Autonomous Learning in a PBL Approach

By

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Abstract

This paper reports a case integrating a problem-based learning (PBL) approach with the “Drug & Nutrient Interactions” online course. The main objectives of this PBL approach were to engage students in self-direction, professional reasoning, and self-determination within an autonomous learning setting. The use of the task-oriented learning approach in PBL encouraged students to acquire information skills, including searching, selecting, evaluating, and using information in more meaningful ways. Experience with a PBL approach within a Web-based learning context was obtained. During this study, several types of interactive responses were observed, including discussion related to case selection, information posting and sharing, defining and finalizing, and casual chatting. With the PBL approach, students’ autonomous learning and active involvement in self-direction, professional reasoning, and self-determination in the Web-based interactive activities contributed to successful learning achievements.

Keywords: information skills, information literacy, problem-based learning, nutrition education

Introduction

Problem-based Learning (PBL) has been adopted for the preparation of professionals in fields as diverse as medicine, engineering, law, and business. PBL seeks to engage students in an active process of individual and cooperative learning of interrelated themes (Valadares, 2007). Its characteristic focus on the presentation of authentic cases as the starting point for learning has substantially enhanced students’ motivation to learn and has augmented their ability to integrate knowledge from foundation disciplines in pursuit of a solution to practical professional problems (Albion & Gibson, 2000; Haghighparast, Sedghizadeh, Shuler, Ferati & Christersson, 2007; Valadares, 2007). Task-oriented approaches and autonomous learning of self-direction, professional

reasoning, and self-determination are addressed as ways to foster learning in a Web-based PBL approach.

Self-direction

The PBL approach involves a task-oriented approach that occurs in a specific sequence. First, the students identify the problem in the case provided, analyze the problem, and develop hypotheses to account for it. Next, the students assess their own ability to solve the problem and start collecting information from various resources. Finally, the students discuss the problem and summarize what they have learned (Woody, Albrecht, & Hines, 1999). Through the process of accomplishing the learning task, students successfully develop the skills of self-directed learning, professional reasoning, and decision-making. From an experiential learning perspective, the PBL approach is expected to achieve a knowledge base that lasts longer than one attained purely from lectures.

In PBL, the use of learning activities often has explicit educational goals and typically involves a task-oriented approach that organizes the curriculum around a series of cases profiling dilemmas of practice. Student professionals read, diagnose, discuss, and explore strategies for solving these problems (Valadares, 2007). A student-centered and task-oriented problem-solving learning approach is consistent with the constructivist perspective that learning is the interaction of knowing and doing (Adeogun, 2006). Situated cognition and the notion of participation through practice offer a way of approaching professional development (Moore & Barab, 2002).

Professional reasoning

As applied, PBL has been shown to help students develop better reasoning, critical thinking, and communication skills as well as an increased motivation to learn. The role of the library in its provision of electronic access to resources has become increasingly important as learning has moved towards project work, which requires students to find their own information using research and information searching skills and to construct their own understanding of knowledge (McNichol, Ghelani & Nankivell, 2002; LeBeux & Fieschi, 2007). Since searching for information by means of the Internet is common among various health and medical professionals, providing guidance in determining reliable sources of Internet information on various health-related information is an area of importance (Dey, Reid, Godding & Campbell, in press). Much attention needs to be paid to the relationship between information provision and the development of students' reasoning and critical thinking skills in

school and within the wider community (Lindstrom, Shonrock & Columnists, 2006).

In higher education, the development of professional thinking skills has become a crucial part of providing fruitful learning experiences with technology (Kasowitz-Scheer & Pasqualoni, 2002; Lindstrom, Shonrock, & Columnists, 2006). In the day-to-day work of a PBL classroom, information technology can be used for foraging for information or in targeting a specific knowledge area (Reznich & Werner, 2001). When searching for information to solve a problem or to answer a question, students need to evaluate their results for quality and for relevance to the problem/question. The use of the Internet and the skills needed for searching for information and integrating knowledge have potential impacts on students' learning experiences in a PBL environment (Snively, 2004).

