher in the study by Steele et al. in the USA among second year medical students, and there was no significant difference between the faculty-led and student-led group scores in their study.[16] A pilot study by Kaliyadan et al. among fifth year medical students in Saudi Arabia gave similar results.[17] A review by Athena Li et al from McMaster University reveals that majority of the studies analyzing the effect of facilitator qualification on student achievement found no significant association although some studies favored expert facilitators.[8]

In the pretest, performance of the second year students was better than performance of the first year students which might be due to greater prior coverage of the topics in the lectures in the case of the second year. The performance in the posttest was comparable for both years which suggests that the first year students did at least equally well in the PBL despite the fact that PBL model was new to this cohort.

The qualitative component of our study also supports these quantitative findings where the students reported that they had "in-depth study" with "clinical orientation" and the faculty members also appreciated the performance of the students in the wrap-up seminars.[12] Barrows et al., the pioneers of PBL, have also stated that PBL can be adopted under the facilitation of a faculty tutor or students themselves provided that they are well acquainted with its philosophy and practice.[18]

Since our study shows significant improvement in content knowledge of the students on adoption of the student-facilitated PBL, it suggests that this model may provide as an alternative for faculty-facilitated PBL in resource-limited scenario.

Major limitations of this study are its retrospective nature, small sample size and lack of a control group. Other extraneous variables such as self study, possible simultaneous coverage of contents in the lectures etc. that might have affected the results could not be controlled for.

CONCLUSION

This analysis has showed that the student-facilitated PBL module was effective for acquiring content knowledge. This suggests that the students can be benefitted from PBL adopting student-facilitated approach when/if it is difficult to arrange faculty members to facilitate PBL. Future studies with prospective experimental design with a control group may rule out the role of other extraneous variables. such as self study, possible simultaneous coverage of contents in the lectures etc..

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CONFLICT OF INTEREST

The author(s) declare that they do not have any conflicts of interest with respect to the research, authorship, and/or publication of this article.

AUTHOR CONTRIBUTIONS

Concept of research & Design of research: LRJ, PN, DH, CKT, AA, KA; Literature search: LRJ, KA; Data collection: LRJ; Data analysis: LRJ; Data Interpretation: LRJ, JPJ, KA; Drafting and Reviewing of the manuscript for important intellectual content: LRJ, PN, DH, CKT, AA, JPJ, KA; Final approval of the version ready for submission: LRJ, PN, DH, CKT, AA, JPJ, KA; Agreement to be accountable for all aspects of the work: LRJ, PN, DH, CKT, AA, JPJ, KA

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