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The process, dialogues, and attitudes of vocational engineering high school students in a web problem-based learning (WPBL) system

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This study aims to explore how high school students collaboratively solve problems in a web problem-based learning (WPBL) system in an 8-week digital logic course using discourse analysis. Employing in-depth interviews, this study also investigated the students’ attitudes toward the WPBL system. The number of teaching assistants’ responses had a negative relationship with the number of peer responses. Regarding dialogue quality, extended questions and brainstorming stimulated each other. Elaboration facilitated problem solving, whereas organizing knowledge from books or websites decreased reflection. Students affirmed the usefulness and effectiveness of the web system because it created an interactive, flexible, comfortable and collaborative learning environment.

Keywords: engineering education; computer-mediated communication (CMC); problem-based learning (PBL); web problem-based learning (WPBL); dialogue quality

1. Introduction

Traditional pedagogical approaches, such as simple or face-to-face lecturing, seem to be less attractive than before. This unattractiveness results partly from the wide use of computer-mediated communication (CMC). Some argue that CMC has changed traditional perceptions, methods and strategies of teaching and learning (Lin & Hsieh, 2001; Wang, Huang, Jeng, & Wang, 2008). One of the most obvious changes is in the transformation of traditional courses into electronic forms (Oliver & Omari, 2001).

Three characteristics of CMC have sustained this transformation. The first one is that CMC enables learners to learn regardless of time and space boundaries and in his/her own preferred tempo (Şendağ & Odabaşı, 2009; Van Merriënboer & Brand-Gruwel, 2005). In other words, the relationship between teachers and learners is entirely shifted from the teaching paradigm to a learning paradigm, making the teacher become a facilitator or a manager (Pahl, 2003). It allows a learner to

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organize his/her own learning tasks and contents (Van Merriënboer & Brand-Gruwel, 2005). No matter what has been defined as web-based learning (Oliver & Omari, 2001; Wang, Huang, Jeng, & Wang, 2008), computer-based learning (Pahl, 2003) or e-learning, this new learning module creates a different way in which learners perceive learning, allowing them to take control of and be responsible for their own learning (Shih, Feng, & Tsai, 2008). Ariely (2000) observed that greater control of information was generally connected with better memory and learning. The second characteristic is that CMC increases reflection opportunities. Since most CMC discussion is text-based and stored in a computer database, students can always retrieve the data for reflection and discussion. They have enough time to process high-level thinking like analysis and elaboration. Finally, students share various opinions from different perspectives in online forums, which stimulate thinking and expand vision.

Another important reason that detracts from traditional pedagogical approaches is the appearance of problem-based learning (PBL). PBL is a strategy of instruction in which students are assigned to collaboratively solve problems. Even though various forms of PBL are found in traditional education practices, in assessments such as situation judgment tests, and many other forms, it has now been widely accepted and extensively used in disciplinary areas such as medicine, economics, law and psychology (Perrenet, Bouhuijs, & Smits, 2000; Stewart, MacIntyre, Galea, & Steel, 2007). PBL has four features. First, learning has to be student-centered, collaborative and in small groups. Second, teachers are considered to be facilitators, guides or mentors. Third, problems play the role of the vehicle for the development of problem-solving skills and the problems are authentic and unstructured (Secundo, Elia, & Taurino, 2008). Fourth, self-directed learning is used to gain new information (Dochy, Segers, Den Bossche, & Gijbels, 2003; Secundo et al., 2008). PBL nourishes the development of “analytic, methodical and transferable skills” (Kolmos, 1996, p. 144) and learners’ diagnostic skills (Stewart et al., 2007). Given that PBL has always been considered 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 decontextualized knowledge and focused on large group lectures (Dochy et al., 2003; Oliver & Omari, 2001; Perrenet et al., 2000; Prince, 2004).

At the same time, PBL has been criticized for its weaknesses. For example, the knowledge learned with PBL may be too contextualized and not abstract enough for good generalization to other knowledge. In addition, during the early stages of learning, novice learners may find it difficult to process large amounts of information in a short amount of time (Kirschner, Sweller, & Clark, 2006). Thus the rigors of active problem solving may become an issue for the students. Therefore, to avoid these issues when designing a PBL course, sufficient back-up assistance from teachers should be accessible to learners, especially during the early stages of PBL.

