A team-teaching model for practicing project-based learning in high school: Collaboration between computer and subject teachers

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**Abstract**

Project-based learning (PBL) is a highly effective means of motivating students to learn independently. However, training or encouraging teachers to practice PBL in their classrooms is challenging, especially if the educational system does not accommodate creative teaching practices. In particular, in a test-driven educational system, time constraints and an excess of teaching content make it difficult to practice PBL at the high school level. This work presents a novel team-teaching model that is based on collaboration between subject teachers and the computer teacher to facilitate PBL in the classroom. A two-year experiment was conducted to study the feasibility of the proposed model, in which the school computer teacher conducts PBL with the 10th grade students in the first year, and subject teachers conduct PBL with the 11th grade students in the second year. Experimental results indicate that the proposed model is feasible in the given educational setting. No class time was lost, and the subject teacher successfully conducted PBL activities. Furthermore, a follow-up survey indicated that the students enjoyed the PBL activities in both classes.

**1. Introduction**

The effectiveness of the conventional models of education has been a focus of research over the years (Chai & Tan, 2009; Savery & Duffy, 1995; Solomon, 2003). Passive learning by students has motivated educators constantly to seek innovative ways to motivate students and improve learning outcomes (Finn, 1991; Hafner & Ellis, 2004; Lewis, Alacaci, & O’Brien, 2002; Marina, 2009). Project-based learning (PBL) was introduced in the early twentieth century to motivate student self-learning (Kilpatrick, 1918). The PBL method calls for learners to acquire and develop core learning concepts through collaborative projects that require the learning and application of contextual knowledge. The literature has shown that PBL enables students to become interactive learners (Blumentfeld et al., 1991; Lin & Hsieh, 2001; Synteta & Schneider, 2002) and to construct knowledge through exploration (Edward, 1995; Jang, 2006a; Johnson & Aragon, 2003; Prince & Felder, 2007). Recent PBL studies have described the use of new technologies to different ends. PBL has proven particularly effective when combined with computer technology (Barron et al., 1998; Edelson, Gordin, & Pea, 1999; Solomon, 2003; Stites, 1998). Given the growing pervasiveness of the Internet, technology is now a major tool in PBL (Land & Greene, 2000). However, although technological advances change the tools that are used in support of PBL, they do not change its fundamental principles. Therefore, an important challenge for educators and policy makers is to train teachers in not only PBL pedagogy but also the technology needed to implement PBL successfully in the classroom (Barab & Luehmann, 2002; Barak & Dori, 2004).

Uses of technology to facilitate PBL implementation can be categorized as technology-supported or multimedia technology-assisted. In technology-supported PBL, the technologies are often used as communication tools (Hafner & Ellis, 2004), research tools (Land & Greene, 2000), scaffolding tools (Intel\(^{\text{TM}}\) Teach Program, 2009; Synteta & Schneider, 2002), project management tools (Denis, Harald, Hermann, & Nick, 2005; Rooij, 2009), and telecollaboration tools (Anderson, 2002; Harris, 1998). In multimedia technology-assisted PBL research, however, such technologies are often used as production tools that enable students to organize and present their research work through multimedia. Cognitive load theory (Penney, 1989) and the cognitive theory of multimedia learning (Moreno & Mayer, 2000) indicate that,
when learners process multimedia data simultaneously, they integrate numerous types of information and form mental models based on their understanding of the learning material. Multimedia technology-assisted PBL thus affords students opportunities to demonstrate organized learning outcomes and to increase their knowledge and self-efficacy in the subject matter. However, some possible barriers to multimedia technology-assisted PBL projects include technical difficulties with software, hardware, and networks, as well as time constraints, and the need for teacher training (Steelman, 2005). Lack of prompt technical support may cause anxiety for a teacher. Teachers must also customize instruction to prevailing knowledge levels and learning goals (Seo, Templeton, & Pellegrino, 2008). An even greater challenge for a subject teacher is to address the technical needs of students who may have varying proficiency and interest in the use of computers.

