On-line dialogues of college students in a Web Problem-Based Learning (WPBL) context

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ABSTRACT: This study aims to explore how university students solve problems collaboratively in a Web Problem-Based Learning (WPBL) system during a five-week engineering course. In particular, this study used discourse analysis to examine the process and nature of the students' online dialogues in order to understand their cognitive learning in the WPBL system during six PBL tasks: problem confirmation, recognition and discovery, planning, alternatives assessment, construction and evaluation. In addition, the impact of prior academic performance on the online dialogues was examined by comparing differences between the log files of students from two national universities and those from three private universities.

INTRODUCTION

Computer-mediated communication (CMC) has changed the traditional perceptions, and the methods and strategies of teaching and learning because it enables learners to learn regardless of time and space boundaries and in his/her own preferred pace [1-4]. It also allows a learner to organise his/her own learning tasks and contents [5]. CMC also increases opportunities for reflection. Since most CMC discussion is text-based and stored in a computer database, students can always retrieve the data for reflection and discussion. Students are allowed enough time to undertake high-level thinking such as analysis and elaboration. Finally, students share various opinions and gather different perspectives in online forums, and these stimulate thinking and expand insight.

Problem-Based Learning (PBL) originated in 1969 for the study of medicine in Canada, and is now widely accepted and used in other disciplinary areas such as economics, law and psychology [6]. PBL has four features. First, learning has to be student-centred, collaborative and within small groups. Second, teachers are considered to be facilitators, guides or mentors. Third, problems play the role of a vehicle for the development of problem-solving skills. These problems are authentic and unstructured [7]. Fourth, self-directed learning is used to gain new information [7][8]. PBL nourishes the development of *analytic, methodical and transferable skills* and learners' diagnostic skills [6][9]. Given that PBL has always been considered as an instructional approach through which students can build up their life-long learning skills, some argue that it is thus superior to the traditional teaching approach that has always de-contextualised knowledge and focused on large group lectures [8][10][11].

Although both Web- and Problem-Based Learning approaches tend to encourage learners to be more collaborative [6], motivated and self-paced [5][7][10], most research has investigated them separately. Therefore, in this study, the joint effect of Web- and Problem-Based Learning approaches on the cognitive learning process of university students during a five-week WPBL project are investigated. The following research questions directed this study:

1. What is the nature of students' cognitive learning in the WPBL system? In particular, what is the quantity and quality of their online dialogues in the six tasks of PBL: problem confirmation, recognition and discovery, planning, alternatives assessment, construction, and evaluation?
2. Does prior academic achievement influence students' online dialogue? In particular, do students with different levels of prior academic achievement show different quantities and qualities of online dialogues?

METHOD

Thirty college students from five universities in Taiwan, who were majoring in engineering, participated in this experiment. The five universities belong to two principle types of university in Taiwan. One type is the national

technology university. The other is the private technology university. The main difference between the students in these two types of university lies in the students' prior academic performance. The entry exams scores for students in national technology universities are much higher than those of students' in private technology universities. Both types of university were chosen to make up the sample so as to be representative of all college engineering students in Taiwan. Furthermore, this sample allows to compare the online dialogues of students with different levels of academic performance.

Six students were recruited from each university and they were formed into a group to finish a group project - to design and construct a *multi-functional electric vehicle*. The project was designed to last for a five-week period in 2008 according to a model proposed by Lavone, Meisalo and Lattu [12]. Students were required to finish six tasks within six specified periods: 1) *problem confirmation* (22-24 January) involves identifying, formulating, and specifying problems; 2) *recognition and discovery* (25-28 January) refers to searching facts, ideas and resources related to the problem; 3) *planning* (29-31 January) includes setting goals, modifying programs, and building models for solving the problem; 4) *alternatives assessment* (1-5 February) is defined as the generation and evaluation of original and new ideas; 5) *construction* (6-15 February) concentrates on programming and practicing the planned model, and 6) *evaluation* (16-21 February) deals with the testing and debugging of the model.

No formal class curriculum was actively taught (such as by traditional lecture). An instructor and a teaching assistant supervised each group to finish the project. The students were required to use a Web Problem-Based Learning (WPBL) platform regularly to receive course-related information, post and answer questions, interact with their group members, and seek help from the instructor and the teaching assistant. The online interaction was primarily asynchronous and text-based.

