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Effectiveness and Impact of Technology-enabled Project-based Learning with the Use of Process Prompts in Teacher Education

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This study investigated the effectiveness and impacts of process prompts on students' learning and computer self-efficacy within the technology-enabled project-based learning (PBL) context in an undergraduate educational technology course. If the aim is to prepare prospective teachers to effectively, efficiently, and engagingly use technologies in changing professional circumstances, it is important to provide learning tasks that are not only authentic and meaningful, but also strengthen computer self-efficacy. Technology-enabled PBL with the assistance of process prompts was used to elicit prospective teachers' perceptions of their learning experiences in past courses in the program to help them integrate knowledge acquired prior to solving instructional problems and to assist them in self-assessing their own knowledge. Thirty-five prospective teachers enrolled in a Web-Based Instruction for English Language Teaching (ELT) course worked collaboratively for a duration of four months in groups of five to complete a project. Collected data included surveys, interviews, final projects, and reflections. Students' interviews and reflections revealed that process prompts were important in facilitating problem-solving efforts; they support metacognitive thinking, and facilitate the construction of knowledge in technology-enabled PBL. The surveys showed significant gains on students' computer self-efficacy after the completion of technology-enabled PBL. The findings contribute to the field of technology education through PBL and provide a point of reference for other teachers who want to implement PBL in their curricula. The implications of the approach for the use of technology-enabled PBL for teacher education are discussed.

INTRODUCTION AND PROBLEM STATEMENT

Researchers have stressed the need for teacher education to promote and evaluate the development of multiple kinds of knowledge and skills through authentic learning experience (Darling-Hammond & Snyder, 2000; Lave & Wenger, 1991; Wiggins, 1993). Teacher education programs have often approached the concept of maximizing authentic learning through student teaching, case studies, classroom observations and project-based learning. Despite the plethora of rhetoric about the potential of authentic learning, there is still a paucity of empirical data addressing the implementation of project-based learning to promote authentic learning, or about its impact on teaching and learning practices.

In the past two decades, we have witnessed an unprecedented increase in technology usage in classroom settings. Hence, preparing pre-service teachers for successful integration of educational technologies into their teaching and learning practices has become an important goal for teacher education institutes (e.g., Krueger, Hansen, & Smaldino, 2000). Classes of technology integration offered by teacher education programs generally help students to gain technology skills and model good examples of using technology for teaching (Kay, 2006). However, researchers have argued that many educational technology courses fail to provide prospective teachers with a clear vision of how technology can be used to support educational best practices and to enhance computer self-efficacy (Ertmer, Gopalakrishnan, & Ross, 2001; Roblyer, 1993). In fact, the understanding of how we can best prepare our student teachers to teach effectively, efficiently, and engagingly with the use of technology while increasing their computer self-efficacy requires further investigation and discussion. In this study, we will investigate how process prompts can be used to facilitate prospective teachers' learning in the context of technology-enabled project-based learning in educational technology courses and examine its impact on their learning and computer self-efficacy.

REVIEW OF RELEVANT RESEARCH

Technology-enabled Project-based Learning (PBL)

One of the greatest opportunities in higher education is the chance for students to become independent thinkers and problem-solvers who can construct their own knowledge. Higher education is also meant to prepare students to become qualified professionals who can solve real-world and complex problems based on professional and scientific knowledge in specific professional areas. A prominent strategy used in higher education to achieve this end is the effort to help students confront real and meaningful tasks and problems. PBL provides a multitude of unique learning experiences that mimics the real-world context and encourages meaningful learning through student-directed investigation (Blumenfeld et al., 1991). Originating with Dewey (1959), PBL cultivates problem-solving skills by encouraging learners to take learning initiatives to recall and apply their prior experiences or previously acquired knowledge, and to alter their approaches to accommodate inconsistency or failed expectations. Generally, the PBL context involves searching for answers to questions, collaboration, scientific investigation, and evidence gathering (Thomas, 2000). When students are immersed in such a context, they engage in problem-solving, decision-making, and investigation over longer periods of time; the results include products and presentations (Jones, Rasmussen, & Moffitt, 1997).

Seo, Templeton, & Pellegrino (2008) found that PBL contributed to the enhancement of a knowledge base and professional growth with respect to domain knowledge. Through PBL, students reflect on their own learning and establish a more concrete, insightful teaching philosophy. Grounded in constructivism, PBL promotes social interaction in which teachers, students, and community members work together on an activity to construct shared understanding and reach consensus through negotiation and articulation. As a result, the process amplifies and expands what students can learn (Duffy & Jonassen, 1992). In teacher education, PBL has been used as a teaching method as well as an evaluation strategy in educational technology courses (Gulbahar & Tinmaz, 2006; Land & Greene, 2000).