Students are facing a knowledge world characterized by an explosive growth of readily accessible information in a diverse mixture of both traditional and new formats. Learning and reasoning from examples are important components in the development of expertise, especially in ill-structured domains where problems are not clearly defined and where there may be no single agreed-upon solution (Albion & Gibson, 2000). With technology integrated in PBL, students are exposed to such various Web activities as online discussion and conducting research. It is important to examine new developments both for improving students' knowledge construction and for helping students acquire lifelong learning skills.

Self-determination

To provide opportunities for decision-making in a PBL environment, the Web also offers an environment for training and experiencing. Since resources are available in all subject areas, students can apply knowledge and learn to make decisions to solve real-life problems (Schroeder & Zarinnia, 2001). Students today face a daily explosion of information resources and the challenge of using these resources effectively and responsibly. Information literacy instruction requires a shift in focus from teaching specific information resources to teaching a set of critical thinking skills involving the use of information (Kasowitz-Scheer & Pasqualoni, 2002). In PBL, guided through stage-by-stage cognitive processing, students gain a deeper understanding and a holistic view of knowledge.

In order to enhance students' necessary skills and knowledge in PBL, students should be provided with opportunities to gather and analyze information concerning their

topics, compare other cases with the specific attributes of their own problem, and develop a best-practice approach to the task (Harwell & McCampbell, 2002). Students need to be encouraged to take responsibility for their projects, develop a suitable plan, and use the Internet as a research and problem-solving tool that allows information to be retrieved quickly to facilitate both discussion among members and the synthesis of knowledge. Several studies have shown successful integration of Web-based technology with PBL where students were provided with self-determination opportunities to search for solutions as well as to contact experts and to solve the problem (Milbury & Silva, 1988; Sage, 2000; ChanLin & Chan, 2007).

The integration of Web-based technology and a PBL approach for conducting research and solving realistic problems could potentially enrich a Web-based learning environment. Specifically, the purposes of this research were to study students' perceptions and experiences in the Web-based PBL context and to evaluate students' learning development in terms of self-direction, professional reasoning, and self-determination for accomplishing their assignment. A case study approach was employed to observe how students learned and progressed within the task-oriented PBL approach.

Method

In this study, tasks were designed to encourage a sense of involvement in the use of reference materials to solve problems. For example, for each PBL scenario, students were requested to use references to support their assumptions and findings. The presentation of authentic problems served as the starting point for increasing the students' motivation. By integrating knowledge from foundation disciplines, students could pursue solutions to practical professional problems.

Participants were 101 college sophomores majoring in nutrition during 2006 and enrolled in the "Drug & Nutrient Interaction" elective course. In this course, the Web-based learning followed nine weeks of traditional lectures. To educate students to become life-long learners and professional dietitians, it is essential to help them understand how to access and use various Web resources and database information. Web-based information literacy instruction regarding how to prepare a research project and how to use academic electronic medical resources and databases was integrated into the course. Students were provided with opportunities to search for research topics and with information to assist in exploring the area of interest. The Web-based instructional materials were divided into the PBL scenario—presentation of

instructional content, related resources, and information literacy in teaching library and information skills.

In teaching library and information skills, the Web-based instructional materials not only contained links to various Web-based resources but also provided instruction in searching related library databases such as PubMed, BioMedNet, Helix Medlin, Medical Matrix, NLM Gateway, Biomedical Journal Title Search, Virtual Hospital, Hardin Meta Directory of Internet Health Resources, CliniWeb, Healthwise, and MedWeb. In addition, special databases related to the course were introduced in the Web site. For example, the use of DRUGDEX, POISINDEX, IDENTIDEX, TOMES, REPRORISK, AltMED, MARTINDALE, Dosing & Therapeutic Tools, INPHARMA, and REACTIONS provided students with various options for accessing pharmacy-related information.

