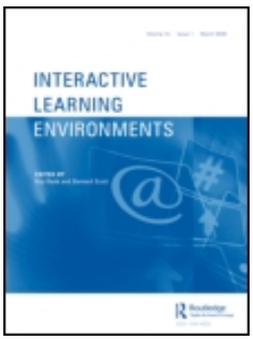

Interactive Learning Environments

ISSN: 1049-4820 (Print) 1744-5191 (Online) Journal homepage: https://www.tandfonline.com/loi/nile20

Using a Web-based portfolio assessment system to elevate project-based learning performances

Chi-Cheng Chang & Kuo-Hung Tseng

To cite this article: Chi-Cheng Chang & Kuo-Hung Tseng (2011) Using a Web-based portfolio assessment system to elevate project-based learning performances, Interactive Learning Environments, 19:3, 211-230, DOI: 10.1080/10494820902809063

To link to this article: https://doi.org/10.1080/10494820902809063

Interactive Learning Environments
Vol. 19, No. 3, June 2011, 211–230

Routledge
Taylor & Francis Group

Using a Web-based portfolio assessment system to elevate project-based learning performances

Chi-Cheng Chang[a]* and Kuo-Hung Tseng[b]

[a]*Department of Industrial Technology Education, National Taiwan Normal University, No. 162, Section 1, He-Ping E. Road, Taipei, Taiwan 106;* [b]*Graduate Institute of Business Management, Meiho Institute of Technology, No. 23, Ping Kuang Road, Neipu Hsiang, Pingtung, Taiwan*

(*Received 6 July 2007; final version received 17 January 2009*)

This study examines the effect of a Web-based portfolio assessment system on the performances of students undertaking project-based learning (PBL). The research targets were 60 students from two grade-8 classes taking senior high school computer courses. The experimental group comprised 30 students, who used the system to perform PBL and assessment in one class. The control group comprised of 30 students who employed conventional assessment for PBL of another class. Experimental results indicate that the system has no significant effect on student achievement, but had a statistically positive effect on self-perceived learning performances. In addition, teacher-assessment and self-assessment of project achievements produced different results.

Keywords: project-based learning; project works; portfolio assessment; self-perceived effect

Introduction

Project-based learning (PBL) (Krajcik, Czeniak & Berger, 1999) emphasises learning by doing. The process focuses on real problems that often occur in people's lives, and on the learning community comprising students, teachers and experts. This framework cultivates problem-solving capacities of students through proposing and defining problems; collecting and analyzing data; communicating with others, and creating concrete results (Blumenfeld et al., 1991). Assessment of PBL is performance assessment, and can be performed using a portfolio (Furger, 2005). In portfolio assessment, the teachers can assess the students' cognitive abilities based on not only the students' works, reflection, evidence of progress and the performance of each of the learning activities in the portfolio, but also their learning attitudes and progress. Portfolio assessment can concurrently assess both the learning processes and outcomes of the students.

PBL emphasizes knowledge integration, and cultivates the problem-solving capacities of students. Assessment in PBL focuses on various multi-dimensional processes that examine the process of portfolio assessment. The portfolio content

*Corresponding author. Email: samchang@ntnu.edu.tw

ISSN 1049-4820 print/ISSN 1744-5191 online

DOI: 10.1080/10494820902809063
http://www.informaworld.com

concentrates on the presentation of work. In addition, PBL treats the output of project work as a major learning outcome. Hence, both PBL and portfolio assessment should be practiced simultaneously. Dennis, Hardy, and White (2006) and Driscoll (2000) concluded that reflection on learning might be shown in daily journals, in a portfolio, or as part of project work, implying that creating a portfolio or project work requires writing reflection. As a matter of fact, these two schemes can be integrated. Moursund (1999) concluded that PBL supported by information technology can help students establish a sense of responsibility and participation, practice self- and peer assessment and construct portfolios. Moursund (1999) also indicated that PBL should adopt the portfolio as the assessment tool. Barker (2006) proposed employing an e-portfolio as a management and assessment tool in PBL. Forkosh-Baruch, Mioduser, and Nachmias (2006) applied Web-based project work and portfolio assessment to curriculum and instruction reforms. They concluded that both PBL and portfolio assessment can simultaneously be employed to manage innovations in teaching and assessment.

Web-based portfolio assessment has recently been applied to PBL. Masayuki, Shinichi, Yuzuki and Wachs (2006) developed a Web-based portfolio system for their project, enabling students to participate in the project in order to present their research processes and results. Advisors could use the system to examine the research processes followed by students during the project. The system allows members to share their ideas, and to examine each other's work content and progress, thus raising the incentive to work. A research group at Northwestern University developed PBL activities through a Web-based collaborative learning environment. The students presented the results of collaborative learning and manage reflection in portfolios, whereas the teachers offered their feedback and encouraged peer feedback (ePortfolio Consortium, 2003). Second-grade students of a senior high school in Indianapolis city, Indiana, conducted online PBL activities on a Web-based learning community system displayed the outcomes in portfolios (Furger, 2005). Students at Abilene Christian University, Australia, used Web-based portfolios to collect and manage the content of reflection when performing project work (Dennis, Hardy, & White, 2006).

The above studies reveal that PBL performance can feasibly be assessed using portfolios. However, most works have only examined the use of conventional or Web-based portfolio assessment in PBL, and have rarely studied the effect of Web-based portfolio assessment on PBL performance. Some works did not compare experimental and control groups, and thus could not accurately determine the effect of PBL performance. PBL can develop learners' abilities, and enhance learning performance (Simkins and Michael, 1999). Portfolio assessment can elevate students' learning progress and interest. The effect of Web-based portfolio assessment on PBL performance is an interesting research topic. Although some studies have demonstrated that portfolio assessment raised the students' learning abilities, effects and achievements (Barrett, 2000; Dennis et al., 2006), they did not describe the stated improvements in detail. Meanwhile, although some other works have discussed in some detail the improvements in abilities, effects and achievements (Chang, 2001; Singh and Ritzhaupt, 2006), they did not fully discuss the performance. Therefore, this study addresses in detail the significant improvements in abilities, effects or achievements resulting from portfolio assessment.

Research objectives and questions

This study examines the effect of a Web-based portfolio assessment system on PBL performance, including achievements and self-perceived learning performance. The following research issues are addressed:

(1) Whether the achievements (project work and test) of the experimental group (using the system) and the control group (not using the system) show a statistically significant difference;
(2) Whether the self-perceived learning performance of the two groups shows a statistically significant difference in, and
(3) Whether the self-perceived learning performance before and after using the Web-based portfolio assessment system in the experimental group shows a statistically significant different.

