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Taking it Online – The Effects of Delivery Medium and Facilitator on Student Achievement in Problem-based Learning

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Abstract

This study compares the effects of delivery medium (online vs. face-to-face) and facilitator content expertise on academic outcomes in a problem-based learning (PBL) course in anatomy for pre-health/medical majors. The content of online PBL sessions was examined to gain insight into the problem-solving process taking place in these situations. Neither the delivery medium nor the facilitator's content expertise had any statistically significant impact on students' quiz performance. Although students initiated most of the questions during online PBL sessions, the majority of these questions were at the lower levels of Bloom's Taxonomy and focused primarily on gathering information about the cases.

Keywords

Problem-based learning, clinical education, online instruction, Bloom's taxonomy.

Introduction

Given the rapid growth of online courses in general (U.S. Department of Education, 2003) and the need to accommodate students pursuing pre-health programs and medical degrees (both human and veterinary), we felt it important to offer clinically-based electives online at the undergraduate, graduate and professional school level. Problem-based learning (PBL) has been offered to a variety of audiences in the College of Veterinary Medicine and Biomedical Sciences, ranging from pre-health undergraduate students to third-year veterinary students. For the past 15 years, these classes have been offered in a traditional, face-to-face format, adapted from the Bowman-Gray Medical School curriculum (Philp & Camp, 1990). We recently began experimenting with the use of web-based materials to support PBL teaching in the

veterinary medical program. Based on the success of this innovation, we decided to examine the effects of offering segments of a PBL course completely online. Given the fact that it is important and desirable for premedical students to begin the process of critical thinking and evaluation of clinical situations early in their career, we chose this population as an audience for the study, as they have no prior experience with PBL. Prior research on PBL outcomes has focused on either the impact of delivery method on PBL outcomes or the effect of facilitator content knowledge. In this study, we combine these two factors in order to examine the feasibility of having non-content experts facilitate online PBL courses to accommodate the ever-increasing demands on clinical faculty members' time.

Theoretical Framework

Problem-Based Learning is a constructivist instructional technique frequently employed in medical programs to promote integration of content across the basic science areas and development of clinical problem-solving skills. The origins of the instructional technique can be traced back to McMaster University Medical School, where it was first implemented in 1969, as an answer to concerns about students' inability to solve clinical problems (Barrows, 1996). Given its success in this setting, many other medical schools, ranging from Maastricht (in the Netherlands) to Newcastle (Australia) and Harvard Medical School (Glick, 1991) began integrating PBL into their curricula, at least as a supplement to didactic lectures, during the 1970's and 1980's. Beginning in the 1980's (Tavakol & Reicherter, 2003), PBL made its way into allied-health curricula, including physical therapy, pharmacy and veterinary medicine.

To implement the PBL method, students are placed in small groups and given an authentic patient history. Their task is to identify and diagnose the problem and suggest a course of treatment. In order to accomplish this, the group (with the aid of a facilitator), needs to decide what they know about the case, what they need to learn in order to solve it, and how they are going to accomplish these tasks. There is no set curriculum because important concepts arise naturally, so all the content is ultimately covered. The facilitator's task is to encourage the use of higher-order thinking and questioning skills, and to promote the development of effective metacognitive skills and group processes (Savery & Duffy, 1995).

PBL is frequently employed in medical (human and veterinary) programs to enhance integration of content across the basic science areas and development of clinical problem-solving skills (Hmelo & Evensen, 2000) by promoting the "activation of prior knowledge and its elaboration" (Schmidt, 1993, p. 422). In fact, the PBL teaching method itself was developed as a response to dissatisfaction with the way future physicians were being prepared (Barrows, 1996) A study sponsored by the Association of American Medical Colleges, entitled "Report of the Panel on the General Professional Education of the Physician and College Preparation for Medicine" (known as the GPEP Report) (Muller, 1984), resulted in even wider implementation of PBL methodologies across the allied health professions, as its recommendations included promoting independent learning and problem solving. These findings were seen as support for the PBL method. According to Barrows (1986), PBL is designed to encourage the development of clinically useful knowledge, clinical reasoning strategies,

effective self-directed learning strategies, increased motivation for learning, and effective collaboration. This study explored how each of these objectives was accomplished over the course of a semester in a PBL environment utilizing a combination of web-based materials and face-to-face instruction.

