

# Integrating inter-disciplinary experts for supporting problem-based learning

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The study reported in this paper has explored the use of an electronic forum facility in order to provide support for problem-based learning (PBL). A Web-based course involving the use of PBL (called ‘Drug and Nutrient Interactions’) was implemented and was augmented with interdisciplinary expert support using electronic forums. As part of their PBL experiences, students interacted with their peers, the teacher, the facilitator and experts (a dietician, a doctor, and a librarian) in order to enhance their knowledge and complete a group project. Students’ online interactions and their written reflections were used to identify the types of online support which contributed to self-directed, Web-based learning in a PBL context. The study concluded that both *cognitive support* (guidance, clarification, suggestion, inquiry, information) and *affective support* (comment, confirmation, reminding and encouragement) are needed in order to facilitate the process of learning. Overall, students were positive about this approach.

## Introduction

Problem-based learning has been used for training professionals in diverse fields like medicine, engineering, law and business. Its characteristic focus is on the presentation of authentic cases as the starting point for learning. This approach can be used to enhance students’ motivation to learn and augment their ability to integrate knowledge from foundation disciplines in pursuit of a solution to practical professional problems (Albion & Gibson, 2000; Prince & Felder, 2006).

The PBL approach to learning involves several processes that occur in a specific sequence. First, the students identify the problem in the case provided, analyze it and develop hypotheses to account for it. Next, the students assess their own ability to solve the problem, and start collecting information from various sources. Finally, they discuss the problem and summarize what they have learned (Woody *et al.*, 1999). Throughout the process, coaching plays a very important role in providing cognitive and affective support for accomplishing learning. With a well-planned, scaffolded learning approach, students should be able to develop skills of self-directed learning, professional reasoning, and decision-making (Dunlap, 2005; Liu *et al.*, 2006).

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From an experiential learning perspective, the PBL approach is expected to achieve a knowledge base that lasts longer than that attained purely from lectures (Yeung *et al.*, 2003). Several studies have provided evidence to suggest that learning in a PBL format can lead to long-term retention of knowledge; it can also enhance the integration of knowledge and result in an increased intrinsic interest in the subject (Shore *et al.*, 2004; Gijbels *et al.*, 2005). Along with the advancement of modern Web-based technology, the Internet has also strongly influenced students' PBL experiences in terms of electronic cooperation. Several examples have shown successful integration of Web-based technology with PBL, where students were provided with opportunities to use the Internet for achieving content interaction as well as human interaction (Oberlander & Talbert-Johnson, 2004; Taradi *et al.*, 2005; Liu *et al.*, 2006). As a means of enhancing the necessary skills and knowledge, students are often provided with opportunities to explore the potential of technology in PBL. Situations that are conducive to meaningful learning through technology include: providing a real-world context for learning, connections to outside experts, visualization and analysis tools, scaffolds for problem solving and the opportunity for feedback (Bransford *et al.*, 1999).

During the process of problem-based learning, gradual development of expertise in specific subjects is important. Lajoie (2003) suggests that in all domains, learning is a lifelong process that can be monitored and scaffolded with the help of experienced practitioners and experts. Students are encouraged to be self-directed, and use the Internet as a research and problem-solving tool that allows information to be gathered, shared and consulted with experts quickly to facilitate the synthesis of new knowledge. PBL is also characterized as a task-oriented approach. In order to accomplish an assigned task, integrating technology into PBL has become a crucial part of providing fruitful PBL experiences (Hersam *et al.*, 2004; Oberlander & Talbert-Johnson, 2004). When PBL is used as a group-based learning activity, information and support should be provided to group members to help them cope with dynamic learning issues related to the subject area (Papastrat & Wallace, 2004). Unlike conventional methods of instruction, where students are often graded on a competitive basis, the learner-centred orientation of PBL provides opportunities for students to work together and develop their skills in teamwork and cooperation, thus deepening their knowledge and understanding (Verhovesk & Striplin, 2003).

Like many recent scientific developments, nutrition education exists at the interface between traditionally defined disciplines. Students who will enjoy successful dietician careers must effectively communicate their specific knowledge and perspective with experts from various related fields in the context of interdisciplinary problems in the future. Facing the clinical situations, students learn to decide what knowledge is essential to solve problems effectively. More than a case study approach, PBL encourages students to identify their knowledge gap and to hypothesize solutions. The experts act as tutors, resource people and mentors as students work through the complexities of case-based situations (Papastrat & Wallace, 2003). The electronic support addressed in this study attempts to develop these skills through interdisciplinary learner-centred group work.