To promote career growth and to help them become life-long learners, students were provided with the opportunity to solve clinical problems they might encounter in the future. Students must be able to navigate the wealth of information available online in order to cope with clinical tasks and be successful problem solvers. In the study, learning of information literacy was emphasized. Opportunities to allow students to practice information skills in locating, evaluating, and using information via electronic resources were a major component of the PBL experience.

To provide real-life experience, the Web-based learning was arranged around a framework of problem themes geared toward developing students' problem-solving skills through use of a variety of resources. Students signed up in teams composed of five to six persons for a total of 18 teams. Each team had its own discussion forum embedded with a scoring mechanism. For each of the students' postings, one point was awarded automatically. Extra points (one to three) were awarded if the information posted made a significant contribution to critical knowledge content. The process for grading the postings provided students with an opportunity for review of their thoughts and encouraged more constructive interactions within the groups. Remote help was also provided when learning obstacles were observed. Students were required to use the Web-based instruction independently but to interact with group members through online discussion. During the learning process, each team had to decide upon a topic for exploration related to the content area and to submit a paper to report their findings. In this study, students' online postings and their group projects were retained for further analysis.

Results

A total of 2753 messages were posted throughout the semester (March-June, 2006), and each posting was responded to by an instructor. Throughout the learning process, students obtained interactive feedback from experts and peers. Reconstruction of knowledge became explicit through the multiple channels of communication. From an instructional approach, students in the PBL environment received a case or real-life problem. They explored and analyzed the problem and developed a reasonable hypothesis. Through the process of exploring, searching, evaluating, and integrating information, students experienced the virtues of PBL. From the processes used in PBL case selection (including information searching and sharing and refinement and finalization of their reports as shown in Table 1), students' autonomous learning was revealed in their effort of self-direction, professional reasoning, and self-determination (Table 2).

Table 1. Types of postings gathered from group discussion forums

Type of postings	PBL Cases Selection	Information Searching and Sharing	Refinement and Finalization	Casual Chat	Total Postings
Group 1	45	22	68	10	145
Group 2	65	100	70	30	265
Group 3	10	25	22	10	67
Group 4	80	22	113	24	239
Group 5	66	50	56	21	193
Group 6	70	17	55	19	161
Group 7	38	22	27	20	107
Group 8	22	54	48	22	146
Group 9	60	47	51	38	196
Group 10	25	40	27	23	115
Group 11	40	32	21	23	116
Group 12	48	42	70	45	205
Group 13	43	19	6	10	78
Group 14	19	54	23	12	108
Group 15	40	30	40	14	124
Group 16	45	33	16	15	109
Group 17	56	39	55	21	171
Group 18	41	97	32	38	208
Total	813	715	800	389	2753

PBL cases selection: Within an instructional setting, PBL used essential questions to guide students to self-study the topic of interest and to set their plan for accomplishing their assignment. When chatting about the problem cases provided in the course,

students connected the problem scenarios to clinical cases they found on hospital Web sites. For example, students in Group 6 related an anemia case with the use of antibiotics for enteritis found on a hospital Web site. Several questions were used among groups to self-explore the case, for example, “How do we approach the problem?” “What information is needed to study the problem?” “How do we gather the information needed?” And, “How do we integrate and report what we have found?”. Before deciding on a topic of interest, students used the given problem scenarios to extend the areas of observation for a particular case. Much time was spent screening relevant information and coming up with a focus of research. Twelve out of the eighteen groups used problem cases and proposed relevant issues for a specific area of research. They then started gathering related information, identifying several resources for the group members to read as well as discussing and reviewing information pertinent to these cases.