Accordingly, many teachers have recognized the importance of using technology in their classrooms (e.g., Beichner, 1993; ChanLin, 2008; Fulton, 1993). Yet researchers have found that they often have a limited understanding of and limited experience with various educational aspects of technology usage (Ertmer, 2005). Technology-enabled PBL can offer an ideal opportunity for students to demonstrate mindful application and integration of various technological tools into their instruction design (Moore, 1995). In technology-enabled PBL, students typically design an instructional plan prior to the development of a sound multimedia-based instruction. The design plan of instruction should reflect the outcomes of needs analysis which include detailed information on the learners (i.e., performance, knowledge, skills, and experience), the content (i.e., prerequisites and instructional goals), and the learning environment (i.e., description of existing environment and tradeoffs). The outcomes of needs analysis inform the development of actual instructional products and the strategies (i.e., learner-centered, knowledge-centered or assessment-centered) that would be implemented for the delivery of the content. In addition, when it comes to evaluate students' technology-enabled PBL, it is important to ensure that the design plan of instruction is aligned with the product.

While PBL has garnered significant popularity in professional teacher education because of its potential to contextualize knowledge in authentic situations (Blumenfeld et al., 1991; Foulger & Jimenez-Silva, 2007; Seo et al., 2008), the investigation of technology-enabled PBL should shed light on the effectiveness of PBL in improving student-teachers' learning regarding technology integration.

Scaffolds for Technology-enabled PBL

Technology-enabled PBL is student-centered and requires self-regulation and sophisticated forms of cognitive processing such as analysis, application, and synthesis (Greene & Land, 2000). However, students who do not possess adequate knowledge or who lack metacognitive skills often face great difficulties in such a complex learning environment. In fact, researchers have advised that the provision of support for learning within the context of PBL is critical for novices (e.g., Greene & Land, 2000; Land & Greene, 2000; Mettas & Constantinou, 2007; Murphy & Gzai, 2001).

Scaffolds are instructional supports that are designed to direct students' attention towards typical problem area(s) and monitor or regulate their own learning by responding to the questions being asked (Rosenshine, Meister, & Chapman, 1996). Studies have consistently pointed to the advantages of using process prompts in promoting effective and productive problem solving (e.g., Choi & Lee, 2009; Ge & Er, 2005; Lee & Chen, 2009). For example, Ge, Chen, and Davis (2005) found that prompts facilitated the development of students' domain-specific or structured knowledge and activated their metacognitive knowledge (i.e., knowledge of cognition) and skills (i.e., planning, monitoring, and evaluation). Moreover, process prompts have been seen to provide temporary support for students' initial learning before they reach intended goals and also may act as a "more able other" when a human tutor is absent (Davis, 2003; Palinscar, 1986; Rosenshine & Meister, 1992; Rosenshine et al., 1996).

Greene and Land's (2000) study illuminated the use of scaffolds among college students working on web-enhanced PBL in an educational computing course; the authors found that scaffolds such as process prompts effectively facilitated the completion of PBL. In the current study, process prompts were used to guide students' attention towards the process of multimedia-based instructional design and development and to provide the expected support necessary for learners engaged in technology-enabled PBL. The process prompts were framed based on a globally known multimedia-based instructional design (ID) model, which includes five phases—(1) analysis, (2) design, (3) development, (4) implementation and (5) evaluation, represented by the acronym ADDIE (Gustafson & Branch, 1997). Specific process prompts were also designed under all five phases. For example, in the analysis phase, there are four sub-phases: (1) context analysis, (2) content analysis, (3) task analysis, and (4) technology analysis. Under each sub-phase, process prompts were given to the students, as shown in Table 1. For example, in the content analysis, students were required to answer "What is the existing instruction in terms of its efficiency and effectiveness?" and "What is the existing teaching strategy behind the current curriculum?".

Table 1

Samples of process prompts in the analysis phase

Analysis phase	Examples of process prompts
Context analysis	1. What are the characteristics of the teachers? 2. What hardware and software are available in the school? 3. What are the characteristics of the facilities and of the classes and that will use the web-based instruction? 4. What types and quantities of hardware are available in the school? 5. What are the characteristics of the school system or organization in which the new instruction will take place? 6. What is the philosophy and what are the taboos of the larger community in which the school system exists?
Content analysis	1. What is the existing instruction in terms of its efficiency and effectiveness? 2. What is the existing teaching strategy behind the current curriculum?

Table 1 continued

Analysis phase	Examples of process prompts
Task analysis	1. What are the discrepancies between "what was" and "what should be"? 2. What are the learning goals and learning types? 3. How will you present the information-processing analysis of learning goals? 4. What are the learning prerequisites? 5. What are the learning objectives for the learning goals and each of the prerequisites?
Technology analysis	How will each of the five applications listed in the project description be used as instructional and technological strategies to support all the lessons identified? ■ Word or Spreadsheet ■ Drawing tools and graphic editing ■ PowerPoint ■ Animation ■ WebQuest ■ Inspiration/Kidspiration ■ Movies Provide sufficient details and explanation regarding how each application is used in a specific lesson context to achieve the desired learning outcomes as related to the objectives of the lesson.