The aforementioned overview reveals the fact that both web- and PBL-approaches have some similar advantages over the traditional learning approach. Compared to the traditional approach, these two approaches tend to encourage learners to be more collaborative (Özmen, 2008; Stewart et al., 2007), motivated (Lim, 2005; Oliver & Omari, 2001; Shih et al., 2008) and self-paced (Secundo et al., 2008). Web- and PBL- approaches are constructivist approaches, as they motivate learners to actively construct knowledge with a greater depth of understanding (Rosen & Salomon, 2007; Stewart et al., 2007). In the constructivist learning model,
learners learn better because they communicate with their peers, find information beyond textbooks, discover things for themselves, pose relevant questions and research possible answers. Knowledge is constructed by learners, rather than given by instructors (Lin & Hsieh, 2001). Given that web- and PBL- approaches have been drawing more attention than older instructor-centered ones in recent years, it can thus be argued that educational epistemologies are shifting from traditional pedagogy that emphasizes the memory of a body of knowledge and procedural questions to a constructivist one that focuses on pursuing personal understanding and asking deep domain-specific questions (Hung, Tan, & Koh, 2006).

Although both web- and PBL- approaches have some commonality, most research has investigated them separately. The combination of these two approaches points to a new direction for constructive learning. Furthermore, relevant research has long been confined to higher education rather within K-12 populations (Goodnough & Hung, 2008; Hmelo-Silver, 2004), even though CMC and PBL have been gradually applied to high school engineering education. Taiwan has gradually adopted a dual educational system consisting both of vocational high schools and normal high schools. Finally, when investigating the PBL and CMC approaches, previous studies have usually investigated the students’ behavior for a short period of time or examined the learning outcomes at a cross-sectional point. In contrast, genuine school-teaching context and longitudinal data could largely increase the validity of studying the process and nature of WPBL learning. Therefore, in this study, we investigated the joint effect of web- and PBL- approaches on high school students in an 8-week digital logic course. Additionally, this course was designed to integrate collaborative learning processes, web- and PBL- processes. It was proposed to allow students not only to learn collaboratively via CMC, but also to take the initiative of their learning through PBL approach.

The following specific questions directed this study.

1. What is the process of K-12 students’ collaborative problem solving activities in the web problem-based learning (WPBL) system?
2. What is the nature of their cognitive learning in the WPBL system? In particular, what is the quantity and quality of their online dialogues?
3. What are the students’ attitudes toward the WPBL system in terms of its usefulness in the PBL learning?

2. Methods

2.1. Participants
Thirty-five engineering students from a national engineering vocational high school in Taiwan were involved in this study. Twenty-eight of them are males. They are divided into six teams that will each finish a group project. The subject of the one-semester course is “Digital Logic”. Besides classroom instruction, they are required to use a WPBL platform regularly to receive course-related information, post answers to questions, interact with their group members, and seek help from teaching assistants.

Figure 1 shows the main page of the platform. This e-learning platform is characterized by collaborative interaction and with openness to time, space, and objective (Chen, 2009). Compared with common e-learning platforms (Chen, 2009),
teaching assistants play a more active role in WPBL. Three teaching assistants in turn monitored the discussion forum constantly, answering questions, posting relevant information, and providing guidance according to the students’ PBL progress. The online interaction is primarily asynchronous and text-based.

Researchers indicated that the traditional e-learning is somewhat problematic (Shen, Lee, & Tsai, 2008). In the traditional e-learning system, a web-learning platform was utilized simply as a vehicle to store instructional materials, demonstrate in-class activities, and showcase projects. Additionally, the traditional e-learning is considered as teacher-centered which students receive teacher’s instructions passively. Research showed that in some engineering courses, students acquired related declarative knowledge and then applied some of the acquired knowledge to simple exercises (Khoumsi and Hadjou, 2005). Since they merely learned and utilized a portion of knowledge and experiences needed in real-life scenario, it might not be practical for pupils to put what they learned in class into practice. However, the WPBL was evidenced to provide a highly-motivated and absorbing environment for students (Jonassen & Murphy, 1999). Additionally, the WPBL was confirmed to improve students’ skills for solving ill-defined problems in real-life situation which is one of the most essential characteristics that vocational students should equip with (Lee & Kim, 2005). In the WPBL, with the teaching assistant’s mentoring, students were asked to post their project-related discussion on the website. Most importantly, the students formed a learning community which to collaborate with members, monitor, and evaluate their progress (Ahlberg, Kaasinen, Kairola, & Houtsonen, 2001; Barrows, 2002). Furthermore, the students were able to take control of their learning and to explore information, define problems, find solutions, and finally solve problems.