Students’ discussion flow revealed that their choice of a topic for research required a thorough analysis of problems, instructional content, and the connections between the problem scenarios and the research materials available. The presentation of problem scenarios in Web-based PBL instruction offered authentic learning contexts, allowing students to have a choice in their interest area. The basic information provided in the Web-based instructional content provided students an overview of what research areas might be involved in a particular case. Most students were concerned with the completion of the final projects, and their choice of a research topic for their final project was somewhat dependent on the availability and the amount of information they could obtain from various resources.

To make sure enough resources were available, students conducted a preliminary search for relevant literatures before deciding on a research topic. If enough resources were not found, they would give up on the problem case and consider another research topic. Some groups (Groups 2, 4, 5, 6, 9, 17) spent long periods of time in deciding on a research topic because they wanted to ensure that they could obtain sufficient information to write a research paper. *“Regarding our last discussion on the relationship between caffeine and theophylline, the information we can get is very limited. I suggest we readjust our area of research”* (Group 6).

Information searching and sharing: Students searched relevant information for two major purposes: to decide on a topic for research and to gather further information for the selected research topic. Students’ experience with the preliminary search was

frequently frustrated and unsuccessful. *“Too much information and too little information both bothered us”* (Group 4). Online guidance was provided to help students develop an understanding of the use of various information resources. Posting and reviewing of relevant information among members was observed. *“Too much information was covered. We need to digest before searching more information”* (Group 9). *“Please read the following websites. . . . They might be helpful in understanding the relationship between statins and the cause of polymyositis.”* *“Here is a list of information I found related to the use of Vitamin E and Dicumarol/Digoxin. . . . Please read it. We need to get familiarized with the terms before our next search”* (Group 5).

When searching information for a topic, students extended their search from the use of commercial Web sites to professional databases and e-journals. From their searching experiences, students learned different terminology and key words used in searching specific drugs and nutrients. Consequently, students changed their use of terms, key words, and search strategies to find relevant information. *“We switched the terms for keywords search. Different resources were found.”* *“Reading the content of specific information might help us determine which keywords to use for the next search”* (Group 3).

The ability to both search information and to retrieve relevant knowledge to understand a problem is essential in the PBL process. Students applied the knowledge they learned from the course content and used it as a basis for identifying relevant keywords and terms during the search process. The more students were involved in searching and accessing relevant resources, the more they were able to extend their understanding of the knowledge area. More appropriate keywords and terms for further search were used when students became better acquainted with a specific area.

Students' involvement in the process of reviewing and selecting appropriate information affects the quality of their work. Students were guided by their instructor for more in-depth study of their final projects. For example, students in one group gathered information about the “interaction of nutrients and anti-hypertension drugs.” Suggestions were provided by the instructor for focusing on diuretics with anti-hypertension actions that might interact with nutrients, not just a broad introduction of all anti-hypertension drugs. Through on-going searching, accessing, and reading of relevant resources, students extended their understanding of the knowledge area. They also became more critical of the information resources for their

project. *“Reliable sources of information are important for preparing the project. We need to read and re-read in order to comprehend thoroughly the contents, problems, and resources obtained by team members. Information we gathered and basic knowledge obtained from online instruction provide us a basis for reasoning and making logic inferences”* (Group 2). *“The discussion forum is a way by which we put all pieces together and to lay out selected information for writing the project”* (Group 12).