Computer Self-efficacy

According to social cognitive theory, self-efficacy is the foundation of human motivation and accomplishments (Bandura, 1977). Bandura points to four sources affecting self-efficacy: experience (actual success in task performance); vicarious experience (observing successful task performance); social persuasion (others expressing positive persuasion regarding successful task performance); and physiological factors (one's perception or belief in the implications of physiological responses during task performance). Compeau and Higgins (1995) use the term computer self-efficacy to describe one's perceived ability to accomplish a task with computers. Studies have found that well-designed and engaging learning experience can increase students' computer self-efficacies (Abbitt & Klett, 2007; Koh & Frick, 2009; Milman & Molebash, 2008).

Increasing teachers' computer self-efficacies is expected to improve the likelihood of their integrating technology into their teaching (Ertmer, Evenbeck, Cennamo, & Lehman, 1994) . Beyerbach, Walsh, and Vannatta (2001) found that faculty modeling appears to enhance pre-service teachers' confidence in using technology for teaching. Brush and his colleagues (2003) also found that pre-service teachers' confidence was increased regarding the design and implementation of technology-integrative lessons after modeling and with the technology support provided by faculty members. Although the strategies for increasing teachers' computer self-efficacies have been studied, there is a dearth of research examining the relationship between technology-enabled PBL and computer self-efficacy. In the context of technology-enabled project-based learning environments, prospective teachers are immersed in different stages such as planning, design, development, implementation, and evaluation that may potentially lead to the increase of computer self-efficacy. In this study, pre- and post-surveys were used to investigate the impact of technology-enabled project-based learning on teachers' self-efficacy with computers.

PURPOSES OF THE STUDY

The present study aims to understand the development of knowledge and computer self-efficacy about prospective teachers' learning in the context of technology-enabled PBL, and with that, to develop knowledge about learning through process prompts. Specifically, this study will examine the following questions:

Research question 1: To what extent did the process prompts in technology-enabled project-based learning influence students' learning regarding technology integration?

Research question 2: In which ways did the design of technology-enabled project-based learning influence students' learning regarding technology integration and computer self-efficacy?

METHOD

Participants

Thirty-five undergraduate pre-service teachers (32 female, 3 male) from a college in southern Taiwan participated in the study. All participants were juniors or seniors between the ages of twenty-one and twenty-six. Participants were enrolled in an elective *Designing Web-Based Instruction for English Language Teaching (ELT)* course and were compensated with extra credit for participating in the study. Participants were homogeneous in terms of their ethnic background, but they represented different levels of prior knowledge, experience and efficacy in teaching, instructional design and information technology. They worked on different project topics and with self-selected group members. Group descriptions, project topics, and ratings of knowledge of multimedia design tools and computer self-efficacy are provided in Table 2. The ratings of knowledge of multimedia tools and computer self-efficacy were self-reported and given at the beginning and end of the semester. The rating of knowledge of multimedia tools asked students if they knew how to use various multimedia tools, such as PhotoImpact, Dreamweaver, Flash, and Captive. Computer self-efficacy asked about students' confidence levels in terms of performing computer-related tasks (Cassidy & Eachus, 2002). Table 2 provides an overview with the descriptions of participants and projects. In total, seven groups, each with five students participated in the project. All projects represented information richness and provided complete data sets (e.g., interviews, observations, and portfolios) that allowed the researchers to conduct in-depth analyses.

Table 2
Participant and project descriptions

Group, project title and project descriptions	Team Members	Knowledge of Multimedia Design Tools[1]	Efficacy of Computer-related Tasks[2]
Group 1: Have fun with prepositions. Target learners: *6th grade students* Proposed objectives: *identify and define prepositions, demonstrate correct usage of prepositions, and use prepositions to indicate the precise location of objects*	Shally Cynthia Amy Natalie Mandy	Low High Low Low Low	Low High Med High Med
Group 2: Amusement park. Target learners: *4th and 5th grade students* Proposed objectives: *learn English words and sentences associated with how to ask for direction and how to buy tickets in the context of an amusement park*	Deborah Maggie Doreen Eleven Seny	Med Low Med Low Low	High Med Med Med Low

Table 2 continued

Group, project title and project descriptions	Team Members	Knowledge of Multimedia Design Tools[1]	Efficacy of Computer-related Tasks[2]
Group 3: Travel around the world. Target learners: *6th grade students* Proposed objectives: *learn about world geography, and about cultures and about food in Asian countries*	Lucy Joanna Sammy Kim Angela	Low Low Med Low Low	Med Med High Low Med
Group 4: Daily routine with proper grammar. Target learners: *6th grade students* Proposed objectives: *learn about daily routines and English grammar*	Randy Betty Nelly Alice Ivy	Low Med Low Med Low	Low Med High High Med
Group 5: Farm animals. Target learners: *6th grade students* Proposed objectives: *develop clear pronunciation and comprehension of elements of English grammar, such as appropriate subject-verb agreement*	Rebecca Emily Olivia Rafael Sherry	Low Low Low Med Low	Low Med Med High Med
Group 6: Daily routine and telling dates and times. Target learners: *6th grade students* Proposed objectives: *learn vocabulary associated with daily routine, date and time in English*	Alex Joyce Vicky Flora Karin	Med Low Low Low Med	Med Med Med Low High
Group 7: In the house. Target learners: *6th grade students* Proposed objectives: *learn vocabulary related to houses and furniture together with English language structure*	Sabrina Sandy Apple Jane Cindy	Low Med Med Low Low	Low Med Med Low Low

[1.2.] On a scale of 1(not confident at all) to 5 (very confident). Low: below 2.5. Med: between 2.5 to 3.5. High: 3.5 and above.