In addition to the technical issues, there are also contextual issues that hinder the practice of PBL. In many Asian countries, Taiwan in particular, the educational environment is still very much test-driven. The National Subject-Competency Test (NSCT) score is still the major indicator of student academic achievement and the predominant factor in determining which colleges and universities high school graduates may attend. Thus, changing the pedagogical practices of subject teachers is extremely difficult. Any unproven change in teaching and learning practices would bring about strong parental objections. Even if a subject teacher is willing to try new teaching practices, learning the necessary technology and then teaching students the technology are daunting tasks.

In recent years, we have experimented with ways for high school subject teachers to practice PBL in their classrooms, in which team-teaching provides a feasible mean to overcome both the aforementioned technical and contextual problems. Team-teaching is one variation of co-teaching (Cook & Friend, 1996). Team-teaching (Sandholz, 2000; Welch & Sheridan, 1995) involves two or more teachers sharing teaching expertise in the classroom and engaging in reflective dialogue with each other (Eick & Dias, 2005; Jang, 2006b). Team-teaching offers several advantages over traditional single-teacher teaching methods, including the provision of multiple learning perspectives (Smith, Hornsby, & Kite, 2000), reduction of teaching redundancy (Hartenian, Schellenger, & Frederickson, 2001), and the promotion of teamwork and communication between teachers (Andrews & Wooten, 2005). On the other hand, a disadvantage of team-teaching is the potential conflict arising from variations in teaching styles and procedures. Carefully listening to the perspectives of team members are important starting point in resolving conflict (Shapiro & Dempsey, 2008).

In this study, we propose a team-teaching strategy that involves collaborations of computer teacher and the subject teacher to implement PBL in the classrooms. There are two main research questions: first, how feasible and effective is the proposed team-teaching model under the current test-driven educational environment? And secondly, how do the participants of the study, both the teachers and the students, embrace PBL in terms of continuing participation in future classes? A quasi-experimental study with mixed-method design was carried out to answer the research questions. The rest of this paper presents the team-teaching model, experimental setup, research findings, discussion of implications and conclusions.

2. Proposed teacher collaboration model

In Taiwan, computer courses are typically taught during the first year of high school (10th Grade). Since computer courses are not on the NSCT, computer teachers have freedom in what and how they teach. Typically, computer teachers teach introductory computer science concepts as well as practical software tools. However, NSCT subject teachers must follow rigid rules regarding teaching content and progress. Therefore, most subject teachers are unwilling to deviate from their usual teaching routine and to experiment with new teaching strategies and activities. However, the following team-teaching model takes advantage of the instructional freedom given to computer teachers, and can be implemented to enable students to perform PBL activities in an NSCT subject area with minimal time and effort from the subject teacher.

As Fig. 1 shows, the computer teacher and the subject teachers formed a teaching team to introduce PBL in a regular class. The proposed model has two phases. In the first phase, the computer teacher conducts PBL on computer-related topics to familiarize students with the process of completing a PBL activity and to train them in the necessary technological skills, including productive software usage, fact finding on the Internet, and the operation of hardware (such as digital cameras, camcorders, scanners, and other devices). Another important purpose of conducting PBL in the computer class is to enable students to practice various research tasks, including facts finding, data analysis, report writing, and oral presentation. It also helps students to develop their collaboration and time budgeting skills. In phase II, the subject teacher can then conduct subject-specific PBL activities, knowing that students have already been pre-trained to perform project work. Although the subject teacher must still plan the PBL activities, no other student training is required. Therefore, little or no class time is lost due to student training and only minimal effort is required on the part of the subject teacher.

In short, the proposed model requires the computer teacher to perform PBL activities to train students to complete projects successfully. The subject teacher can then focus on subject-specific learning goals in subsequent PBL activities.

3. Experimental setup

A two-year teaching experiment was performed to test the proposed team-teaching model for implementing PBL in classrooms. The experiment was conducted at a suburban high school with about 2000 students. Like any other typical high school in Taiwan, the school had students of grades 10–12. In this study, 10th grade students participated in Phase I of the experiment, before participating in Phase II of the experiment in the subsequent year. The following subsections outline the experimental setup and procedure.