Refinement and finalization of report: In this instance of Web-based PBL, students developed skills through observing and analyzing a problem as well as through evaluating relevant information for solving the problem. After searching for information, students brought results back to the group. Students learned to apply course content; develop critical-thinking abilities; and acquire skills of lifelong learning, communication, and the team approach. *“From cases we searched, we have observed that depression might cause abnormal food intake. However, it might not be relevant to drug and nutrient interaction.” “We need to search to determine whether there are cases related to interaction of nutrients and medications for melancholia.” “Is there a relationship between nutrients and medications for melancholia?” “Here are some cases discussing the mechanism of anti-depression”* (Group 2). In preparing for their research paper, students spent a significant amount of time and effort specifying the problems, putting relevant information together, reviewing their own content, and following the format requirements of professional writing. As revealed in their final projects, students tended to study their topic of interest from a situational basis. For example, in their discussions and reports, they occasionally used cases gathered from newspapers/magazines or hospitals to reflect the key issue of their topics. *“From the clinical cases provided, the use of newly developed antidepressant, reversible inhibitor of MAO-A(RIMA), such as moclobemide(Aurorix®) does not cause the interaction with tyamine like MAOIs do in treating patients”* (Group 11). Also, students tended to draw assumptions from different professional areas, including issues from medical science, pharmacology, and dietetics. Different perspectives were covered before using induction to focus on the key issues. *“This is a new experience of learning that I have never had before. We have worked as a team in discussing and searching information. We know each other’s progress from the web. This type of group learning is very helpful. We share responsibility and learn from each other”* (Group 6).

Table 2. Autonomous learning from PBL approach

Processes	Involvement		
	Self-direction	Professional reasoning	Self-determination
PBL cases selection	Relating the cases with the use of medications from hospital Web site; using guideline questions for self-explored cases; sharing information and resources for the group members to read	Using given problem scenarios to extend the areas of observation for a particular case; reviewing information pertinent to these cases	Eliciting possible topics for research; discussing cases and resources obtained; coming up with a focus of research; deciding upon a research topic
Information searching and sharing	Experiencing the preliminary search for various resources including journals, books, Web sites, and databases	Using academic resources; using different terminology and key words; changing search strategies to find relevant information; becoming more critical of the information resources for their project	Posting and reviewing of relevant information among members; choosing more reliable resources from professional databases and electronic journals
Refinement and finalization of report	Presenting a topic of interest through the use of clinical cases; adjusting their report to professional writing format; providing cases to help convey important ideas	Reporting problems' issues from different perspectives before focusing on the key issues; employing problem-solving strategies in observing, analyzing, evaluating, and inducting	Spending more time on specifying the problems, putting relevant information together, and reviewing their own content; drawing assumptions from different aspects, including issues from medical science, pharmacology, and dietetics

Achievement of PBL Web-Based Interaction

In the study, students' learning outcomes were defined as intended learning resulting from the PBL process. Student learning outcomes assessment measures whether the learning outcomes and the set objectives are being met. From this perspective, the final summative assessment of the project revealed that all students achieved their learning objectives. The students' final report was graded based on the following criteria: content thoroughness (60%), format correctness (20%), and organization (20%). The students' final group reports all reached a satisfactory level, with a mean score = 79.93

(± 5.60) (Table 3). In the task-oriented learning process, students were involved in cooperative online discussion with other team members in order to prepare their final group project.

Table 3. Students' Learning Outcomes for PBL

Criteria of Assessment	Min.	Max.	Mean	SD
Content thoroughness (60%)	60	90	79.76	7.44
Format correctness (20%)	70	85	76.83	5.78
Organization (20%)	70	90	82.23	5.68
Score of final report	66	89	79.93	5.60

Using the PBL approach, students benefit from the interactive process of learning. In the learning model, students worked through sequences of activities that involve complementary thinking and problem-solving approaches. These activities achieved their instructional purposes to (1) introduce a problem and provide motivation for solving it by relating it to students' experience; (2) provide pertinent resources and opportunities for students to explore the knowledge; (3) provide guided hands-on practice in searching and sorting relevant information; and (4) allow and encourage cooperative effort among team members to apply the learned materials together. From the problem-based learning activities, constructive learning was observed in various forms based on the following stages:

- students were presented with a challenge (problem scenario) intended to establish a need to know the content and master the skills, including knowledge content (drug and nutrient interactions) and information skills.
- The students formulated their thoughts, reflecting on what they thought and knew about the context of the challenge and generating ideas about the task they were supposed to accomplish. Debates about the use of various medications for patients in different cases reflected a form of critical thinking among students.
- Perspectives and resources were shared among team members to offer insights and various dimensions for interpreting the information they gathered and resources they read.
- During the process, guidance for finding appropriate resources and feedback for clarifying misconceptions were provided by the students' instructor as an on-going process accompanying students' learning.
- Assessment was carried out in which students applied what they knew and identified what they needed to learn, including engaging in online discussion, self-exploration, and writing a report.