Literature review

Assessment rubrics and effects of PBL

Simkins and Michael (1999) noted that Web technologies play positive roles in PBL activities, and can develop the learners' five capacities and improve learning performance. These five capacities are project management, data collection, organizing, presentation and reflection. Huang (2002) found that PBL can cultivate the capacities of the students for problem solving, project management, research, organization, presentation, reflection, collaborative learning and applying information technologies. Lee (2004) indicated that incorporating information technology into PBL could raise students' problem-resolving capacities. Hung (2002) concluded that students with low performance strongly developed their learning attitude and ability following Web-based collaborative PBL. Wang (2002) showed that incorporating information technology into PBL could enhance learning attitude and computer skills of sixth-grade students in elementary schools. An experimental school in Indianapolis city, USA, required each student to undertake three research-based projects every year, and to manage discussions and presentations. The teachers' assessment dimensions were individual intellect, mastery fact, skills and concepts, project quality, communication and reflection and thinking (Gardner, 1993). The assessment dimensions of several high schools in California practicing PBL include information access, information selection, information process, information organization, information presentation, personal task management, personal time management, group task management, group time management and group collaboration (Buck Institute for Education, 2006).

The above literature reveals that PBL has positive effects on gathering and organizing data, continuous improvement and discovering and solving problems. Other learning effects can be located from assessment rubrics for assessing Web-based portfolios.

Web-based portfolio assessment rubrics and performance

Abilene Christian University in Australia asked students to use a Web-based portfolio to accumulate and manage their own growing evidence, reflections and assessments in order to enhance their professional development (Dennis et al., 2006). These Web-based portfolio systems resembled an online database. The students

could save their learning outcomes. The teachers could examine the performance of students, and provided feedback to enhance the quality of teaching and learning. Creating the portfolios involved collecting, selecting, inspecting, reflecting and evaluating data or works. These behaviors could be employed as performance indicators in assessing the portfolio.

The Web-based portfolio development process involves self-evaluation, and setting up achievement goals for long-term professional development (Barrett, 2000). The evidence in the portfolio should reflect personal achievement. Dennis et al. (2006) concluded that the portfolio should not only present evidence of professional development and personal abilities, but also facilitate professional development and raise personal abilities. Emden, Hutt, and Bruce (2003/2004) concluded that the portfolio should emphasize the improvement of self-development or self-growth, rather than simply demonstrating evidence of personal abilities. Singh and Ritzhaupt (2006) identified the following learning effects of Web-based portfolios: elevating information technology capacities; receiving feedback from teachers and classmates; encouraging reflection; demonstrating knowledge and skills; raising writing ability and facilitating self-examination and improving learning outcomes. Accordingly, performance in self-evaluation, goal setting, data gathering, revision, feedback, reflection, writing and inspection could be treated as assessment dimensions for portfolios.

A Web-based portfolio evaluation study by Chang (2001) concluded that Web-based portfolios had the following effects on students:

(1) Setting of learning goals: helps plan the direction of their own learning.
(2) Self-reflection and evaluation: assists self-control and reflection on their learning processes.
(3) Learning from work by peers: helps improve the quality of projects.
(4) Learning from the content of peers' portfolios: helps understand the classmates' learning situations, thus raising the interaction and exchange among the classmates, and further reflecting their own learning.
(5) Learning from the peers' learning goals: helps students to understand research interests of their classmates.

These learning effects have been found to be valuable for academic growth and progress, and to have a positive effect on learning processes and outcomes. Lee (1999) found that portfolio assessment triggered learning interests; cultivated self-responsibility and active learning spirit; improved cognition, attitude and skills; improved both process and results; raised self-reflection; increased peer communication; improving teacher-student relations; improved diversity of presentation; stimulated creativity, expression and organization capacities, and had authentic assessment outcomes.

Accordingly, this work identifies six dimensions or criteria as the major measures of learning performance in the Web-based portfolio assessment system: ability to set learning goals, project quality, reflection, self-evaluation, peer assessment and peer interaction.

Building a Web-based assessment system

Functionalities of the system

Student portfolios can be created by filling out forms provided by the system. In this case, all student portfolios have the same format. The creation of a portfolio

comprises a student profile, the setting of learning goals, reflective writing and the uploading of work (different versions such as draft, in-progress, final and improvement) and 'other entries'. The first four entries are requirements, and the 'other entries' are optional elements. Student portfolios can thus be conveniently inspected and assessed by teachers and peers.

The 'other entries' may include course notes or abstracts of course contents (.doc or .pdf file-types), website resources sharing (IP address or .htm), reference books or handouts sharing (any type of file), evidence of progress (.doc or .pdf file-types), records of classroom or group discussion (.doc or .pdf file-types), photographs of class teaching or group discussion (jpg or gif file-types), audio recordings of class teaching or group discussion (.wav or .mid file-types), or documentary footage of class teaching or group discussion (.avi or .mpg file-types).

A user may be allowed to review portfolio contents such as digital artifacts, reflections, learning goals and other entries. Assessment rubrics in the system can be employed to perform teacher assessment, student self-assessment and peer assessment. This e-portfolio system resembles a management platform, and thus is also called a Web-Based Portfolio Assessment Management System.

Student module

(1) 'Portfolio Guidance' assists users by illustrating the process of creating portfolio entries.
(2) 'Portfolio Creation' comprises a student profile, the setting of learning goals, the uploading of work, reflective writing.
(3) 'Portfolio Assessment' encompasses student self-assessment, peer assessment and teacher assessment. Students may review peers' portfolio contents prior to assessment in order to gain knowledge about the peers (Figure 1).
(4) 'Portfolio Grade' consists of scores obtained by student self-assessment, peer assessment and teacher assessment. Students may access these scores.
(5) 'Course Illustration' comprises teacher profiles, course syllabuses and course content outlines.

Teacher module

This module relates to the selection, deletion and addition of course units (each unit has work gathered in a student portfolio). By accessing 'selecting course', teachers can review student portfolios can be reviewed and click the 'system management' button. In other words, teachers can use the same functionalities as students, except for portfolio creation. Both teachers and system managers may use the 'system management' function, which comprises the following sub-functions:

(1) 'Course Unit' involves grading unit work, uploading the syllabus, creating grade rubrics, setting work submission deadlines, and establishing grading rates for teacher assessment, student self-assessment and peer assessment.
(2) 'Notice of Work Submission' enables teachers to notify students by email if they have not submitted their work within a deadline.
(3) 'Student Grade' enables teachers to examine the grading of students' work and their portfolio assessment outcomes.

