A comparison of learning outcomes and attitudes in student- versus faculty-led problem-based learning: an experimental study

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Objectives To compare learning outcomes and perceptions of facilitator behaviours and small-group process in problem-based learning (PBL) groups led by students and those led by faculty.

Design A prospective, Latin-square cross-over design was employed. Second-year medical students participated in 11 PBL cases over the course of the academic year. For each case, half the student groups were led by faculty and the other half by a student group member selected randomly to serve in the facilitator role. Learning outcomes were assessed by performance on objective examinations covering factual materials pertinent to the case. Perceptions of facilitator behaviours and of group functioning were assessed with a questionnaire completed at the end of each individual case. Focus-group discussions were held to gain more in-depth information about student perceptions and experience. Student-led sessions were observed at random by the investigators.

Setting A state-supported, US medical school with a hybrid lecture-based and problem-based curriculum.

Subjects One hundred and twenty-seven second-year medical students and 30 basic science and clinical faculty.

Results No differences were detected in student performance on the objective evaluation based on whether the facilitator was a faculty member or peer group member, nor were there any differences in the perceptions of group process. Students gave peer facilitators slightly higher ratings in the second semester of the experiment. In the focus-group discussions, students voiced a general preference for student-led groups because they felt they were more efficient. Observation and focus-group reports suggest that groups led by students sometimes took short cuts in the PBL process.

Conclusion In a hybrid lecture- and PBL-based curriculum, student performance on objective examinations covering PBL materials is unaffected by the status of the facilitator (student vs. faculty). However, in peer-facilitated groups, students sometimes took short cuts in the PBL process that may undermine some of the intended goals of PBL.

Keywords Attitude of health personnel; curriculum; education, medical, undergraduate, *methods; outcome assessment, health care; problem-based learning.

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Introduction

In the autumn of 1991, the College of Medicine at the University of Nebraska Medical Center (UNMC) implemented a revised curriculum for first- and second-year medical students. This curriculum included the development of conceptually integrated, interdisciplinary cores to replace departmentally based, discipline-defined courses and the addition of a problem-based learning (PBL) component to serve as an adjunct to more traditional lecture and laboratory-based instruction.[1] At UNMC, problem-based learning cases are highly structured.[2] Each is designed to be covered over a 2-week period in three 1–2-h sessions. Cases unfold sequentially in these sessions. The case author specifies the order in which case material should be distributed and the number of pages to be covered in any given session. The expectation is that students will identify learning issues as they pursue the case and that all will engage in self-directed study of these issues between PBL sessions. The case author provides the

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facilitator with a list of questions to draw upon as needed to stimulate discussion. The facilitator is also provided with a list of intended learning objectives for each case. These can be used to monitor group process and to ensure that the group is on task. At the conclusion of the case, the case author's learning objectives are distributed to students so that they can assess their learning and identify knowledge gaps prior to examination. Cases are designed primarily to reinforce and to supplement information presented in lectures and to provide students with opportunities to use their knowledge to solve clinical problems. Faculty facilitators, drawn from volunteers in the basic and clinical sciences, are not expected to be content experts.

Although the cases were developed to exemplify and amplify concepts addressed in the basic science cores, at the time of this study PBL was an independent course and awarded its own semester grades. Student grades were based on performance in knowledge-based examinations, an end of the semester triple jump designed to assess student reasoning ability, and on the faculty facilitator's judgement of the level and quality of each student's participation in the small group sessions that he or she facilitated. The objective knowledge examinations were weighted at 50%, the triple jump accounted for another 15% and the faculty facilitators' evaluations made up the remaining 35% of the grade.