Discourse analysis was employed to examine the written interactive language on the Web platform to examine the content structure and process of human communication [13]. Discourse data provided evidence that can be used to trace the learning that occurred, examine the effectiveness of the teaching or provide insight about the learning environment. The full transcripts of the forum discussions over the five-week project constituted the data. The unit of analysis is a message. Randomly analysed were 484 messages (53.9% of the total messages posted online), ranging from one-line comments to multi-page articles. In the analysis, two trained coders independently analysed the transcript according to its major types of dialogue quality (reliability test Holsti R=0.85). The messages were analysed and categorised according to the knowledge-building quality criteria proposed by previous research and the detailed definitions of the dialogue-quality categories are listed in Appendix 1 [14-17].

RESULTS

There were 899 messages in the WPBL platform discussion log. This study randomly analysed 53.9% of them (n=484). Among those messages, 148 (30.6%) messages were copied from other sources. Among the original ones remaining, 83 messages (24.7%) dealt with general discussion and explanations that had no constructive knowledge. In addition, 27 messages (8%) were of organised information from books, websites or other sources. Several messages belonged to the two categories of *Response* (11.3%) and the three categories of *Question* (12.2%). In particular, 23 simple questions (6.8%), 14 clarification questions (4.2%) and four extended questions (1.2%) generated 31 simple answers (9.2%) and seven extended answers (2.1%).

Furthermore, 21 messages (6.3%) focused on complicated problems that required elaboration or further context, and 17 problem-solving messages (5.1%) concentrated on the solutions to those problems that provided an explanation or revision for errors. Meanwhile, 14 brainstorming messages (4.2%) tried to introduce new ideas and innovative opinions to solve the problems and 40 analysis messages (11.9%) proposed the causal relationships among different viewpoints and 6.5 percent of the messages (n=22) indicated reflection on students' own thoughts and feelings. Finally, the students also posted 29 messages (8.6%) for administration purposes.

As shown in Table 1, the 15 types of message were distributed unevenly in the six tasks of PBL, χ^2=188, df=84, p<.001**.** During the problem confirmation task, the students asked a lot of questions (22.5%), which generated many responses (17.5%) and general explanations (17.5%). At the same time, they put a lot of effort into administrative affairs (17.5%).

In the task of recognition and discovery, the students posted 75 messages (15.5% of total messages), where they focused on copying materials from other sources (34.7%), asking questions (14.7%) and proposing the causal relationships among different viewpoints (14.7%). The students were least active in the task of planning (n=39, 8.1% of total messages). When choosing among alternative solutions, the students quoted 18 messages (31%), posted eight analyses (13.8%), seven questions (12%) and six responses (10.3%). In the task of construction, besides quotations (n=12, 26.1%), the students concentrated on elaborating on complicated problems by providing explanation and context (n=8, 17.4%) and proposing relationships among viewpoints (n=5, 10.9%). The students posted most messages (n=226, 46.7% of total messages) within the task of evaluation, during which they made the most general explanations (n=63, 27.9%) and provided quotations from other sources (n=80, 35.7%).

Group differences in terms of webpage viewing, message posting and dialogue qualities are summarised in Table 2. On average, a student from the two national universities visited the Web platform more often (M=118.2) and posted more messages (M=22.3) than students from the three private universities (M=107.5 and M=12.1). However, the average length of the messages posted by the students from national universities is significantly shorter than those posted by the students from private universities (t=-5.24, df =482, p<.001).

Table 1: Frequencies of the categories of dialogues in the six tasks of the WPBL.