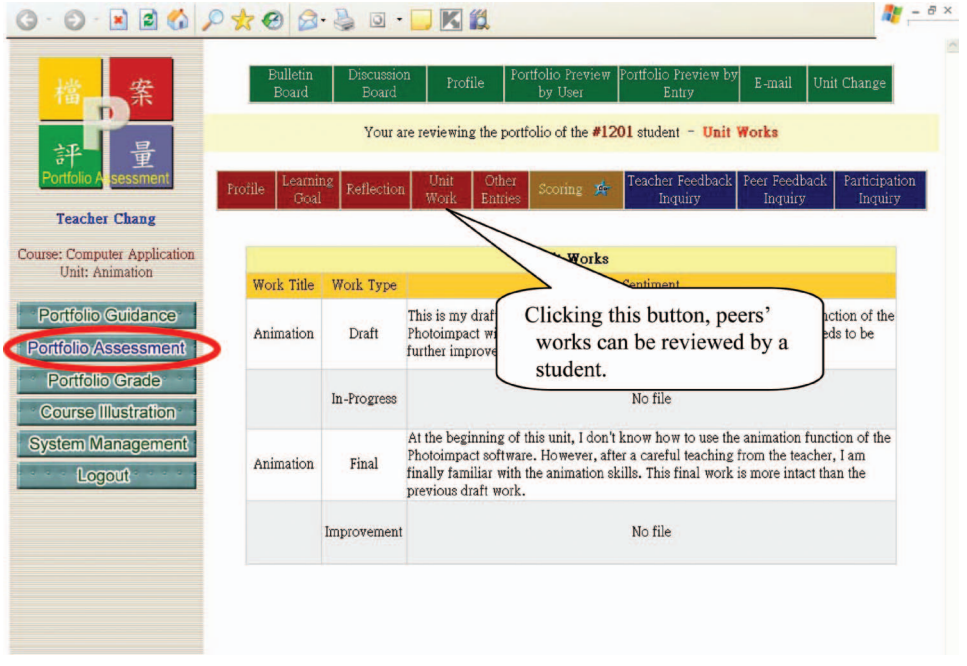

Figure 1. Prior to carrying out peer-assessment, a student may review the works in a student portfolio while getting into the area of 'Portfolio Assessment'.

(4) 'Adding and Deleting Student' enables teachers to add and delete student accounts from a course.
(5) 'Student Profile' provides teachers with access to student accounts and basic information.

Commonly used modules

The following modules are commonly used by teachers, students and system managers: (1) bulletin board; (2) discussion board; (3) user profile; (4) preview of personal Web portfolio (which may be searched on portfolio entry, user name and work); (5) e-mail system and (6) changing course changing units.

Research method

Subjects

The research targets were 60 students from two grade-8 classes in computer courses from some senior high school. The experimental group comprised 30 students in one class, who used the Web-based portfolio assessment system to proceed with PBL and assessment. The control group comprised 30 students who employed conventional assessment, rather than the portfolio assessment system, for PBL. The students practiced for 2 h per week over 10 weeks. The teaching content was the same in both groups: two units of 'Animation production using PhotoImpact' and 'Web page production with Dreamweaver'. The project work was one of the major collections of the experimental group students in their portfolio.

Research design

This study adopted a design with non-equivalent groups, and pre-testing and post-testing, as shown in Table 1. The academic achievements and computer course achievements of the students in the two groups in the previous semester were gathered before the test. The experimental group and the control group were given pre-tests of pre-requisite and self-perceived learning performance. Post-tests were conducted to measure self-perceived learning performance, project work and knowledge understanding (final paper-based test in classroom).

Figure 2 depicts the research framework. First, a *t*-test was applied to identify differences in pre-requisites between the two groups, to determine the statistical analysis method to be employed in the rest of the experiment. If the differences were not statistically significant, then the *t*-test would have been applied. Otherwise, ANCOVA would have been employed. Consequently, the two groups did not exhibit any significant difference in pre-requisites (see the Results and Discussion section for details). Therefore, the *t*-test was employed to examine the difference in self-perceived learning performance between the two groups. A significant difference would imply that student perceived learning performance arising from portfolio assessment to be better than that from conventional assessment. Similarly, the *t*-test was also adopted to examine the difference between the pre-test and post-test of self-perceived learning performance of the experimental group. A significant difference would mean that students perceived portfolio assessment as effective in raising learning performance. Furthermore, the *t*-test was also utilized to examine the difference in achievements between the two groups. A significant difference would indicate that portfolio assessment was more effective than conventional assessment in raising achievement in project work and knowledge testing.

The following research variables were employed in this study:

(1) 'Achievement' consisted of project achievements for two units, and achievements in tests following treatment.
(2) 'Self-perceived learning performance' comprised PBL performance and portfolio assessment performance. PBL performance was divided into three dimensions: gathering and organizing data; continuous improvement, and

Table 1. Pre-test and post-test non-equivalent-group design in quasi-experimental research.

Groups	Subject numbers	Pre-test	Treatment	Post-test
Experimental group	30	Pre-requisite (Academic achievements for last semester, Computer course achievement for last semester) Self-perceived learning performance	Using the Web portfolio assessment system (portfolio assessment)	Self-perceived learning performance Achievement (including project work, test)
Control group	30	The same as experimental group	Traditional assessment	The same as experimental group