Research on faculty perceptions of PBL reveals that concerns about faculty time is an impediment to the implementation of PBL.[3–5] This practical issue, coupled with the observation that well-functioning groups 'run themselves', led us to devise an experiment to assess the efficacy of peer-facilitated PBL. If it can be shown that students perform as well on objective learning measures in peer-directed groups as they do in groups facilitated by faculty, then it should be possible to conserve faculty resources by structuring PBL so that the groups can be led by students. Furthermore, giving students the responsibility for facilitating their own small group learning is consistent with the widely held tenet that one goal of medical education should be to promote the development of the skills and habits of lifelong, self-directed learning.[6]

Methods

Sample

The subjects of this study were 127 second-year medical students at the University of Nebraska Medical Center during the 1994–95 academic year. Blocking for gender and grade point average in the first year of medical school, students were assigned randomly to one of 13 10-student groups. Groups remained intact for one semester with the students assigned randomly to different groups in the second semester. Participation in PBL is mandatory. The study was restricted to second-year students to ensure that subjects were thoroughly conversant with the PBL process. A total of 30 faculty members participated over the course of the year. Thirteen participated during the first semester and 17 during the second. On average, each faculty member facilitated two cases.

Experimental design and intervention

A Latin-square cross-over design was employed in this study. For each PBL case, half the groups were randomly assigned to a faculty-led condition and the other half to a peer-facilitated condition. Thus, on alternating cases, groups were led either by a faculty member or a student. Peer facilitators were student members of the group who were selected randomly to serve in that capacity for a given case. No student facilitated more than one case. Student and faculty facilitators attended separate pre-case orientation sessions with one of the authors (JDM). In these sessions facilitators were given case materials, case objectives and suggested questions to stimulate discussion. Student facilitators were given an additional set of guidelines to assist them in their facilitator role. These guidelines stressed that the student was to facilitate the group process by keeping the group on task, monitoring participation and by distributing case material in the designated sequence. Students were reminded that they were not expected to be content experts and that they should participate in self-directed study as they would in any PBL case. Student facilitators did not evaluate the performance of their peers.

Measures

Learning outcomes

Learning was assessed through a 15-item objective examination following each case. Multiple choice and matching questions were developed by the case author, PBL director (JDM) and/or a basic science core director. Questions were based on the learning objectives associated with the case. Points were summed over the semester, and each student received two percentage scores per semester: a percentage score for all test questions for cases facilitated by a faculty member and a percentage score for all test items on cases covered with a peer facilitator. Because the triple jump was administered only once at the end of each semester, after students had been in groups facilitated by both students and faculty, its results are not included in this analysis.

Facilitator behaviour and group process

Perceptions of facilitator behaviour and group process were assessed by a 30-item questionnaire completed by students at the conclusion of each case. Eighteen items on this instrument assessed perceptions of group process on a five-point Likert scale. Example items included: 'the group and its members worked efficiently' and 'the group and its members formulated reasonable hypotheses'. The remaining items assessed the role of the facilitator. Example items here included: 'the facilitator asked thought-provoking questions' and 'the facilitator helped the group integrate learning issues'. This instrument was originally developed by Mayo and colleagues[7] for a study of student perceptions of PBL.

Qualitative data

In addition to these outcome measures, the PBL director (JDM) made unannounced visits to each of the 13 groups over the course of the year to observe group functioning. Finally, the first author (DJS) conducted two focus-group discussion sessions each semester with representatives drawn randomly from each group. At these discussions, students were invited to compare and contrast their experiences in student- vs. faculty-facilitated PBL sessions. They were also asked to discuss their perceptions of the advantages and disadvantages of faculty- and of peer-led groups. These discussions were conducted in an informal atmosphere over lunch that was provided for the students. These sessions were not recorded. The focus-group leader took notes and dictated his observations and summary immediately following the session.

Analysis

Multivariate analysis of variance (MANOVA) was employed to assess differences in student examination performance based on the status identity of the facilitator (faculty vs. peer) and perceptions of group process and facilitator skills. The analysis included the two independent variables of group (i.e. the 13 PBL groups) and facilitator (faculty or student) and three dependent variables: (1) test score, (2) student assessment of facilitator behaviours and (3) student assessment of group process. The objective of this analysis was to determine whether the dependent variables, as a group, resulted in significant findings and, if so, to determine which variables contributed most to these findings using discriminant analysis.[8]

Results

The questionnaire response rate for the first semester of the experiment was 88·3%. This rate fell to 69·1% during the second semester, suggesting that respondents grew weary of completing questionnaires at the conclusion of each PBL case. Only complete data were included in the analysis. If students failed to complete portions of the questionnaire or failed to provide group identification, the data for that student were dropped from the analysis. There were no differences in response rate by facilitator role identity (student vs. faculty) that would influence the results for either the first ($\chi^2 = 3{\cdot}54$, $P = 0{\cdot}06$) or second semester ($\chi^2 = 2{\cdot}15$, $P = 0{\cdot}14$); nor were there differences in the examination performance of responders and non-responders in either semester (Mann–Whitney U, semester 1 = 18 639·00, $P = 0{\cdot}269$; Mann–Whitney U, semester 2 = 37 713·00, $P = 0{\cdot}215$).