	WPBL tasks						
Dialogue-quality type	Problem confirmation	Recognition & Discovery	Planning	Alternatives	Construction	Evaluation	Total
General explanation	7 (17.5%)	3 (4%)	5 (12.8%)	4 (6.9%)	1 (2.2%)	63 (27.9%)	83 (17.1%)
Organisation	2 (5.0%)	7 (9.3%)	2 (5.1%)	1 (1.7%)	2 (4.3%)	13 (5.8%)	27 (5.6%)
Quote	2 (5.0%)	26 (34.7%)	10 (25.6%)	18 (31.0%)	12 (26.1%)	80 (35.7%)	148 (30.6%)
Simple question	6 (15.0%)	3 (4.0%)	3 (7.7%)	5 (8.6%)	2 (4.3%)	4 (1.8%)	23 (4.8%)
Clarification question	2 (5.0%)	6 (8.0%)	2 (5.1%)	1 (1.7%)	1 (2.2%)	2 (9%)	14 (2.9%)
Extended question	1 (2.5%)	2 (2.7%)	0 (.0%)	1 (1.7%)	0 (.0%)	0 (.0%)	4 (0.8%)
Analysis	4 (10.0%)	11 (14.7%)	4 (10.3%)	8 (13.8%)	5 (10.9%)	8 (3.6%)	40 (8.3%)
Elaboration	0 (.0%)	2 (2.7%)	0 (.0%)	4 (6.9%)	8 (17.4%)	7 (3.1%)	21 (4.3%)
Simple response	6 (15.0%)	6 (8.0%)	2 (5.1%)	5 (8.6%)	4 (8.7%)	8 (3.6%)	31 (6.4%)
Explanation response	1 (2.5%)	0 (.0%)	1 (2.6%)	1 (1.7%)	0 (.0%)	4 (1.8%)	7 (1.4%)
Brainstorming	2 (5.0%)	2 (2.7%)	1 (2.6%)	3 (5.2%)	4 (8.7%)	2 (0.9%)	14 (2.9%)
Problem-solving	0 (.0%)	0 (.0%)	3 (7.7%)	5 (8.6%)	0 (.0%)	9 (4.0%)	17 (3.5%)
Reflection	0 (.0%)	2 (2.7%)	2 (5.1%)	1 (1.7%)	2 (4.3%)	15 (6.7%)	22 (4.5%)
Administration	7 (17.5%)	5 (6.7%)	4 (10.3%)	1 (1.7%)	4 (8.7%)	8 (3.6%)	29 (6.0%)
Off task	0 (.0%)	0 (.0%)	0 (.0%)	0 (.0%)	1 (2.2%)	3 (1.3%)	4 (0.8%)
Total	40 (100%)	75 (100%)	39 (100%)	58 (100%)	46 (100%)	226 (100%)	484 (100%)

The students from the two types of university posted a significantly different number of messages in the six tasks of PBL (χ^2 =49.1, df=6, p<.001). In particular, both groups generated the most messages (47.5% and 45.6% for national university and private universities) in the *evaluation* task.

However, the students from private universities posted more messages (16.6% and 17.5%) in the *problem confirmation* and *recognition and discovery* tasks, while students from national universities posted more messages (10.9% and 15.7%) in the *planning* and *alternatives assessment* tasks.

The students from the two types of university also posted significantly different types of dialogue on the Web platform (χ^2 =69.4, df=14, p<.001). The major message categories that were generated by the students from national universities are general explanation (24.7%), quoting other sources (22.1%) and questioning (11.6%), whereas for students from private universities, the major categories were quotation (41%) and analysis (8.3%).

Table 2: Group difference in online discussion: webpage viewing, message posting and dialogue qualities.

	National universities	Private universities
Frequency of viewing the webpages (per group, n=6)	709	644.7
Number of posted messages (per group, n=6)	133.5	72.3
Average length of the messages	93.4	156.9 t= -5.24, df=482, p<.001
Dialogue quality	χ^2 =69.4, df=14, p<.001	
General explanation	66 (24.7%)	17 (7.8%)
Simple question	16 (6.0%)	7 (3.2%)
Clarification question	12 (4.5%)	2 (0.9%)
Extended question	3 (1.1%)	1 (0.05%)
Simple response	22 (8.2%)	9 (4.1%)
Explanation response	6 (2.2%)	1 (0.5%)
Organisation	10 (3.7%)	17 (7.8%)
Analysis	22 (8.2%)	18 (8.3%)
Elaboration	9 (3.4%)	12 (5.5%)
Brainstorming	10 (3.7%)	4 (1.8%)
Problem-solving	11 (4.1%)	6 (2.8%)
Reflection	5 (1.9%)	17 (7.8%)
Administration	12 (4.5%)	17 (7.8%)
Quote	59 (22.1%)	89 (41%)
Off task	4 (1.5%)	0(.0%)
Total	267 (100%)	217(100%)
PBL tasks	χ^2 =49.1, df=6, p<.001	
Problem confirmation	4 (1.5%)	36 (16.6%)
Recognising and finding	37 (13.9%)	38 (17.5%)
Planning	29 (10.9%)	10 (4.6%)
Alternatives	42 (15.7%)	16 (7.4%)
Constructing	28 (10.5%)	18 (8.3%)
Evaluating	127 (47.5%)	99 (45.6%)
Total	267 (100%)	217 (100%)