In a PBL Web-based environment, students need to learn various ways of approaching problems either deductively or inductively. Since experts' roles (in helping students learn to become self-reliant and independent in the Web-based learning context) are important, the purpose of our study was to explore how the electronic support helped students' learning in a PBL context. Specifically, the study intended to (1) examine the use of electronic interdisciplinary expert

support in relation to coaching students' during their learning processes, and (2) examine students' progress in knowledge acquisition and achievements in their project tasks.

## Method

### *Subjects and settings*

Subjects participating in the Web-based learning were 50 students (12 males and 38 females) who were taking a course in Food and Nutrition at Providence University in Taiwan. They were enrolled in an elected module called 'Drug and Nutrient Interactions' in 2004. This module was intended to make students acquainted with various drug and nutrient interactions and prepare them for becoming dietitians. Students signed up with four or five other people (as a team) to accomplish a group research project in order to fulfil the course requirements.

In the Food and Nutrition course, 'Drug and Nutrient Interactions' is an advanced module for students electing to take it. The module covered various complex issues related to drugs and nutrient interactions observed in clinics. A Web-based version of the module was arranged within a framework of problem themes. The specific design issues and the evaluation of the module have been discussed in a previous study (ChanLin & Chan, 2004). Within the PBL learning setting, instructional materials were presented as authentic problems and organized in a manner that required students to learn in small groups. Various clinical problem cases relating to the most frequently found drug and nutrient interactions were used as a learning context and explored by students. Students were required to discuss each of the cases in groups, and then choose a topic and conduct research on it for their final project.

### *Data collection*

In this study, the Web-based instruction was augmented with the electronic interactive tool, 'e'Forum, to support students' learning in the PBL context. Since having sufficient experience and clinical knowledge is critical for coping with students' needs (in a PBL situation), an interdisciplinary method for providing electronic support by experts was employed. 'e'Forum included 11 group forums to support group interaction and three expert forums to support interaction with experts. Experts from related fields were invited (into the discussion forum) in order to chat with students. The structure of the Web-based interaction support is shown in Figure 1.

In order to encourage students' participation in online discussion, 15 points were allocated to this in their final project score. Students were informed about how they would be evaluated at the beginning of the course. Qualitative data from the learning process was used for content analysis. This included: messages from discussion forums, students' group projects, written reflections from students and oral information from participants (students, the instructor, the facilitator, and experts).

## Results

Students' learning outcomes were assessed from the performance of their group research project. Each student's score in the final project was obtained by adding the group's final project

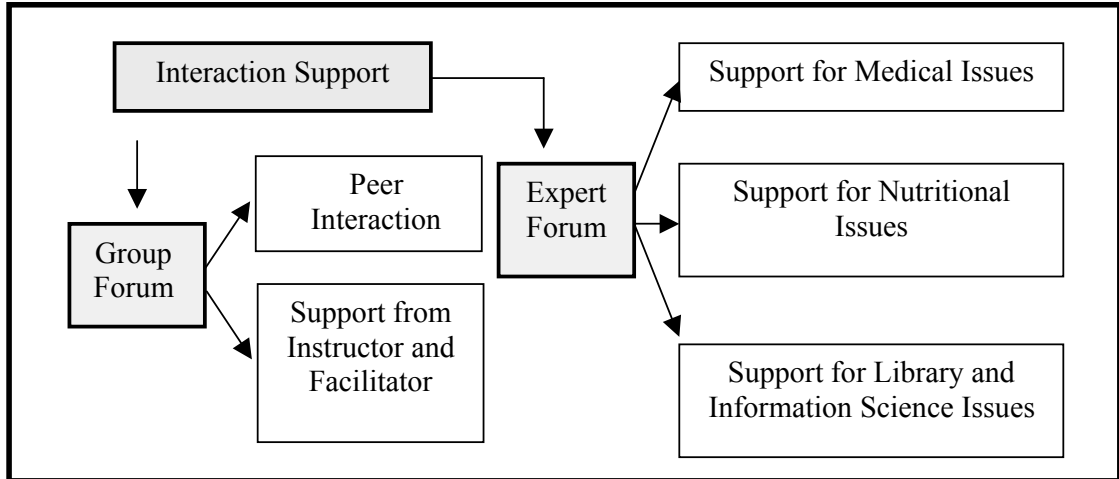


Figure 1. Structure of PBL Web-based interaction support

mark (which counted for 85 points) to his/her score for participation in the online discussion (which counted for 15 points). From the students' final projects, it was observed that they had acquired a deep understanding of the content they had studied. Students were able to construct their own knowledge based on the problem defined and information gathered and explored. The mean score obtained by the students was 74.38 (SD = 7.09) with individual scores ranging from 64 to 96. All students achieved their learning objectives.

