Exploring the Effects of Web-Enabled Problem-Based Learning and Self-Regulated Learning on Enhancing Low Achieving Students' Skills of Appling Software: A Quasi-Experimental Approach

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Abstract: - This study explores the relative effects of web-enabled problem-based learning (PBL), self-regulated learning (SRL), and their combination on enhancing low achieving students' skills of applying software. A series of quasi-experiments were conducted for this exploratory study. Two classes of 102 freshmen in a one-semester course took part in the experiment. A full model of the relationships among variables representing the treatments on students' development of computing skills was tested. Results were generally positive as expected, showing enhanced computing skills. The authors further discussed the implications of these results for schools, particularly for vocational schools, and scholars and teachers engaged in e-learning.

Key-Words: - Web-Based PBL, Web-Based SRL, e-learning, Computing education, Low achievers

1 Introduction

Professionals with a vocational degree represent a major portion of work force in Taiwan. Vocational education is highly competitive in that it must attract enough students to enroll, and faces a continually decreasing birthrate and compete with a rapidly increasing number of schools. Students in these schools tend to have lower levels of academic achievement, and spend more time on part-time jobs, do not adequately get involved in their schoolwork, and care less about their grades. Teaching in such contexts, particularly teaching the computing curriculum, is a great challenge to most scholars.

No one doubts the guiding principles of practical applications in the vocational education in Taiwan [1]. However, most of teaching and learning efforts in this area have been devoted to helping students pass written tests. Computing courses traditionally emphasize memorization by applying short, disjointed, lack-of-context examples. There is a gap between what is learned in school and what is required in the workplace [2]. 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 develop practical skills, problem-based learning (PBL) is considered to be most appropriate. PBL use

real-world, simulated, contextualized problems of practice to motivate, focus and initiate content learning and skill development [3, 4, 5]. We believe that PBL would help students to develop practical computing skills through online courses.

Web-based instruction seems to be an ideal learning environment because students can access an almost unlimited amount of information and apply it in multiple ways [6]. However, implementing e-learning for low-academic-achievement students inevitably runs high risks. For instance, Internet addiction is quite common among low-academic-achievement students. Many students like to chat with each other frequently via MSN messenger even though they are in the same classroom. They browse shopping website and play online games even while the teacher is lecturing in this classroom. It is even more difficult for students to concentrate on online learning because of this addiction to the Internet and a lack of on-the-spot teacher monitoring. To respond to this challenge, we turn 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 [7]. It is very critical to develop students' regulation of learning before providing online courses to them. Students' motivation may benefit from web-based instruction with self-regulated learning (SRL) strategies. Students in the online environment equipped with SRL competence become more responsible for their learning and more intrinsically orientated [8]. Consequently, we apply SRL in this study to help vocational school students concentrate on their learning, leave time for learning after their part-time job, and furthermore, take responsibility for their learning.

There are few studies that have discussed effective online teaching methods for university students. In this area, the restructuring and translation of traditional computing courses into e-learning has seldom been documented. Thus, we have redesigned the computing course to integrate innovative teaching methods and learning technologies to help students learn and apply what they have learned. Specifically, this study explores the potential effects of web-based PBL and SRL on the development of students' skills on applying packaged software and their pass rate. Moreover, a full model of the relationships among variables representing the treatments on students' development of computing skills was tested.

2 Methods

2.1 Participants

The participants in this study are 102 freshman students who take the compulsory 'Packaged Software and Application' in a university of science and technology in Taiwan. None of them major in information or computer technology. However, in an institution for technological/vocational education, practical applications of technology are guiding principles [1]. Students are expected to spend much more time and effort in mastering a variety of technological skills than those students of general universities in Taiwan.

2.2 Course Setting

The course under study is a semester-long, 2 credit-hour class, targeted at the first-year college students in different majors. Students solve a series of authentic tasks by applying Microsoft Office (including Word, Excel, and PowerPoint).