DISCUSSION AND CONCLUSIONS

The students posted a large number of messages in the WPBL platform. Of the 899 messages posted, only 0.8% were chat (off task). This demonstrates that the interaction of the WPBL is primarily task-oriented. In this study, the problem-solving activities were classified into six tasks. Over the five-week period, the students generated the most messages in evaluating the project, recognising and finding related materials, and the least messages in identifying problems and planning the project.

Online dialogue is an interactive and dynamic process, in which questions and responses influence each other. Asking and answering questions mainly occurred in the first four tasks, especially in problem confirmation and choosing among alternative plans. This reveals that the Web platform is effective for communication. Messages that were quoted from other sources constituted a large portion of the total messages, which indicates that the platform is a good place for sharing and storing viewpoints from diverse sources.

The results show that the students most often dealt with general discussions and explanations that had no constructive knowledge, proposed related or contrasting viewpoints (analysis), and integrated information from various sources (organisation). Much less often, they introduced new ideas or innovative opinions to solve problems (brainstorming), provided explanations or revision for errors (problem-solving), elaborated and contextualised complicated problems (elaboration), and examined their own thoughts or feelings (reflection). Comparatively speaking, the least frequently used types of dialogue require higher levels of cognitive ability, which are more difficult to cultivate. This finding is consistent with previous findings that students have difficulties benefiting from self-directed situations, especially in complex projects [18].

The students with better academic performance used the Web platform more often and posted more messages. Compared to students with poorer academic performance, they posted more messages in the tasks of planning and generating alternatives but posted fewer messages in the tasks of problem confirmation. They asked and answered more questions online and quoted fewer messages from other sources.

This study had at least two limitations. First, when designing the experiment based on the six tasks, this study only focused on the major linear patterns and might have ignored some dynamic procedure of the problem-solving process.

The second limitation is that the finding was only based on the dialogue file of thirty students from five different universities. These findings need to be generalised with caution. A future study could test the results by using larger and more representative samples.

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Appendix 1: Categories of dialogue quality in the on-line discussions.

Categories		Illustration	Examples
General Explanation		This category deals with general discussions and explanations that have no constructive knowledge.	*I think that if all members are together, it's time to begin…*; *Now I realise what you thought before…*
Organisation		This category organises and integrates information from books, websites or other members' thought.	*Download this file; it will benefit your learning and engineering drawing…*; *This is a list of reference books…*
Question	simple	This category deals with simple questions that usually generate short answers.	*What does* keeping original status *mean?*
	for clarification	This category deals with clarifying information concerning questions asked or answered	*I don't totally understand what your question is; could you give me the circuit?*
	extended	More expansive than a simple question and usually generates more than a simple response. Because the question may not be very clear initially, a QC may be invoked.	*This idea is good, but how to design and make it?*
Analysis		Students propose the related or contrasting viewpoints	*In order to make this function possible, we need a timer…*; *It is possible! Because we used dry batteries so that…*
Elaboration		Focuses on a complicated problem and provides elaboration or context about it.	*Now we are going to test the function that when someone pushes the button, the seven-segment display will show their team number…*
Response	simple	A short reply to a certain topic or other peers' response as a simple feedback or praise to others' contributions.	*It is because of a contact fault*.
	explanation and/or elaboration	More detailed and expansive than a simple response.	*If you forget to add an electric resistance, the seven-segment display will be broken*
Brainstorming		Attempts to introduce new ideas or provide innovative opinions to solve the problem.	*In an article, I read that either solar energy or wind energy can generate electricity; we can try to use one of them on our car*.
Energy Problem-Solving		Solution to certain questions; usually providing an explanation or revision for errors.	*The solution is to change the original electric resistance to 220Ω*
Reflection		The process of examining their own thoughts or feelings on the dialogue of team discussions.	*When using this platform, we can connect and discuss with others at home. So it's helpful to learn*.
Administration		Management of affairs of the project, such as arranging meeting, writing reports, and monitoring the progress	*We need to upload the title and research purpose of our project by the end of this month. Please think about this*.