From the statistical analysis of the students' postings to the *'e'Forum*, 949 were from group forums (Table 1) and 218 were from expert forums (Table 2).

Among the group forums, five groups posted more than 100 messages. The messages posted in the 1st, 5th, 8th, 9th, 12th, 13th and 15th week were higher than 60, reflecting several peaks in students' effort in discussion processes for knowledge acquisition and accomplishing their project tasks. These included: getting acquainted, studying problem scenarios, exploring topics of interest, deciding on a topic, gathering information and writing up their project report. The types of support and progress in knowledge acquisition among students are summarized below.

#### *Supportive interaction for learning*

In order to achieve effective learning in the PBL context, both experts and students were actively involved in electronic interaction. All the messages posted to *'e'Forum* were read and responded to by the instructor, the facilitator or one of the experts. The instructor, facilitator and the team of experts responded to students' learning problems and reflections, and extended students' learning interest to other related knowledge areas. The different types of support that were provided are summarized below. In the tables and discussions that are presented, we reference statements from the various forums (and other sources) using different codes such as: G (group forum), M (medical forum), N (nutritional forum), L (library and information forum), WR (written responses). For example, the coding G4-7:0512-11:02:44 refers to a message from the

Table 1. Group posts (by week) in group forums

Week	Group											Week total
	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	
1st	11	0	0	1	5	1	6	2	23	13	2	64
2nd	9	3	3	2	8	4	10	2	1	7	5	54
3rd	0	8	3	7	4	0	1	7	1	5	4	40
4th	13	0	1	2	1	5	2	1	0	1	7	33
5th	22	0	0	1	1	1	1	4	7	28	2	67
6th	8	1	0	23	0	0	20	4	0	2	0	58
7th	0	0	0	21	2	2	2	8	0	2	0	37
8th	1	3	3	8	4	0	0	16	15	20	2	72
9th	17	1	3	6	1	0	5	3	25	1	0	62
10th	15	0	3	5	7	0	1	3	11	2	2	49
11th	6	3	2	3	2	1	0	0	2	2	4	25
12th	34	0	11	1	6	9	23	19	7	1	28	139
13th	6	5	2	14	0	4	8	9	12	3	11	74
14th	4	3	1	0	2	3	4	11	11	0	7	46
15th	1	1	5	17	0	10	31	43	10	2	9	129
Group total	147	28	37	111	43	40	114	132	125	89	83	949

fourth group forum, topic number 7 posted at 11:02:44 on May 12. Similarly, N:0311-01:54:13 denotes a message from the nutritional forum at 01:54:13 on March 11. The notation ST#*nm* is used to denote material contributed by a student whose reference number is *nm*.

*Support from the instructors.* Most of the support from the instructors was related to the instructional content, course requirements, and the preparation of the group research projects. The support that was provided included the following types: guidance, clarification, comment, inquiry, confirmation, suggestion, reminding, and encouragement. As summarized in Table 3, learning guidance was used to support students' understanding of the conceptual knowledge relating to nutrients and medications. The instructors also provided coaching in relation to the key concepts involved in analyzing a problem and also gave clarification in situations where possible misconceptions were identified. Instructors also commented on students' reflections or

Table 2. Group posts in the expert forums

Group	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	Total
Medical	31	8	1	0	10	4	3	0	2	3	2	67
Nutrition	27	12	2	0	8	4	5	1	0	6	5	70
Library and information	14	1	2	0	5	5	8	23	5	13	5	81
Group total	72	21	5	0	23	13	16	24	7	22	12	218