Every group is assigned to a final project – to design a game show buzzer machine. The purpose of this assignment is to investigate how the students used the
web platform to transfer the classroom-learned knowledge to the design of the buzzer machine. At the end of the experiment, four experts were invited to evaluate the quality of the final project produced by each group based on four dimensions: the quality of the problem-solving steps, the interaction among team members, the quality of the buzzer created and the quality of their reflection on the learning processes. The total scale was 100 points. The internal consistency (Cronbach’s $\alpha$) among the four experts is 0.86. These scores were used to relate the quality of each group’s online dialogue and their interview data assessing the WPBL. Even though there are only six groups, this gives the readers an idea of whether the grades correlated in any way with the qualitative results.

2.2. Discourse analysis – dialogue process, type and quality

Discourse analysis is a qualitative approach drawn from linguistics, which involves the explicit analysis of spoken or written interactive language to examine the content structure, and process of human communication (Lapadat, 2007). Discourse data provide 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 8-week course constituted the data. The unit of analysis is one message. There were 845 messages in total, ranging from one line comments to multi-page articles. In the analysis, three trained coders independently analyzed the transcripts, including three components of online dialogues: the tasks of the PBL process, dialogue type and dialogue quality. Therefore, every message is coded into these three variables. They co-coded 212 random messages (25% of the total) and got an average percent agreement of 80.9% and a range of agreement from 57.6% to 100%. Holsti’s formula (1969) produced a reliability coefficient of 0.93 across all categories among three coders.

The first variable is the task of the process. The students’ collaborative problem-solving processes are divided into six tasks: problem, recognizing and finding, planning, alternatives, constructing and evaluating. This categorization was proposed by Lavonen, Meisalo, and Lattu (2002), who videotaped, edited and classified the process of the collaborative problem solving of 8th-grade pupils in a controlled technology learning environment. According to them, problem involves identifying, formulating, and specifying problems. Recognizing and findings refers to searching facts, ideas and resources related to the problem. Planning includes setting goals, modifying programs, and building models for solving the problem. “Alternatives” is defined as the generation and evaluation of original and new ideas. Constructing concentrates on programming and practicing the planned model. At last, evaluating deals with the testing and debugging of the model. The inter-coder reliability is 0.89. Students were also required to self-report the collaborative process of their WPBL. Their reports were used to improve the validity of the coding results.

The two major types of dialogues include: cognitive and non-cognitive messages. Cognitive messages focus on the subjects of their study and responses to the subject-based discussion, while non-cognitive messages are either irrelevant to the study subjects or repeat the statement of others. The inter-coder reliability is 1.

Cognitive messages were further analyzed and categorized according to the knowledge-building quality criteria proposed by Bodzin and Park (2000). A detailed definition of 12 categories of dialogue quality is presented in Table 1. Two-tailed
Pearson correlations were calculated to probe the relationships between the two types of dialogue and among the categories of dialogue quality. It is worthy to note that there are only six teams constituting a very small sample size in this study (\(N = 6\)). For this reason, the statistical results mainly serve an exploratory purpose,
which started a new track for future study to test with large and representative samples. The intercoder reliability is 0.86.

The quantity of online dialogue provides a more accurate description of the learning process, helps to examine the relationships among different dialogue qualities, and aids in predicting the scope and degree of the potential impact of different types of dialogue quality.

2.3. In-depth interview – students’ attitudes

Another source of data came from in-depth interview. After the course was finished, each student was interviewed for about 30 min to probe his or her attitudes and feeling toward the WPBL system. The questions were “After applying the WPBL system to the digital logic course, please evaluate its usefulness in improving your learning process”, “Why do you think the WPBL system is useful or if not, why?” and “Please evaluate the function and design of the WPBL system.” Taking the data labels of S1A001 or S1B002 as an example, “S1” represents the 1st team of the students; “A” or “B” represents the first or second respondent; “001” or “002” represents the sequence of responses.