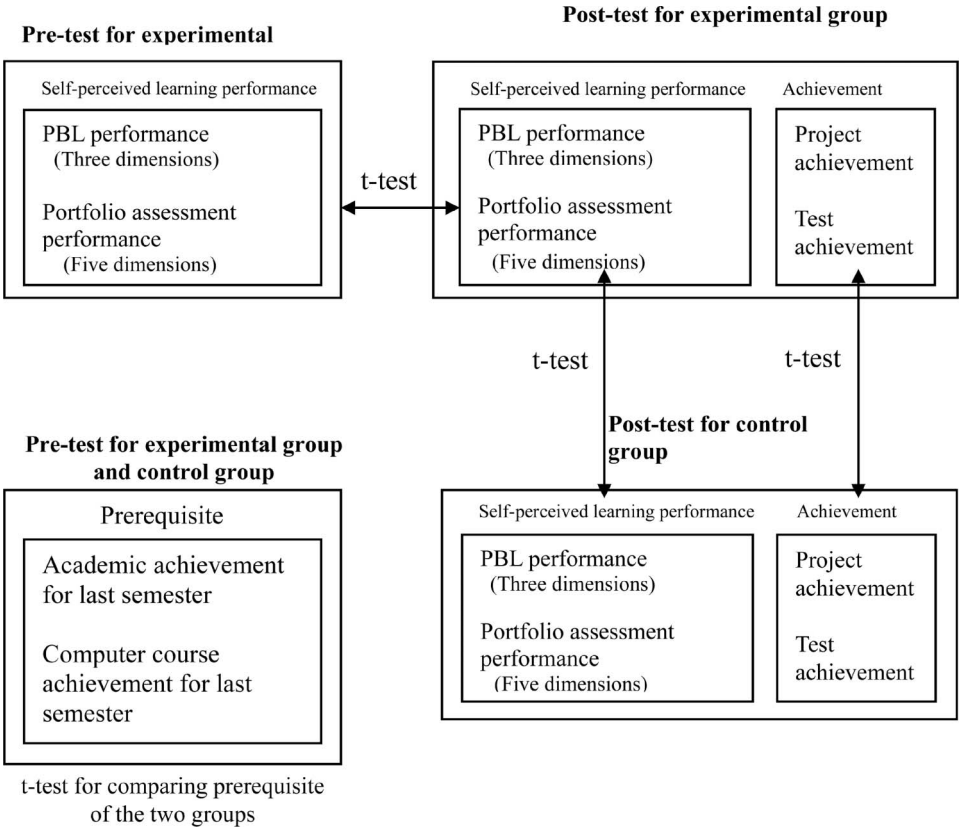

Figure 2. Research framework.

discovering and solving problems. Portfolio assessment performance was divided into six dimensions: setting learning goals, project quality, reflection, self-evaluation, peer assessment and peer interaction. The scale had nine dimensions in total, each comprising five assessment questions. The questionnaire was composed of 45 questions (see details in the next section 'Self-Perceived Learning Performance Questionnaire').

Experiment

Procedure

Preparation stage (1st week). For the experimental group, the teachers first explained the concepts of PBL, the portfolio assessment method and the skills of writing reflection to the students in class. They also described the courses, demonstrated how to operate the system and encouraged the students to try it out. For the control group, the teachers explained PBL to the students in class. The two groups proceeded with the pre-test of pre-requisite and self-perceived learning performance.

The first unit (2nd to 5th week). The experimental group students proceeded with the PBL activities such as project subject selecting, data gathering, discussion and

project revision once they had gained an initial understanding of the system. They also participated in various activities on the Web-based portfolio assessment system after class, including setting of learning goals, project submission, reflective writing, creation of other portfolio items, online discussion, viewing and emulating peer projects, self-assessment, peer assessment and feedback. The control group proceeded with conventional PBL in the classroom without portfolio assessment, but performed other tasks such as project subject selection, data gathering, discussion, viewing and emulating peer projects, project revision and project presentation.

The second unit (6th to 9th week). This involved teaching different units, and repeating various activities at the second stage.

Assessment (10th week). The teachers conducted the final test and post-test of self-perceived learning performance for students in both groups at the end of the course.

To avoid the so-called Hawthorne effect (Robbins & Coulter, 2003) during the progress of the experiment, the students using the Web-based assessment system were asked to behave as they would normally, rather than excessively participating in the experiment due to curiosity.

Validity and reliability of questionnaires

The first draft of the questionnaire on self-perceived learning performance was based on the literature review. The final draft was established following several modifications from the experts. Thus, the questionnaire had expert validity. Table 2 presents the content of the questionnaire, including PBL performance and portfolio assessment performance. Each dimension had five questions, and the score was based on a five-point rating scale. The first three questions measured abilities, and the final two questions measured effects. Ability was assessed with locutions such as 'you would try to', 'you know how to' and 'according to', and effect was assessed with locutions such as 'achieve', 'improve' and 'elevate'.

Table 2. Cronbach α values of self-perceived learning performance questionnaire.

Performances	Pre-test for experimental group	Post-test for experimental group	Post-test for control group
Portfolio assessment performances (ability and effect)	0.9556	0.9687	0.8458
Setting learning goal	0.7527	0.8442	0.7134
Project	0.8158	0.8636	0.7493
Reflection	0.7650	0.8245	0.7631
Self-assessment	0.8453	0.8016	0.7677
Peer assessment	0.8499	0.8232	0.6942
Peer interaction	0.8636	0.8489	0.8463
PBL performances (ability and effect)	0.9642	0.9333	0.6837
Gathering and organizing data	0.8938	0.8589	0.7232
Continuous improvement	0.9260	0.8635	0.7188
Discovering and solving problems	0.8871	0.8234	0.7441
Overall (ability and effect)	0.9764	0.9770	0.8657

For instance, ability and the effect on setting learning goals were measured with the following statements:

(1) You try to set your learning goals.
(2) You know how to set your learning goals.
(3) You make effort to achieve your goals.
(4) The effort of your learning often achieves your goals.
(5) You believe that setting goals helps improve your learning or works.

Ability and effect on self-assessment

(1) You try to perform self-assessment on your works to identify their merits and problems.
(2) You know how to perform self-assessment of your work, and discern directions for improvement.
(3) You improve and adjust your learning method based on the self-assessment results.
(4) Your self-assessment behavior helps improve your learning and works.
(5) You believe that self-assessment helps discover the good and bad aspects of your own work, and to improve the quality of your work.

Ability and effect on peer interaction

(1) You try to discuss work with your classmates.
(2) You know how to discuss work with your classmates.
(3) You adjust your learning method based on suggestions from the discussion with your classmates.
(4) Discussion and communication with your classmates helps to improve your learning and work.
(5) You believe that discussion and communication with the classmates is helpful for finding out the good and bad aspects of your own works, and helps improve the quality of your work.

Ability and effect on continuous improvement

(1) You continuously try to correct and improve your work.
(2) You know how to continuously correct and improve your works.
(3) You make continuous effort according to the direction of corrections on the works, and adjust your own way of learning.
(4) Continuously correcting your work helps enhance your learning and work.
(5) You believe that finding the good and bad aspects of works through continuous corrections on your work helps further improve the quality of the works.

Table 2 shows that, in the experimental group, the overall Cronbach α-value of the pre-test in the questionnaire was 0.9764, and that of the post-test was 0.977. In the control group, the overall Cronbach α-value of the post-test in the

questionnaire was 0.8657. These experimental results reveal that the questionnaire had a high overall reliability. All Cronbach α-values values were higher than 0.7, except for two low values (0.6942 and 0.6837) in the control group. These findings indicate that the questions in the questionnaire had high internal consistency.

Project assessment form

The researcher measured the performance grades of the students in experimental and control groups using the project assessment component of the portfolio assessment form in the Web-based portfolio assessment system (Wu, 2008). Wu's portfolio assessment form yielded a high reliability with a Cronbach α-value of 0.9228. The project assessment component through the factor analysis held a high validity with an explained variance of 66.71%.