Table 3. Online support from the instructor

Online support	Purpose	Example
Guidance (cognitive support)	Provide learning direction, or guidance for study	'You need to pay more attention on the relationship between MAOI and Tyramine in order to make information search more relevant' (G1-9:0519-22:02:45)
Clarification (cognitive support)	Clarify a concept or misunderstanding	'The functions of various diuretics are different. What you have mentioned is only one of them' (G3-3:0317-19:36:36)
Comment (affective support)	Provide comments toward students' statements	'Very good'; 'Need to work harder'; 'Very constructive' (G8-1:0426 00:14:04)
Confirmation (affective support)	Confirm students' actions	'You are on the right track'; 'Keep on finding more resources focusing on this issue' (G2-2:0317-21:47:39)
Suggestion (cognitive support)	Provide options for students' actions	'You might want to choose one or two foods instead of including too many varieties' (G8-10:0418-23:24:59)
Reminding (affective support)	Remind students for synthesizing knowledge	'You should not paste the web-article on discussion forum. Instead, summarize what you found' (G7-1:0520-22:05:12)
Inquiry (cognitive support)	Ask students to relate conceptual information	'How does the intestinal mucosa change to cause malnutrition' (G3-:0509-19:52:07)
Encouragement (affective support)	Cheer students up, when students facing frustration	'Don't give up. You still have time!' (G4-7:0512-11:02:44)

actions, and responded to inquiries. They also gave confirmation, reminders, and encouragement in support of students' work.

*Support from the medical forum.* The support from the medical forum was related to the medical treatment of specific diseases and symptoms in response to questions raised by students. The supportive input from the medical expert involved in the forum was categorized into the following types: guidance, clarification, comment, confirmation, suggestion, inquiry, and information (see Table 4). Conceptual knowledge development about a specific therapy was guided by the expert. For example, the doctor provided appropriate protocols for using various medications with patients and gave clarification of the different outcomes arising from the use of specific medications for particular symptoms. Other functions that the medical expert undertook included: commenting on students' experiences and confirming inferences about cases; making suggestions for providing alternative actions; and stimulating inquiry for reflection towards a specific decision. Informative support was also provided in order to help students identify appropriate laboratory procedures.

*Support from the nutrition forum.* Support from the nutrition forum was intended to meet students' epistemological needs in relation to the nutrition profession. Nutrition support was categorized into the following different types: guidance, clarification, comments, confirmation,

Table 4. Online support from the medical forum

Online support	Purpose	Example
Guidance (cognitive support)	Provide conceptual knowledge for therapy	'Lifelong replacement of thyroid hormone is necessary for permanent hypothyroidism. Monitoring the thyroid function is also important' (M:0519-22:02:45)
Clarification (cognitive support)	Clarify the use of medical treatments	'Anti-biotic is for bacteria infection. Symptomatic treatment is for virus infection' (M:0228-20:04:22)
Comment (affective support)	Comment on students' responses	'Nice comment' (M:0328-14:10:53); 'Nice reference to us' (M:0329-22:35:37)
Confirmation (affective support)	Confirm students' inferences on health problems	'Yes. It is a systemic disease. There are some methods to detect, but not 100%' (M:0309-01:59:38)
Suggestion (cognitive support)	Suggest actions for health problems	'Uric acid may destroy kidney. Some drug for pain has side effect to kidney. Discussion with a doctor is needed' (M:0226-23:26:38)
Inquiry (cognitive support)	Ask students to trace more other data for specific symptom	'Alcohol? Genetic? General disease? Endocrine disease? Acute pancreatitis may develop if TG>1000' (M:0302-15:38:30)
Information (cognitive support)	Provide information about specific testing procedure	'Try laboratory manual of hematology!' (M:0516-15:51:47)

suggestions, and inquiry (see Table 5). Guidance from the dietician supported students' conceptual understanding of nutrients and diseases. For example, information on the causes of hyperthyroidism guided students toward divergent thinking in making a conclusion. Ambiguous and misleading thoughts presented by students were also clarified. For example, identifying the use of the same ingredient in different foodstuffs helped students to make rational cause-effect

