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Comparing the Self-Regulated Learning Strategy and Non-Self-Regulated Learning Strategy in Cognitive Load and Learning Effectiveness in an Exercise System

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Abstract: Knowledge of the database management system is quite important. Effectively organizing, managing and analyzing data are indispensable capabilities in a database management system. In Taiwan, the low birth rate trend leads to that university students' learning level becomes low and uneven. And, in traditional classrooms, teachers aren't able to take high or low prior knowledge students into account at the same time. Self-regulated learning can let learners set their own goals and learning strategies to achieve learning goals and to improve their self-efficacy. E-learning can let learners handle their own learning contents, time and progress, to conform to the personalized learning. Therefore, self-regulated learning and e-learning can be applied with each other coordinately. There are many researches developing self-regulated learning system for learners to enhance their learning effectiveness. But with respect to the non-self-regulated learners, self-regulated learners which have higher autonomy might spend more time with efforts to adjust the learning goals and strategies. And few studies investigated the psychological burden of self-regulated learners. Thus, this study inspected cognitive load between self-regulated learners and non-self-regulated learners. In this study, there were two classes at a university in central Taiwan, attending a database management system course and were divided into an experimental group and a control group. The numbers of effective samples were 34 and 41, respectively. The experimental group used an exercise system with self-regulated learning strategy. On the other hand, the control group applied non-self-regulated learning strategy. We had carried on an empirical research to investigate the effect of two kinds of learning strategies (self-regulated and non-self-regulated) on students' cognitive load and learning effectiveness during a semester (17 weeks). The result of this study showed that the self-regulated learning caused students achieving higher learning effectiveness but having higher cognitive load.

Keywords: Self-regulated learning, cognitive load, learning effectiveness, database management system, exercise system

1. Introduction

Information technology is indispensable to the country's development, and everyone requires IT ability. There are large and diverse messages in life. How to effectively organize, manage and analyze the received information is important (Zehra et al., 2004). A database management system can effectively integrate data, logically manage data, and facilitate analysis and use of data (Ahmad, Khan, Abd Alla, & Beg, 2010). Therefore, the importance of personnel training for the database management system technology is ineffable. The departments of universities about information mostly regard the database management system course as a required subject. However, in Taiwan, the low birth rate trend leads to that university students' learning level becomes low and uneven. Therefore, the education of the database management system course is into trouble. When teachers teach rapidly, students having the low learning level aren't able to adapt. On the other hand, when teachers teach slowly, students having the high learning level feel bored. Slavin (1990) had pointed out that when a group of students' learning

ability was significantly different, the course content should be suitable for the majority of students. Most teachers could not take high and low learning effectiveness students into account at the same time. Therefore he recommended that teachers shouldn't teach students with the same progress and scoring criteria. This is because that the difficulty of achieving learning goals may affect students' learning motivation. Bandura (1977) proposed self-efficacy would affect the self-behavior, if the learning goal was too difficult, students might feel frustrated thus reducing the willingness to learn; if the goal was too easy, it might lead students lacking of motivation. To solve the above problems, the present study introduced the self-regulated learning strategy, through autonomy setting goals and identifying learning strategies to achieve their goals, and students could enhance self-efficacy (Zimmerman, Bonner, & Kovach, 1996).

The greatest advantage of e-learning is able to provide learners with personalized service. Ruiz, Mintzer, and Leipzig (2006), and Butz, Hua, and Maguire (2004, Sept.) considered e-learning allowed learners to know learning content, learning time and order of study courses well, for meeting learners' personal learning goals. Therefore, e-learning and self-regulated learning strategies can be combined to use. Huang et al. (2007) proposed students' self-learning ability was very important. They established a computer-assisted self-regulated learning model and practically applied to information courses. They found online self-regulated learning auxiliary mechanisms indeed enhanced students' self-regulated learning ability. Yang, Hwang, Yang, SJH, and Hwang (2015) mentioned that the programming was an important skill for students with the information specialty. They built a system for e-learning courses on programming, the study found that this kind of learning improved students' willingness to learn, and effectively improved the ability of students in the program design.

Hwang et al. (2015) developed an exercise system with self-regulated learning strategy for different cognitive style students in a database management system course. Students used this system to repeated practice database management system course topics in order to establish the correct concept and skills of database management. Hwang et al. hoped to enhance the students' self-efficacy and learning performance of the database management system course. However, the study only confined development and the usability evaluation of their system, so there was no analysis of the learning effectiveness in their study. Most of the students did not understand about the database management system before the course and have lower prior knowledge. Tuovinen and Sweller (1999) found that low prior knowledge students' cognitive load in database program was high. In addition, students' cognitive load might be affected by different learning styles. Self-regulated learners may spend more time with efforts to adjust the learning goals and strategies, with respect to the non-self-regulated learners. Therefore, this study used the system developed by Hwang et al. (2015) as a research tool to investigate the correlation of cognitive load and learning effectiveness for students with non-self-regulated learning and self-regulated learning strategies. In summary, this study wanted to understand whether course content causing pressure on student mental aspects, and whether the complex operating system causing on students psychological burden. The results showed that the learning effectiveness of students with self-regulated learning was better than that of students with non-self-regulated learning. However, the self-regulated learning strategy increased students' cognitive load.