The Cronbach α-values of the project assessment form for both groups were 0.9686 in the unit 1 test, and 0.9856 in the unit 2 test. These two tests had high reliabilities, revealing that the questions in the scale had high internal consistency. The assessment items of the project assessment form comprised project correction, appropriateness, completeness, difficulty, creativity, understanding of project content, the process generated by the project (the students submitted other related works representing the work production process, such as practice work, rudimentary project and revised project) and overall evaluation. Each item was scored out of ten points, with a total maximum score of 80 points.

Test

The teacher designed the test paper based on the course content. The teacher had taught the computer course in one senior high school for 7 years. This test paper had been adopted for several years, and revised annually based on changes in teaching content and the students' performance. Thus, the course could be considered to have a high the content validity. This test paper had ten multiple-choice questions. Table 3 presents the knowledge measured and numbers of questions. Each

Table 3. Item analysis, difficulty and discrimination analysis and reliability analysis in the test paper.

		Item analysis	
Item	Contents	*t* (Sig)	Correlation (Sig)
1	Skill of time axis control	6.01 (0.00)	0.428 (0.00)
2	Skill of animation	4.34 (0.00)	0.386 (0.00)
3	Skill of animation	6.35 (0.00)	0.439 (0.00)
4	Knowledge of time axis control	9.42 (0.00)	0.517 (0.00)
5	Skill of time axis control	7.12 (0.00)	0.458 (0.00)
6	Skill of time axis control	7.89 (0.00)	0.462 (0.00)
7	Knowledge of animation	8.75 (0.00)	0.489 (0.00)
8	Knowledge of animation	4.01 (0.00)	0.381 (0.00)
9	Skill of animation	5.74 (0.00)	0.407 (0.00)
10	Knowledge of time axis control	5.02 (0.00)	0.401 (0.00)
	Cronbach $\alpha = 0.71$		

Note: When the difficulty values or percentages of numbers of people with correct answers were larger, it meant the questions were easier

question in this test paper was worth 10 points, and the total maximum score was 100 points.

The reliability test of the test paper was measured using item analysis. The scores of 60 participant students were classified as high or low. An independent *t*-test was performed to examine the difference between high-scoring and low-scoring groups for each question. The Pearson's Production-Movement Correlation was then utilized to examine the extent of correlation between each question and the total score. The results demonstrated significant differences between the high-scoring and low-scoring groups. Namely, each question could significantly distinguish the high-performing students from the low-performing students. A significant correlation was observed between the score of each question and the total score, revealing sufficient consistency between each question and the whole test. Table 3 presents the determinant value (*t* value) and correlation coefficient of each question.

The reliability verification results for internal consistency indicate that the Cronbach α value reached 0.71, revealing sufficient reliability and a high degree of correlation among the questions.

Results

In comparison with pre-requisites

Table 4 compares the experimental and the control groups in the academic achievement and the computer course achievement for the last semester, and indicates no statistically significant difference between them. This finding implies that the pre-requisites of the students in the two groups were similar, meaning that the learning effects of these two groups were comparable. The *t*-test employed in the next section was thus meaningful, and ANCOVA (Analysis of Covariance) testing was not necessary to use. Furthermore), the result of the 'difference' examination was reliable.

Effect of using portfolio assessment system on achievements (project and test)

The results of the Levene's homogeneity-of-variance test, shown in Table 5 indicate that the three *F* values were not significant ($p > 0.05$). This finding reveals that the population of the experimental and control groups satisfied the hypothesis of variance homogeneity. Although the average test achievement of the experimental group was higher than that of the control group, the difference was not significant.

Table 4. In comparison with pre-requisites between the experimental group and the control group (independent *t*-test).

	Experimental group		Control group			
Pre-requisites	Mean	SD	Mean	SD	*t*	Sig
Average academic achievement for last semester	77.36	13.14	74.79	13.13	−1.163	0.249
Computer course average achievement for last semester	74.65	9.23	76.23	7.34	0.766	0.446

This finding reveals that utilizing the Web-based portfolio assessment system did not significantly affect test achievement. The control group had insignificantly higher average project achievement than the experimental group, revealing that using the Web-based portfolio assessment system did not elevate the project achievement. Notably, the proposed system was a computer-aided assessment tool, rather than an e-learning application. Thus, the system supported assessment, but did not improve learning as much as e-learning material would have done. In addition, the overall achievements (mean of project and test) between the two groups were not significantly different, implying that using the Web-based portfolio assessment system did not significantly affect achievement.

Effect of using portfolio assessment system on self-perceived learning performances (post-tests for two groups)

Table 6 compares the abilities and effects of the two groups. The table data demonstrate that for the post-test results, both overall and most of individual abilities and effects were higher in the experimental group than in the control group. With the exception of the ability of peer assessment and the effect on discovering and solving problems, all other abilities and effects showed a significant difference between the two groups. This finding implies that the use of the Web-based portfolio assessment system significantly affected the students' self-perceived learning performances (including portfolio assessment ability, PBL ability, portfolio assessment effect and PBL effect). The application of the Web-based portfolio assessment system did not significantly elevate ability in peer assessment, but it raised the peer assessment effect. Restated, the peer assessment ability needed further enhancement. We suggest that the peer assessment capacity can be strengthened by simplifying the assessment items, adding some further details to the peer assessment descriptions, and practicing assessment. In contrast, the use of the Web-based portfolio assessment system did not significantly enhance the effects of discovering and solving problems, but did elevate their capacities. This finding demonstrates that the effects of discovering and solving problems from PBL need to be strengthened. This aim can be accomplished through teachers' direction, peer collaboration, clear problem-resolving steps and real situations that trigger the motivations or discovery learning activities.

Table 7 presents the overall performance results, combining ability and effect, for both groups. The comparison data in Table 7 demonstrate that all self-perceived

Table 5. Difference in achievements (project, test) between the experimental and the control group (independent *t*-test).

	Homogeneity-of-variance test		Experimental group		Control group			
Achievements	*F*	Sig	Mean	SD	Mean	SD	*t*	Sig
Project	3.79	0.75	60.00	6.33	62.47	5.86	−0.702	0.496
Test	4.15	0.54	61.70	7.56	61.30	6.08	0.053	0.958
Mean of project and test	3.98	0.67	60.35	6.99	61.89	6.02	−0.397	0.683

Table 6. Difference in pre-test of self-perceived learning performances (ability, effect) between experimental and control group (independent *t*-test).

