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Applying Web-Enabled Problem-Based Learning and Self-Regulated Learning to Add Value to Computing Education in Taiwan's Vocational Schools

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ABSTRACT

This article describes the design and delivery of a compulsory course in packaged software at vocational schools in Taiwan. A course website was devised and deployed to supplement learning activities in the traditional classroom. A series of quasi-experiments was conducted with innovative instructional designs, that is, web-enabled problem-based learning (PBL), self-regulated learning (SRL), and their combinations. The impacts of these web-enabled pedagogies on students, instructors, and course design were evaluated. The effects of web-enabled pedagogies were mostly positive, thus reinforcing the instructor's confidence for further application to the rest of his courses. The authors further discuss the implications for schools, scholars, and teachers who plan to implement, or are already engaged in, e-learning.

Keywords

Web-enabled PBL, Web-enabled SRL, E-learning, Computing education

Introduction

It has become tougher and much more competitive in recent years for vocational schools in Taiwan to attract sufficiently high student enrollment. This is mainly the result of a continually decreasing birthrate and, at the same time, a rapidly increasing number of new schools. While students graduating with vocational degrees represent a significant proportion of the higher education population, they, on average, receive a much lower public investment compared with their counterparts in the universities. A typical student in a vocational school tends to have a lower level of academic achievement and spends more time on out-of-class jobs. These students also do not get adequately involved in their schoolwork and tend to care less about their grades. The above conditions challenge almost every teacher in this sector who tries to help develop students to be more competently skilled and competitive in the labor market.

No one doubts the guiding principles of practical applications in vocational education in Taiwan (Tai, Chen, & Lai, 2003). However, most of the teaching and learning efforts in this area have been devoted to helping students pass written tests in order to receive awards or official certificates. Schools, feeling the increasing pressure of competition, often emphasize the proportion of students awarded such certificates before they graduate instead of the quality of learning. This materialist approach results in students' attention being less on practicing skill applications and more on preparing for tests through memorization. Consequently, students who have passed an examination may still be unable to apply what they have learned in school, and worse, they may lack the motivation to learn more in the future.

Computing courses traditionally emphasize memorization by applying short, disjointed, lack-of-context examples. This results in a gap between what is learned in school and what is required in the workplace (Wu, 2000). In this regard, the computing education in vocational schools in Taiwan can hardly be deemed as effective. In order to increase students' learning motivation and to develop practical skills, problem-based learning (PBL) is considered to be one of the most appropriate solutions. PBL uses real-world, simulated, contextualized problems of practice to motivate, focus, and initiate content learning and skill development (Boud & Feletti, 1991; Bruer, 1993; Williams, 1993). We believe that PBL would help less academically inclined students to develop practical computing skills.

Web-enabled instruction seems to be an ideal learning environment because students can access an almost unlimited amount of information and apply it in multiple ways (Kauffman, 2004). However, implementing e-learning for lower academically achieving students inherently has high risks. For instance, Internet addiction is quite common among these students. When students enter the traditional classroom, they are used to logging on to MSN messenger and checking their e-mail first. Many students like to chat with each other frequently via MSN messenger even when they are in the same classroom. They might browse shopping websites or play online games while the teacher is lecturing in the class. It is even more difficult for students to concentrate on online learning because of this addiction to the Internet and the lack of on-the-spot teacher monitoring. To respond to this challenge, the authors turned to an approach that can help students better regulate their learning.

Success in online courses often depends on students' abilities to successfully direct their own learning efforts (Cennamo, Ross, & Rogers, 2002). It is very critical to develop students' regulation of learning before providing online courses to them. This particularly applies to low academic achievers. Students' motivation may benefit from web-enabled instruction with self-regulated learning (SRL) strategies. Students in the online environment who are equipped with SRL competence become more responsible for their learning and more intrinsically orientated (Chang, 2005). Successful students in an online course generally used self-regulated learning strategies, and the effect of the self-regulation variables on students' success was statistically significant (Yukselturk & Bulut, 2007). Consequently, SRL was applied in this study to help vocational school students concentrate on their learning, to leave time for learning after their out-of-class jobs, and furthermore, to take responsibility for their learning.

This study reports a learning journey of transitions experienced by an instructor. The instructor has taught a course called Packaged Software and Applications for many years, and held a strong belief that traditional teaching methods are still the best. This belief was built largely from his past success in helping students pass licensure exams and thus receive certificates. However, a closer look at students' performance reveals that receiving certificates does not equate to quality learning. When the above web-enabled pedagogies became plausible alternatives, the instructor's advisors suggested that he try them in his classes. Instead of directly translating the teaching materials into electronic form, the instructor redesigned the course and conducted a series of quasi-experiments to examine the effects of web-enabled PBL, SRL, and their combinations.