In summary, the PBL approach to teaching and learning achieved its intended objectives in the acquisition of factual knowledge, the development of problem-solving and interpersonal skills, and the retention of knowledge. A more positive attitude toward learning was achieved through the experiences of self-direction, professional reasoning, and self-determination. Moreover, high-level skills in critical thinking, useful for students in lifelong learning, were obtained.

Discussion

In PBL, the task-oriented approach reflects the key concept emphasized in inquiry learning (Owen, Hester, & Teale, 2002; Prince & Felder, 2006). In the study, students experienced professional reasoning as well as self-directed and self-determined learning. It was observed that a team's choice of topics in PBL was influenced by considerations of various dimensions: interest in the topic, amount of information obtained from a preliminary search on the topic, and the students' prior knowledge of the topic. In their research, students learned from the process of formulating questions about the topic; gathered, sifted, and synthesized information; and systematically presented their research report. The learning process also revealed students' achievements in constructing their understanding of information and their efforts in accomplishing a challenging task. The findings of this study were consistent with Prince and Felder's (2006) point about guided inquiry learning that uses questions and problems to provide contexts for learning and a sufficient level of challenge to help students develop better thinking skills and to encourage self-motivated learning.

Marcum (2002) has addressed the concept that the transformation from information to knowledge requires students' understanding and conceptualization of what they obtain. Integration of library and information literacy into professional education is the key to the successful interdisciplinary learning approach that encourages students' use of both knowledge areas (Lindstrom, Shonrock, & Columnists, 2006). In this study, library and information instruction embedded in the course offered opportunities for collaboration between library and academic efforts. From the student-centered learning perspective of PBL, construction of knowledge counts not only for the content and meaning of the gathered information but also for students' management of the amount and form of information (Schroeder & Zarinnia, 2001). Continuous feedback and guidance through coaching helped students develop their abilities in managing their own learning. Observations of students' learning indicate that gathering sufficient information did not necessarily mean acquisition of knowledge. Embedding literacy activities in the

context of something meaningful and interesting to students might increase the chance of success in this area.

Students' involvement in the process of self-direction, professional reasoning, and self-determination impacted the quality of their research project reports. PBL involves more than just reporting on a topic; it requires students to move beyond the classroom context and to employ inquiry-based learning and critical thinking. Owen, Hester, & Teale (2002) note that when inquiry-based learning is used well, students engage in understanding the meaningfulness and the usefulness of information. They are pushed to expand their understandings by creating new connections. Since the ability to search for information and apply knowledge to understand a problem were both essential in the PBL process, students who were deeply involved in learning were more likely to obtain required information skills, including identifying and using relevant keywords and terms during the search process. Active participation and deep involvement were key to achieving the main objectives of PBL and in developing the skills of self-directed learning, professional reasoning, and decision-making within an easily retrievable knowledge base.

Conclusion

In this study, the use of a PBL approach provided novice students with opportunities to participate in intellectual problem-analysis. Student professionals could acquire a repertoire of structures and transfer a case to the framing and the solving of problems associated with real practice. In the process of learning, students required information skills in order to search for information relevant to their interest area. Integrating information skills and reasoning from examples are both important components in the development of expertise, especially in ill-structured domains where problems are not clearly defined and where there may be no single agreed-upon solution. The PBL Web-based learning experiences exhibited these characteristics. Students' participating in activities and studying problem cases were key elements in constructing knowledge and experience. In future implementation, encouraging students' involvement in the activities provided in PBL is essential.

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