3.1. Subjects

Three teachers and six classes participated in this study. A computer teacher and two subject teachers, namely geography and English, conducted the two-year teaching experiment. Each teacher had more than ten years of teaching experience. The computer teacher was chosen because she was formally trained in conducting PBL and was a certified Master Teacher for the Intel Teach Program (Intel® Teach Program, 2009), a program that trains teachers to integrate technology into the classroom and promote problem solving, critical thinking and collaboration skills among students. The two subject teachers volunteered for the study after participated in a 1-h call-for-
participation meeting at the school. Both subject teachers had little experience with PBL or technology-integrated teaching. Before the experiment, the computer teacher led several rounds of discussion on strategies and procedures for successful implementation. By the end of these discussions, all three teachers were convinced that the experiment would benefit the students.

In the first year of the experiment, all 10th graders had the same computer teacher for their computer classes. The computer teacher conducted PBL in all 16 10th grade classes. In year two, students in the 16 classes were randomly re-assigned to different classes in accordance with school policy. The geography teacher taught four of the second-year classes, and the English teacher taught two. Therefore, six distinct classes were involved in both years of the study. Two of the classes of the geography teacher were designated the control group, and the other two were designated the experimental group. One class of the English teacher was designated the control group and the other was designated the experimental group. Table 1 shows the number of students in each class. Overall, the control and experimental groups formed from the classes of the geography teacher each included 89 students, whereas those from the classes of the English teacher each included 42 students.

### 3.2. Procedure

Table 2 outlines the timetable and weekly progress for the PBL activities for both years. In the first year, the computer teacher conducted PBL for eight weeks during the second semester. Since class time was 1 h per week, by the time the PBL activity was assigned, students had received 20 h of introductory computer science lectures and training in computer skills. During the experiment, students in each class were asked to form groups of three or four. Each group was asked to research and report on an important information technology development.

### Table 1

Number of students in the control and experimental groups.

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th>Experimental group</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Geography</td>
<td>89 (45 + 44)</td>
<td>89 (45 + 44)</td>
<td>178</td>
</tr>
<tr>
<td>English</td>
<td>42</td>
<td>42</td>
<td>84</td>
</tr>
</tbody>
</table>
During the eight-week experiment, the computer class focused on project work. The computer teacher checked student progress and provided weekly feedback.

In the second year, the geography teacher and the English teacher conducted PBL for six weeks in the second semester. In Taiwan, the 18-week long semester is naturally divided into three sessions with a school-wide examination on all subjects at the end of each session. Each session of classes is six weeks long. PBL activities were conducted during the second session of the semester. Students were asked to form groups of three or four as in the first year. The project topics were chosen from the learning content during these six weeks, such that the PBL activity was used to reinforce the geography/English learning. Since both geography and English are NSCT subjects, the classes for the two subjects met several times a week—three times for geography and six for English. For the experimental groups, the two teachers reduced the lecture material and the regularly assigned homework to give students time to work on the project. During the experiment, each of the two teachers devoted one class period per week exclusively to the project. The teachers also used that class period to assess the progress made by the group during the week. For the control groups, the normal in-class lecture and take-home assignment routine was maintained. Therefore, the control group received more lectures and assignments than did the experimental group did, since none of its class time was used for PBL activities.

For the English PBL, the teacher asked each student group to study the assigned readings (in English) on a particular animal; and then expand their knowledge by searching the Web to answer some open-ended questions; finally writing short report with a set outline. In the report, students were to practice English writing with different sentence structures. The goal of the project was to have students sharpening their reading skills and to practice writing humanistic reporting essay. As for the geography class, the teacher assigned a different South America/Latin–America country to each group. Each group was to research and report on the geological terrain, history, culture, and economy of the assigned country. Although the textbook already covered all those topics, students were required to go in more depth in their final report group. So the goal was to have each group research a particular country, and learn about other countries from other groups’ reports.

### 3.3. Data collection

Data were collected from multiple sources, including class journals that were kept by the teachers, in-class handouts, interviews with teachers and their transcripts, student progress reports, student questionnaires and student interviews.

### 4. Results and discussion

#### 4.1. Analysis of the achievement test

One-way covariance analysis (ANCOVA) and a posterior comparison were performed to analyze the differences between the achievements of the experimental and control groups. The level of significance chosen was 5%. Since no pretest was administered, the grades from the first midterm examination (at the end of the first six-week school session) were used as the covariate in the analysis. The second midterm examination (at the end of the PBL experiment in the second six-week school session) was used as the test of achievement. The geography achievement test contains 30 multiple-choice questions and 20 fill-in-the-blank questions. Each question is worth two points and the test has a maximum score of 100 points. The English achievement test also has a maximum score of 100 points. The test contains 60 multiple-choice questions and 32 fill-in-the-blank (vocabulary, guided translation) questions, with one point awarded to each correctly answered question. The test papers were independently prepared and the two teachers involved in this study played no role in the creation of the test papers.