There are few studies that have discussed effective online instructional designs for low academic achievers. In this area, the restructuring and translation of traditional computer software courses into course websites has seldom been documented. This study is the first trial for this instructor to implement innovative instructional designs, including PBL, SRL, and e-learning, in his classes. A steep learning curve is inevitable. The adaptation of innovative instructional designs and new technologies challenges not only the teacher but also the students. In this study, the authors provide the valuable experience of deploying web-enabled pedagogies by this teacher, who is an expert in traditional teaching methods but a novice in innovative teaching methods, to foster student learning through the Internet. Looking at the results, we believe that experiences learned through this implementation of web-enabled pedagogies are worthy of consideration by other teachers who plan to implement, or are already engaged in, e-learning.

Research approach and study settings

In this study, the main goal was to improve students' learning, explore the web-enabled learning effects, refine the online course, and reinforce the teacher's professional development. Therefore, mixed methods were applied. Specifically, the case study method was adopted to describe how students and the teacher adapted to the online course, and to detect deficiencies in design ideas and associated implementations for possible remedies in future trials. The authors intervened in students' learning via different instructional designs and deployed quasi-experiments to explore the effects of the intervention.

Course design

A required course in a vocational school, Packaged Software and Applications, focuses on the development of students' computing skills in applying packaged software. The course under study is a semester-long, two-credit-hour course, targeted at first-year college students with majors in different areas. A credit hour in Taiwan is defined as 16 hours of instruction (including exams) over the period of one semester, so in a two-credit-hour course, students receive 32 hours of instruction. Upon successful completion of the course, as measured by exams, papers, and project work, a student will be awarded a grade valued at two credits. Students solve a series of tasks by applying Microsoft Office (including Word, Excel, and PowerPoint). There were two classes in this study. One was a PBL class, and the other was a non-PBL class. In addition, each class had two groups divided according to whether the students were involved in SRL or not. Therefore, there were four groups (conditions) in this study (see Figure 1).

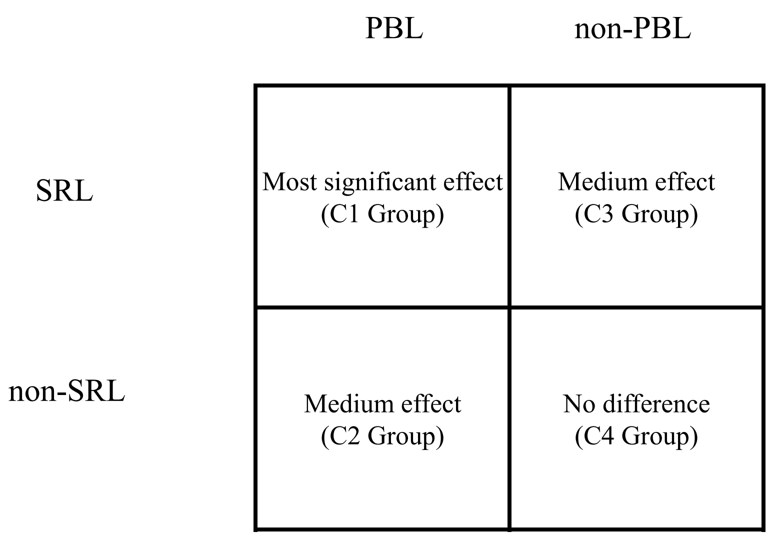

Figure 1. The expected effects of different instructional designs

Learning activities

The course was divided into three sequential modules: the Word module, the Excel module, and the PowerPoint module. A skill test was held after the completion of each module. The first test was held during the midterm examinations, the 8th week, the second test was held in the 13th week, and the final one in the 16th week. A detailed schedule of the experiment is depicted in Figure 2.