Performances	Experimental group		Control group		*t*	Sig
	Mean	SD	Mean	SD		
Portfolio assessment abilities	57.30	9.82	48.90	5.39	4.091	0.000***
Setting learning goals	11.37	2.10	9.43	1.92	3.725	0.000***
Reflection	11.53	2.19	9.43	1.63	4.206	0.000***
Self-assessment	11.50	2.06	9.53	1.61	4.112	0.000***
Peer assessment	11.70	2.26	10.97	1.81	1.387	0.171
Peer interaction	11.20	2.41	9.57	2.37	2.643	0.011*
PBL abilities	34.43	6.25	28.70	3.25	4.457	0.000***
Gathering and organizing data	11.17	2.34	9.13	1.46	4.407	0.000***
Continuous improvement	11.67	2.44	9.93	1.48	3.324	0.002**
Discovering and solving problems	11.60	2.24	9.63	1.69	4.840	0.000***
Overall ability	91.73	15.54	77.63	7.50	4.475	0.000***
Portfolio assessment effects	58.47	10.32	49.50	6.06	4.104	0.000***
Setting learning goal	7.57	1.48	6.43	1.52	2.924	0.005**
Project	19.27	3.54	16.50	2.57	3.463	0.001**
Reflection	8.03	1.61	6.53	1.43	3.816	0.000***
Self-assessment	7.83	1.68	6.63	1.27	3.115	0.003**
Peer assessment	7.90	1.54	7.10	1.40	2.107	0.039*
Peer interaction	7.87	1.66	6.30	1.51	3.827	0.000***
PBL effects	23.13	3.99	20.53	2.49	3.029	0.004**
Gathering and organizing data	7.47	1.74	6.63	1.10	2.221	0.031*
Continuous improvement	7.83	1.53	6.70	1.21	3.181	0.002**
Discovering and solving problems	7.83	1.32	7.20	1.40	1.806	0.076
Overall effect	81.60	13.94	70.03	7.51	4.000	0.000***

Note: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

learning performance levels (portfolio assessment performance, PBL performance, and overall performance) in the post-test of the experimental group were higher than those in the control group. All performance levels, except for peer assessment performance (ability and effect), showed a significant difference between the two groups. These findings indicate that using the Web-based portfolio assessment system significantly affected the students' self-perceived learning performance. However, the system did not significantly enhance peer assessment performance, indicating that peer assessment performance should be further upgraded.

We suggest that assessment can be attained by providing convenient online peer assessment mechanisms, or enhancing peer assessment abilities.

Effect of using portfolio assessment system on self-perceived learning performances (pre-test and post-test for experimental group)

Results of research questions no. 1 and no. 2 were both compared with the experimental group and the control group; however, since the pre-requisites of two groups were not exactly the same, the results might not be sufficiently reliable. Therefore, the results of research question no. 3 were compared with the pre-test and the post-test of the experimental group to determine the insufficiency. Table 8 presents these comparison results, and demonstrates that all abilities and effects,

Table 7. Difference in post-test of self-perceived learning performances (mean of ability and effect) between experimental and control group (independent *t*-test).

Performances	Experimental group		Control group			
	Mean	SD	Mean	SD	*t*	Sig
Portfolio assessment performances (ability and effect)	115.77	19.46	98.43	10.10	4.330	0.000**
Setting learning goals	18.93	3.35	15.87	2.78	3.859	0.000**
Project	19.27	3.54	16.50	2.57	3.463	0.001*
Reflection	19.57	3.55	15.97	2.75	4.393	0.000**
Self-assessment	19.33	3.35	16.17	2.53	4.133	0.000**
Peer assessment	19.60	3.41	18.07	2.52	1.981	0.053
Peer interaction	19.07	3.66	15.87	3.47	0.476	0.001*
PBL performances (ability and effect)	57.57	9.79	49.23	4.68	4.205	0.000**
Gathering and organizing data	18.63	3.78	15.77	2.34	3.528	0.001*
Continuous improvement	19.50	3.76	16.63	2.28	3.572	0.001*
Discovering and solving problems	19.43	3.21	16.83	2.15	3.683	0.001*
Overall (ability and effect)	173.33	28.57	147.67	13.14	4.470	0.000**

Note: *$p < 0.01$, **$p < 0.001$.

Table 8. Difference in self-perceived learning performances (abilities, effects) between pre-test and post-test of experimental group (dependent *t*-test).

Performances	Pre-test		Post-test			
	Mean	SD	Mean	SD	*t*	Sig
Portfolio assessment abilities	32.73	9.10	57.30	9.82	−10.054	0.000**
Setting learning goals	6.73	2.13	11.37	2.09	−8.495	0.000**
Reflection	6.37	1.99	11.53	2.19	−9.554	0.000**
Self-assessment	6.83	2.36	11.50	2.06	−8.144	0.000**
Peer assessment	6.33	2.14	11.70	2.26	−9.444	0.000**
Peer interaction	6.47	2.28	11.20	2.41	−7.801	0.000**
PBL abilities	19.27	6.92	34.43	6.25	−8.906	0.000**
Gathering and organizing data	6.43	2.42	11.17	2.33	−7.714	0.000**
Continuous improvement	6.37	2.62	11.67	2.44	−8.109	0.002*
Discovering and solving problems	6.47	2.36	11.60	2.24	−8.646	0.000**
Overall ability	52.00	15.70	91.73	15.54	−9.853	0.000**
Portfolio assessment effects	32.67	10.15	58.47	10.32	−9.764	0.000**
Setting learning goals	4.40	1.43	7.57	1.48	−8.437	0.000**
Project	10.87	3.38	19.27	3.54	−9.396	0.000**
Reflection	4.33	1.73	8.03	1.61	−8.584	0.000**
Self-assessment	4.07	1.89	7.83	1.68	−8.146	0.000**
Peer assessment	4.40	1.75	7.90	1.53	−8.216	0.000**
Peer interaction	4.60	1.79	7.87	1.66	−7.333	0.000**
PBL effects	12.83	5.12	23.13	3.99	−8.692	0.000**
Gathering and organizing data	4.43	1.83	7.47	1.74	−6.581	0.000**
Continuous improvement	4.23	1.83	7.83	1.53	−8.253	0.000**
Discovering and solving problems	4.17	1.86	7.83	1.32	−8.821	0.000**
Overall effect	45.50	14.74	81.60	13.94	−9.744	0.000**

Note: *$p < 0.01$, **$p < 0.001$.

overall ability and effect for experimental group were significantly higher in the post-test than in the pre-test, and reached a level of difference. Hence, the use of the Web-based portfolio assessment system had a significant effect on the students' portfolio assessment abilities, PBL abilities, portfolio assessment effects and PBL effects.

Table 9 presents the results of combining ability and effect into learning performance, indicating that all self-perceived learning performances (portfolio assessment performances, PBL performances, overall performance) for the experimental group were significantly higher in post-test than in the pre-test. Restated, the use of the Web-based portfolio assessment system significantly affected the portfolio assessment performance, PBL performance and overall self-perceived learning performance.