Table 2 shows the descriptive statistics of the results of the achievement test. Before the analysis was performed, the underlying assumptions of ANCOVA were examined. The Levene test of equality was performed to test the homogeneity of differences between the groups: (Geography: $F = 1.936, p = 0.166 > 0.05$; English: $F = 0.004, p = 0.951 > 0.05$). The ANCOVA results (Geography: $F_{105} = 4.682, p = 0.032 < 0.05$; English: $F_{105} = 4.282, p = 0.042 < 0.05$) showed that the experimental groups performed significantly better than the control groups in terms of learning achievement. Although no PBL activities were carried out in the third six-week school session, we also compared the results of the third examination scores between the designated control and the experimental groups. The Levene test indicated that there was homogeneity.
between the two groups (Geography: \( F = 0.000, p = 0.992 > 0.05 \); English: \( F = 0.066, p = 0.798 > 0.05 \)). However, the ANCOVA results (Geography: \( F_{1,85} = 0.830, p = 0.364 > 0.05 \); English: \( F_{1,81} = 0.038, p = 0.846 > 0.05 \)) showed that the experimental groups did not perform significantly better than the control groups. Therefore, in response to the first research question, ANCOVA results indicate that the proposed team-teaching model for practicing PBL in subject classes is effective in enhancing students’ learning.

### 4.2. Student questionnaire on PBL activities

Table 4 presents the student questionnaire and the cumulative statistical data on the students’ responses at the end of the two-year experiment. Although the questionnaire employed a 5-point Likert Scale system, for ease of presentation, the “Strongly Agree” and “Agree” responses were grouped into one category and the “Strongly Disagree” and “Disagree” responses were grouped into another. The data in the table represent cumulative responses from all students in the three experimental groups.

#### 4.2.1. Comparison of PBL and traditional lectures

At the beginning of the experiment, approximately one quarter of the students already knew something about the assigned topic (Question 1: Geography 24%; English 33%). However, most students learned something new, regardless of their familiarity with the chosen topic (Question 2: Geography 88%; English 90%). When asked to compare learning through the research project with learning through in-class lectures, about half of the students favored the new PBL approach (Question 3: Geography 52%, English 50%) while most of the other half were indifferent (Question 3: Geography 43%, English 48%). Student participation was also higher during project work (Question 4: Geography 51%, English 74%). When asked about future PBL activities, over half of the students expressed interest in participating in future PBL activities (Question 5: Geography 52%, English 57%). Few students said they were uninterested in participating in future PBL activities (Question 5: Geography 12%, English 7%). Given the perceived learning through the process, the proposed model for conducting structured PBL activities in a test-driven academic environment is not only feasible; it should be actively encouraged.

In the interviews, students gave many encouraging comments regarding their learning. For example, the students considered that the PBL project helped their learning. This finding is important if school principals are to encourage other subject teachers to adopt PBL in their teaching activities. Some of the comments included the following.

Unlike sitting through lectures in class, I learned more when researching and preparing the final report.

I think PBL is an effective means of learning geography. The teacher instructs on the issues and the main concepts, and we learned the details through research work. It was a lot more fun to learn on our own. …

The textbook covers too much material; it’s difficult to learn it all. I learned more from our group project.