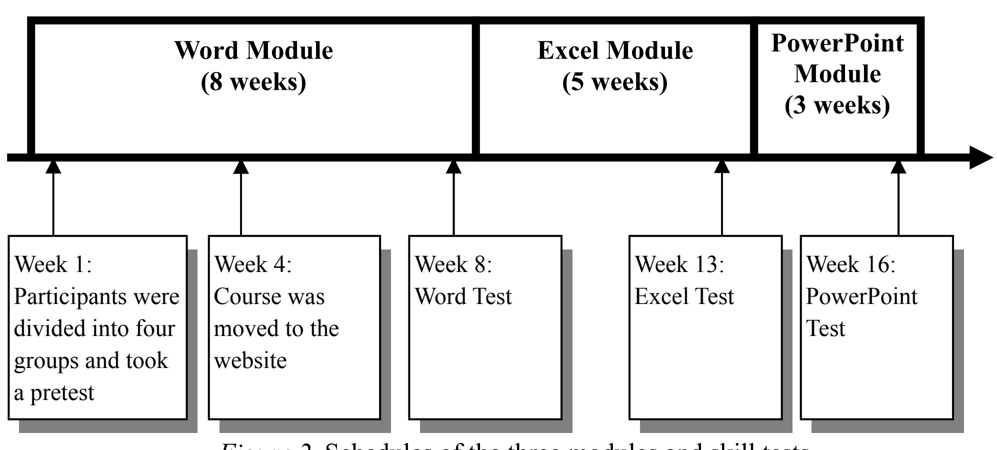

Figure 2. Schedules of the three modules and skill tests

In the beginning of the course, students were encouraged to adapt and learn via a course website. Teaching in this period took place in the traditional classroom. The teacher first recorded every session of his lectures and then translated these lectures into HTML files with flash, video, and voice. These HTML files were then loaded onto the course website. Students could preview and review the course sessions via this course website. After three weeks, most of the coursework was moved into the website. The instructor helped students adapt to learning on the net and lessen the feelings of isolation. Within these three weeks, the instructor adjusted students' learning gradually and smoothly. On this course website, students got support not only from the instructor, but also from their peers.

Design of the course website

This was the first attempt by this instructor to adopt innovative teaching technologies, including a course website and audio-recording software. Before that semester started, the instructor searched for an appropriate online teaching platform. The content management system, XOOPS (eXtensible Object Oriented Portal System), was adopted as the course website. XOOPS is an open source framework and provides functions of user management, anonymous discussion forum, file downloading, file uploading, website links, and group management (see official website at: http://xoops.org).

The course website mainly consisted of four sections: course information, course content, course discussion, and student system. "Course information" provided course description, syllabus, assignments, grading, and course-related information; "course content" included the audio files and the examples for students' exercises. Students could download the files and listen to the recording via the website to review or complete exercises repeatedly. The instructor could ask questions in the course discussion board in order to promote discussion and interaction between students and himself. In addition, students in SRL groups were asked to regularly keep learning journals. These journals were located in the student system.

Design of quasi-experiments

The experimental design was a 2 (PBL vs. non-PBL) × 2 (SRL vs. non-SRL) factorial pretest/post-test design. The participants were randomly assigned to one of the four experimental conditions; each group contained about 30 participants. However, as mentioned above, vocational students in Taiwan tend to have lower level of academic achievement and involvement in learning, and care less about their grades. They give up on their learning easily. Twelve students withdrew from this course during the instructional process. At the end, 102 students remained in the classes.

Students in the four groups solved the same tasks but in different learning conditions. Students in the PBL and SRL group (C1, $n = 28$) were required to prepare and read the textbook, papers, and related documents before classes. Furthermore, they were taught to solve a problem or build a business file in an authentic situation. The PBL and non-SRL group (C2, $n = 25$) focused on the teaching effectiveness in an authentic situation without the teacher's help focusing on forming self-regulated learning habits in these students. They just participated in this course by listening to the teacher; however, they were not asked to preview or review the content of classes. The non-PBL and SRL group (C3, $n = 24$) was taught in a traditional teaching style, but students were required to prepare the course material before classes. Groups C1, C2, and C3 were experimental groups, while the non-PBL and non-SRL group (C4, $n = 25$) was the control group. Students in group C4 were treated and taught in the most traditional way without any simulated problems or requirement for self-regulated learning. That is, teaching this group still emphasized traditional memorization by applying short, disjointed, lack-of-context examples, although the content was delivered via the Internet.

PBL Treatment

The teacher created interesting, challenging, and authentic problem situations. In the first Word module, students were required to apply for a job as marketing assistant for an online-game company. They were required to design and then build autobiographies and resumes by applying computing skills they had just learned. In the Excel module, students played roles as if they were employed by this same software company, and a marketing manager asked them to compare expenses resulting from different distribution channels. They had to survey data and then complete a worksheet with graphs to contrast the differences between channels. Additionally, they had to come up with a recommendation regarding the best combination of channels. In the last module, they were promoted to marketing managers. They were asked to develop a business proposal for a new online game. They had to present this proposal with visual aids to convince the managing director to enter the market. Therefore, a persuasive PowerPoint file was built into this phase. In summary, authentic and continuous problems were applied in the PBL class throughout the semester.

Teaching in each of the three modules proceeded similarly, as follows: First, the teacher would demonstrate how to approach the situation and solve the problem through web-enabled multimedia. In addition to teaching computing skills, the teacher also discussed similar situations and related applications. In the latter, teacher would guide students in constructing their own models for problem-solving.