Study Context and Project Requirements

The classroom context represented an open-ended learning environment in which students were responsible for generating and pursuing their own ideas to solve real-world instructional problems. During the class, students were taught to use different multimedia tools and familiarize themselves with the theory of technology integration. Students were instructed to complete a technology-enabled project as a final project for the class. Project requirements and guidelines were explained at the start of the class. For the technology-enabled project, students were asked to design and develop learning materials supplementary to the course contents for local primary school students. Two local primary schools agreed to participate; both had good reputations for their English language teaching and a great interest in using technology in teaching. One school in particular had an e-Learning team that was dedicated to promoting the design and development of online learning materials. Student groups were assigned to design instructional materials for fourth to sixth grade students in these two primary schools.

Consistent with traditional PBL, technology-enabled PBL requires students to conduct authentic investigations, construct goals and objectives for the target audience, compose orchestra storyboards, develop and implement products, and finally evaluate their instructional outcomes. The project involved three main components: a) the identification of multimedia needs analysis; b) the creation of multimedia instructional design and activities; and c) the completion of multimedia development and final portfolio. Students were asked to include the following in the final portfolio: a) an analysis of the problem context underlying the project idea; b) a discussion of different multimedia tools used and solutions to the identified problems; c) the steps for implementation; d) a statement of the types of academic and/or technological skill or knowledge demonstrated; e) reflections on the experience; and f) a list of references (URLs). The instructor of this course (also the first author of this manuscript), one researcher, and two additional research assistants all participated fully in the teaching and research aspect of the study.

Study Procedures

The technology-enabled PBL lasted approximately four months during the fall semester of 2008. The instructor explained the project requirements on the first day of the class and collected consent forms for participation in this study. The topics being taught by the instructor in this class are listed in Table 3. Topics included the theory of technology integration and technology skills such as PhotoImpact, Flash, Captivate, and Dreamweaver. Practice time in which students could use these tools in the classroom was arranged.

Table 3
Objectives for course subjects and hours/weeks of instruction

Subjects	Themes	Weeks/Hours
Instructional Design	Instructional systematic design	1 week / 2 hours
	Rapid prototyping	1 week / 1 hours
	ARCS model	1 week / 1 hours
	A.S.S.U.R.E model	1 week / 1 hours
	ADDIE processes	1 week / 1 hours
	Dick-Carey versus Morrison-Ross-Kemp ID models	1 weeks / 2 hours
Technology Applications	PhotoImpact	1 weeks / 3 hours
	Flash	2 weeks / 6 hours
	Dreamweaver	2 weeks / 6 hours
	Multimedia Tools	1 weeks / 3 hours
	Hot potatoes	1 weeks / 3 hours
	Captivate	1 weeks / 3 hours
	Powercam	1 weeks / 3 hours
Total Instruction Hours		15 weeks / 35 hours

All students received the same materials and instruction from the instructor. Process prompts were also provided to students while they worked through the different stages of designing technology-enabled projects. See Table 1 for examples of process prompts. At the end of the semester, students were asked to submit their final projects and to participate in a follow-up interview of approximately 20 minutes.

Study Design and Data Collection

The design of this study was descriptive and naturalistic, utilizing quantitative and qualitative case study research principles (Creswell, 2002). Students' computer self-efficacy and submitted final projects were assessed quantitatively. For the qualitative portion, each group was studied as a separate case and analyzed for similarities and differences (Yin, 1994). Collected data included a self-report computer self-efficacy scale, group final projects, and student interviews. Next, we succinctly describe each piece of the data that were collected.

Computer Self-efficacy Scale

To investigate research question 2, a computer self-efficacy scale adopted from Cassidy and Eachus (2002) was used to measure confidence in one's ability to perform specific computer task activities. Students rated their computer self-efficacy on a 5-point Likert scale, where 1=not confident at all, 2=slightly confident, 3=moderately confident, 4=quite confident, and 5=very confident. A high Cronbach's alpha of .87 was obtained for the computer self-efficacy scale.

Student Interviews

Follow-up interviews were conducted upon completion of the project, and the questions were geared toward students' learning experiences and their perceptions of technology-enabled project-based learning. Sample interview questions included the following: "Do you think the project facilitated your learning of this particular subject? If yes, why? If not, why not?"; "Do you think process prompts were useful in completing the project, and how did you or your group go about completing the project? Please provide examples"; and "When you encountered problems, how did you solve them?" All interviews were audio-taped and then transcribed and analyzed.

Final Project and Reflections

In this study, researchers collected each group's final project, which included all of the design documents and information that the students chose to include. Along with the final project, students also submitted a copy of a final product for a web-based lesson for primary school children. Students' reflection reports, in which they reflected on what they had learned and their perceptions of and experiences with technology-enabled project-based learning, were also collected .