3. Results

3.1. The process of collaborative problem solving on the WPBL platform

The frequencies of the tasks in the WPBL over the 8 weeks are presented in the matrix of Table 2. It took the students six days to identify, formulate, and specify the problem of the game-show-buzzer-machine project. Then, they spent 8 days on searching facts, ideas and resources related to the problem. They worked for 11 days on planning the project including setting goals, modifying programs and designing models. After discussing new and original alternatives for 12 days, they began to draw circuit figures and built the buzzer machine in the next 11 days. In the end, they spent 8 days in testing and debugging their model machine. Among the six stages, the longest time was spent on the stages of planning, discussing alternatives and constructing. It was shown that the students spent the least time on identifying the problem and evaluating their buzzer machine. It is possible that, at the beginning and end of the semester, they felt the most time pressure than at the middle stages.

<table>
<thead>
<tr>
<th>The level of problem solving</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
<th>Week 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem</td>
<td>6 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recognizing and finding</td>
<td></td>
<td>8 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td></td>
<td></td>
<td>11 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative</td>
<td></td>
<td></td>
<td></td>
<td>12 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constructing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11 days</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8 days</td>
</tr>
</tbody>
</table>

Table 2. Frequencies of the categories of tasks in the proceeding of the WPBL.
3.2. Types of messages on the WPBL platform

Totally, there were 845 messages in the WPBL platform discussion log, among which 785 (93%) messages are cognitive and the remaining 60 (7%) messages are irrelevant to the course subject or repeated the statement of others. Among those cognitive ones, 238 (28.2%) messages initiated discussion on new topics; 469 (55.5%) messages are responses from peer students, and 79 (9.4%) messages are responses from teaching assistants and the course instructor. A large proportion of relevant messages mean, to a certain extent, that most students regarded the WPBL platform as a tool for learning rather than a room for chatting.

Pearson correlations in Table 3 show the relationships among message types. The number of peer responses has a significantly negative relationship with the number of TA responses \(r = -0.81, p = 0.049\). This means that if a team received more responses from the teaching assistants, its group members would respond to each other less, suggesting that increased responses provided by the teaching assistants may result from or lead to decreased responses from peer group members.

3.3. Dialogue quality on the WPBL platform

Based on previous studies (Bodzin & Park, 2000; Klein & Doran, 1999), 12 categories (defined in Table 1) were used to analyze the quality of the cognitive messages shown in the platform. The results show that 85 messages (10.8%) dealt with general discussion and explanations which had no construction of knowledge. Additionally, 49 messages (6.2%) organized information from books, websites or other sources. Most messages belonged to the two categories of “Response” (29.6%) and the three categories of “Question” (19.6%). In particular, 62 simple questions (7.9%), 26 clarification questions (3.3%) and 66 extended questions (8.4%) generated 141 simple answers (17.9%) and 92 extended answers (11.7%). Furthermore, 40 messages (5.1%) focused on complicated problems which required elaboration or context about them, and 75 messages (9.5%) concentrated on the solutions to those problems which provided an explanation or revision for errors. Meanwhile, 36 messages (4.6%) tried to introduce new ideas and innovative opinions to solve the problems and 60 messages (7.6%) proposed the causal relationships among different viewpoints. Finally, 6.9% of the messages indicated reflection on students’ own thoughts and feelings.

Pearson correlations in Table 4 yield several significant results. First, general discussion and explanation is positively and significantly associated with extended questions \(r = 0.91, p = 0.01\) and analysis \(r = 0.85, p = 0.03\). That is, when a group had more general discussion and explanation, it generated more complicated questions like why and how, as well as more viewpoints on cause-effect relationships.
Table 4. Pearson correlations among different dialogue quality categories.