SRL Treatment

There was a SRL group for each class. Students in SRL groups received an after-class course teaching them SRL strategies. The two SRL groups from the PBL class and non-PBL class gathered in a classroom for a two-hour lecture discussing how to manage study time and regulate their learning. The content of this SRL course was composed of the four processes addressed by Zimmerman, Bonner, & Kovach (1996), including self-evaluation and monitoring, goal-setting and strategy planning, strategy implementation and monitoring, and monitoring of the outcome of strategy. Students were taught how to implement these four processes to become more self-regulated learners.

In addition to the two-hour lecture, students in the SRL groups were required to regularly prepare and read the textbook before classes, and to review or practice the computing skills they had learned after class. They were also required to record their learning behavior every week. The data was recorded on the course website instead of in their notebooks in order to prevent falsification. The teacher scanned students' records. The treatment among the four groups is illustrated and compared in Table 1.

Table 1. Teaching and learning activities in different experimental groups

Group	Teaching Activities	Learning Activities
C1	The teacher… ● demonstrated how to solve authentic problems and discussed potential applications. ● taught SRL skills and urged students to study regularly.	The students… ● took on authentic tasks and learned by problem solving. ● practiced SRL and recorded learning behaviors every week.
C2	The teaching activities were the same as C1 but without SRL lectures.	The students experienced authentic situations and solved the problems without extra requirements of SRL.
C3	The teacher… ● converted his traditional way of teaching into an online format without any other modification. ● taught SRL skills and urged students to study regularly.	The students… ● received the traditional computing course through the Internet. ● practiced SRL and recorded learning behaviors every week.
C4	The teaching activities were the same as C3 but without SRL lectures.	The students experienced the traditional style of teaching and did not deal with the extra requirements of SRL, although teaching was conducted via the Internet.

Data collection and measurement approach

Through a pretest/post-test, quasi-experimental design, the researchers empirically assessed the differences in the four groups at the beginning and end of the study. Therefore, the authors measured students' computing skills and involvement before the course started. In Taiwan, almost every student learns Microsoft Word before learning any other packaged software. That is, a student without the computing skills of Word may be considered extremely limited in skills for other application software. The experiment conducted in this study was to measure students' improvement in Microsoft Office (including Word, Excel, and PowerPoint) with Word as the first module in this course. Therefore, it is believed that Word could be a predictor of knowledge or skills in Microsoft Office. In this regard, the instructor first measured students' computing skills using Word as a baseline at the beginning of the course. Students completed three Word documents as a pretest, and the score showed a uniformly low skill level. The difference among students' computing skills on the pretest among the four groups was not statistically significant. This confirmed that all participants in the four groups had low levels of knowledge and skills involving packaged software. Thus, the researchers ruled out initial differences as a plausible alternative explanation for the differences detected after treatments (Gribbons & Herman, 1997).

Moreover, Zaichowsky's (1985) Personal Involvement Inventory (PII) was used in this study to measure students' involvement at the beginning of the online course. The definition of involvement used in constructing the PII had much in common with motivational theory (Schmidt & Frieze, 1997), and measured three constructs: interests, needs, and values. In order to avoid uneven distribution of students among the groups in regard to level of involvement and motivation in this new course that combined innovative instructional designs and technologies, the authors tested students' involvement before the course started. The differences among the four groups in student involvement in the course at this beginning stage were not statistically significant. Therefore, it is considered that the students had equal levels of skill in Microsoft Office and involvement when they began this course. In addition, none of them had any experience in taking a web-enabled course. The authors then evenly and randomly divided the students into the four experimental groups.

At the end of each module, a skill test was given to students. Before testing, students were assigned to random seats. All students were tested at the same time. The questions in the test related to the content and examples in the course. Every test consisted of 5 to 7 questions. The teacher graded and recorded the results immediately after each test. A surrogate grade representing computing skills was averaged from the scores of these three tests. Finally, the enhancement of computing skills in a module was the result of one's surrogate grade minus his pretest grade. The authors tested the differences in the enhancement of computing skills under different conditions.

In addition to the quantitative data, qualitative data were also collected. During the semester, students in the two SRL groups were required to record their reading, previews, and reviews as evidence of their self-regulated learning activities on the teaching website. After the course was completed, research assistants collected the data into tables. At the end of the course, the instructor in this study interviewed eight students from the four groups. Two students were chosen randomly from each of the four groups. The interviews were recorded, transcribed, and analyzed.

In this study, the same instructor was responsible for teaching and overseeing the four groups. The impact of the implementation of web-enabled pedagogy on the instructor was investigated through his own journal entries. The same instructor also tracked critical incidents throughout the semester.