2. Literature

2.1 Self-Regulated Learning

Bandura (1977) indicated that learners control their behavior which was called self-regulated. It let learners have different learning method in the past. Zimmerman et al. (1996) proposed a self-regulatory learning cycle which includes four processes, "self-evaluation and monitoring", "goal-setting and strategic planning", "strategy implementation and monitoring" and "strategic outcome monitoring". Zimmerman et al. considered that the self-regulated learning let learners set their own goals and find out learning strategies or methods to achieve goals. At any time, learners could modify their strategies or goals via monitoring their learning portfolios.

In the past, many scholars found that learners had nice learning effectiveness via self-regulated learning strategy in many different learning areas, e.g., the English language area (Chen, Wang, & Chen, 2014; Chen & Huang, 2014), mathematics area (Hackett & Betz, 1989; Malpass, O'Neil, & Hocevar,

1999; Pajares & Miller, 1994; Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014), natural sciences area (Betz & Hackett, 1983; Britner & Pajares, 2006; Chen & Usher, 2013), social area (Hwang, Kuo & Hsu, 2008) and information area (Hwang et al., 2007; Hwang et al., 2014).

Hwang et al. (2015, May) developed a self-regulated learning exercise system. This system let learners set their learning goals and strategies: the pass score, days and times. Learners can modify their goals via querying their learning portfolios. The study applied this system as an experimental tool. Through the self-regulated learning system, we wanted to know whether the learners could effectively understand the contents of the course. About the system operation and the difficulty of the course, we also introduced cognitive load questionnaire to observe learners' mind.

2.2 Cognitive load

Paas (1992), and Sweller, Merriënboer and Paas (1998) thought that the cognitive load was a multifaceted concept. It includes mental load and mental effort. Mental load was psychological burden of students for difficulty of teaching material degree; mental effort was psychological burden of students for complexity of operating media. Either students felt learning contents more difficult, or students felt more difficult system operations, would increase their cognitive load. Tsai, Yang, Hsu, and Chang (2015, May) explored effects of cognitive load about collaborative learning on programming, for traditional pair programming and remote pair programming. Their research found that mental load of remote pair cooperation programming was higher than that of traditional pair cooperation programming. Tuovinen and Sweller (1999) found that while learning a database software, the low prior knowledge students with worked-example teaching method had lower cognitive load than those with exploration teaching method. Chuang, Hwang, Shih, Yang, and Chu (2009, May) used blended mobile learning method to investigate the cognitive load. The experimental group's students used Personal Digital Assistants (PDAs) as learning tools to learn local culture. Because the PDA provided a personal learning environment, students learned and repeated exercise, according to their own learning progress. Therefore, these students' mental effort was lower. On the other hand, the control group's students learned from the traditional method. But it had led to some students could not follow the progress. They had higher psychological burden. In summary, students' cognitive load might be affected by using the information technology in learning process, or using the different teaching methods.

This study used the exercise system with self-regulated learning strategy in a database management system course. The content of database management systems courses might cause students higher mental load. And, the operation complexity of the self-regulated learning exercise system might cause students higher mental effort. Therefore, we wanted to understand students' cognitive load via using a cognitive load questionnaire.

Our research questions sort out as follows:

1. Is the learning effectiveness of students with the self-regulated learning strategy different from that with the non-self-regulated learning strategy?
2. Is the cognitive load of students with the self-regulated learning strategy different from that with the non-self-regulated learning strategy?

3. Methodology

In this study, there were 112 students from two classes at a university in central Taiwan. These students attended a database management system course and were divided into an experimental group and a control group. The experimental group used an exercise system with self-regulated learning strategy. The numbers of all samples and effective samples were 49 and 34, respectively. On the other hand, the control group applied non-self-regulated learning strategy. The numbers of all samples and effective samples were 63 and 41, respectively. Students in the experimental group could perform one exercise by several tests, and could set their learning goals and strategies for each exercise. Learning goals of each exercise included the passing score (60, 70, 80, 90 points) and the time period limit (20, 30, 40 minutes). Learning strategies of each exercise included the required days and times for finishing an exercise. Students in a control group could not set their learning goals and strategies. The learning goals and strategies of a control group were fixed. Learning goals of each exercise included that the passing

score is 75 points and the time period limit was 30 minutes. Learning strategies of a control group included that the required days to finishing one exercise were most 7 days (a week after the teacher completing the teaching), and one exercise could be performed most five tests.

