Introducing a technology-enabled problem-based learning approach into a health informatics curriculum

Carolyn J. Green a,*, Geraldine H. van Gyn b, Jochen R. Moehr a, Francis Y. Lau a, Patricia M. Coward a

a School of Health Information Science, University of Victoria, PO Box 3050, STN CSC, Victoria, BC, Canada
b Learning and Teaching Centre, University of Victoria, Victoria, BC, Canada

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Summary Purpose: To investigate the effect on learner satisfaction of introducing a technology-enabled problem-based learning (PBL) approach into a health informatics curriculum. Course redesign was undertaken to prepare students for three 4-month work terms and a rapidly changing professional environment upon graduation. Methods: Twenty-six Canadian undergraduate students of a redesigned course in biomedical fundamentals completed a midterm questionnaire in 2002. Eight of these students participated in a focus group.

Results: Students agreed that seven of nine functions provided by the web-based online course management system enhanced their learning: private email (92.3%), calendaring (88.5%), course notes (88.5%), discussion forums (84.5%), online grades (84.5%), assignment descriptions (80.8%) and online quizzes (80.8%). Although students agreed that two PBL activities enhanced learning (learning to present information (84.5%) and learning to identify information needed (73.1%), the majority of students (69.2%) expressed a preference for the traditional lecture approach over the PBL approach. Students reported feeling uncertain of what was required of them and related anxiety accounted for most of the negative feedback.

Conclusion: These findings give us clear goals for improvement in the course beginning with a comprehensive, carefully guided introduction to the processes of PBL. The positive trends are encouraging for the use of web-enabled courseware and for the further development of the PBL approach.

1. Background
Health informatics students require sophisticated computer skills throughout their coursework, during work term placements with employers and subsequent professional life. They must be adept lifelong learners as the workplace undergoes continuous and sometimes rapid change. The bachelor of science program in health information science at the University of Victoria (UVic), British Columbia, Canada, is currently undergoing curriculum redesign in order to improve such skills and to support distance delivery of its courses. This includes using web-based courseware combined with a problem-based learning (PBL) approach.

The initial commitment of the department to employ a PBL approach was reinforced by feedback from a survey of employers accepting students for work terms [1]. Employers suggested the
curriculum include more hands-on learning, more leadership training, and more clinical informatics and classification systems. Employers generally commented favorably that the health information science students have a broad knowledge base, are prepared and successful, have a willingness to work and learn, are self-directed, and have good leadership and team skills.

The need for proactive set of learning skills among health informatics professionals supports the adoption of PBL as these are the skills attributed to the PBL approach and decades of experience have accumulated with the approach. Schwartz et al. [2] report that there is reasonably strong empirical support that “Students from PBL curricula are superior to their counterparts from traditional curricula with respect to their: approach to study (being more likely to study for understanding rather than for short-term recall); long-term retention of knowledge; clinical performance; knowledge of the clinical sciences; ratings by supervisors as post-graduates; motivation for learning; perceptions of their education (being more positive); perceptions of stress during their education (perceiving less stress); and use of resources for learning. [As well,] faculty members are more positive about their roles and about the students in PBL curricula than in traditional ones” [2].

2. Objective
This paper outlines the redesign approach and its results for a course developed using web-based online course management system for a course on biomedical fundamentals. It was intended that other courses be modeled on this approach as part of a comprehensive curriculum redesign. The aim of redesign is to immerse students in an electronic learning environment, and, concurrently, to support learning through access to course materials, provision of enhanced learning resources, opportunities for online interaction and collaboration, access to mechanisms for performance tracking and opportunities to give and receive feedback. All these processes may also enhance student satisfaction in the course. Problem-based learning was selected as the pedagogy of choice to prepare students for three 4-month placements in the workplace and to enter a rapidly changing professional environment upon graduation. Additionally, the PBL approach enables students to learn terminology, and the structures and functions of the human system within the framework of a medically relevant dilemma, which should enhance retention of the information.