Outcomes

Impact on students

As the quantitative data show in Table 2, the enhancement of students' computing skills in terms of their average grades on three modules (Word, Excel, and PowerPoint) in the PBL class (67.48) was significantly higher than that in the non-PBL class (57.00) ($p = 0.000$). That is, in a web-enabled learning environment, the effects of problem-based learning on enhancing students' computing skills may be positive, and higher than of those without PBL.

Moreover, the results from Table 2 show that the enhancement of computing skills in the SRL group (66.39) was significantly higher than that of the non-SRL group (58.34) ($p = 0.001$). This supports the claim that the effects of web-enabled SRL on students' computing skills may be positive, and that students with SRL may perform better than those without SRL.

Table 2. Independent sample *t*-test: Improvement of grades

Dependent Variable	Group	*n*	Mean	S. D.	F	*t*-value	df	***p***
Averaged scores of	PBL	53	67.48	9.248	7.913	4.760	100	.000***
three skill tests	non-PBL	49	57.00	12.821				
minus the score of	SRL	52	66.39	10.978	1.647	3.501	100	.001**
pretest	non-SRL	50	58.34	12.233				

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Finally, data from Table 3 show that the combination of PBL and SRL resulted in that group having the highest grades among the four groups in this research. The enhancement in computing skills of students in C1 was higher than those of C3 and C4 in a statistically significant manner ($p < 0.05$), and also higher than C2, though insignificantly. Thus, it may be concluded that students' computing skills were improved by simultaneously applying web-enabled problem-based learning and self-regulated learning.

Table 3. One-way ANOVA: Average of the improvement of grades

Dependent Variable	(I) Group	(J) Group	Mean Difference (I – J)	Std. Error	Sig.
Same as appeared in Table 2	1	2	6.735	2.891	.151
		3	9.238(*)	2.923	.023
		4	17.895(*)	2.891	.000
	2	1	-6.735	2.891	.151
		3	2.503	3.003	.874
		4	11.160(*)	2.972	.004
	3	1	-9.238(*)	2.923	.023
		2	-2.503	3.003	.874
		4	8.657(*)	3.003	.046
	4	1	-17.895(*)	2.891	.000
		2	-11.160(*)	2.972	.004
		3	-8.657(*)	3.003	.046

* The mean difference is significant at the .05 level with Scheffe test.

As revealed in the interview data, most students in the PBL class had received a spoon-fed computing education in their senior high schools. Despite having taken computing courses for three years, they still could not apply skills and knowledge learned to real-life problems. They did not know when and how to apply what they had learned in previous classes. A student who had successfully earned related certificates during her senior high school years made the following comments:

> I had difficulties in "applying it" rather than "learning it." Many times, I had no idea how to solve the problems, nor how to find ways in dealing with them, although I had taken computing courses and received the related certificates for many years. The traditional teaching materials and examples did not contribute to problem-solving when we faced the problems.

After the intervention of PBL, students agreed that this series of authentic problem-solving exercises had raised their interest and helped them understand the situations and how to apply their acquired skills. One student shared his thoughts regarding the new experience gained in learning:

> This course provided special learning experiences that differed from those of the past computing courses. The simulated problems and the problem-solving processes helped us realize and reflect on how, where, and when to apply what we learned. For example, being a student in the department of business administration, I know how to compare different expenses by using a table and illustrate them with graphs after this course…The interesting examples associated with real situations also helped me concentrate on learning in the online course.

In contrast with students' welcome of the implementation of PBL, students experienced difficulties and persistently struggled to self-regulate their learning. In the interviews, most students in the SRL groups admitted that they were still not used to the practices of SRL, such as preview before class and review after class. Very few students studied and practiced regularly. The students were not willing to spend extra time on their coursework after school, and resisted taking responsibility for their own learning. For instance, many students in the SRL groups did not prepare, practice, and record their learning within the deadline. Worse, three students in the C1 group even dropped out of this group because they did not want to spend more time on this course after school. One of the participants in the SRL groups described the processes of regulating his learning:

> Although the teacher asked us to learn and record our learning in the regular time, we did not complete it in time…We have received a spoon-fed teaching method since we were elementary students. It is difficult for us to change our learning styles, that is, preview, review, and practice regularly, within a short time. Besides, it is a big challenge for those students with out-of-class jobs to be more involved in their learning. For these students, few learning tasks and records were done within the pre-specified time span.

However, the teacher still encouraged the students in SRL groups and insisted that students should persist in regulating their learning. At the end of the course, their achievement suggested that this effort was valuable. Interestingly, students in the four groups expressed that they would like to take more online courses for the rest of their school years. They felt comfortable and unrestrained in this online course. E-learning seemed to be more popular for those students who did not get adequately involved in their schoolwork and cared less about their grades mainly because of the conveniences and advantages of web-enabled learning. This unexpected finding impressed the instructor. Although the results of implementing SRL in this study were mixed, we may conclude that e-learning is not only possible but also effective for less academically motivated students, if appropriate pedagogies are well designed and implemented.