2.3 Experimental Design and Procedure

The experimental design was a 2 (PBL vs. non-PBL) × 2 (SRL vs. non-SRL) factorial pretest-posttest design (see Fig. 1). Students in the four groups solved the same tasks but in different learning conditions. The participants were randomly assigned to one of the four experimental conditions in such a way that each condition contained 24 to 30 subjects. The PBL and SRL group (C1, N=28), PBL and non-SRL group (C2, N=25), non-PBL and SRL group (C3, N=24) were experimental groups, while non-PBL and non-SRL group (C4, N=25) was the control group.

	PBL	non-PBL
SRL	The most significant effect (C1 Group)	Medium effect (C3 Group)
non-SRL	Medium effect (C2 Group)	No difference (C4 Group)

Fig. 1 Expected effects of variation in teaching methods

The course is divided into three subsequent modules: the Word module, the Excel module, and the PowerPoint module. There is a skill test held after the completion of each module. The first test is held during the midterm examination (8th week). The second test is held in the 13th week and the final one

in the 16th week. The schedule of module teaching and skill test is depicted in Fig. 2:

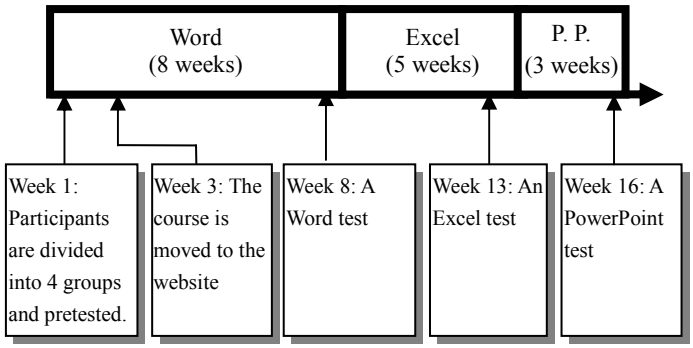

Fig. 2 The schedules of the three modules' tests

In the beginning of the course, students are encouraged to adapt and learn via a course website. Teaching in this period is in a traditional classroom. The teacher first audio-taped every session of his lecture and then translated these lectures into a HTML file with flash, video, and voice. These HTML files are then loaded into the course website. Students can preview and review the course sessions in this course website. After three weeks, most of the coursework are moved into the website. We help students adapt to learning on the net and lessen the feelings of isolation.

PBL Treatment

The teacher creates interesting, challenging, and authentic problem situations. In the first Word module, students are required to apply for a job as Marketing Assistant in an online-game company. They are required to design and then build autobiographies and resumes by applying computing skills they have just learned. In the Excel module, students play roles as if they are employed by this same software company, and a marketing manager asks them to compare expenses resulting from different distribution channels. They have to survey and then complete a worksheet with some graphs to contrast differences between channels. Additionally, they must come up with a recommendation regarding the best combination of channels. In the last module of PowerPoint, they are promoted as Marketing Managers of higher rank. They are asked to develop a business proposal for a new on-line game. They have to present this proposal with visual aids to convince the managing director to enter the market. Therefore, a persuasive PowerPoint file is built into this phase.

The teacher demonstrates first how he could approach the situation and solve the problem accordingly through web-based multimedia. In addition to the teaching of computing skills, similar situations and related applications are also discussed in the class. In the latter, the teacher guides students in constructing their own models of problem-solving.

SRL Treatment

Students in SRL groups received instruction in an after-school lecture teaching them SRL strategies. The two SRL groups from the PBL class and non-PBL class were gathered in a classroom and a two-hour lecture was delivered. The content of this SRL course was composed of the four processes addressed by Zimmerman, Bonner and Kovach, that is, self-evaluation and monitoring, goal-setting and strategy planning, strategy implementation and monitoring, and monitoring of the outcome of strategy [9]. Students were taught how to implement these four processes to become more 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 skills of application software they had learned after school. 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 of records. The teacher casually examined students' records. The treatments in four groups are illustrated and compared in Table 1.