3. Redesign
The redesigned course was taught in the fall of 2002 to 75 students over a 12-week period. Seventy-five percent of student respondents were in first or second year, and the other 25% were third or fourth year university students. Sixty-nine percent of the students were under the age of 20.

Revised objectives introduced process objectives (e.g. “Apply new knowledge to real life problems within a team setting”) as well as retained more content-oriented objectives (e.g. “Describe the major functions and structures of the circulatory, respiratory, nervous, special senses, digestive, musculoskeletal, integumentary, reproductive, urinary, endocrine and immune systems”).

A hybrid approach was adopted which combined lecture with PBL group work. The course consisted of two sessions of 1.5 h duration per week, one of which was devoted to conventional lectures, covering one system each. The other was devoted to group work on one of four problem cases assigned over the term.

PBL cases typically have a real world context and an inherent puzzle without the information needed for understanding and resolving related dilemmas. The topics of problem cases related to: (1) a rare sometimes fatal disease with a higher risk in first year university students (meningococcal meningitis); (2) a data dictionary for an electronic patient record in a sports medical clinic (information fields to be found in case report); (3) understanding the journey of a cardiac patient through the health care system (by producing a case report); and (4) a murder case featuring controversy over the DNA analysis of identical twins.

Students were instructed to follow these basic PBL steps in fulfilling assignments: “(1) Identify what you already know collectively and then list what you need to find out to fulfill the assignment. Divide up the research among team members; (2) Do your research largely independently outside of class. Come to the next team meeting prepared to present what you have found; (3) Present your findings and gather information from other team members in your team meetings; (4) Together synthesize collected information to fulfill the assignment; (5) Present your group strategies and findings a report and in class during a wrap-up session”.

A roving tutor model was adopted for PBL group facilitation. One graduate student teaching assistant and one volunteer peer facilitator (fourth year student) joined the primary instructor (CJG) in supervising approximately 25 students in groups of 5. The facilitators changed groups after every case. Cases were distributed to the groups initially
in class and instructors ‘roved’ between groups assisting students. Between the classes devoted to PBL group work, students were encouraged to use the collaborative options of the courseware to communicate with other group members and contact facilitators if necessary through the email function.

Two problem cases were submitted as group reports contributing 30% to the final grade. Variations of the other two cases appeared as essay style exam questions on the midterm and final exams worth (25% of exam marks) along with multiple choice and short answer questions on the basic structures and functions of body systems and select pathophysiology, which also related to content accessed from the PBL cases (75% of exam marks). Exams contributed 55% of the final grade. Students had the opportunity to practice accessing course content and answering multiple choice questions through five online quizzes (25% of final grade) that they took on their own time and had the opportunity to repeat up to three times. The courseware quiz function permits the random selection of questions from a standard question database on every exam attempt, which discourages collaboration. The quizzes are added and taken off line at prearranged times as the course progresses. Grading is automatic and fed back to students immediately upon submission.

The web-based online course management system used was the one supported by the University of Victoria at the time—WebCT version 3.6 Standard Edition. Over and above the functionality associated with the tool itself, university wide support provides a number of advantages for the instructor. The system was accessible only to registered students in the course through the use of their campus wide unique personal identifier and password protection—also used for such essential functions as course registration, e-mail and computing accounts and accessing student records and library resources. The university provides the support for importing data on registered students, computer support including help desks and phone lines as well as the technical support for installing, maintaining and providing training for both instructors and students to use the system.

A textbook was selected which covered the body systems in a systemic way illustrated by select examples of pathology and accompanied by password protected web-based support providing supplementary materials for students and instructors [3]. This included lecture materials and question databanks as well as interactive games for students, image databanks, and animated video clips that were coordinated with the text.