Data Analyses

The analyses of students' interviews and final projects were slightly different. Analyses of students' interviews focused on thematic elements. Researchers first read the transcripts several times and wrote marginal notes. The marginal notes were then entered and indexed into a data display matrix. This matrix provided an overview of within and cross-case comparisons of student learning. The next level of analysis was group-related segments that led to explanations of the research question (Miles & Huberman, 1994). The two researchers were in agreement on 88 of 95 student descriptions, yielding an inter-rater agreement of .95.

A scoring rubric was developed to assess students' final projects and the web-based instruction they developed for primary school children. The rubric, as shown in Table 4, included three parts with associated subcomponents: (1) the design plan for web-based instruction, (2) the implementation strategies of web-based instruction, and (3) the product of web-based instruction.

Table 4

Rubric for scoring students' technology-enabled project

Part A. Design plan for web-based instruction
Phase 1: Analysis (content, learners, and context)
A. Performance analysis 8pts Define learners' prior knowledge for tasks including essential and peripheral components. 6pts Define requisite knowledge for task success. 4pts Define criteria for task success. 2pts Vaguely define criteria for task success. 0pts No identification of any criteria for task success. B. Learner KSA analysis 8pts A statement of evidence of learners' current knowledge, domain expertise, pre-existing performance skills, and prior domain experience. 6pts A statement of evidence of learners' current knowledge, domain expertise, pre-existing performance skills. 4pts A statement of evidence of learners' current knowledge, domain expertise. 2pts A statement of evidence of learners' current knowledge. 0pts No statement of learner KSA. C. Learner needs analysis 8pts Identify learners' perceptions, attributions, preferences (i.e., structure, control, and media), and general content approach/avoidance tendencies. 6pts Identify learners' perceptions, attributions, and preferences (i.e., structure, control, and media). 4pts Identify learners' perceptions and attributions. 2pts Identify learners' perceptions. 0pts No identification of learner needs.

D. Content analysis 6pts Identify prior knowledge requisite for content area and in domain. 4pts Identify prior knowledge requisite for content area or in domain. 2pts Identify requisite prior knowledge to access content. 0pts No identification of content area or in domain. E. Situational analysis 6pts A statement of realistic contextual opportunities, tradeoffs, and rationale for optimal balance. 4pts A statement of contextual opportunities, tradeoffs, and rationale for optimal balance. 2pts A statement of contextual opportunities. 0pts No statement of any situational analysis.
Phase 2: Instructional goals (content for web-based instruction)
A. Cognitive/affective/developmental 4pts Identify 2 or more cognitive goals of instruction. 2pts Identify one cognitive goal of instruction. 0pts Identify no cognitive goals of instruction. B. Behavioral/performance 4pts Identify 2 or more goal behaviors and task achievement for instruction. 2pts Identify one goal behavior for instruction. 0pts Identify no goal behaviors for instruction. C. Motivational 4pts Identify 2 or more motivational goals of instruction. 2pts Identify one motivational goal of instruction. 0pts Identify no motivational goals of instruction. D. Social 4pts Identify 2 or more social goals of instruction. 2pts Identify one social goals of instruction. 0pts Identify no social goals of instruction.
Part B: Development of web-based instruction
Phase 1: Features of learning environment
A. Learner-centered 1pt Attentive to learner needs, interests, reference points. 1pt Acknowledge learner values, interests, and goals. 1pt Aware of individual construct of meaning. 1pt Attentive to academic and social intentions. 1pt Facilitate deliberate transfer. B. Knowledge-centered 1pt Well-organized knowledge to support knowledge acquisition. 1pt Actively facilitate learning and transfer. 1pt Define skills and knowledge required. 1pt Emphasize on the structure of knowledge. 1pt Foster integrative understanding of domain. C. Assessment-centered 1pt Provide opportunities for self-assessment of understanding and performance.

1pt Enable choice of performance options and preferences. 1pt Activities are congruent with learner and instructional goals. 1pt Emphasize knowledge improvement and participation. 1pt Provide constructive feedback for revision of understanding.
Phase 2: Events of instruction
A. Content/knowledge objects 6pts Content is appropriate to learner needs and abilities. 4pts Content is attentive to requisites of domain. 2pts Content is aligned with learning goals. 0pts Content is not aligned with learner goals. B. Arrangement of learning space and events 8pts Facilitate access to resources. 6pts Facilitate interaction with and among learners. 4pts Pace appropriate to learner needs and abilities. 2pts Sequence appropriate for content and tasks. 0pts No consideration of arrangement of learning space and events. C. Quality of practice opportunities 8pts Practices are meaningful and linked to real-life and instructional goals. 6pts Practices are relevant and linked to real-life. 4pts Practices are appealing and engaging. 2pts Practices enable learners see results. 0pts No practice opportunities. D. Selection of materials 6pts Materials are appropriate to learner needs and abilities. 4pts Materials are comprehensive to the knowledge development. 2pts Materials used are ideal to the enhancement of learning. 0pts No selection of any materials. E. Assessments 6pts Design practices are aligned with goals and analysis (e.g., involve learners in decisions/design, make purpose & criteria clear, prepare learners & provide rationales, and every assessment is goal-driven). 4pts Design practices are somewhat aligned with goals and analysis. 2pts Design practices are not aligned with goals and analysis. 0pts No design practices in the final product.
Part C: Implementation of web-based instruction
A. Identification of instructional strategies 6pts As identified in design, planned strategies are robust, fit with needs identified by learner analysis. 4pts As identified in design, analytical links are clear and strategy appropriate. 2pts Strategies used are not aligned with proposed in design. 0pts No strategies are used or defined in the product. B. Implementation strategies 4pts Identify and implement motivational strategies appropriately and effectively. 2pts Identify motivational strategies but fail to implement them appropriately and effectively. 0pts No identification or implementation of motivational strategies.