2.4 Measures

We first measure students' computing skills in Microsoft Word as a baseline at the beginning of the course. Students complete three Word documents as a pretest, and the score shows a uniformly low skill level. We choose Microsoft Word for the pretest because almost every student in Taiwan learns Word before he learns other packaged software.

Later, a skill test is given at the end of each module. Before testing, students are assigned to random seats. All students are tested at the same time. The questions in the test relate to the content and examples in the course. Every test consists of 5 to 7 questions. The teacher grades and records the results immediately after each test. A surrogate representing computing skills is averaged from the scores of these three tests. The enhancement of computing skills in the course is the result of one's grade minus his pretest grade. Then, a regression model of the relationships among variables representing the treatments on students' enhanced computing skills was tested. Finally, a student whether pass depends on his averaged grade is

higher than 60 or not. We test the differences of pass rate in the course of 'Packaged Software and Application' under different conditions.

Table 1 Teaching and learning activities in different experimental groups

Group	Teaching Activities	Learning Activities
C1	The teacher… ● demonstrates how to solve authentic problems and discusses its potential applications. ● teaches SRL skills and urges students to study regularly.	The students… ● take on authentic tasks and learn by problem solving. ● practice SRL and record learning behaviors every week.
C2	The teaching activities are the same as C1 but without SRL lectures.	The students experience authentic situations and solve the problems without extra requirements of SRL.
C3	The teacher… ● converts his traditional way of teaching without any modification into an online format. ● teaches SRL skills and urges students to study regularly.	The students… ● receive the traditional computer software course through Internet. ● practice SRL and record learning behaviors every week.
C4	The teaching activities are the same as C3 but without SRL lectures.	The students experience the traditional style of teaching and do not deal with the extra requirements of SRL, although teaching is conducted via the Internet.

3 Results

The Chi-Square ($\chi 2$) test was used to compare the different pass rate of learning promoted by PBL and non-PBL instructional methods. As shown in Table 2, the pass rate of PBL class (94.3%) was significantly higher than that of the non-PBL class (65.3%). In the category of failure to pass, only 15% came from the PBL class, however, 85% came from the non-PBL class. Therefore, it is believed that web-enabled PBL contributed to enhance students' skills of deploying application software and helped students pass this computing course.

Table 2 The comparison of pass rate between PBL and non-PBL

		Pass		Total	χ^2
		No	Yes		*Sig.*
PBL	n	3	50	53	.000
	% within PBL	5.7	94.3	100.0	
	% within pass or not	15.0	61.0	52.0	
	% of Total	2.9	49.0	52.0	
non-PBL	n	17	32	49	
	% within non-PBL	34.7	65.3	100.0	
	% within pass or not	85.0	39.0	48.0	
	% of Total	16.7	31.4	48.0	
Total	Count	20	82	102	
	%	19.6	80.4	100.0	

The results presented in Table 3 supported that the pass rate of SRL group (94.2%) was significantly higher than that of the non-SRL group (66.0%). In the category of failure to pass, only 15% came from the SRL class, however, 85% came from the non-SRL class. Thus, it could be concluded that web-enabled SRL improved students' skills of application of computer software and helped students pass this computing course.

Table 3 The comparison of pass rate between SRL and non-SRL

		Pass		Total	χ^2
		No	Yes		*Sig.*
SRL	n	3	49	52	.000
	% within SRL	5.8	94.2	100.0	
	% within pass or not	15.0	59.8	51.0	
	% of Total	2.9	48.0	51.0	
non-SRL	n	17	33	50	
	% within non-SRL	34.0	66.0	100.0	
	% within pass or not	85.0	40.2	49.0	
	% of Total	16.7	32.4	49.0	
Total	n	20	82	102	
	%	19.6	80.4	100.0	

We applied the regression analysis to build a full model of different combinations of teaching methods to explain students' enhanced computing skills (i.e. enhanced computing skills are defined as the result of one's average of Word, Excel and PowerPoint grades, minus one's pretest grade). In general, a regression model is represented as $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_i x_i$,.where y is the dependent variable, x_i the independent variable, and β_i the coefficients for x_i. Three dummy variables (x_1, x_2, and x_3) were set to represent the four groups

in this study. The dummy variables were illustrated in Table 4.

