Utilizing Computer-mediated Communication Tools for Problem-based Learning

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ABSTRACT
This study aims to strategically use computer-mediated communication (CMC) tools to build online communication environments for problem-based learning (PBL). A six-stage process was proposed for online PBL learning in this study: 1) identifying the problem, 2) brainstorming, 3) collecting and analyzing information, 4) synthesizing information, 5) co-building knowledge, and 6) refining the outcomes. The one hundred undergraduate students who participated in this study were randomly grouped into 13 groups. Multiple methods of data collection were adopted to investigate students’ learning activities in the online PBL course. The methods of data triangulation and investigator triangulation were used to analyze the following: 1) the use of CMC tools, 2) students’ learning achievement, 3) students’ experience in the online PBL course, and 4) group learning activities. The empirical evidence showed that students were able to communicate, discuss, and co-build the knowledge from the collected information. With the online communication, they were able to seek solutions to the problems in learning activities. Meanwhile, students were satisfied with the online PBL course. The successful experience of course design in this study can encourage instructors to use open-source or free-hosted CMC services to develop online PBL courses.

Keywords
Blog, Computer-mediated communication (CMC), Microsoft Network (MSN), Problem-based learning (PBL), Wiki

Introduction

Problem-based learning (PBL) was derived from the research project conducted at the Department of Medicine, McMaster University (Canada). PBL is an approach emphasizing students’ learning through active inquiry in small groups (Sonmez & Lee, 2003). In a review of research, Schmidt and Moust (2000) concluded that PBL follows the “seven jump” procedure in a typical tutorial group, in which students do the following: 1) clarify unknown terms and concepts in the problem description; 2) define the problems; 3) analyze the problems by brainstorming, in an attempt to produce as many different explanations as possible based on prior knowledge and common sense; 4) criticize the explanations proposed and try to produce a coherent description of the processes; 5) formulate learning issues for self-directed learning; 6) fill the gaps in their knowledge through self-study; 7) check whether they have learned, share findings with peers, and try to integrate the knowledge acquired into a comprehensive explanation for the problem.

Many studies provide evidence of the effects of PBL in terms of improving students’ learning, and PBL has been adopted widely in educational settings (Savery & Duffy, 1995). PBL can foster students’ intrinsic motivations and develop their self-learning skills because it provides a student-centered and self-oriented learning for students to seek solutions to real world problems (Barrows, 1997; Gallagher, Sher, Stepien, & Workman, 1995; Prince & Felder, 2006). Norman and Schmidt (1992) indicated that the learning in a PBL format can lead to a long-term retention of knowledge, enhance the integration of basic science concepts into clinical problems, and result in an increase in intrinsic interest in the subject. Antepohl and Herzig (1999) suggested that students consider PBL to be an effective learning method and favor it over the lecture format. Furthermore, students reported positive effects of PBL in terms of use of additional learning resources, interdisciplinary courses, team work and learning fun. Tiwari, Lai, So, and Yuen (2006) proposed that those who undertook PBL are significantly better in the development of critical thinking dispositions, as measured by the California Critical Thinking Disposition Inventory (CCTDI), than those who took lecture courses.

With the advancement of technology, small-group discussion in the classroom can be replaced by transmitting messages via networked computers. Such computer-mediated communication (CMC) allows interactions among geographically separated students, who can communicate and learn through dialogue exchanged on the Internet. Online courses are, therefore, designed with learning activities for small groups of five or six heterogeneous
members who collaborate or cooperate to complete a common task (Henri & Rigault, 1996). The majority of these online courses use constructivist educational principles (Bangert, 2004). Using CMC in the PBL process was proposed and defined as an approach to distributed problem-based learning (dPBL) (Cameron, Barrows, & Crooks, 1999).