The raters separately evaluated and assigned ratings to each project. The initial inter-rater reliability coding displayed 85% agreement. When differences occurred, the two raters discussed the discrepancies in the coding results until a consensus was reached. Independent coding of the second discussion achieved a 91% inter-rater reliability. Based on this rating, it was determined that both the accuracy and the reliability of this coding instrument met the general check-coding standard, which requires a 90% range.

FINDINGS AND DISCUSSION

The findings will be presented in terms of each research question and followed by a discussion. For each question, we begin with a summary of our findings, and then we provide specific examples from the data to support and explain our summary.

Research Question 1

The examples from the qualitative data we collected exemplified instances that were influenced and facilitated by the process prompts in many ways, particularly through the facilitation of problem-solving efforts, the promotion of self-monitoring skills, and the encouragement of knowledge construction. The major findings of the interviews and reflection reports are summarized below.

Facilitating Problem-solving Efforts

The students from group 1 indicated that the process prompts helped them focus and strategize regarding appropriate steps for project completion. As a result, group members adopted task-oriented tactics that helped them focus on what they needed to do to complete each task. Students in group 1 also used the prompts to divide tasks among group members and to help each other work collaboratively. Each member was able to take part in tasks about which he or she felt most confident.

> "The process prompts are important. If we don't have this information, we don't have any clues regarding how to go about completing the final project." (Group1)
>
> "We basically divided the questions [process prompts] into tasks. Each of us took part in observing and address-

> ing the task. Some of the questions [process prompts] were difficult to answer, so we made an appointment with the instructor after class. These questions [process prompts] constitute an important stage in the design of WBI. We need to have a better understanding of learners' needs and ability levels. We must learn that before we begin our project; we have to ask students' opinions about their learning processes and understand what they really need so that our final project will include suitable materials for our target audience". (Group1)

Students in group 2 used the process prompts as procedural guidance to help them monitor their problem-solving processes. The process prompts reminded them to think about what they had learned and how the knowledge should be used; this helped them to think more comprehensively and deeply about relevant perspectives and organize their ideas more coherently.

Students from group 4 revealed that the prompts helped them to consider multiple points of view, which in turn gave them more ideas for designing a suitable teaching website to help students learn English in a fun and engaging way.

> "By going through the questions [process prompts], we learned what to observe in the classroom. We observed not only the students but also the teachers. We were able to evaluate what each teacher was doing in the class and saw the students' reactions to his or her teaching. Through this project, we realized that we have to prepare well in order to do the work well when we are involved in any project." (Group4)
>
> "We think this was a very good experience. We learned many things and skills from this project. We did many things that we had not done before. Although we still think it's very hard to design a website for a group of students whose first language is not English, we know that we have overcome many challenges and difficulties. Although the questions [process prompts] were helpful, we still needed the instructor to explain in greater detail for us." (Group4)

In the context of technology-enabled PBL, the support provided by the process prompts served as the "goals" for the students to complete the projects. Without the prompts, the students could possibly approach the projects according to their instinct or their previous experience. When the prompts were provided, the students tackled the questions directly, and the prompts helped them to make a sound project. Since the students had these "goals", they had to follow them and fulfill the requirements of the questions. Therefore, the students made efforts to understand the questions and to accomplish them. In other words, the process prompts drove them to find answers to the questions. Through this process, when problems came up, the students were focused to solve them. In fact, enhancing problem-solving skills is one of the purposes of PBL (Dewey, 1959), and the support for the students through the process prompts facilitated it, which is consistent with Greene and Land's (2000) findings. The process prompts used in technology-enabled PBL enabled students to be persistent when facing problems and difficulties regarding technology integration. This kind of problem-solving oriented attitude may determine students' future academic success.

Promoting Self-monitoring Skills

Students in group 2 stated that with process prompts, they were able to accomplish what they thought to be an impossible task. Members of group 2 mentioned having spent significant time gathering relevant information and trying to make sense out of the information they had collected. They faced cognitive dissonance and inconsistency because of the large amount of information found by different group members.

> "We spent lots of time reading academic study books on unfamiliar topics and surfing the Internet to collect information about new content or teaching approaches or to look for classroom materials. We found that we needed to gather sufficient helpful information to answer the questions [process prompts]. (Group2)
>
> "We discussed and shared what we had found individually, and we tried to identify and state areas of agreement and disagreement. When we had disagreements, we tended to let our group leader make the decision because she had more experience than we had." (Group2)

The process prompts guided students' attention towards self-monitoring and evaluating. Process prompts function through self-awareness, which can lead to better and more appropriate control of cognitive strategies. Those strategies can contribute to success in staying on task and task completion during project-based learning. Students also mentioned that the prompts gave them a clear sense of direction. They often used it to monitor their progress, and they frequently reflected upon whether they could complete such a daunting task.