As seen in Table 1, there was a significant 'group by facilitator' interaction and a 'group' main effects for each semester. The independent variable of interest, 'facilitator', was only significant in the second semester. Thus, the status of the facilitator (student or faculty) was inconsequential for student examination scores and

Table 1 MANOVA summary (Wilks' lambda) for student examination performance based on student- vs. faculty-led groups (facilitator) and 13 PBL small groups (group)

Source	Value	Approximate *F*	Hypotheses d.f.	Error d.f.	*F* significance
First semester (n = 673)					
Facilitator	0·98992	2·18877	3	645·00	0·088
Group	0·83366	3·36334	36	1906·45	0·000
Facilitator by group	0·90281	1·86468	36	1906·45	0·001
Second semester (n = 439)					
Facilitator	0·95626	6·26628	3	411·00	0·000
Group	0·72993	3·79469	36	1215·07	0·000
Facilitator by group	0·77738	3·00291	36	1215·07	0·000

evaluation of the PBL process in the first semester of the experiment. Multivariate discriminant follow-up analysis was conducted on the significant main effect of facilitator for the second semester using a Lambda cut-off of > /0·40/. Perceptions of facilitator behaviour (Lambda = −0·48) accounted for the significant difference between student- and faculty-led PBL cases. Test score (Lambda = 0·06) and perceptions of group process (Lambda = 0·34) did not contribute substantively to the significant finding.

Learning outcomes and assessment of group functioning and facilitation

Table 2 summarizes the means and standard deviations of the dependent variables for student-led and faculty-led PBL cases. There were no significant differences by facilitator type during the first semester, and differences in test scores and perceptions of facilitator behaviour and group process were also negligible. For the second semester, the significant difference between type of facilitator was attributed to facilitator behaviour with student-led PBL cases favoured over those facilitated by faculty (54·8 vs. 53·5). Although statistically significant, this difference is so small as to be of questionable practical significance.

Table 2 Means and standard deviations of dependent variables (test scores, facilitator behaviour scores, and group process scores) by facilitator type (student vs. faculty) for autumn and spring semesters*

Dependent variable	*n*	Mean	Standard deviation
First semester			
Test score			
Student-led	337	85·13	10·58
Faculty-led	336	83·45	12·08
Facilitator behaviour score			
Student-led	337	51·79	8·39
Faculty-led	336	51·72	7·64
Group process score			
Student-led	337	76·53	10·30
Faculty-led	336	77·30	8·93
Second semester			
Test score			
Student-led	221	79·18	16·63
Faculty-led	218	79·91	15·54
Facilitator behaviour score			
Student-led	221	54·81	6·61
Faculty-led	218	53·52	8·97
Group process score			
Student-led	221	79·24	10·58
Faculty-led	218	80·64	9·46

*Test score range (0–100); facilitator behaviour score range (0–60); group process score range (0–90).