<table>
<thead>
<tr>
<th></th>
<th>Organization</th>
<th>Simple</th>
<th>Clarification</th>
<th>Extended</th>
<th>Analysis</th>
<th>Elaboration</th>
<th>Simple</th>
<th>Extended</th>
<th>Brainstorm solving</th>
<th>Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explanation</td>
<td>0.423</td>
<td>0.581</td>
<td>-0.228</td>
<td>0.913*</td>
<td>0.848*</td>
<td>0.531</td>
<td>-0.649</td>
<td>-0.356</td>
<td>0.799</td>
<td>0.675</td>
</tr>
<tr>
<td>Organization</td>
<td>0.028</td>
<td>-0.490</td>
<td>0.166</td>
<td>0.352</td>
<td>-0.201</td>
<td>-1.144</td>
<td>0.217</td>
<td>-0.148</td>
<td>-0.033</td>
<td>-0.070</td>
</tr>
<tr>
<td>Simple question</td>
<td>0.375</td>
<td>0.543</td>
<td>0.429</td>
<td>0.376</td>
<td>-0.144</td>
<td>0.067</td>
<td>0.223</td>
<td>0.443</td>
<td>0.223</td>
<td>0.443</td>
</tr>
<tr>
<td>Clarifying question</td>
<td>-0.152</td>
<td>0.107</td>
<td>-0.223</td>
<td>0.099</td>
<td>0.154</td>
<td>-0.228</td>
<td>-0.228</td>
<td>-0.110</td>
<td>0.380</td>
<td></td>
</tr>
<tr>
<td>Extended question</td>
<td>-0.097</td>
<td>0.707</td>
<td>0.427</td>
<td>-0.698</td>
<td>-0.615</td>
<td>0.875*</td>
<td>0.525</td>
<td>-0.078</td>
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<td></td>
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<tr>
<td>Analysis</td>
<td></td>
<td></td>
<td></td>
<td>-0.724</td>
<td>-0.243</td>
<td>0.707</td>
<td>0.628</td>
<td>-0.276</td>
<td></td>
<td></td>
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<tr>
<td>Elaboration</td>
<td></td>
<td></td>
<td></td>
<td>-0.634</td>
<td>0.345</td>
<td>0.605</td>
<td>0.954**</td>
<td>0.134</td>
<td></td>
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<tr>
<td>Simple response</td>
<td></td>
<td></td>
<td></td>
<td>0.298</td>
<td>-0.935**</td>
<td>-0.741</td>
<td>-0.353</td>
<td>-0.072</td>
<td></td>
<td></td>
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<tr>
<td>Extended response</td>
<td></td>
<td></td>
<td></td>
<td>-0.492</td>
<td>0.278</td>
<td>0.686</td>
<td>0.182</td>
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<tr>
<td>Brainstorm</td>
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<tr>
<td>Problem solving</td>
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<tr>
<td>Reflection</td>
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</table>

Note: *Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed); N = 6.
relationships. In addition, brainstorming is positively and significantly correlated to extended questions ($r = 0.88$, $p = 0.02$) but is negatively and significantly correlated to simple responses ($r = -0.94$, $p = 0.006$). This means simple responses might result from or lead to reduced introduction of new ideas and innovative opinions. By contrast, extended questions and brainstorming stimulated each other.

Moreover, elaboration is positively and significantly correlated to problem-solving ($r = 0.95$, $p = 0.006$). Providing elaboration and context to a complicated problem helped to reach a solution for that problem. An interesting finding was the negative and significant association between organization and reflection ($r = -0.95$, $p = 0.003$). A group, who organized and integrated more knowledge from books, websites or other sources, was less likely to examine their own thoughts and feelings.

No significant correlation was found between the scores of the final project and the frequency of any type or quality of the online dialogue. That is, the groups who achieved higher scores (above 85 out of 100) did not post significantly different types of dialogue on the WPBL system from what the groups who achieved lower scores (below 85) posted.

The three TAs and the instructor only posted 85 messages total, mainly during the tasks of “recognizing and finding” (27.1%) and “evaluating” (37.6%). Most of the messages were general explanations (72.9%) and asking questions (17.7%). Throughout the process of WPBL, the teaching assistants played an important role in helping student define, understand, and determine the scope of the problem by providing explanations, asking questions and supervising the schedule.

### 3.4. Students’ attitudes to the WPBL

The results of in-depth interviews show that the students held highly positive attitudes toward the WPBL system, regardless of their quality of problem solving. Most of them affirmed that the platform helped them to study. They mentioned four reasons for this. The first one referred to the increased interaction with the instructor and/or TAs on the platform, where students received fast and specific guidance from them. This assistance positively facilitates students’ self-learning motivation and capabilities by offering students a feeling of security and satisfaction. As one of the students claimed, “the WPBL platform allowed us to keep learning because … TAs usually provided us with advice on questions we posted on the platform” (S4A008). Another student said that as long as questions appeared on the platform, their teacher would “give us some suggestions, and tell us how to resolve the difficulties straight away” (S3A104). One student confessed that their teacher helped them “carry on learning” (S4A029). In addition, they perceived that their instructor became more “easy-going and humorous” while on the platform (S6B096).