Impact on instructor

As mentioned before, the focal instructor had previous success in helping students pass official exams and earn related certificates. Not sure about whether this success might be sustained, the focal instructor worried a lot in the beginning of his attempts to conduct these experiments about the indeterminate outcomes and that all his efforts might be wasted. In the phase of teaching Word, the instructor recorded the following comment in his teaching journal:

> Students seem very stand-offish and unwilling to adapt to the new technologies and innovative instructional designs. They look unhappy when they are assigned tasks and asked to solve the problems. I think that they expect me to spoon-feed them in the way that they are used to and that I am also skilled in. However, I prepared for this online course, and designed the teaching website and course for several months. Will my efforts contribute to students' improvement of computing skills, or just be wasted?

However, an unanticipated learning event occurred in his class and thus removed some of his doubts. In the third week, the instructor left for an unexpected meeting during class. Before the instructor left the classroom, the students in the PBL class were told to practice and design a show bill in groups. After the teacher left the class, students started to discuss what and how to design by applying what they had learned. When the instructor came back, the show bills presented by the students were very exquisite and attractive. This instance encouraged the instructor greatly, and the instructor was convinced that the effects of web-enabled PBL were very likely effective, even for low academic achievers.

As for SRL, the instructor experienced many hurdles to lead and guide students in their transition to becoming self-regulated learners. Section 3.1 described students' unwillingness to change during the implementation of SRL. On numerous occasions, the instructor almost gave up on the intervention of SRL. The instructor recorded frustration in his journal:

> Each time when I hear students' moans and complaints about the extra homework and assignments, I really want to give up SRL intervention in the experiment. They seem to take these course requirements as merely burdens. Does the intervention of SRL harass both students and me? It seems that only I, the instructor, am struggling to improve students' practical computing skills to

> strengthen their competitiveness in the job market. Students' resistance and carelessness have almost dried up my patience and enthusiasm.

Nevertheless, with encouragements from the instructor's advisers, this instructor continued on the intervention. Eventually, based on quantitative data, students' enhancement of computing skills in SRL groups was significantly higher than that of in the non-SRL groups ($p = 0.001$). This suggested that the effects of SRL among lower academic achievers could be significantly improved even by a limited amount of intervention such as a two-hour lecture regarding SRL at the beginning of the teaching program and later by students' monitoring of their own learning. Thus, the authors conclude that teachers should maintain their confidence, even when the inevitable resistance is daunting, and encourage students to persist in SRL.

Impact on course design

Findings of the quasi-experiments showed that the enhancement of computing skills of students in C1 was significantly higher than that of C3 and C4 and also higher than that of C2, though insignificantly (see Table 3). For those teachers who wish to stick to traditional methods of teaching, directly translating their teaching materials into electronic form may not be a fruitful approach. Students in the control group (C4) received the poorest grades among the four groups, and the differences in grades among them were significant ($p < 0.05$). Students who have a lower level of academic achievement may suffer from less effective learning if they receive traditional instructional designs and materials online without reconsideration and redesign. Inappropriate instruction through the Internet that lacks teacher's on-the-spot monitoring cannot provide positive effects. Moreover, it may even dampen the original effects achieved with the same content in a traditional classroom. In this regard, it is suggested that teachers should redesign their courses and then adopt appropriate instructional methods and technologies to fully exploit the benefits of deploying web-enabled learning environments.

It was found that the courses in computing skills were appropriate to be instructed via Internet. However, the innovation in teaching and associated experiments in this study was far from perfect. Many problems occurred during the one-semester intervention. For example, the design of the learning environment left much room for further improvement to attract students' attention. The next version of PBL design could be more structured in procedures and more adequate in text writing. Teachers should invest significant efforts in this design and start to prepare the design well in advance of its first implementation. In addition, the instructor should frequently check students' learning records and provide timely feedback and support for the SRL groups in the initial phase to assist students in regulating their learning.

Discussion

Effects of web-enabled pedagogies

It is important to know what kinds of learning activities may best engage students in learning through the Internet. Talay-Ongan (2003) advised that teachers should shift or adapt traditional lectures to web-enabled-PBL to achieve constructive alignment in online teaching. In the present study, web-enabled PBL was found to play a relatively positive role in enhancing students' skills of deploying application software in contrast to those students instructed without PBL. It was demonstrated that PBL via e-learning facilitated development of students' skills of applying computer software in general, and students of vocational schools in Taiwan in particular (see Table 2). The findings in this research were also similar to those in Chanlin & Chan's (2004) study, which revealed that students in the PBL treatment group performed better than those from the control group in a web-based approach.