Focus group and observational data

Forty students representing each of the PBL groups were selected randomly to participate in one of four focus-group discussions held over the course of the experiment. Our goal was to learn more about the experience from the student perspective. The consensus in these sessions was in favour of the peer-facilitated groups for most of the PBL cases. The students reported that peer-only groups were more co-operative, more efficient and less stressful than those sessions led by a faculty member. When a faculty member facilitated the groups, students felt there was more posturing and competition to impress the faculty facilitator. This, no doubt, reflects the fact that for grading purposes faculty facilitators provided evaluations of the level and quality of each student's participation in the group. The students also agreed that in the presence of a faculty member more time was devoted to discussion of issues students defined as 'trivial' or 'esoteric'. However, there was also consensus that some cases, those that the students regarded as complex and technical, should be facilitated exclusively by faculty. For example, one case cited by focus-group participants required interpretation of electrocardiogram tracings. Focus-group discussants in the student-led groups reported feeling anxious that they were not receiving the information they needed and worried that if they were making errors in their interpretations, no one was qualified to recognize it and to provide corrective feedback. In an effort to adjust by covariance for case difficulty, two faculty members (one clinician, JDM, and a basic scientist with considerable experience in case development and facilitation) reviewed each case and reached a consensus classification of high, medium and low difficulty. The correlation between the consensus classification and the dependent variables was low and not statistically significant. Consequently, this variable was not included in the analysis.

There were interesting parallels between the student comments about their experiences and the observations made by the PBL director when he made his unannounced visits to the small groups. He observed several instances in which student-facilitated groups took 'short cuts' in an effort to speed up the process. These included distributing the learning objectives prepared by the case author at the beginning of the case, rather than waiting until the end to serve as a check on the group's own self-defined learning issues; dividing learning issues among group members rather than

having all members do their own self-directed study as was the expectation in the UNMC approach to PBL; and rushing through the case by explicitly limiting discussion and sanctioning members for raising alternative hypotheses or explanations for the information contained in the case. Reports filtered back to the authors that one or two groups went so far as to 'hand out all the paper at once' so that students could skip the group discussion entirely and concentrate individually on the material covered in the case. Even when groups adhered to the PBL process in the presence of the observer, the participants often joked that they had to do so because the faculty observer was there to keep his eye on them.

Discussion

When effectiveness is operationalized as performance on knowledge-based examinations, this study suggests that student-led PBL can be as effective as faculty-led groups. These findings are consistent with much of the research on peer facilitation in problem-based learning. While some researchers report that student achievement suffers when learning is facilitated by a fellow student,[9,10] others have found peer facilitation to be as effective as faculty facilitation.[11] DeVolder and colleagues[9,12] report that in two out of three learning blocks, first-year health science students performed as well on knowledge-based examinations when they were in PBL groups led by fourth-year students as they did when in groups facilitated by faculty. The one block where this was not the case occurred early in the year. This led DeVolder and his co-authors to suggest that faculty guidance may be particularly important in the early learning stages before students have acquired a foundation upon which to base subsequent study and learning. It is also possible that a certain amount of time is needed for students to acclimate to PBL.[2] A faculty tutor may be particularly helpful in facilitating knowledge acquisition while students are also learning how to function in a PBL environment. In the study reported here, students had a year's experience in faculty-facilitated PBL before the initiation of the experiment. Thus, they were highly conversant with the process as implemented in our setting.

Schmidt[2] explores the efficacy of peer facilitation in terms of the research on the role of content expertise in facilitating PBL.[13–15] He suggests that tutor content expertise is likely to be most advantageous when learners have little prior knowledge of a domain or when the learning activity is not 'highly' structured. Highly structured learning activities are those that provide clues and guidance about what is important to study. When they lacked prior knowledge of a domain, Schmidt found that students participating in PBL groups led by content experts performed better in examinations than students in groups that were facilitated either by fellow students or by faculty lacking content expertise. Interestingly, under 'low structure' conditions, student performance is enhanced by being in groups led either by content experts or by students. The advantage of content expertise in low structure cases lies in the expert's ability to stimulate thinking and learning by posing appropriate questions and by recognizing student errors. On the other hand, Schmidt speculates that in low structure conditions student facilitators are able to communicate more effectively with their fellows, identify points of confusion and achieve mutually understandable explanations and understandings. He describes this as a situation of 'role congruence' and of 'cognitive congruence'.