#### Table 4

<table>
<thead>
<tr>
<th>Questions</th>
<th>Geography class ((n = 89))</th>
<th>English class ((n = 42))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Strongly) agree</td>
<td>Neutral</td>
</tr>
<tr>
<td>1. Before this project, I knew very little about our choice of topic.</td>
<td>42%</td>
<td>34%</td>
</tr>
<tr>
<td>2. From this project, I gained much knowledge about our chosen topic.</td>
<td>88%</td>
<td>11%</td>
</tr>
<tr>
<td>3. I can learn more doing my own research as oppose to learning through lectures in class.</td>
<td>52%</td>
<td>43%</td>
</tr>
<tr>
<td>4. During the project weeks, my in class participation is much better than other weeks of school.</td>
<td>51%</td>
<td>48%</td>
</tr>
<tr>
<td>5. If given the opportunity, I like to participate in project-based learning activities in the future.</td>
<td>52%</td>
<td>36%</td>
</tr>
<tr>
<td>6. Our final project report is content rich.</td>
<td>58%</td>
<td>38%</td>
</tr>
<tr>
<td>7. Our final project report is well organized.</td>
<td>65%</td>
<td>35%</td>
</tr>
<tr>
<td>8. Our final project report is artistically illustrated.</td>
<td>49%</td>
<td>45%</td>
</tr>
<tr>
<td>9. I understand all the contents in our final project report.</td>
<td>85%</td>
<td>10%</td>
</tr>
<tr>
<td>10. Overall, I am satisfied with everything in our final project report.</td>
<td>73%</td>
<td>23%</td>
</tr>
<tr>
<td>11. Our final project report meets or exceeds all the criteria set forth by the teacher.</td>
<td>65%</td>
<td>31%</td>
</tr>
<tr>
<td>12. We did a good job on our oral presentation of the final project report.</td>
<td>75%</td>
<td>19%</td>
</tr>
</tbody>
</table>
4.2.2. Work quality

Generally, students felt good about the overall quality of their work. In particular, the students tended to be more confident about the content and organization of their final reports than they were about the aesthetic aspects of the report (Question 6: Geography 58%, English 76%, and Question 7: Geography 65%, English 74%, as oppose to Question 8: Geography 49%, English 64%). However, fewer than 5% of the students thought they needed to improve in one or more of the three aspects. Most of the students understood everything that went into their final reports (Question 9, Geography 85%; English 88%), which finding was extremely gratifying. Most students were satisfied with their performance while only 4% thought otherwise (Question 10, Geography 73%; English 81%). Additionally, over half (Question 11, Geography 65%; English 81%) of the students indicated that they had done a better job than is required of them and less than 7% thought otherwise (Question 11, Geography 4%; English 7%). Students’ confidence in their own reports carried over to their final oral presentations (Question 12, Geography 75%; English 67%).

Students attributed the success of their PBL projects to the training they had received in the preceding year. The training and experience gained from the Computer class PBL helped the students do the work and improved its quality.

Students’ comments included the following.

The teacher doesn’t have to tell us what to do (research work). We learned what to do in the computer class a year ago.

We already know how to find the necessary data on the Internet. Therefore, we can spend more time analyzing the data and composing the final report.

4.3. Teachers’ reflections

4.3.1. Preparing and implementing the PBL activities

Although the computer teacher had several years of experience in conducting PBL activities, she had not been required to prepare students for future PBL activities in other subject areas. The computer teacher was also required to train the geography and English teachers in PBL implementation. The computer teacher felt that almost twice as much time was spent on preparation than the actual PBL activity. The usual content-specific PBL materials were prepared, including a list of topics, project assessment rubrics, and the progress checklist. Additionally, she made notes on successfully conducting PBL activities based on her past experience.

The computer teacher allotted two more class periods to PBL activity than she had in the past. During the PBL activity, the computer teacher took extra time to explain PBL procedure and what constitute a good project. Specifically, an extra week (one class period) was allotted for project presentations, which enabled the teacher to give detailed feedback to each group of students.

The computer teacher’s comments included the following.

Students had very little experience working on projects. They require additional practice in many areas, including finding reputable websites as information sources and using application software for writing reports and preparing presentations.

Organization and analysis of collected data is another weakness (of the students). I had to spend additional time helping each group to structure their final report.

In the second year, the geography and English teachers prepared and conducted the PBL in six weeks. One class period was allotted weekly to PBL activities for both the geography and the English classes, which met three and six times a week, respectively. The research topics were the same as those covered in class during the six-week experiment. For the experimental groups, both the geography and the English teacher had to abbreviate some of their lectures because one class period each week was used for PBL activity. However, since the students were asked to research the topics covered, no learning content was omitted. The two teachers followed the procedure that was outlined by the computer teacher, preventing any confusion regarding what to do in each PBL class period. At the end of the experiment, the two teachers commented that the class preparation time was independent of whether or not a PBL activity was planned. From the final group reports, the teachers noticed that PBL activities allowed most student groups attain greater depth of knowledge than did classroom learning alone. Therefore, the teachers concluded that no class time was lost and that no learning content was omitted, even though six class periods were allotted to PBL activity. Additionally, they observed that the PBL activity enhanced student learning. This observation was validated by the results of the second school-wide subject examination (post-test), in which the experimental group students performed significantly better than the control group students (Table 3).