Table 5. Online support from the nutrition forum

Online support	Purpose	Example
Guidance (cognitive support)	Provide guidance for further study in the case	'Are all the hyperthyroidism due to insufficient intake of iodine? Or there might be some other causes? Study more about it' (N:0228-23:42:01)
Clarification (cognitive support)	Point out the ambiguous and misleading thoughts reflected from students	'Identify the content both in chocolate and brown sugar? If caffeine is the key factor, why does brown sugar have the same effect?' (N:0311-00:18:02)
Comment (affective support)	Provide comments toward students' reflections	'Good suggestion' (N:0303-21:56:02); 'Please look for more reliable information' (N:0328-20:44:26)
Confirmation (affective support)	Provide confirmation toward students' reflections	'One tablet per day should not be a problem' (N:0303-11:50:31)
Suggestion (cognitive support)	Provide suggestions for dealing with nutrition cases	'Please check information about hepatitis B, and chronic carrier. Be aware of the diet for these patients' (N:0303-11:38:43)
Inquiry (cognitive support)	Ask students to reason from different analytical approach	'Do you think the secretion of hormone will change due to the change of diet? Or, human body adjusts according to our need?' (N:0311-01:54:13)

Table 6. Online support from the library and information forum

Online support	Purpose	Example
Guidance (cognitive support)	Provide guidance for use of online resources	'You can use Boolean operators, such as "and", "or", "not" together with key word search to broad or narrow-down your search' (L:0315-10:18:02)
Clarification (cognitive support)	Clarify appropriate use of information resources	'You need to know the differences between academic publications and publications for advertisement' (L:0417-17:09:42)
Comment (affective support)	Comment on students' sharing of search experiences	'Thank you for sharing your searching experience' (L:0506-15:11:36); 'Keep on working on it' (L:0418-09:30:32)
Confirmation (affective support)	Confirm students' actions and use of information	'You are on the right track. From the strategies you used for search, I can see that you have incorporated these strategies as part of your knowledge' (L:0419-00:09:40)
Suggestion (cognitive support)	Suggest search of in-depth and updated information	'For scientific information, you should conduct your search on the foreign database as well. Most up-dated research was published in English' (L:0311-01:54:13)
Encouragement (affective support)	Cheer students up	'Don't be frustrated' (L:0417-12:44:25); 'Don't give up. Try again' (L:0417-12:44:25)
Inquiry (cognitive support)	Ask students about further search	'What have you done from the resources you gathered? Did you read the articles you found? What did you find?' (L:0331-11:43:32)
Information (cognitive support)	Provide students with the website for searching relevant resources	'Here are some useful websites for you to look at National WebHospital and MedlinePlus...' (L:0505-01:24:36)

inferences. Commentary and confirmative supports were also provided in response to students' reflections on nutrition problems. Analytical reasoning was also suggested and applied when dealing with specific nutritional cases.

*Support from the library and information forum.* Students accessed the library and information forum for resource help. Support from the librarian was categorized into the following types: guidance, clarification, comments, confirmation, suggestion, encouragement, inquiry, and information (see Table 6). For example, students were coached with respect to: strategies for accessing academic resources; use of Boolean operators (such as 'and', 'or' and 'not' together with the use of keyword searching) in order to broaden or narrow-down a search; and appropriate use of different sources of information. Comments, confirmations, suggestions, and encouragement in response to students' actions and frustrations in relation to searching for information and the use of search tools were also provided.

*Support from the facilitator.* Support from the facilitator included: suggestion, reminding, information, and chatting (see Table 7). The role of the facilitator was to act as a coordinator between



Table 7. Online support from the facilitator

Online support	Purpose	Example
Suggestion (cognitive support)	Provide options for students' actions	'Since you have decided the interactions between drugs and juice, you might want to identify the types of juice that interact with drugs. Narrow it down to a specific area so that you can study its mechanism' (G2-5:0511-02:00:31)
Reminding (affective support)	Remind students to work harder	'Any progress for your final project? Have not seen you for a long time. Work harder before too late' (G11-1:0419-11:08:39)
Information (cognitive support)	Provide resources for search of illustrations	'To find the graphical illustration you mentioned, you might want to try library database such as PubMed in Medline, or SDOS' (G10-9:0527-03:48:12)
Chatting (affective support)	Chat with students about their progress	'Congratulations! You finally find INR [a hematological test]' (G5-6:0517-22:05:02)

the instructor, the experts, and the students. This role also involved reminding students about what they should accomplish and how they should check their own progress. From the students' group forums, the facilitator monitored the students' progress, and reminded them of what needed to be done—especially for those who made slower progress. The facilitator also provided suggestive information for students' actions and informative support. Some groups treated the facilitator as a companion.

#### *Progress in knowledge acquisition and the project tasks*

From the PBL process, group cooperation in the Web-based environment revealed a constructive process—through which students created knowledge. From the group interactions, high-level thinking skills and collaborative effort were observed. Reflections on the process at individual or group level were revealed. Learning processes in the Web-based learning context were categorized into the following six stages.