The importance of self-regulation for effective learning in Internet-supported instructional environments has been emphasized heavily in the literature (see Winnips, 2000). Providing students with opportunities to integrate their knowledge through web-enabled instruction may not be effective if they lack adequate skills needed to regulate their learning. Strategies that prepare students for the rigors of learning at a distance, which may increase the probability of retention and success, must be put into practice (Chang, 2005). In this regard, this study also found that the effects of SRL on enhancing students' computing skills are positive compared to students' skill development without SRL intervention (see Table 2).

Though the SRL effects were relatively positive, however, one should not be too optimistic about this finding. Challenges remain ahead. Vocational students in Taiwan are immersed in a culture of spoon-fed teaching and learning from the time they are elementary students. Thus, the requirement of SRL for low achievers should not be too rigorous, as they cannot get used to taking responsibility for their learning in a very short time. Excessive and overly strict requirements, without adequate communication, before applying SRL, may lead to great resistance and antipathy to the treatment. To resolve the dilemma of assisting students in developing SRL skills and preventing their antipathy in the new experiences in e-learning, a teacher should adopt those SRL strategies that are more instrumental and acceptable to the students, low achieving students in particular.

With respect to the effects of combination of instructional methods, the outcomes showed some support. As shown in Table 3, the results revealed that the effects of a combination of PBL and SRL intervention on enhancing students' skills of deploying application software were positive and higher than for those who did not receive PBL or/and SRL, although the difference between C1 and C2 was not statistically significant. This result is consistent with other results in the literature. For examples, Paris & Paris (2001) revealed that PBL facilitated SRL because it placed the responsibility on the students to discover information, to coordinate actions and people, to monitor understanding, and to reach goals. In Perels, Gürtler, & Schmitz's study (2005) of mathematical problem solving, it was found that combined training in self-regulatory and problem-solving strategies was effective for enhancing self-regulatory competencies in solving problems. Moreover, Kramarski, & Gutman (2006) revealed that SRL students significantly outperformed the non-SRL students in solving problems in the procedural and transferal tasks regarding mathematical explanations in web-based learning environment. Taking the above evidence together, this study suggested that teachers should consider, for the good of student learning, applying PBL and SRL simultaneously to their courses in the context of e-learning, rather than deploying them singly.

Unexpected effects of learning to change both teaching and learning

Many instructors earnestly explore innovative approaches to employ technologies to enhance the quality of teaching and learning in higher education (Reeves, Herrington & Oliver, 2005). Some scholars conduct design research to meet these new challenges. Two innovative instructional methods and associated technologies were employed in this design research to help vocational students improve their computing skills. This journey of designing web-appropriate materials, climbing a stiff learning curve, and overcoming much resistance might pose challenges to both instructors and students before the achievement of promising, or even acceptable, results. The experienced and technologically inclined teacher who actually taught the computer courses in this study had entry barriers to adopting new technologies, and the barriers were even higher while transforming his fundamental teaching methods. The instructor experienced a difficult transition from being a traditional classroom teacher, who was confident about helping students pass exams and receive official certificates, to becoming an effective online teacher. This indicates that some other teachers, particularly those with limited technological exposure, may find this process similarly daunting.

The strength of the Internet is in delivering information directly to individuals; however, this may also be one of its greatest dangers. The applications of e-learning allow students to work on their assignments whenever and wherever they want (Schwieren, Vossen, & Westerkamp, 2006). Nevertheless, students retreating to the isolation of their computers may avoid school activities and course involvement, and instead be content with self-gratifying Internet entertainment (Treuer & Belote, 1997). Studies indicate that vocational students were more Internet-addicted than general students (Yang & Tung, 2007). Therefore, it is a big challenge for teachers to help vocational students to be involved in an online course in an environment that is full of Internet allure with millions of shopping websites and free online games, and even MSN Messenger. It is difficult for students to concentrate on and be involved in online courses because of this addiction to the Internet and lack of on-the-spot teacher monitoring. In this regard, teachers should redesign their courses to attract students' interest and help them to be more involved in the online courses. This study suggests that web-based pedagogies such as web-enabled PBL and SRL can improve students' concentration on study and further contribute to student learning. Teachers and researchers can adapt the web-enabled PBL and SRL suggested in this study to their courses, or adopt other innovative instructional methods to elaborate on the benefits of e-learning.

With the students' struggle and teacher's persistence, the web-enabled pedagogies applied in this study not only contributed to students' improved skills in application software, but also to this teacher's professional development.

Further, after the first attempt of implementing web-enabled pedagogies, the preliminary results raised the instructor's confidence and enthusiasm to extend the scope and depth of the experiment in the near future.