Reflective comments by the two subject teachers included the following.

English teacher: I didn’t know how to integrate technology into my teaching. After this experiment, I now know what to do and am willing to try teaching with technology in the future. … I was surprised to see that students can actually focus on the project topic. The depth and breadth of their research work are much greater than I had anticipated.

Geography teacher: The extra preparation time before the project start was manageable. During the six-week experiment, going around and helping each group with their project was actually easy and fun. … It’s good that students are already familiar with the (PBL) process and already possess the necessary technical skills.

In summary, the proposed team-teaching model for conducting PBL activity has the computer teacher spending time preparing the students and subject teachers for future PBL activities through PBL activities in the computer class. As a result, the two subject teachers found that no additional time is needed to train the students on PBL. Furthermore, they were pleased with the outcome of the PBL activities, as students actually learned more effectively than they would have in traditional lecture-only classes.

4.3.2. Reflections on students’ work

The computer teacher thought the students were generally enthusiastic about doing project work even though the group project was a new experience for them. The two extra class periods that were allotted to student projects enabled her to advise each group, greatly increasing the quality of the students’ work. Further, since students were unfamiliar with conducting group research, several non-content
learning related and collaboration skills were also being practiced for the first time. The computer teacher observed that students require more practice to improve in the following four areas: intra-group communication, responsibility sharing, report writing and oral presentation.

The two subject teachers tried to ensure the quality of the project work by checking group progress weekly. They agreed with the observations of the computer teacher regarding the students’ work, but they noted that the students’ progress increased as the students gained more experience in the project work. The two teachers were particularly surprised at the enthusiasm of the students when they were working on assigned projects and were impressed with their capacity to work as a team and meet weekly deadlines. They also noted that students were able to aggregate facts and evidence in their research topics. Overall, the two subject teachers thought that the students were prepared from the start of the experiment and thus performed adequately well in their research projects. They thought that most student groups acquired a sufficient depth of knowledge to compensate for the material that was omitted from class lectures. The PBL activity allowed the teachers to interact with the students in ways that would not be possible in a traditional classroom. In summary, the teachers agreed with the students’ satisfactory assessment on their own project work.

However, two teachers also agreed with the computer teacher that students require more guidance in organizing their final reports and that the students needed to improve their oral presentation skills. They suggested that the language arts teacher could conduct PBL activities jointly with the computer teacher in the first year, emphasizing report writing and oral presentation. The teachers also noted that the students had difficulty in judging whether the materials they found on the Internet were indeed correct and unbiased. The weekly progress check by the teacher helped to prevent the inclusion of incorrect or unsubstantiated data or facts in the final report.

4.4. Challenges and lessons learned

4.4.1. Lessons learned

Despite the additional effort required to train the students and subject teachers in conducting PBL activity, the computer teacher was gratified to see that the students used the skills that were learned in her class to improve their performance in other subject areas. Students no longer regarded computer class as “just for fun.” Furthermore, the computer teacher sensed a newfound respect from other teachers for helping them increase their teaching effectiveness by integrating technology.

Journal entries made by the computer teacher included the following.

Although the teaching load and responsibility were greater than in the past, it is good to know that I am helping students to become more involved in their studies in other subject areas.

We (the other two subject teachers and I) now have a closer working relationship. I am seen not just as a teacher at the school, but as an instrumental colleague who sparked subject teachers’ interest in trying out a new teaching and learning method that uses technology.

Upon completion of this study, the two subject teachers, who were initially skeptical about the learning outcome and had expressed concerns about lost class time, became believers in PBL and expressed newfound interest in the use of technology to improve student learning. Pre-training the students in PBL in separate classes not only ensured that the subject teachers were not burdened with the need to train students in the technologies that were required for PBL activities, but also actually motivated the subject teachers to conduct PBL. The subject teachers appreciated the manner in which the student-centered learning was introduced into their classes. Moreover, after taking this first step, they felt that they were contributing to the movement to reform instructional methodology and were helping students to improve their learning performance. Our approach and findings of involving an experienced teacher to help bridge the gap between theory and practice of PBL for novice practitioners is consistent with research results on mentoring new teachers by experienced teachers (Harrison, Lawson, & Wortley, 2005). In the post-experiment interviews, the two subject teachers made the following comments.