Secondly, the convenience of the platform promoted students’ positive learning attitudes. For most of the students, not only did the function of the platform attract them but also its mobility, because they could get on the platform wherever they were and whenever they wanted. As one of the students revealed, “the platform helped us, in a sense, that it allowed us to learn not only at school but also at home”. He further said that “we posted what we were not sure about at school onto the website to ask for help and advice … in this case, we think that we learned more things not at school, but at home because the system allowed us to do that” (S4B089). One of the advantages of this mobility was its efficiency because “the teacher usually provided his opinions a few minutes after the questions were posted” (S3A123).
The comfortable atmosphere created by this virtual platform was the third factor influencing students' learning attitudes. It is believed that as long as students feel at ease and comfortable with the platform, they are more likely to use it, allowing more things to be learned through it. The WPBL platform in this study gave comfort to the students as some of them claimed that they felt “relaxed” (S3A177), “happy and a sense of achievement... because it was interesting” (S6A152). Another student said: “that sort of thing (the platform) released our stress to some degree... on which all of us interacted with each other, making us more coherent” (S4A183). They were also more willing to ask the instructor questions because “(when others saw my questions) I was not there, it's just impossible for me to raise hand and ask the same question in front of the class” (S6B091). It can be said that the WPBL system encouraged students to learn by creating a supportive and comfortable atmosphere.

Finally, the WPBL system encouraged cooperative knowledge sharing among peer students. The WPBL task of designing a game show buzzer machine provided students an opportunity to cooperate with each other. To complete the task, relevant knowledge of digital logic was shared, reviewed and discussed together. For instance, a student revealed that some study materials can be “found and downloaded from the website. We don’t need to print them out, we just put them on the platform where our team could share, review and discuss them, and then decide where to go or what to do next... As long as we got some problems, we searched relevant information through the internet, posted them onto the platform, discussed them with the team members, and then resolved the problems together” (S3A026). Another student claimed that the platform “nourished discussions among each other... so that it can be seen as a form of collective collaboration”. The student further stated that “in fact, this collaborative form had several advantages, one of which was pressure release” (S5A009). “We got help and knew more after our questions were posted and discussed on the platform” (S5A066).

4. Discussion and conclusions

In this study, the problem-solving activities were classified into six tasks. Over the 8-week period, the students spent the most time on planning, discussing alternatives and constructing, and the least time on identifying problems and evaluating their buzzer machine. It is possible that, at the beginning and end of the semester, they felt the most time pressure than at the middle stages. These results are consistent with the findings of Tseng, Chiang and Hsu’s study (2007), in which students spent a similar length of time on problem, recognizing, finding, and constructing. In contrast, Tseng et al.’s experiment design lasted only for 5 weeks, in which students reduced the time they spent on planning, discussing alternatives and evaluating. This suggests that under time pressure, students would spend less time on these tasks. Even though this study reports the general pattern of this process, it is noteworthy that most problem-solving processes are not completely linear (Lavonen et al., 2002). When students met difficulties in the later stages, they return to the initial stages such as redefining problems or finding additional information.

The students and teaching assistants posted a large number of messages in the WPBL platform. Of the 845 messages posted, most were related to the course subject, and only a very small portion was irrelevant. This demonstrates that the students behaved in a mature way and focused on the task by keeping unrelated or “nonsense” messages at a minimum. This result was in line with earlier studies which
claimed that interaction in the context of PBL is primarily task oriented (Chanlin & Chan, 2004; McAlpine & Stothard, 2005; Yang & Liu, 2004). The WPBL provided the students a useful tool to accomplish the task, where the students reviewed, shared, and discussed relevant knowledge.

Online dialogue is an interactive and dynamic process in which responses influence each other. This study found that the number of TA responses had a negative relationship to the number of peer responses. That is, increased responses provided by the teaching assistants may result from or lead to decreased responses from peer group members. These results showed that the teaching assistants applied the scaffolding pedagogical ideas proposed by Vygotsky (1978) on the platform. When the students were inactive in the discussion, the teaching assistant would post comments to stimulate their motivation, provide demonstration, point out key issues in their projects, and direct their focuses. However, when the students grew active and capable in their projects, to let them become independent learners, the teaching assistants would gradually reduce the scaffolding (Mercer & Fisher, 1997).