Discussion

Analytical results of research questions no. 1 and no. 2 demonstrate that project achievement was higher in the control group than in the experimental group, but that the difference was not significant ($p = 0.496$). Conversely, the self-perceived learning performance on project quality of students was significantly higher in the experimental group than in the control group ($p = 0.001$), i.e. the opposite result to that of project achievement. The result of the research question no. 3 also demonstrates a significant difference between the pre-test and post-test of self-perceived learning performance on project quality for the experimental group. These findings reveal that the assessment on the students should not simply incorporate the scores given by teachers, but should also incorporate the students' views on their own performance. One student reflected in his portfolio that

> 'I thought that I would have a high score for my work. After looking at my score graded by the teacher, I found a gap between teacher evaluation and my own evaluation. My viewpoints on the work were probably different from that of the teacher. Hopefully, students' viewpoints could be taken into account the next time the teacher scores our

Table 9. Difference in self-perceived learning performance between pre-test and post-test for experimental group (dependent *t*-test).

Performances	Pre-test		Post-test			
	Mean	SD	Mean	SD	*t*	Sig
Portfolio assessment performances (ability and effect)	65.4	18.52	115.77	19.46	−10.270	0.000*
Setting learning goals	11.13	3.25	18.93	3.35	−9.156	0.000*
Project	10.87	3.38	19.27	3.54	−9.396	0.000*
Reflection	10.70	3.40	19.57	3.55	−9.887	0.000*
Self-assessment	10.90	3.85	19.33	3.35	−9.051	0.000*
Peer assessment	10.73	3.64	19.60	3.41	−9.739	0.000*
Peer interaction	11.07	3.81	19.07	3.66	−8.292	0.000*
PBL performances (ability and effect)	32.10	11.77	57.57	9.79	−9.108	0.000*
Gathering and organizing data	10.87	4.03	18.63	3.78	−7.694	0.000*
Continuous improvement	10.60	4.30	19.50	3.76	−8.541	0.000*
Discovering and solving problems	10.63	3.92	19.43	3.21	−9.514	0.000*
Overall (ability and effect)	97.50	29.72	173.33	28.57	−10.070	0.000*

Note: *$p < 0.001$.

works. The scores of student self-evaluations and peer-evaluations could be counted into the grading of the works. Even if these only contributed a small part of the final grade, I would feel good. That will be inspiring to students'.

Therefore, the students' self-assessment should contribute to the total score. The teachers can consider involving it as part of the assessment plan. (Note: the project assessment methods for the experimental group comprised teacher assessment, online teaching assistant assessment, student assessment and peer assessment. The control group did not utilize the Web-based portfolio assessment system, and thus only participated in teacher assessment and teaching assistant assessment. To ensure consistency of achievements in the two groups, the final project achievement score did not incorporate the student self-assessment or peer assessment achievements

Results of research questions no. 2 and no. 3 demonstrate that all abilities, effects and performances (ability and effect) were significantly higher in the post-test of the experimental group than in the control group, except for peer assessment ability, the effect of discovering and solving problems and peer assessment performance (ability and effect), where the difference was not significant. Furthermore, all abilities, effects and performances of the experimental group were significantly higher in the post-test than in the pre-test.

The two findings corresponded to each other. The result of the independent sample could supplement the insufficiency of the result of the dependent sample, which could also compensate for the error incurred by the case where two groups might not have exactly the same pre-requisite. The two results strengthened each other's reliabilities. Hence, the result that 'there were significant influences on self-perceived learning performances (abilities, effects) for using the Web-based portfolio assessment system' became increasingly convincing. The significant levels of the comparisons between the pre-test and post-test of the experimental group were nearly all 0.000, indicating that the differences in these comparisons were more significant than those between the experimental and control groups, among which only some were 0.000. These findings reveal that the statistical test outcome of the use of the Web-based portfolio assessment system, in terms of the dependent sample (experimental group), was more significant than that of the two independent samples (experimental and control groups). The reason for the difference might be that the pre-requisites in two groups were not exactly the same, thus reducing some effects.

Conclusions

(1) Statistically positive effects on self-perceived learning performances (abilities, effects) were observed when using the Web-based portfolio assessment system.

All abilities and effects in the post-test of self-perceived learning performances were higher for the experimental group than for the control group, and most of them reached significant difference. All abilities and effects of self-perceived learning performances for the experimental group were significantly higher in the post-test than in the pre-test. According to these results above, the significances shown in the latter results (dependent sample) were mostly higher than those in former results (independent sample). These two results reveal that the use of the Web-based portfolio assessment system significantly affected the students' self-perceived learning performance

(in terms of abilities and effects). The results are consistent with each other, and demonstrate a positive effect of the use of the Web-based portfolio assessment system on self-perceived learning performances.

The result was consistent with most of the research results, which demonstrated that 'the use of portfolio assessment could enhance self-perceived learning abilities or effects' (Chang, 2001; Barrett, 2000; Dennis et al., 2006; Singh and Ritzhaupt, 2006). However, those previous studies did not validate detailed abilities or effects. This study validates the improvements in abilities and effects including ability and the effect on setting learning goals, project, reflection, self-assessment, peer assessment (not including abilities), peer interaction, gathering and organizing data, continuous improvement and discovering and solving problems (not including effects).

(2) The learning effects should not only address the achievements from the teachers' assessment, but should also involve the students' self-assessment and peer assessment achievements.

Project achievement was higher in the control group than in the experimental group (but not significantly so), while the self-perceived project achievement of the experimental group was significantly higher than that of the control group. These two results contrast with each other. Additionally, the students in the experimental group also thought that the use of the Web-based portfolio assessment system could significantly enhance their project achievement. These findings reveal that in order to meet the spirit of portfolio assessment, student assessment should be based not only on scoring by teachers, but also on the student self-assessment and peer assessment. According to the George Lucas Education Foundation (2002, 2005), PBL should provide students with self-assessment tools to raise their active participation and motivation. A teacher-student forum can be provided for communication when the gap between self-assessment and teacher assessment is too wide, giving the students opportunities to explain their projects. Self-assessment is regarded as the most important aspect of portfolio assessment, and therefore assessment should not rely solely on the scores given by teachers (Popham, 2002).

(3) Web-based portfolio assessment system may be applied in PBL; however, its interference with learning should be lowered.

The Web-based portfolio assessment system significantly enhanced student self-perceived learning performance, but not the project achievement as assessed by the teacher. Although PBL could employ the Web-based portfolio assessment system to support the teaching and assessment, we suggest that its interference in learning should be reduced. The students should be provided with extra individual instruction and time to undertake projects in order to raise the effect of the system on teaching and assessment. Furthermore, the system could be upgraded, for instance with any of the following measures to lower the burdens of the system on learning: simplifying the operational functions; strengthening the students' setting of learning goals, writing reflections and the convenience of online self-assessment and peer assessment, and simplifying the questions in the portfolio assessment form.