Students already know what to do and what to expect in a PBL activity is helpful, and allows me to focus on content-related matters. I think we have found an effective means of implementing student-centered learning in my classes. Orientation by the computer teacher was vital to making it happen.

Since students indeed learn better, we should promote this learning method in other subjects as well. The computer teacher has already trained all the students, so there is no reason why it cannot be done.

Since the three teachers were very satisfied with the results of their PBL activities, they have continued PBL beyond the completion of this study. The computer teacher has continued to train the first-year high school (10th grade) students in group projects in her computer class. She has also recruited two additional subject teachers, a history teacher and a math teacher, to conduct PBL activities with their second year high school (11th grade) students. The geography teacher and the English teacher that participated in this study have also decided to conduct another round of PBL activities with the same group of students in their 12th grade classes.

In all, despite being the first time experience for both the teachers and the students, they are very much satisfied with the new teaching and learning method. The teachers appreciated the team-teaching model that facilitated their PBL implementation where as the students very much engaged in their learning activities and rip the benefit of better learning achievements. As a consequence, both parties are willing to participate in future PBL activities.

4.4.2. Challenges and limitations

There was one noticeable challenge faced by the two subject teachers in this study. Although the two subject teachers were experienced teachers, they were not sure how much demand and pressure to put on the students through project work. Too much guidance and demand would undermine intend of independent learning, while not enough directions could result in unbalanced project outcome. Throughout the six-week experiment, the two teachers had to keep a close-eye on student’s progress to ensure the project works were on-track. Since this challenge only happens with inexperienced PBL teachers, a pre-project meeting with an experienced PBL practitioner (e.g. the computer teacher in this study) to discuss their project design can likely reduce teachers’ anxiety.

The success of this team-teaching model hinges on two important factors. First, the computer teacher was an experienced PBL practitioner. The computer teacher was able to conduct computer subject related PBL project, and at the same time, use the project to enhance
students’ technical skills in preparation for future PBL activities. If the computer teacher was a novice to PBL, then an experienced PBL practitioner should also be involved. Secondly, the two subject teachers were experienced teachers, though PBL novices. Their wealth of teaching experience allowed them to decide what lecture content to be abbreviated and how the project should be designed to make up for the missing lectures. Furthermore, their classroom management experience was also an invaluable asset during the PBL class period as it was well documented that students tend to be more active and hyper in a computer lab. It takes experienced teachers to make sure students make good use of their time in the computer lab.

5. Conclusions

Many studies have demonstrated the effectiveness of the PBL method in increasing motivation to learn. However, owing to education system differences in different countries, PBL practitioners face different challenges. In Taiwan, conducting PBL activities in NSCT subjects are particularly difficult. The subject teachers are already short on time to cover all the learning materials tested by the NSCT. Hence, asking subject teachers to conduct PBL activities on their own is not feasible. Moreover, students have to be trained to use the proper technology for the required group work. This study therefore proposes a team-teaching model to address these time constraints and skill training issues. Instead of working alone, the computer teacher in this study, who was also an experienced PBL practitioner, help trained the students on PBL in her own computer class. When the subject teacher subsequently conducted PBL activities, the students already had some PBL experience. The subject teacher found that no extra preparation was required. Although some class time was dedicated to PBL activities, students easily compensated for skipped material by performing their own research work. Hence, no class time was lost and students actually learned better being involved in the PBL activity.

The team-teaching approach that was tested herein was a win–win situation for all teachers involved. The computer teacher earned newfound respect from her colleagues. The subject teachers had more effective interactions with their students and joined the education reform movement in a practical way. The students achieved better learning outcomes while practicing other important life skills, including communication, organization, and presentation skills. The proposed teacher-collaboration model provides a feasible means of enabling teachers and students alike to conduct and to reap the benefits of student-centered learning in an otherwise traditional educational setting. The encouraging results of this two-year study warrant further long-term study, which is currently being undertaken.

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