4. Evaluation methods

Data on students’ assessment of the course and their learning was gathered at the midway point in the course using an established survey [4] as well as focus groups conducted according to a protocol that had been approved by the university ethics committee. The first part of the survey consisted of 20 questions related to the technology-enabled problem-based learning approach. The first 10 questions concerned our use of the technology (e.g. “The following online documents and features enhanced my learning experience . . . Multiple Choice Quizzes Taken On My Own Time and with the Option to Repeat’’) as well as the PBL approach (e.g. “The following activities enhanced my learning experience . . . Collaborating in Learning Teams’’). A three-point Leikert-scale was chosen to categorize the answer options in order to decrease the effort for respondents. Survey questions were tested for face validity among the department among students and instructors and had previously been applied within the department as part of a graduate student thesis. The questions on links to websites with simulations or animations were combined in reporting. The second part of the questionnaire was based on work by Doyle and included 10 questions covering biographical, perceived learning abilities and personality characteristics exhibited in learning environments [5].

In the focus group students discussed the extent to which the problem cases support the development of new learning strategies, critical thinking skills for inquiry. Regarding team performance, students were asked how well their team worked collaboratively and for advice as to how teams could be supported to function more effectively. Recommendations on improved use of the course management system were sought.

At the end of the course, student also completed a standard UVic course assessment survey reflecting traditional effectiveness criteria. This university wide assessment mechanism is applied to all courses when classes end but before receiving their final exam and grades.

5. Findings

Twenty-six of the students (37%) completed the midterm survey. Results indicate relative student experience with both the technological and pedagogical approach taken: only 8% reported experience with courses using a PBL approach, 23% with courses supported by online educational technologies, and 31% with courses having group
assignments. The majority of the students claim to get grades of B or better (80%) and many were pessimistic about their achievement in this course, with 42% indicating they expected to receive grades ‘lower than I usually get’. The average grade achieved by the class was 81%, which falls in the A-range, the usual grade average in this course. Most respondents (81%) claimed that they were either ‘very uncomfortable’ (19%) or ‘uncomfortable’ (62%) when they felt that ‘things are getting out of control in my life’. There was no strong trend in preference for teaching styles or type of learning activities.

Usage statistics indicate high usage of the web-based online course management system by students with an access frequency of 210 ± 112 times, and a range from 47 to 637 times. The discussion function had 331 messages posted over the term in private groups (218) and on the main public discussion (113). There were 619 private e-mail messages exchanged between instructor and students and this largely replaced office hours, though it may have been more time consuming. All students who completed the survey reported that they found the WebCT course management system easy to use (100%).

A high proportion of respondents agreed that seven of nine web-based online course management system functions enhanced their learning: private e-mail (92.3%), calendaring (88.5%), course notes (88.5%), discussion forums (84.5%), online grades (84.5%) assignment descriptions (80.8%) and online quizzes (80.8%). There was less agreement that links to websites with animated learning objects (53.9%) and chat rooms permitting real time discussions with fellow students (42.3%) enhanced student learning. See Table 1 for detailed results on the course management system evaluation.

Respondents agreed that two components of PBL activities enhanced learning: learning to present information (84.5%); and learning to identify information needed (73.1%). Other components were assessed as positive by fewer respondents: use of real life case scenarios (65.4%); collaborating in teams (57.7%); learning to access information needed (57.7%); learning to synthesize information (57.7%); having instructors available but not leading teams (46.2%). See Table 2 for results on the evaluation of the PBL activities. Nonetheless, the majority of students expressed a preference for the traditional lecture approach over the PBL approach (69.2%). The majority also indicated that they would not take other courses that used a PBL learning approach (61.5%) nor would they recommend this course in the current format to other students (69.2%).