Both teaching and learning with the dPBL approach have greatly contributed to the inquiry into the use of CMC (e.g., ChanLin & Chan, 2007; Steinkuehler, Derry, Woods, & Hmelo-Silver, 2002; Oberlander & Talbert-Johnson, 2004). There are various forms of CMC, such as instant messaging, peer-to-peer networks, e-mail, bulletin boards, online chat rooms, and massive multiplayer online (MMO). Usage is either synchronous or asynchronous. CMC can be accessed by commercially available applications like Blackboard and WebCT, which are designed particularly for teaching. Open sources such as MSN, blogs, and wikis can be designed to manage online learning. These CMC tools can be user-friendly communicative environments for today’s students, who are familiar with the use of CMC. Based on accessibility, feasibility, and cost-effectiveness, this study aims at strategically using open-source software as CMC tools to build an online course for PBL.

Methods

Participants

One hundred undergraduate students from nine departments (66 freshmen, 10 sophomores, 17 juniors, and 7 seniors) chose the two-credit, 15-week, web-based elective course, a general education course called Applied Science in Life. They were randomly divided into 13 groups with an average of six or seven members per group. The instructional objective of this course was to develop students’ abilities in constructing new knowledge through the researcher-designed PBL approach.

CMC environment for the online PBL classroom

Figure 1 shows the design of a CMC environment for the online PBL classroom in this study. The online PBL classroom needs CMC tools for the following: 1) synchronous discussion in the process of problem solving; 2) asynchronous communication that allows students to take their time to read, write, and give comments to members within a group; and 3) a platform that allows students to collaboratively edit their group project and to learn from other groups. Therefore, three tools were used: instant messaging (IM) for synchronous discussion, blogs for intra-group communication, and wikis for collaborative group work and inter-group learning.

![Figure 1. Design of the CMC environment as the online PBL classroom](image)

MSN (or MSN Messenger) is one of the most popular IM interfaces for college students in their daily lives. In this study, students invited the group members to join their learning community so that group members could communicate synchronously in the PBL process if necessary. Students were requested to invite the research-designed virtual contact, called the PBL recorder, to record what they had discussed.

A blog is a website that contains frequently updated posts, with the most recent entry at the top of the page and the previous ones displayed in reverse chronological order. This study set up one blog for each group (Figure 2) using
Movable Type Open Source 4.1 (http://www.movabletype.org/). Group members could asynchronously post the information they find, make comments on learning issues, incorporate hyperlinks to other blogs or news sources, and discuss related topics. This means that a blog was the asynchronous intra-group communication tool while members were seeking data to solve a problem.

A wiki is software that allows users to easily create and edit collaboratively. This study used open source MediaWiki (http://www.mediawiki.org/wiki/MediaWiki), free server-based software whose site gets millions of hits per day. Group members collaboratively wrote group reports on the wiki (Figure 3) after they had discussed each learning issue on the blog. Further, the group wiki reports could also be reviewed by other groups. That is, wiki became the collaborative documenting tool for group members and the group presentation interface for each group to review.

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**Figure 2.** Blog for learning issues

**Figure 3.** Wiki for co-editing
Course design

In the first two weeks, students came to the conventional classroom for the orientation on how to work online in a group. The web-based course began in the third week to learn six issues in 12 weeks, that is, two weeks for each learning issue. The learning issues include topics of housing, food, clothing, household goods, transportation, and entertainment. In the fifteenth week, the teacher and students came to the classroom for face-to-face feedback, evaluation, and final discussion.

For each learning issue, a six-stage process was proposed as follows: 1) identifying the problem, 2) brainstorming, 3) collecting and analyzing information, 4) synthesizing information, 5) co-building knowledge, and 6) refining the outcomes:

- At the first stage, the problem for the learning issue was posted on wiki in the form of text, pictures, sound, video clips, or hyperlinks for students to access the original information. The learning issues, selected from newspapers, magazines, TV news, or Internet news, were current issues that do not have just one answer or one definite solution. For example, one of the learning issues is that a renewable fuel, biodiesel, has been produced to reduce serious air pollutants, and therefore, is expected to reduce global warming. Students were asked to answer whether they would choose biodiesel if they had a car.