Since PBL is a student-centered instructional methodology, there is much speculation as to whether or not the faculty facilitator's level of expertise affects student outcomes (Neville, 1999). In a true PBL environment, students are responsible for identifying gaps in their own knowledge and locating the information to fill these gaps. We hypothesized that facilitator expertise should, therefore, have no effect on student achievement, and this fact would allow for the use of non-expert tutors. Given other demands on faculty time, this would make PBL courses more feasible/cost effective for large numbers of students. Prior research studies in this area have had mixed results. For example, Regehr et al. (1995) found no significant differences in student learning and satisfaction between PBL groups led by expert and non-expert faculty. However, all faculty facilitators in this study were physicians, and expertise was defined as the tutors' experience and comfort in managing cases related to the problem being presented in PBL. Schmidt, VanDerArend, Moust, Kokx, and Boon (1993) performed a similar study and found that students in groups facilitated by content-matter experts spent more time on self-directed study than students in groups led by non-experts. This effect was more pronounced for novice students than for advanced students. In contrast, Kaufman and Holmes (1998) found that "tutors who are content experts find it difficult to maintain the 'facilitator' role" (p. 255). Steele, Medder, and Turner (2000) conducted a study comparing the academic outcomes from PBL sessions led by faculty versus student peers. Although they found no significant difference on objective examinations, they did observe that students sometimes took shortcuts in the PBL process when they were in peer-led groups.

With the widespread advent of online instruction, there has been much research conducted on the effects of different delivery media on academic outcomes, but very few published studies (e.g., Kamin, Deterding & Lowry, 2002) focus on the effects of online delivery on PBL instruction in a medical setting. Kamin et al. (2002) found that students completing cases with associated video, either face-to-face or at a distance, felt the cases were more memorable than did students completing paper-based cases.

In summary, prior research has focused on either the impact of delivery method on PBL outcomes or the effect of facilitator content knowledge on PBL outcomes. In this study, we combine these two factors in order to examine the feasibility of having non-content experts lead online PBL courses in order to accommodate the ever-increasing demands on clinical faculty members' time.

Research Questions

The specific research questions under consideration in this study were:

1. Does the delivery medium affect student class participation in a PBL course?
2. Does the delivery medium affect learning outcomes (i.e., development of problem-solving and higher order thinking skills) in a PBL course?

3. Does the facilitator’s content knowledge affect student class participation in a PBL course?
4. Does the facilitator’s content knowledge affect learning outcomes (i.e., development of problem-solving and higher order thinking skills) in a PBL course?

Methods

Participants (N = 23) were recruited from students enrolled in a graduate level Domestic Animal Anatomy course. Students in this study were assigned to one of the two PBL sections based on their existing class schedules. Each group began the course by meeting with their facilitator and working through the first PBL case in a traditional, face-to-face setting. Group 1 consisted of 14 students (mainly upper-level undergraduates) and was initially led by the non-content expert facilitator (instructional designer and science educator). Group 2 consisted of 9 students (all pursuing a Master’s degree) and began the course under the guidance of the content expert facilitator (veterinary medical doctor). Both facilitators received training in leading PBL groups. The content expert facilitator attended a two-week course on PBL facilitation offered at Bowman-Gray University (aimed at medical faculty). The non-content expert (educator) has attended a variety of conferences and seminars on PBL facilitation in addition to conducting research on the topic. Both groups completed the next 2 PBL cases completely online, exchanging facilitators for Case 3, so that each group had the opportunity to work with each facilitator. See diagram below.