Eight students took part in the focus group assessment. The focus group approach was used to probe the reasons for their learning preferences and to help identify areas of strengths and weaknesses with the pedagogical approach to this course. Student responses on preferences and challenges corresponded well with survey results. There was a high degree of support for the use of WebCT and concern over the PBL approach. Probing questions revealed that students felt very uncertain of what was required of them and commented that the preparation for the PBL assignments was not sufficient for them to feel confident in relying on this strategy for their learning. It was very clear

| Table 1 | Survey results: proportion of students who agreed, disagreed, or had no opinion that WebCT courseware functionalities enhanced their learning experience |
|------------------|---------------------------------|-----------------|-----------------|
| WebCT courseware functionality                  | Agree (%) | Disagree (%) | No opinion (%) |
| Private course e-mail                             | 24 (92.3) | 2 (7.7) | 0 (0.0) |
| Weekly course notes with graphics/internet links | 23 (88.5) | 2 (7.7) | 1 (3.9) |
| Course schedule/calendar with updates            | 23 (88.5) | 0 (0.0) | 3 (11.5) |
| Online grades as soon as available               | 22 (84.5) | 3 (11.5) | 1 (3.9) |
| A discussion forum for raising questions and getting feedback from the instructor and classmates | 22 (84.5) | 2 (7.7) | 2 (7.7) |
| Multiple choice quizzes taken on my own time and with the option to repeat | 21 (80.8) | 6 (26.0) | 0 (0.0) |
| Assignment descriptions with graphics/internet links | 21 (80.8) | 3 (11.5) | 1 (3.9) |
| Links to websites with animated video clips      | 14 (53.9) | 3 (11.5) | 9 (34.6) |
| A chat room for real time discussions with classmates | 11 (42.3) | 8 (30.8) | 7 (26.9) |

a The online documents and features which enhanced my learning experience.

b One student both agreed and disagreed.
that the uncertainty led to anxiety and accounted for most of the negative feedback on PBL and the associated requirement to work in groups.

The end of term standard university wide standard assessment survey found that overall the course was not rated as highly on a five-point scale from ‘very good’ (1) to ‘very poor’ (5) as other courses offered to the same class at the same level or other courses offered in the school in the same term. The ratings were, however, consistent with the midterm assessments. The 2.2 average rating for the course over 10 statements reflects an ‘adequate’ ranking whereas the other 100 level conventionally taught course received an overall 1.0 or ‘good’ rating and the courses overall received an average of 1.3. Similarly the teaching effectiveness evaluation over 20 criteria was low with an average ranking of 2.4 versus 0.7 for the other 100 level course and 1.4 overall. The criteria assume a lecture delivery style and therefore may be invalid for evaluating problem-based learning and hybrid approaches.

6. Discussion

This course was added as a core course to a long-standing health information science undergraduate program that had previously not required student exposure to human biology. Health informaticians nevertheless need an understanding of the basis of health information expressed in health information systems. Instructors of subjects such as patient care support systems and medical methodology found the lack of foundational knowledge were limiting. The goal of providing health informatics students with a basis for understanding health information by understanding its roots in the biological sciences would appear to be sound.

Feedback from the students in the study are not consistent with the perceived stress reduction or more positive perceptions of education that we would expect on the basis of the Schwartz et al. review [2]. Then again, these findings are consistent with the eight-step grief model proposed by Woods [6] to describe the reaction of students who are exposed to PBL methods for the first time. This model would predict that students would go through the stages of shock, denial, strong emotion (anger), resistance, acceptance and struggle before emerging at better understanding, integration and, ultimately, better performance (see Fig. 1). It is likely that our midterm evaluation occurred at about the time the students were hitting the bottom of the curve depicted in Fig. 1 and well before they received the benefits. It is also understandable that some students would prefer traditional methods because there is less uncertainty. They know through experience how to get the grades that they want when a course is delivered in the traditional manner [7]. Therefore, they will predictably resist change to course design.

![Fig. 1](image-url)
This model may also be applicable for instructors who concurrently experience an increase in anxiety with a decline in reported student satisfaction with their instruction as well as the extended effort required in redesign and change management. Others have reported similar experiences with the introduction of alternative learning environments [8]. Coexisting alongside more traditional approaches and being evaluated in part by tools that reinforce instructor directed learning would tend to discourage innovation in learning and teaching approaches. Nevertheless, prominent programs designed to train providers of health services have successfully adopted the PBL approach as the basis for their curriculum so it is reasonable to expect that the initial concern over the PBL approach would diminish over time as both students and instructors gained experience. This course was the first within an otherwise instructor directed learning environment to attempt PBL.