- At the second stage, students needed to brainstorm or generate ideas. They could use MSN to discuss online in real time with fellow group members. They needed to tackle the problem through self-directed questioning. For example, in order to answer whether they would use biodiesel, students needed to raise questions like the following: What is biodiesel? How does the diesel engine work? What is the difference between biodiesel and conventional fuel? Is biodiesel good for the diesel engine? How much should we pay for biodiesel? This kind of self-regulated questioning was aimed to arouse students’ intrinsic motivation.

- At the third stage, group members were assigned to collect information. They had to fulfill their own task by the deadline that was agreed upon. They discussed via MSN or posted on the blog what they found and what they learned. Thus, they collaboratively collected useful information.

- At the fourth stage, the collected information was critically analyzed so that the relevant data could be synthesized to solve the problem. Generally speaking, knowledge building occurred in the process of collecting, analyzing, and synthesizing stage.

- At the fifth stage, students presented the solution to the learning problem/issue collaboratively on wiki. Students reflected and elaborated on what they had learned.

- At the final stage, the course instructor gave feedback and suggestions to help students improve. For example, they might be directed to another group report on wiki. In this way, students learn from other groups and are not limited in their own group.

To assist the implementation of learning activities, especially in the negotiation of the time of online discussion, group members elected a leader. They established networks of communication in their group by e-mail, cell phone, and MSN. The group leaders had to stay connected throughout the networks of communication to ensure that group members were present at the learning activities. The group leaders would inform the tutor if the absences were frequent.

The course instructor and a research assistant played the roles of tutors in the PBL work. However, they did not play the role of experts as tutors in the conventional PBL process did. Instead, they guided students as supervisors and facilitators in the learning activities. The research assistant monitored the learning process for nine hours a day (i.e., three hours in the morning, afternoon, and evening). At the final stage, the course instructor concluded the learning issues with feedback and suggestions but no answers.

Multiple assessment methods were adopted to evaluate students’ learning, including 1) the achievement test (20%), 2) the group report (20%), 3) the self and peer assessment (30%), and 4) the interactions intra-group (30%). The achievement test was based on knowledge of the learning issues. The group report was graded by the course instructor according to the content and the inferences that the group members documented on the wiki. The self and peer assessment was a 5-point Likert scale (Cronbach $\alpha = 0.9198$) with 11 items (four items for self evaluation and seven items for peer evaluation) developed by Chung Shan Medical University in 2005 (Chen, Lee, Lee, Wang, Lin, & Yang, 2006). The course instructor who observed their performances in the process of discussion for each learning issue evaluated students’ interaction in the group, scoring them from 0 to 5.
Data collection and analysis

Multiple methods of data collection were adopted to investigate the students’ learning activities in the online PBL course via computer-mediated communication tools and to ensure that interpretations of the data will be both reliable and valid in this study. According to the triangulation proposed by Denzin (1978), investigator triangulation and data triangulation (as shown in Figure 4) were designed in this study. Multiple sources of data, as shown in Table 1, were collected, and data triangulation was used to analyze these multiple sources of data. Investigator triangulation was used to synthesize the observations of the course instructor and the research assistant. As shown in Figure 4, two tutors acting as investigators analyzed the multiple sources data to explore clues to understanding students’ learning behavior in the online PBL course. They interpreted the raw data separately first and then presented the interpretations. To clarify the dubious data and different interpretations, they had to interview the students.

<table>
<thead>
<tr>
<th>Sources of data</th>
<th>Means to collect required data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dialogue in virtual classroom</td>
<td>The system recorded all data on the blog, wiki, or MSN for the duration of the learning process and they will be encoded according to the sequence of time. Students completed a questionnaire using a 5-point Likert scale at the end of the course. The aim of the questionnaire was to examine students’ experience participating in course activities and using learning interfaces.</td>
</tr>
<tr>
<td>Questionnaire (Q)</td>
<td>Students completed a questionnaire using a 5-point Likert scale at the end of the course. The aim of the questionnaire was to examine students’ experience participating in course activities and using learning interfaces.</td>
</tr>
<tr>
<td>Interviews (I)</td>
<td>Tutors used interviews when they noticed something unusual in the learning activities or when different interpretations occurred in data analysis.</td>
</tr>
<tr>
<td>Field notes (Fn)</td>
<td>The tutors, as observers and participants, recorded meaningful events for the duration of the study. Field notes include date, time, specific facts, sensory impressions, and immediate reflections or thoughts.</td>
</tr>
<tr>
<td>Reflection on learning experience (RLE)</td>
<td>Students and tutors met in a traditional classroom and shared their learning experience with one another at the end of the course.</td>
</tr>
<tr>
<td>Assessment of students’ learning (ASL)</td>
<td>Multiple assessments consist of the achievement test, the group report, the self and peer assessment, and the interactions intra-group.</td>
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</tbody>
</table>