(4) Ability of peer assessment, and effect of discovering and solving problems, should be enhanced.

The Web-based portfolio assessment system did not significantly elevate either peer assessment ability, or the effect of discovering and solving problems. To improve of ability of peer assessment, we recommend simplifying the peer assessment items, and providing the students with more detailed explanations and practice in peer assessment, as well as sufficient time to finish the peer assessment activities. To improve the effect of discovering and solving problems, we suggest that practice in PBL should provide the students with real situations that can trigger their motivations and the related learning activities, the teachers' direction, peer collaboration and clear problem-solving steps, thus reaching the effect of active discovery and solving of problems.

Acknowledgements

The authors thank the National Science Council of the Republic of China, Taiwan, for financially supporting this research under Contract No. NSC 95-2520-S-027-001-MY3. Sin-Ra Peng is appreciated for his assistance in conducting the experiment in this study.

Notes on contributors

Chi-Cheng Chang is a professor of e-learning technology at the Department of Technological Application and Human Resource Development (Formerly Industrial Technology Education), National Taiwan Normal University. He gained his PhD in Workforce Education and Development from the Pennsylvania State University, USA. His research interests are focused on e-learning strategies and digital assessment. So far, he has conducted many research projects regarding e-portfolio and web-based portfolio assessment and published these research outcomes in several SSCI journals. These research outcomes have been practically promoted and applied at some universities and high schools. He is currently researching advanced issues of e-portfolio and web-based portfolio assessment. He is now a Chair of the Discipline of Applied Science Education, Division of Science Education, National Science Council, Taiwan.

Dr. Kuo-Hung Tseng is a Chair Professor at the Graduate Institute of Business Management, Meiho Institute of Technology and Academic Consultant of Science Education Division, Taiwan's National Science Council. His research interests are web problem-based learning (PBL), knowledge management (KM) and engineering education. He conducted his research group on the use of web PBL and KM systems for teaching and learning in the engineering education field. He has published research findings, including on-line PBL and knowledge-transfer theory and practice, in several SSCI journals. Currently, he is doing research on advanced e-learning issues. He has held the positions of Academic Vice President, Dean of Research & Development, Dean of Teaching Practice and Guidance, and Chairperson of the University.

References

Barker, K.C. (2006). *Environmental scan: Overview of the ePortfolio in general and in the workplace specifically*. Retrieved August 2, 2008, from http://www.FuturEd.com

Barrett, H.C. (2000). Create your own electronic portfolio. *Learning and Leading with Technology*, *27*(7), 14–19.

Blumenfeld, P.C., Soloway, E., Marx, R.W., Krajcik, J.S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, *26*(3&4), 369–398.

Buck Institute for Education. (2006). Project-based learning handbook. Retrieved August 2, 2008, from http://www.bie.org/

Chang, C.-C. (2001). A study on the evaluation and effectiveness analysis of web-based learning portfolio (WBLP). *British Journal of Educational Technology*, *32*(4), 435–458.

Dennis, C., Hardy, J., & White, P. (2006). Development of a model to advance the uptake of e-portfolios for undergraduates in teacher education and registered nurse preparation: An exemplar of best practice. In E. Pearson & P. Bohman (Eds.), *Proceedings of Ed-Media* (pp. 248–253). Norfolk, VA: AACE.

Driscoll, M.P. (2000). *Psychology of learning for instruction*. Boston, MA: Allyn and Bacon.

Emden, C., Hutt, D., & Bruce, M. (2003/2004). Portfolio learning. *Contemporary Nurse*, *16*(1–2), 124–132.

ePortfolio Consortium (2003). *Electronic portfolio white paper*. Retrieved August 2, 2008, from http://eportconsortium.org/

Forkosh-Baruch, A., Mioduser, D., & Nachmias, R. (2006). Diffusion of patterns of ICT-based pedagogical innovations. In E. Pearson & P. Bohman (Eds.), *Proceedings of Ed-Media* (pp. 58–65). Norfolk, VA: AACE.

Furger, R. (2005). *Assessment for understanding*. Retrieved August 2, 2008, from http://www.glef.org/

Gardner, H. (1993). *Multiple intelligences: The theory in practice*. New York, NY: Basic Books Harvard Press.

George Lucas Education Foundation. (2002). *How does project-based learning work?* Retrieved August 2, 2008, from http://www.glef.org/modules/PBL/index.php

George Lucas Education Foundation. (2005). *Assessing project-based work*. Retrieved August 2, 2008, from http://www.glef.org/

Huang, M.-S. (2002). *Design of web project-based teaching model*. Unpublished Master's thesis. Tamkang University, Taipei.

Hung, Y.-L. (2002). *Influences of web collaborative project learning on low achievements of students*. Unpublished Master's thesis. Tainang University, Tainang.

Krajcik, J.S., Czeniak, C., & Berger, C. (1999). *Teaching children science: A project-based approach*. Boston, MA: McGraw-Hill College.

Lee, D.-L. (2004). *Influences of information technology integrating project-based learning on students' science learning attitude and problem-solving ability for elementary schools*. Unpublished Master's thesis. Taipei Municipal Education University, Taipei.

Lee, K.-C. (1999). *Multiple teaching assessment*. Taipei: Shin-Lee.

Masayuki, M., Shinichi, H., Yuzuki, S., & Wachs, S. (2006). Multi-lingual website for foreign visitors to Kyoto based on students group work. In E. Pearson & P. Bohman (Eds.), *Proceedings of Ed-Media* (pp. 97–101). Norfolk, VA: AACE.

Moursund, D. (1999). *Project-based learning using information technology*. Eugene, OR: International Society for Technology in Education.

Popham, W.J. (2002). *Classroom assessment: What teachers need to know*. Boston, MA: Allyn and Bacon.

Robbins, S., & Coulter, M. (2003). *Management*. Englewood Cliffs, NJ: Prentice Hall.

Simkins, C., & Michael, J. (1999). Project-based learning with multimedia. *Thrust for Educational Leadership*, *28*(4), 10–14.

Singh, O., & Ritzhaupt, A.D. (2006). Student perspectives of organizational uses of eportfolios in higher education. In E. Pearson & P. Bohman (Eds.), *Proceedings of Ed-Media* (pp. 1717–1722). Norfolk, VA: AACE.

Wang, M.-Y. (2002). *Action research of information technology integrating project-based learning for curriculam integration*. Unpublished Master's thesis. Taipei Municipal Education University, Taipei.

Wu, M.-F. (2008). *Reliability and validity of web portfolio assessment rubrics*. Unpublished Master's thesis. National Taipei University of Technology.