This study suggests that increased scaffolding for the PBL process may relieve the dissatisfaction with the course related to the PBL component. Like building scaffolds, student supports can be reinforced to the point that strain is matched by support. Ensuring success and leading students stepwise through the first problem cases can lay the foundation for increased case difficulty and independence over the course. The scaffolds can then be withdrawn as independence is comfortably assumed. Within the curriculum subsequent courses benefit from the initial PBL training. Woods recommends the following additional strategies to support students: explain why you are making the change; help students see their personal benefits of the new approach in the short term; explain your role; monitor the program frequently; be flexible; bring in success stories; help students cope with the upheaval when old habits are identified and changed [9].

The examinations and written reports used to assess student performance yielded expected results—the students performed as well as in previous years. Yet the extent to which these tests adequately reveal the enhanced learning which may have occurred is an area where more research would be useful. In a review of recent research on PBL, Major and Palmer concluded that alternative evaluation means such as constructed response items, oral presentations, experiments, or portfolios may enhance the assessment of student learning [10]. This study did not directly evaluate student learning and therefore can make no claims about the effect of PBL on student outcomes nor the effect of using course management systems to enhance certain facets of the course.

The textbook was a major companion technology to the course management system and essential course component [3]. It was chosen for the accompanying extensive online resources including animations and WebCT formatted quizzes. A password for students that was included through the textbook provided access to resources. With the assumption that all textbooks were sold to students taking the course and that no students bought the textbook elsewhere, coverage was 87%. This type of text covers essential content authoritatively but proved deficient in some respects. The needs of health informaticians are quite different from those of the provider of health services who need information to make decisions about patient care or of the scientists who need to develop new knowledge [11,12]. In addition the manner of presentation in the basic anatomy and physiology text is based on more traditional pedagogies.

The favorable response to the course management system would appear to be as good as could reasonably be expected for primarily entry level students with no prior experience in this type of courseware. No systematic assessment of its pedagogical value was undertaken but as with the use of the PBL approach, there was sufficient literature on this type of courseware to indicate that it could facilitate learning through increased opportunities for collaboration, interaction with instructors and for practice on course materials through the use of quizzes. With continued experience with the technology, it should be possible to continue to tailor web-based course materials so that they provide more specific opportunities to interact with the course materials. The decision to use WebCT over other comparable platforms was made for functional reasons. It is the only courseware that our university supports and therefore the instructor is relieved of many additional student support functions. The fact that the students had to use the courseware to successfully complete the course supported one of the objectives of the course and that was to engage the student in online activities and thereby improving their skills in the use of this medium.

7. Conclusions
From a pedagogical perspective, the use of web-enabled course components and the PBL approach are well justified in the literature. However, moving from theory to practice proved to be challenging. The results of a formative survey and focus group, as well as the demographics of the course and students, suggest that three
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factors appear to have contributed to the difficulties that the students experienced in the course. The first was the challenge of a potentially overwhelming amount of content included in this one-term course. The second was the relative inexperience of this student group with any non-traditional methods of course delivery and the third was the relative inexperience of the course instructors with the PBL approach as they designed and conducted the course for the first time. Eighty-one percent of respondents indicated in the student survey that they were not comfortable with uncertainty in their lives. Considering this disposition in the context of the three factors identified previously, the students’ assessment of the PBL approach, and the course in general, is understandable and corroborates Woods model of student responses to PBL when exposed for the first time [6].

The assessment also gives us clear goals for improvement in the course beginning with a comprehensive, carefully guided introduction to the processes of PBL and the integration of the conventional lecture sections of the course with the web-enabled components. Some of the positive trends in the survey results and comments from the focus group are encouraging for the use of web-enabled courseware and for the further development of the PBL approach.

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