![Figure 4. Illustration of data triangulation and investigator triangulation](image-url)
Results

The use of CMC tools

Based on the questionnaire responses, the usage frequency of the three CMC tools shows that MSN was the most popular tool. Most students (96%) were familiar with MSN, and almost all of them (95%) did not have any difficulty using MSN in the process of learning. More than half of the students (63%) were already familiar with blogs prior to the course, but only a few students (10%) knew about wiki. After receiving training in the use of CMC tools in the first two weeks of this course, students showed significant growth in confidence and familiarity with using blogs (81%) and wikis (58%). This indicates that the training in CMC tools was necessary for students to ensure that they were able to participate in the learning activities via these communication tools.

When comparing the synchronous MSN tool with the asynchronous blog for the intra-group discussion, data from field notes (Fn) and reflection on learning experience (RLE) revealed that students tended to discuss in real time. Subsequent to the offline discussing, they did not post the unfinished discussion on the blog. Instead, they preferred to continue the instant discussion. Students said the following:

- “Discussion was often unfinished, when group members were offline and did not continue post it to the blog…” (Fn 950422).
- “I prefer to continue the discussion when they are online next…” (RLE 941803401).

It is likely that students prefer to communicate in the environment that they are familiar with. However, the discourse via MSN was more like what they would say in a conversation, rather than what they would reflect in a piece of writing. For example:


In contrast, data of the asynchronous CMC tools both on the blog and wiki shows that students worked on content and built more organized discussions:

- “Biodiesel is an alternative fuel which derived from the oils and fats of plants and is a valuable form of renewable energy. Biodiesel can be used directly in any existing, unmodified diesel engine like conventional diesel fuel. That is, it will help reduce the countries’ dependence on foreign oil imports if we can produce biodiesel in Taiwan” (DVC G3T1842119).

Students’ learning achievement

The results of achievement tests showed that the difference of the pre-test ($M = 31.70$, $SD = 9.95$) and post-test ($M = 61.55$, $SD = 9.12$) is significant ($t = 26.127$, $p < .001$). This indicates a significant gain in knowledge relevant to the learning issues after the PBL online course. Meanwhile, the results of the self-assessment and questionnaire responses showed high percentages (76% and 86% respectively), and agreed that they acquired knowledge of learning issues in the process of online PBL course.

The group reports presented on the wiki provided evidence that students could solve the problems via the process of the online PBL course. For instance, all groups concluded whether or not they would use the renewable fuel based on the analysis of biodiesel:

- “Biodiesel is a form of diesel fuel manufactured from vegetable oils, animal fats, or recycled restaurant greases. It is safe, biodegradable, and produces less air pollutants than petroleum-based diesel … To sum up, it is an innovation energy which fits in with economic benefits and is good for the environment. We think that we will use the renewable fuel if possible” (DVC G3T2041209).
- “Though biodiesel has a lot of advantages, it has its limits. First, some vehicle manufacturers worry about the use of biodiesel and remain cautious over the use of biodiesel. In the UK, for instance, many only maintain their engine warranties for use with maximum 5% biodiesel (blended in with 95% conventional diesel). Secondly, diesel engine cars are more expensive than conventional ones (so far in Taiwan). It means that we have to pay more money for the car but the effects on environmental protection and economy are limited. Hence, we do not think that we will choose it as fuel of car unless the expense is subsidized by the government” (DVC G9T5041211).
Students’ experience with the online PBL course

Most of the students (76%) thought that it was more interesting to learn in a virtual classroom than in a face-to-face classroom. Students could synchronously search and renew information during the discussion. They were satisfied with the communication interfaces that could provide permanent links to web pages. It was likely that they liked learning in a virtual environment because of the flexibility and the functions of CMC, as demonstrated by the following comments:

- “There was something different … it did not seem to be a formal course because the experience was so different from that of learning in a traditional classroom” (RLE 947702402).
- “It was good that I could search necessary information when I discussed with group members” (RLE 947701705).
- “It was convenient that we could read the contents of online information via hyperlink posted on MSN or blog whenever we needed” (RLE 946023301).