> "One of the questions [process prompts] asked us about the motivation level of the students. When we observed the class, we found that students seemed motivated to learn English because they actively participated in Q&A and games. But we also found that students had difficulty understanding what the teacher said to them in English. Therefore, we set learning goals to improve their listening skills and emphasized practicing and repeating English words." (Group5)

In technology-enabled PBL, the process prompts promoted self-monitoring skills. They helped the students realize what they knew and what they did not know especially regarding technology integration in teaching. Thus, the students knew what they needed to work on, and it facilitated learning autonomy. The instructor did not need to cram knowledge into the students. In fact, the students actively sought the information they needed and made sense out of it. For prospective teachers, the awareness of self-monitoring may also help them evaluate their future teaching. A follow-up research can be done to further examine this effect.

Eliciting Knowledge Construction

PBL aims to enhance a knowledge base and professional growth with respect to domain knowledge (Seo et al., 2008). In this study, the data showed, specifically, that the process prompts had a positive effect on activating student's prior knowledge related to technology integration and their domain area and facilitating knowledge construction from the awareness of what was known and unknown. It confirmed that scaffolds such as process prompts could facilitate the completion of PBL (Greene & Land, 2000). Students expressed that they had little experience of being asked to put what they had learned into practice. They used question prompts as advance organizers when they had to recall what they had learned or experienced. The students found that they had to use much of what they had learned in other classes to adequately address process prompts, and as a result, new knowledge was constructed upon the old one.

> "At the beginning, we had a lot of problems and had no idea how to solve them. Our group tried to use the questions [process prompts] to get the work done, but some

> of them were too difficult for us. We needed much more help. If we were to do this again, we would plan to spend more time searching for information on the Internet." (Group3)
> "When we first started, we were totally lost and felt discouraged. Most of our group members are not good with technology. But when we worked through the steps, we realized that content is the key. We had a lot of problems (mostly technical) to overcome and also had much to learn. We had learned or heard some of the teaching methods before, but had never been called upon to use them in such an authentic way. In completing this project, we learned a lot of technical information, but the most valuable lesson was that we were able to incorporate resources or knowledge we had known earlier." (Group5)

When the students perceived the process prompts as procedural guidance, they were likely to make an effort to address each process prompt and to consolidate various pieces of information or ideas. This sort of consolation facilitated the consistent integration of project methods and resources according to the stated purposes of the project (Land & Greene, 2000). On the other hand, if students perceived the process prompts only as a checklist, they were less likely to self-evaluate and ultimately developed fragmented products.

Moreover, the case study analysis also pointed to some limitations of the process prompts in the context of technology-enabled project-based learning. First, process prompts required prior knowledge and sufficient schema in order to be effective. If the student had an inadequate knowledge base or insufficient experience to relate to the prompt, or if his or her schema was limited, that process prompt could do little to maximize student learning. It was observed that groups 6 and 7 skipped the process prompts and eventually relied mostly on Internet resources. Whether this was due to a failure to recall knowledge that would have helped them to address the prompts or to a lack of confidence in answering the questions, the process prompts had not been able to help them activate their schema. Therefore, for technology enabled PBL, besides providing process prompts to support students' learning, the guidance of the instructors is also important.

Research question 2

Descriptive statistics were used to analyze student's technology-enabled projects, and a t-test was used to analyze computer self-efficacy prior to and after the project. The technology-enabled projects assessed the following three components: (1) a design plan for web-based instruction, (2) the development of web-based instruction, and (3) implementation strategies in web-based instruction. Table 5 shows the results of the project evaluations for all seven groups.

Table 5

Mean scores for group's technology-enabled projects

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Design plan for web-based instruction							
Analysis of learners, content, and context[1]	5.4	5.8	4.4	5.4	5.4	2	1.4
Instructional goals (Content for web-based instruction)[2]	3	3	1.75	2.75	3	0.75	1
Development of web-based instruction							
Features of learning environment[3]	3	3	2	2.67	3	1	1
Events of instruction[4]	5.8	5.4	2.6	5	5.2	1.4	0.8
Implementation of web-based instruction[5]	3.5	3.5	1.5	2.5	3	1	1

[1]the maximum score is 7.2; [2]the maximum score is 4; [3]the maximum score is 5; [4]the maximum score is 6.8; [5]the maximum score is 5.

The descriptive statistics shown in Table 5 indicate that most of the groups received above-average scores for the design plans for web-based instruction, the development of web-based instruction, and the implementation of web-based instruction. This is not a means of comparing group performance on technology-enabled projects, and that was not our focus. Instead, we are interested in how much of the design plan for web-based instruction was actually manifested in the development of web-based instruction.