Table 4 Three dummy variables for representations

Group	x_1	x_2	x_3
C1	0	0	0
C2	1	0	0
C3	0	1	0
C4	0	0	1

As shown in Table 5, the full model could be represented as: $y = 70.665 - 6.735x_1 - 9.238x_2 - 17.895x_3$. This full model was significantly related to the enhanced computing skills (R^2 = .285; Adjusted R^2 = .263; p < 0.001). It is revealed that the traditional teaching delivered through Internet (C4) might contribute only 52.76 ($=70.665-6.735\times 0-9.238\times 0-17.895\times 1$) points to students' enhanced computing skills. This model also showed that applying only SRL in non-PBL context (C3) resulted in an increase of 61.417 ($=70.665-6.735\times 0-9.238\times 1-17.895\times 0$) points in students' test scores of computing skills. The group of PBL and non-SRL (C2) contributed 63.92 ($=70.665-6.735\times 1-9.238\times 0-17.895\times 0$) points to improve students' computing skills. This model also suggested that the combined application of PBL and SRL (C1) may contribute 70.655 ($=70.665-6.735\times 0-9.238\times 0-17.895\times 0$) points to foster students' learning.

Table 5 Results of the stepwise multiple regression analysis

	Coefficients	Std. Error	d.f.	*F*-test	*sig.*
β_0 *(Constant)*	70.655	1.986	3	13.018	.000
β_3	-17.895	2.891			
β_2	-9.238	2.923			
β_1	-6.735	2.891			

4 Discussion

Teachers face tremendous challenges in implementing e-learning among relatively low academic achievers. For example, Internet addiction is common, and it is not immediately clear how to concentrate students' attention and improve their learning in a web-based environment without the teacher's on-the-spot monitoring. In this regard, we believe that our research contributes to e-learning theory in three different ways. First, our research specifies how teachers can engage students in improving learning under authentic conditions and, at the same time, help students to regulate their learning by applying PBL and SRL instructional methods in a web-based learning environment. Second, this study is one of the first attempts to explore the learning effects of the various combinations of PBL, SRL, and web-based learning. Third, this study provides a full model of the relationship between web-enabled PBL, SRL and students' improvement of computing skills.

As to our first teaching method, PBL was found to play a consistently positive role in enhancing students' computing skills and helping them pass this course (see Table 2). There are significant differences between the PBL and non-PBL classes in the pass rate (p = 0.000). It was demonstrated that PBL is good for computing education in general, and e-learning in particular. This result is similar to Polanco, Calderón and Delgado' study that points out that students in PBL groups attain significantly higher scores than those students of control group in a course that was composed of physics, mathematics and computer science [10]. Therefore, teachers could redesign their courses by simulating meaningful and interesting business situations, and thus engaging students' imaginations and interests to solve challenging problems.

Evidence also supports that the second teaching method based on SRL also enhances students' computing skills and helping students pass this course (see Table 3). There are significant differences between SRL and non-SRL groups in the pass rate (p < 0.001). This suggests that the effects of SRL on low achievers' learning can be significantly improved even by a limited amount of intervention such as two-hour lecture regarding SRL at the beginning of the teaching program and later by students' monitoring their own learning.

However, despite the significant differences between SRL and non-SRL groups in the pass rate, the instructor experienced many hurdles to lead and guide students through the transition to become self-regulated learners. On numerous occasions, the instructor almost gave up on the intervention of SRL because of students' resistance. Too many and overly strict requirements and strategies of SRL without communication may lead to greater

resistance. That is, the requirements of SRL for low achievers should not be too rigorous, as they may not get used to take up their learning responsibilities in such a short period.