Refinements for web-enabled pedagogies

The instructor experienced many hurdles in leading and guiding students in the transition to becoming self-regulated learners. On numerous occasions, the instructor almost gave up the intervention of SRL because of students' resistance. Some shortcomings that obstructed SRL in this attempt should be addressed. Firstly, when initiating web-enabled SRL, teachers should enforce the study requirement that all the students study or practice regularly and record their learning every week on the website to prevent their lagging behind in exercising this new strategy. Secondly, it was also very important for the teacher to monitor students' learning via their learning record and to give timely feedback to increase students' awareness about appropriate learning behaviors. Thirdly, the requirements of SRL for low achievers should not be too rigorous, as they could not get used to becoming responsible for their own learning within such a short period. Excessive and overly strict requirements of SRL without adequate communication beforehand may lead to greater resistance. Finally, lecture content about knowledge, action strategies, and exemplar cases of SRL should be strengthened to increase students' willingness and thus confidence. As time goes by, they may have a better chance of becoming self-regulated learners.

With regard to the treatment of PBL, it is not always easy to apply the principle of jointed and related examples throughout the whole semester. However, the next version of PBL design shall be more structured in procedures and provide adequate scaffolding in text. Teachers should invest significant efforts in this design and start to prepare the design far in advance of its implementation.

Limitations and opportunities for further research

Though the quantitative and qualitative data both show positive effects of improving students' computing skills, there were some limitations in drawing firm conclusions due to threats to the validity of the quasi-experimental design. A major problem with this design might be that the four groups were not be necessarily the same before any treatment or instruction took place, and might differ in important ways that influenced their performances. In this regard, the researchers empirically assessed the differences in students' computing skills and involvement in this course among the four groups in the beginning of the study. The differences in students' computing skills and involvement in the pretests were not statistically significant. The researchers could thus rule out initial differences as alternative explanations for the differences detected (Gribbons & Herman, 1997).

Some problems result from students in the comparison group being incidentally exposed to the treatment condition, having more enthusiastic teaching, being more motivated than students in the other group, etc. (Gribbons & Herman, 1997), which might influence the effects of online learning. The enthusiastic and involved teacher may engage more and pay more attention to the experimental groups, which may result in biases and exaggerate the effects of the adopted teaching methods. One should be aware of these contextual factors that may threaten the validity of claims made by this study.

Some other factors might also potentially influence the effects of students' online learning. A student with readiness for self-directed learning may appropriately adapt himself to a web-enabled learning environment, resulting in better learning performance. For example, it was observed that several students with good grades in the traditional classroom recorded their learning regularly, and performed better than those without self-regulation. These students were relatively more self-directed in the traditional classroom instruction and also had better learning effects in the online environment. Moreover, students' preference for computer courses might also lead to better learning effects. For instance, some students with preference for learning software showed conspicuous motivation in this online course. Students who preferred computer courses might adapt better to technology-based instruction and thus perform better. The instructor observed that some of his students still logged on the course website to review the content even after the semester had ended, and asked for other online courses in the coming semester. Altogether, factors such as students in the comparison groups with more motivation, more enthusiastic teaching, students' past grades, preference for computer courses, and readiness for SRL, might influence the effects of online learning. To complement the findings of this study, we advise further studies to explore the relationship between these contextual factors and students' online learning.

Conclusion

Teachers face tremendous challenges in implementing e-learning in the environment where students are surrounded with free online games and shopping websites. So it is not immediately clear how to focus students' attention, improve their learning, and help them be more involved in a web-enabled course without the teacher's on-the-spot monitoring. In this study, we deployed two instructional designs, PBL and SRL, to enhance students' learning through the Internet. Based on the results, experiences, and insights gained from this implementation, we believe that this research contributed in three different ways. Firstly, this study specified how teachers can engage students in improving learning under authentic conditions. At the same time, the teachers helped students to regulate their learning by applying PBL and SRL instructional methods in a web-enabled learning environment. Secondly, this study followed a traditional teacher who had success in helping students pass certification exams along his journey of adapting to the innovative instructional designs that he was adopting in his course for the first time. The results reinforced this teacher's confidence in conducting online courses, particularly for students with lower academic achievement. Thirdly, this study took note of the shortcomings and insufficiencies that were found in the first implementation of the web-enabled pedagogies in this context and suggested refinements for the next experimental round.

This study may provide valuable insights and shed light on new and effective practices for schools (particularly vocational schools), scholars, and teachers who are planning to implement or are presently engaged in implementing e-learning. Moreover, different ways of increasing students' interests and helpful references to ways of helping online students regulate their learning are also provided. The implementation of e-learning and the redesign of the materials for online courses is imperative. We expect that our experiences can provide insight for teachers in their online course design.

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