Group 1's technology-enabled project showed that they had consistently worked on their problems; this resulted in high scores for both the plan design and the development of the actual product. Such consistency can also be seen in groups 2, 4, and 5. Group 3 received a high score on its design plan for web-based instruction, particularly in terms of the analysis of learners, content, and context; however, the group's web-based instruction end product did not demonstrate much of what was indicated in the web-based instruction. The same applied to groups 6 and 7. In those instances, there was a discrepancy between students' design plan and their web-based instruction or the strategies they employed. For example, group 7's project was too broad, and the objectives were stated ambiguously. This affected the project development negatively. The insufficient analysis of target learners, content, and context, together with ill-defined or unclear instructional goals for web-based instruction, could have caused them to develop instructions that were not well-suited to the delivery of web-based instruction.

Another reason could be that the focus of the projects could be off target during the instruction development process. It was found that, for instance, the majority of group 6's time was spent on deciding how the instruction should be structured and the kinds of images or animations that the group members should create or design to capture students' attention. Furthermore, limited prior knowledge of the use of technology and inefficient teamwork may also have contributed to this problem. Group 7 reported that they encountered difficulty completing the project. As can be seen from Table 1, most of them were not confident regarding computer-related tasks, and this also led to unequal task assignments for Sandy and Apple because they were more knowledgeable about multimedia tools and computer-related tasks.

As mentioned previously, the students might choose to ignore the process prompts when they found them too difficult to understand. That could have been one of the factors contributing to the discrepancy. It has been argued that most of the students' instruction designs did not apply to the product under development (McRobbie, Ginns, & Stein, 2000). This study suggested that further research should continue such discussion of the discrepancies between their design plans and actual products so that the overall quality of the instruction can be assured.

In terms of students' computer self-efficacy, technology-enabled PBL appeared to have a positive impact on computer self-efficacy for students. Paired sample t-tests showed a significant difference in pre-test ratings (mean = 2.42) and post-test ratings (mean = 3.30) of students regarding computer self-efficacy $t(30)=16.32$, $p<0.014$ (two-tailed), $d=0.52$. After technology-enabled PBL, students were shown to have significantly higher computer self-efficacy. An increase in computer self-efficacy meant that students' confidence in the use of educational technology was promoted, and it enhanced the likelihood of their integrating educational technology into future teaching in class (Ertmer et al., 1994). A high level of computer self-efficacy together with a solid knowledge of technology will enable more effective integration of educational technology to class teaching. Thus, teaching effectiveness will also be raised. Therefore, consideration should be given to offering technology-enabled PBL in teacher education programs.

Finally, the findings of this study have raised some issues and implications for further discussion. Process prompts work to their fullest efficacy in technology-enabled PBL when students believe them to be useful and meaningful for the attainment of learning goals. This study found that how students choose to work with the scaffoldings also impacts their technology-enabled PBL. It is recommended that scaffoldings are used as a procedural guide and explicitly addressed by the instructor in promoting self-monitoring or evaluating metacognitive strategies. Future research should examine how to better assist students in using (or motivating them to use) process prompts mindfully, so that they can engage in the type of learning that appears necessary to achieve the goals of scaffolding. While our data strongly suggest that the process prompts as effective scaffolding for technology-enabled PBL will depend on students' domain knowledge of and competencies related to the subject, some of our students seemed to experience problems finding information for or answering process prompts due to a lack of content available in forms that suited their project purposes; another reason might be due to limitations associated with their partially developed knowledge and/or project focus. Continued discussion about this topic will shed light on the overall effectiveness of technology-enabled PBL in technology education for prospective teachers.

CONCLUSION

This study had two primary goals: a) to examine the effects of process prompts on scaffolding students' technology-enabled PBL; and b) to investigate the effectiveness of technology-enabled PBL on students' learning and computer self-efficacy. The results supported Greene and Land's (2000) findings with respect to the effects of process prompts in the context of PBL. The results revealed that process prompts in technology-enabled PBL facilitated problem-solving, supported self-monitoring, and facilitated knowledge construction. In addition, this study supported the findings that technology-enabled PBL provides experiences that broaden prospective teachers' perceptions of technology and technology education and improves their computer self-efficacy. The technology-enabled PBL has successfully called attention to the concept of having prospective teachers develop complete web-based instruction for specific learners. Such a project offers a meaningful context in which they can learn what technology tools to use and how to use them in order to integrate instructional technology into the curriculum. In turn, their confidence in technology integration will become stronger; this may enhance the likelihood of integrating educational technology to their future teaching (Ertmer et al., 1994). Nevertheless, when implementing technology-enabled PBL in teacher education, the instructors should pay attention to whether the students understand the process prompts that are given to them to support their activation of PBL and to the problem of discrepancy between students' design plan and their web-based instruction. The instructors may need to monitor the process closely and provide more scaffolding along the way, especially when the students encounter difficulties. Moreover, smaller scale technology-enabled PBL can be employed more frequently to help them gain more experience and to give them more chances to develop their metacognitve skills or self-reflective skills. Thus, the effectiveness of a bigger scale of technology-enabled PBL can be assured. Despite some limitations, to foster prospective teachers, technology-enabled PBL should be encouraged.

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