At UNMC, students participating in the focus-group discussions indicated a general preference for student-led groups because they perceived these groups to be more efficient and co-operative than those facilitated by faculty members. Unannounced visits to student-led groups, along with information disclosed in the focus-group discussions, sheds additional light on the popularity of peer facilitation. When left to their own devices, it was easier for students to take short cuts and to abbreviate the PBL process. In some instances the group would read through the case with little or no discussion. In some student-led groups, the students avoided posting learning issues for self-directed study, preferring to wait until the case author's objectives were distributed in the final session to serve as a study guide, rather than as a tool to assess problem solving and self-directed study. In at least a few instances during the course of this experiment, student facilitators distributed learning objectives during the first session of the case rather than waiting until the final session, as had been intended. According to the students, having access to the intended learning objectives enabled them to use their time more efficiently by not 'wasting' it on fruitless hypotheses generation or discussion of issues that were not as important as the ones outlined in the learning objectives. For these students, the answers and not the process was of paramount importance. Although the students in this study performed equally well on knowledge-based examinations, regardless of whether they had a student or faculty facilitator, those who circumvented the process may have short-changed themselves from the standpoint of learning how to think and reason effectively about clinical problems. In a recent study of the cognitive effects of PBL, Hmelo[16] demonstrates that students in programmes where PBL

is a major vehicle of instruction are more likely to adopt hypothesis-driven approaches to problem-solving. They also generate explanations that are more accurate, comprehensive and coherent than students at the same level of training who have not participated as extensively in PBL-type learning activities. What role the facilitator plays in the process of acquiring these higher order cognitive skills is not known.

Despite our students' general preference for student-led groups, they also noted that some highly complex or technical cases require faculty involvement, particularly that of faculty who have expertise in relevant topic areas. They worried that without faculty guidance they would not master the material and that they would not know when they were making errors of judgement or interpretation. This qualitative finding is consistent with the previously discussed research reported by Schmidt and colleagues.[15] Inexperienced students, either from the standpoint of inexperience in the PBL process or inexperience with the subjects under consideration, may rely more heavily on faculty guidance and feel anxious about their learning in the absence of that guidance. Despite this worry, there were no differences in performance based on case complexity.

There are several limitations to the current study. First, we only measured knowledge acquisition and did so based on faculty-generated questions rather than validated standardized measures. Also, we did not develop measures of problem-solving ability that would permit us to assess whether cognitive impacts varied by type of facilitator. The triple jump examination was given at the end of the semester after students had participated in cases facilitated by both fellow students and by faculty. Consequently, there may be unmeasured cognitive effects that would favour one type of facilitator over another. In a study of a PBL legal education programme, Moust and his colleagues[10] found that students in faculty-led PBL performed better than students in peer-facilitated groups in essay examinations designed to assess higher-order cognitive skills. More research needs to be carried out on the cognitive effects of PBL when facilitated by students vs. faculty.

A second limitation relates to the setting in which this study was carried out. The medical curriculum at UNMC is a hybrid incorporating lecture-based and problem-based modalities. Of the two, lectures are the dominant mode of instruction based on hours of instruction and weight of examinations. Despite the fact that PBL was an independent core awarding its own grades at the time of this study, it was none the less seen as supplementing the lecture-based curriculum by providing a clinical context for material presented largely in a lecture format. Given its subordinate role in the curriculum and the highly structured way in which it is delivered, it may matter little whether a student or faculty member takes on the facilitator role. Furthermore, given the current hybrid structure of the curriculum, there may be little incentive for students to adhere to the PBL process as we intended it to be implemented. Thus, the results of this study may say as much about the limitations inherent in the way PBL is structured and implemented in this setting as it does about the relative efficacy of peer vs. faculty facilitation.

It should also be noted that there is a minor discrepancy between the perceptions reported by students in the focus-group discussions and the results derived from the survey assessing facilitator behaviours and small-group process. It may be that the instrument we employed in this study[7] is not sensitive enough to pick up on the differences noted by the students when they described their experiences in the focus-group sessions. Although this instrument has considerable face validity, its reliability has not been reported.

With these limitations in mind, this study none the less provides evidence that in highly structured PBL cases student-led groups can be as effective as those led by faculty when the measure of effectiveness is performance on knowledge-based objective examinations. However, in our setting, students in peer-facilitated groups took short-cuts in the process that may have undermined the value of PBL to promote the development of more complex and sophisticated problem-solving skills. Programmes considering the use of peer facilitation should develop procedures to ensure that students in their quest for efficiency do not circumvent the process.

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