Finally, we built the full model of the relationship among students' computing skills and web-enabled PBL and SRL. This full model helped teachers to predict effects on students' learning of enhanced computing skills. For example, if a teacher provides an online course that combines PBL and SRL (C1: x_1=0, x_2=0, x_3=0), it may help his students to increase their final scores to 70.655 points. However, if teachers directly translate their teaching materials into electronic form without redesign of their courses and appropriate teaching methods (C4: x_1=0, x_2=0, x_3=1), this may contribute only an increase of 52.76 points for their students. Students in the control group (C4) received the poorest grades among the four groups. For those teachers who wish to stick to traditional methods of teaching, providing online courses without redesign may not be a fruitful approach.

Furthermore, the regression coefficients (β_i) in the full model for the significant predictors were all negative, that is, the combined training of PBL and SRL (x_1=0, x_2=0, x_3=0) would be the best teaching method in the specific context of this study. This result is similar to Perels, Gürtler and Schmitz's study suggesting that the combined training in self-regulatory and problem-solving strategies is effective for enhancing self-regulatory competences in solving problems [11]. Moreover, Kramarski and Gutman indicate that SRL students significantly outperformed the non-SRL students in problem-solving procedural and transferral tasks regarding mathematical explanations in web-based learning environment [12]. Therefore, it is suggested that teachers should redesign their courses and then adopt new instructional methods and technologies to fully exploit the benefits of deploying web-based learning environments.

This study may provide valuable insights and shed light on new and effective practices for schools (particularly vocational schools), scholars and teachers planning to or are presently engaged in implementing e-learning.

References:

[1] C. F. Tai, R. J. Chen, and J. L.Lai, How technological and vocational education, *IEEE Circuits & Devices Magazine*, Vol. 19, No. 2, 2003, pp. 15-51.

[2] T. Y. Wu, *Integrative curriculum planning in technological and vocational education in Taiwan, Republic of China*, 2000. retrieved March 23, 2007 from http://eric.ed.gov/ERICDocs/data/ericdocs2/content_storage_01/0000000b/80/24/dd/9f.pdf.

[3] D. Boud, and G. Feletti, *The challenge of problem based learning*, London: Kogan Page 1991

[4] J. T. Bruer, Schools for thought: A science of learning in the classroom, Cambridge, MA: MIT Press, 1993

[5] S. M. Williams, Putting case-based learning into context: Examples from legal, business, and medical education, *Journal of Learning Sciences*, Vol. 2, No. 4, 1993, pp367-427.

[6] D. F. Kauffman, Self-regulated learning in web-based environments: instructional tools designed to facilitate cognitive strategy use, metacognitive processing, and motivational beliefs, *Journal of Educational Computing Research*, Vol. 30, No. 1 & 2, 2004, pp.139-161.

[7] K. S. Cennamo, J. D. Ross, and C. S. Rogers, Evolution of a web-enhanced course: Incorporating strategies for self-regulation, *Educause Quarterly*, Vol. 25, No 1, 2002, pp. 28-33.

[8] M. M. Chang, Applying self-regulated learning strategies in a web-based instruction - An investigation of motivation perception, *Computer Assisted Language Learning*, Vol. 18, No. 3, 2005, pp. 217-230.

[9] B. J. Zimmerman, S. Bonner, and R. Kovach, *Developing Self-Regulated Learners: Beyond Achievement to Self-Efficacy*, Washington, DC: American Psychological Association, 1996

[10] R. Polanco, P. Calderón, and F. Delgado, Effects of a problem-based learning program on engineering students' academic achievements in a Mexican university, *Innovations in Education & Teaching International*, Vol. 41, No. 2, 2004, pp. 145-155.

[11] F. Perels, T. Gürtler, and B. Schmitz, Training of self-regulatory and problem-solving competence, *Learning and Instruction*, Vol. 15, No. 2, 2005, pp. 123-139.

[12] B. Kramarski, and M. Gutman, How can self-regulated learning be supported in mathematical E-learning environments? *Journal of Computer Assisted Learning*, Vol. 22, No. 1, 2006, pp. 24–33.