However, some students (12 out of 100) felt a sense of unreality and distance in the virtual classroom. As one student stated:

- “The atmosphere of discussing the issues in a learning community in a computer-supported environment was something unreal … and it distanced us … Although discussing in a face-to-face classroom was more serious and formal…” (RLE 945204001)

Group learning activities

The results of the responses of the peer assessment showed a high percentage of satisfaction with group learning. Most students agreed that group participation was good (81%); peer interaction was good (84%); the content of the discussion was systematic, well-organized, and substantial (80%); the group members all strived to search and collect information (75%); group members were keen on PBL (81%); and group members acquired knowledge to meet learning objectives (86%). According to the attendances, dialogues, and interactions in a group, students had scored with a range from 0 to 10 for each item. The researcher was satisfied with students’ performance in the process of learning because students had scored an average of 22 (with a range from 0 to 30).

Most of the group leaders (9 out of 13, or about 70%) successfully maintained the flow of the learning activities throughout this study. Moreover, a competent leader could enhance learning activities, as one student commented on his group leader:

- “I thought that we did a good job. Thanks to our group leader … We just needed to work according to the plan made by the group leader” (RLE 942423203).

Unfortunately, learning activities in three groups were chaotic for lack of leadership. One student sounded anxious about his absent leader:

- “Where is the leader? Can someone get in touch with him? We cannot present the report in time. What shall we do?” (DVC G4T2030501).

Even though the absence of leadership might cause difficulties for group learning, one group did manage to work without a leader. One member from the group seemed to be calm and encouraged others to continue the group work:

- “Ok! Let’s discuss it ourselves. We are going to assign learning tasks if the leader is absent after two days. What do you think?” (DVC G7T1231104).

Generally speaking, the leader plays an important part in an online learning group. An incompetent leader always causes difficulties for group learning unless an alternate leader emerges.

Conclusions and suggestions

In this study, the researcher developed an online PBL course which was supported by CMC tools of open-source software. MSN, blogs, and wikis were strategically used to build an online environment for students to learn via the PBL approach. With the training in MSN, blogs and wikis they had received prior to participating in web-based
learning, students were able to communicate, discuss, and co-build knowledge from the collected information. Through online communication, they were able to seek solutions to problems in learning activities. Moreover, they perceived participation and interaction in a group as motivation to learn. In general, students were satisfied with the online PBL course. The cost-free CMC tools have proved able to serve the purpose of supporting PBL. The successful experiment of course design in this study can encourage instructors to use open-source CMC or free-hosted CMC services to develop online PBL courses. Effectively integrating these separate CMC tools into a unique interface will be the next task.

This online PBL course is designed to be student-centered for self-oriented learning. To further improve the design of web-based learning, the findings of this study suggested taking blended-learning into consideration because the sense of unreality and distance exists in the virtual classroom. A blended approach with appropriate face-to-face encounters is deemed to be more relevant for students' needs in terms of student-centered learning (Donnelly, 2004). In this study, students presented and shared their group reports in a face-to-face classroom environment at the final stage of PBL. Rovai and Jordan (2007) provided evidence that blended courses would produce a stronger sense of community among students than a traditional or a fully online course do. For further design of the online PBL course, variations in disciplines need to be considered. For example, when particular professional knowledge, such as the medical field, is crucial in the PBL courses, tutors must have inter-disciplinary expertise.

Acknowledgements

This work is supported by the National Science Council, Taiwan, Republic of China, under contract NSC94-2516-S-040-003.

References