Compared to traditional PBL, it is suggested that TAs in the WPBL act like supervisors or managers by monitoring the students’ problems, online dialogues, and learning progress, allowing them to take control of and be responsible for their own learning. The assistance in the six tasks, especially in defining, recognizing and evaluating the problem should be continuously available throughout the PBL process. Unlike the traditional PBL, the number of teaching assistant’s responses had a negative correlation with the number of peer responses in this study. This particular result can be explained by the roles of teaching assistants in this course. As mentioned, the teaching assistants played as an authority figure to supervise students’ performance. That is possible that students might feel intimidated to answer teaching assistants, when the teaching assistants gave any directions or comments. Furthermore, more research can be conducted to investigate this finding, especially, with the different samples from other Asian countries.

This study also found several important findings in terms of the quality of cognitive messages shown in the WPBL platform. Even though questions and responses made up the biggest proportion of the cognitive messages, they did not significantly correlate with each other. Instead, when a group asked more complicated questions like why and how, it made more general discussion and explanation, and generated more viewpoints on cause–effect relationships. These three categories of dialogue seemed to grow gradually from simple to complex in the cognitive process. In addition, extended questions and brainstorming stimulated each other. When there were no new ideas generated in the system, students tended to give simple responses. On the other hand, simple responses may also stifle the production of innovative opinions. This study also found that a complicated problem was more likely to be solved if it was elaborated on and contextualized to a deeper degree. When a group concentrated more on organizing knowledge from books or websites, its members tended to neglect the reflection on their own thoughts and feeling.

The interview data also provide insights on the students’ thoughts and feelings about the WPBL. Because the WPBL system provided students an interactive, convenient, comfortable and cooperative context for study, it is regarded as a catalyst for learning. This finding is consistent with previous literature (Atan, Sulaiman, & Idrus’s, 2005; Dunlap, 2005; Girasoli & Hannafin, 2008; Liu, 2004;
Schwartz, Webb, & Mennin, 2001). The students mentioned at least three reasons why the WPBL system encouraged learning. First, the platform facilitates interaction and cooperation among group members. In order to resolve problems, students need to communicate and cooperate with each other. The students were asked to resolve problems at hand, implying that the interaction and cooperation among them was task-oriented. When they tried to acquire knowledge from available resources, they became independent learners because they needed to go through the processes of exploring, analyzing, reasoning, and decision-making (Büttün 2005; Chanlin & Chan, 2004).

The other issue for the students was that the WPBL system provided a safe and convenient learning environment. With the involvement of the instructor and the TAs, the system let students feel secure and comfortable, making them more willing to learn. The WPBL environment allowed interaction not only among students but also between students and the instructor/TAs. In this kind of environment, the students had more chances to participate in a learning community (McLinden, McCall, Hinton, & Weston, 2006). The convenience of the system allowed the students to access the system anytime and anywhere, which provided a free environment where learning became easier and spontaneous. Increased availability of knowledge generates more sharing among the students.

Unlike the traditional e-learning system, the WPBL in this study created a student-centered environment. The professional knowledge can be constructed by students with teacher’s facilitating and teaching assistant’s monitoring. The WPBL was not only to allow students to interact, collaborate, and share their experience and knowledge at users’ convenience, but also to retain the advantages of PBL which to motivate students and to promote self-regulated learning (Gale, Wheller, & Kelly, 2007; Lee & Kim, 2005).

This study has at least three limitations. The first one is in the exploration of the collaborative process of the WPBL. As mentioned earlier, this study did not consider the dynamic (nonlinear) processes in problem solving. Instead, it focused on the major linear pattern in the 8-week longitudinal process. The second limitation is the small sample size (n=six groups) on which the Pearson correlations were calculated. Even though 35 students participated in this study, because the unit of analysis is a group, only six groups formed the sample. The small sample size restricts the generalizability of the statistical results. Future study may test the correlation results with larger and more representative samples. The final limitation lies in the in-depth interview which failed to use interview questions to examine the relationships among different dialogue categories. An example of such a question could have been: “Did you find extended questions useful to stimulate brainstorming when your group discussed the project online?” This deficit results partly from the fact that the in-depth interview was conducted after the course and before the discourse analysis. Based on the findings of this study, future research can certainly avoid this limitation.

The new trend in the Web 2.0 concept emphasizes the correlation between topics and students. Further, the interaction of students in the Web 2.0 environment can be more enthusiastic than in traditional online forums. Further research could study this facet by utilizing Web 2.0 applications.

Furthermore, research on PBL highlights the importance of authentic interaction with the issue. Another facet of this study could develop mobile-based system that allows students to interact directly with the problem or the environment.
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