	Group 1 (n = 14)	Group 2 (n = 9)
Case 1 (2 weeks)	Delivery: face-to-face Facilitator: Educator	Delivery: face-to-face Facilitator: Veterinarian
Case 2 (2 weeks)	Delivery: online Facilitator: Educator	Delivery: online Facilitator: Veterinarian
Case 3 (2 weeks)	Delivery: online Facilitator: Veterinarian	Delivery: online Facilitator: Educator

Results

Student outcomes were assessed via a 3-question, multiple-choice quiz administered through WebCT at the end of each case. The quizzes focused on content issues central to each case. Qualitative WebCT was also used to generate electronic transcripts of each chat session. These transcripts were then analyzed to gain insight about the problem-solving processes that transpired during the online sessions.

Quizzes

Overall mean scores on each quiz ranged from 62.3% (Case 2) to 84.8% (Case 1) (Table 1). When score differences were examined by delivery system and facilitator,

using a repeated measures ANOVA and mixed procedure through SAS software, some overall trends were observed. Whenever there was a difference that could not be attributed to a factor under study (i.e., delivery system or facilitator), the students in Group 2 always scored higher than those in Group 1, but the difference was not statistically significant.

Delivery Method Across Groups

When scores for all participants were compared by case, academic performance on the multiple-choice quiz for Case 1 was significantly higher than performance on the quiz for Case 2. However, academic performance on the quiz for Case 1 was not significantly different from performance on the quiz for Case 3. Since Cases 2 and 3 were delivered online, we cannot attribute exam performance differences to differences in how the cases were delivered. Student performance on Case 2 was significantly different from Case 3 as measured by quiz performance, so it is possible that Case 2 may have simply been more difficult than the other cases. This hypothesis was confirmed by qualitative student feedback.

Facilitator Expertise Across Cases

There was no significant difference in performance on the case quizzes based on whether the facilitator had medical training (i.e., was a faculty member) or was trained in a completely different field (i.e., education). This finding was consistent regardless of whether the facilitation occurred online or face-to-face.

Student Achievement by Groups

It should be noted that whenever there was a significant difference in performance, it was always in favor of students in Group 2. Although students self-selected their own groups based on scheduling, Group 2 was primarily composed of Master's degree students in a medical preparatory program. Many of them had previous human or veterinary medical training and/or exposure.

Online Session Interaction Analysis

For the purposes of this study, we defined an interaction as any utterance in the form of a question. When all interactions were tabulated and classified, students asked 71% of questions, the instructors asked 29%. Given that PBL is student-centered, this was an expected outcome. Interactions were further classified according to their topic and placed into one of 4 categories (Table 2): administrative, content, management or social (see Schoenfeld-Tacher, McConnell & Graham, 2001, for a full definition of each category). Online PBL sessions were content-driven, and students predominantly stayed on task; however, 32% of questions in the PBL course were related to social and administrative functions. There are some true administrative issues that will arise in any course, (i.e., clarifying assignment deadlines), and the percentage observed in this

setting is slightly higher than what we observed in an online Histology course (Schoenfeld-Tacher, McConnell & Graham, 2001). In the PBL course, the remaining 68% of questions were directly related to PBL content (61.9%) and process (6.1%), and thus were course-dependent. These percentages of course-dependent questions indicate that students were engaged and focused at a high level. Of the questions pertaining to content (Table 3), 42.5% were dedicated to gathering facts, 28.1% pertained to learning issues, 20.6% to actions the students wanted to perform on the hypothetical patient, and 8.8% related to hypotheses about the case.

Some general observations included that more questions were asked during the first week of a case than during the second week (70.6% vs. 29.4%), regardless of case or facilitator. In addition, there was equal distribution of questions, regardless of facilitator expertise, and the number of question exchanges was constant across cases and facilitators.