*1. Getting acquainted with the system.* Students first learned how to register, sign-in, and manage their own personal data. For most nutrition students, the Web-based approach was an innovative learning experience. Although most students had experiences in using *Internet Messenger* to chat with others, conversing on academic work was new to them. Students posted queries about technical issues, for example, the use of special fonts and symbols, writing formulae for chemical compounds—such as  $\text{Mg}_3(\text{PO}_4)_2$ —on the 'e'Forum, the use of superscripts and subscripts and setting proxy (L:0308-04:19:00).

*2. Studying problem scenarios.* PBL followed a path in which essential questions were addressed while guiding students towards accomplishing their project work. Students used the given problem scenarios to extend their observation and to relate the cases to their real-life experiences.

Divergent thinking paths were undertaken when various sources of information were involved in analyzing a symptom. Through the use of cases, the mechanism of medications and the nutrient intake from diets were explored.

Some of the cases happen in our daily lives, but we might never consider them as a drug-and-nutrient-interaction related problem. (ST#022-WR)

The problem scenario made me realize the complicated issues existing in real-life situations. The given cases also triggered my interest in the cases I personally experienced, heard, or read from medical reports. Compared with presenting the cause of symptoms for a drug and nutrient interaction, the use of real-life examples encouraged me to think and analyze more profoundly. (ST#020-WR)

Although much time was spent on in-depth study for the cause of a specific drug and nutrient interaction problem, students considered the approach helpful, especially for future dietetic practice.

*3. Exploring topics of interest.* Prior to deciding on a topic for their research projects, students explored the content of the lessons provided and navigated through the links to the resources and related websites—such as hospitals, nutrition-related organizations, and databases—in order to obtain more background information about the tasks involved. Preliminary exploration and negotiation about opinions and reflections was observed.

Every one of us studied first, and shared with others what he/she found. Then, we decided a topic for our research. (ST#05-WR)

In our groups, we discussed many case-topics. We also spent a lot of time sharing our findings. I was afraid that we were too involved in each case-topic to choose one for our final project. (ST#035-WR)

Those topics that related to students' real-life experiences caught much attention among group members. For example, students compared the side-effect and interactions for influenza medication prescribed from their doctors.

My prescription is different from yours. Although we all caught flu, symptoms were different... (G1-1:0304-22:19:55)

We need to attend to the content of our medications, and see what nutrients we might need to supplement our diet, or take precaution when having specific food intake. (G1-1:0309-23:11:34)

*4. Deciding on a topic for the group project.* In order to decide on a topic for a group project, negotiation among group members took place. The various considerations taken into account by the groups included the relevance of the topic to the group-members' interests and real-life experiences and the availability of sufficient resources for the project. Some groups started off with a tentative topic of interest and then, after going through some preliminary research and discussion, changed their research project to one with more available resources.

At first we were interested in antibiotics, because some of us took medications for flu. However, not many resources were available. Later, we found CEPA (caffeine, ephedrine, PPA, aminophylline) anti-obesity therapy was also an interesting topic. Our group members started to search, and found a wide variety of resources about anti-obesity therapy. We then decided to study this topic because more resources available for us to write our paper. (ST#03-WR)

5. *Gathering related information.* Gathering relevant information for writing a paper is a critical aspect of completing the final project. Students shared experiences in searching and gathering information and identified diverse considerations and resources. Advanced searching strategies were observed among students who became more knowledgeable about a topic. Due to the familiarity with the topic, more relevant keywords were used during the search for resources.

When looking for a drug, you will often get the functions and effects of the drug, then you can go further search based on the information you got. For example, I first used Chitosan for key word search, and get information about 'absorbent to lipid', then I used 'Chitosan + lipid' for further search. (M:0428-21:28:03)

6. *Writing the project report.* During the process of writing the project report, students learned to organize and synthesize the material that they obtained into an integrated report. They also learned to use a correct writing style. Group members reminded each other of important issues that had to be covered in the final report and supported each other whenever this was needed.