Content questions were further classified utilizing the six levels in the cognitive domain of Bloom's Taxonomy of Educational Objectives (Bloom & Krathwohl, 1956). These levels increase in complexity and depth of thought, beginning with knowledge, and progressing through comprehension, application, analysis, and synthesis to arrive at the highest level – evaluation. In the online PBL sessions, 79% of questions occurred at Levels 1 and 2 of Bloom's Taxonomy and thus were focused on knowledge and comprehension (Table 4). We expected higher order questions based on trends observed in a Histology course (Schoenfeld-Tacher, McConnell & Graham, 2001), in which students participating in online chats asked more questions at the upper levels of Bloom's taxonomy, but this did not occur. Because of its constructivist, student-centered nature, PBL is expected to promote the synthesis and evaluation of ideas. However, there are several possible reasons why this did not occur in the online chat sessions. Miao, Holst, Haake and Steinmetz (2000) identified two major difficulties associated with the use of PBL in virtual learning environments. They found that participants (facilitators and students) are unfamiliar with the PBL technique and how to behave appropriately within their new roles. And, these problems are further compounded by the use of an online environment, which is socially unfamiliar to the participants. Both of these issues were true for students in the Domestic Animal Anatomy course – they were unfamiliar with the PBL technique and use of online chat for instructional purposes. These issues may have created a large cognitive burden, which prevented students from focusing on the intended learning outcomes.

Conclusions

There were no statistically significant differences in academic outcomes based on delivery method (online versus face-to-face) or facilitator's content expertise (veterinary medical training versus educational training). The observed differences in quiz performance may have been due to unintentional differences in case difficulty or levels of student expertise, as we were unable to assign students randomly to the different experimental groups. The proportion of interactions focusing on lower-levels of Bloom's Taxonomy is an area of great concern, as it appears that in this situation, the metacognitive and problem-solving objectives of PBL were not attained. While this may have been due to the fact that students were unfamiliar with both the instructional

technique and delivery methodology, a more in-depth study is still necessary to verify that PBL can be taught online without adversely affecting its goal of fostering the development of higher-order thinking and problem-solving skills.

Although limited in scope, this research provides preliminary evidence that non-content experts can act as facilitators in online PBL courses without adversely affecting student learning. As clinical faculty are already over-burdened, the use of PBL-trained facilitators in online sessions can enhance the practicality of this approach and make it feasible to provide pre-clinical students with a small-group PBL experience earlier in the curriculum.

Future Directions

While this study provides preliminary data to support the hypothesis that non-content experts can effectively act as PBL facilitators, more research is necessary in order to explore how broadly this idea can be generalized across student populations and delivery methods. For example, replicating the study with a larger sample size would allow for true random assignment of students. This would enable us to determine if the observed differences in student achievement were due to students' prior knowledge (i.e., undergraduate vs. graduate students) or if they were in any way related to the facilitators' expertise. A more in-depth study would also include more cases, for both face-to-face and online delivery, and run for at least an entire semester. This would allow us to observe changes over time. In sum, this study lays the ground work for more in-depth investigations of the effects of facilitator expertise and delivery medium on student achievement in problem-based learning in the allied health sciences.

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Table 1
<u>Mean Quiz Scores by Group, Case and Delivery Method</u>

Group	Facilitator Training	Case	Delivery Method	Percentage Score	Mean Raw Score	Standard Error
1	Education	1	Face-to-face	79.49	2.3846	0.2171
1	Education	2	Online	59.52	1.7857	0.2092
1	Medical	3	Online	78.79	2.3636	0.2360
2	Medical	1	Face-to-face	92.60	2.778	0.2609
2	Medical	2	Online	66.67	2.000	0.2609
2	Education	3	Online	83.33	2.500	0.2767

Table 2
Interactions by Topic

Topic	Total Number	Percentage
Content	591	61.9
Administrative	238	24.9
Social	68	7.1
Management	58	6.1

Table 3
Content Interactions by Function

Function	Total Number	Percentage
Hypotheses	52	8.8
Facts	251	42.5
Learning Issues	166	28.1
Actions	122	20.6

Table 4
<u>Content Interactions by Bloom's Taxonomy Level</u>

Level	Total Number	Percentage
Low		
Knowledge	254	32.3
Comprehension	369	46.9
Medium		
Application	151	19.2
Analysis	10	1.3
High		
Synthesis	0	0
Evaluation	3	0.3