I'll help you with chitosan in its molecular weight, solubility and viscosity, since you did not take 'Nutrition II.' I am still keeping the class handout, and I'll bring it with me and explain it to you. (G1-10:0517-01:03:06)

During the writing process, 'e'Forum served as a writing 'memorandum' to keep group members informed about their progress in relation to putting pieces together. It was also used to present a chart of team members' efforts and progress. For example, in the group forum, the team members kept track of what they had done and what needed to be accomplished until the job was completed:

So far we have Introduction, Interactions of drug and nutrients in human body, Mechanism of interaction, and Applications and side effects. (G1-6:0514-20:38:22)

## Discussion

Through their submitted research projects, students demonstrated their ability to achieve their learning objectives. Working towards accomplishing their tasks, students were involved in a higher level of thinking skills and experienced clinical cases in order to understand the complex interaction mechanisms underlying the use of drugs and nutrients. It was observed that the intended learning outcomes were achieved in the PBL Web-based instruction environment with the help of electronic support from experts.

It has been suggested that for the successful implementation of PBL, a paradigm shift is needed on the part of students and supportive members are a prerequisite (Papastrat & Wallace, 2004). The use of online support in this study created a cultural climate that promoted open and academic dialogue among students and between students and experts. An interactive mode of coaching and learning became the foundation for acquiring knowledge. During this activity, knowledge construction resulted from the process of working towards understanding and the accomplishment of a research project. Higher-order thinking skills and interdisciplinary knowledge was obtained through active participation in the electronic interactive environment.

The PBL approach used in this study was intended to guide students towards becoming experts that would be capable of applying knowledge from related disciplines in order to achieve

their academic goals. Compared with novice students, experts are different, in that they often possess more coherent knowledge, and know how to use relevant elements of their knowledge in a more flexible way to describe and solve novel problems (Gijbels *et al.*, 2005). The conversations between students and experts provided an opportunity for using coaching and mentoring as a means of helping students to achieve both their project goals and their learning goals. Support from the experts, the instructor, and the facilitator included cognitive-related enhancements (guidance, clarification, information, suggestion, and inquiry) and affective-related enhancements (comments, confirmation, chatting, reminding, and encouragement).

From the coaching process, experts gradually developed their strategies in response to students' requests. Instead of providing direct answers to students' questions, the use of inquiry and suggestive feedback provided students with opportunities to reflect upon the issues for themselves. The interactive process has reflected the constructive learning nature of the PBL approach, which emphasizes the need to encourage learners to develop initiative and enthusiasm, as well as self-directed learning and self-reflection abilities (Oberlander & Talber-Johnson, 2004; Liu *et al.*, 2006). With the use of cognitive- and affective-support from experts, the required skills and conceptual knowledge (in medical, nutritional, and the library and information science areas) were obtained.

Like many other e-learning strategies, the use of 'e'Forum for interactive learning has its limitations. Some students were irregular in their use of the discussion forum and did not work well with others in the group. Another concern regarding the approach was the commitment and effort from experts. As pointed out, the use of PBL can be more time consuming than traditional instruction (Bechtel *et al.*, 1999), the results of the study indicate that both students' and experts' participation and involvement were important. When the experts were highly involved in responding, students would be more willing to participate. However, when messages were posted without receiving a response for a long period of time, students were less willing to carry on.

Overall, the design of the interactive learning tool described in this paper brings together a range of nutritional pedagogical practices, including collaborative learning, PBL, and an interdisciplinary approach to the construction of a learning environment in which students were not only exposed to the nutrition and medical issues surrounding the subject knowledge, but were also given the opportunity to develop the interpersonal and critical evaluation skills necessary for effectively advancing into this field in the future.

## Conclusions

With the advent of Web-based learning technology, students are facing new challenges with respect to perceiving knowledge and setting new goals to manage today's global knowledge. In the 'Drug and Nutrient Interactions' module, an innovative approach with expert involvement was implemented in order to enrich the Web-based PBL experience. The course design was primarily inter-disciplinary and problem-based so that students could engage in substantial and meaningful interaction with peers and experts. Through the help of the online discussion forums, students shifted towards independent learning establishing more regular self-directed learning practices in PBL. They were also exposed to inter-disciplinary knowledge across nutrition, medical, and the library and information science fields. They were not only able to

achieve the learning objectives, but were also able to extend their knowledge to a more practical and useful level.

For this approach to PBL to be successful, both cognitive and affective online interactive support is needed. Future implementations of the online feedback mechanisms for supporting students should therefore be well planned. Bearing in mind the complex nature of students' learning processes, further research involving a latitudinal design to observe cross-curriculum learning in other related courses is also needed to confirm our results.

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