The teaching experiment was carried out 17 weeks on a semester. The system was introduced and the pre-test was conducted for students in the first week of the semester. The content of pre-test was involved with basic computer concept. Students made use of this system during the second week to the sixteenth week. The first post-test and second post-test were conducted in the ninth week (midterm) and the seventeenth week (final examination). Students filled in the questionnaire designed by Sweller et al. (1998) with 7-point scale (Likert, 1932). The experimental flowchart is shown on Figure 1.

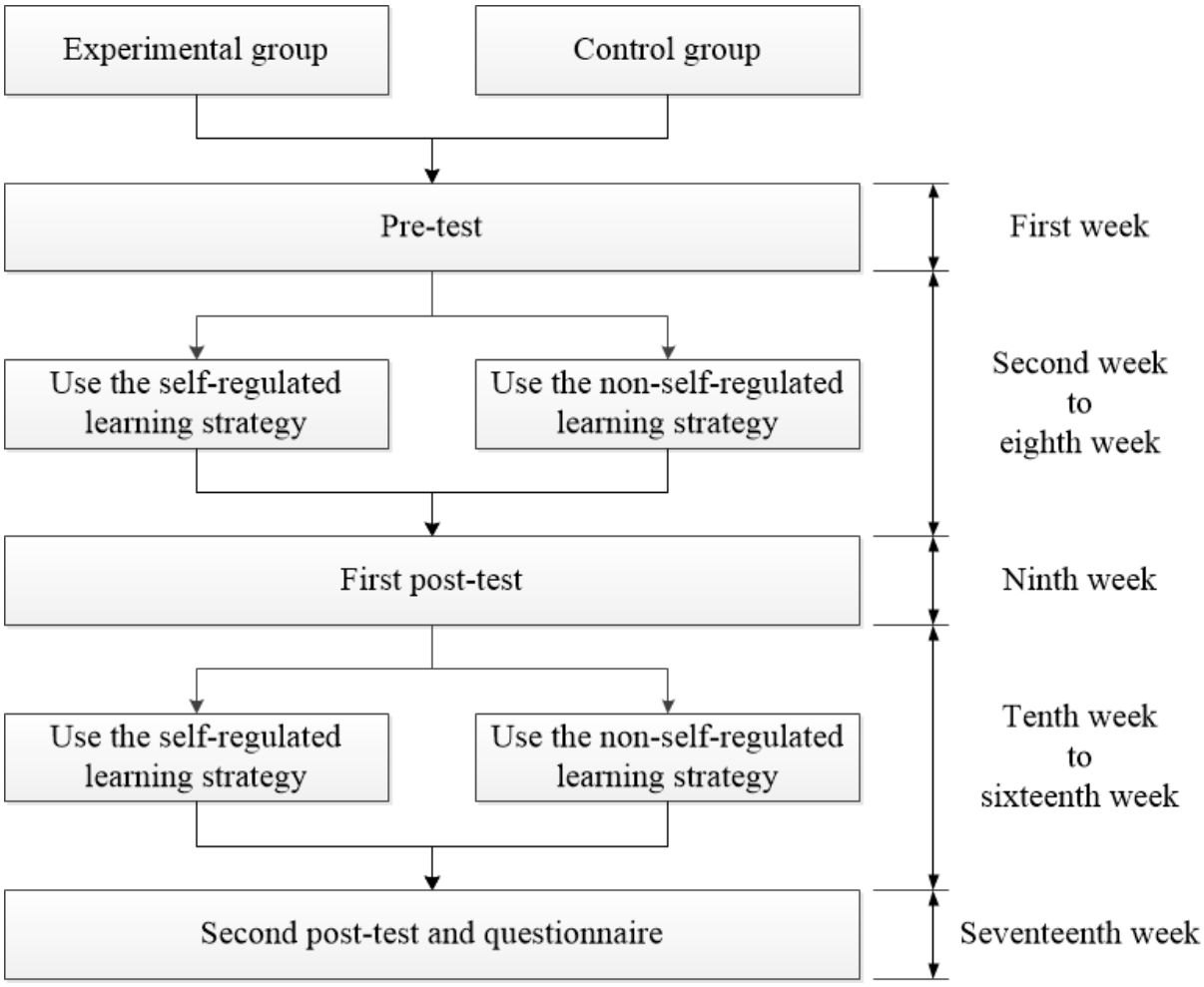

Figure 1. The flowchart of the experiment.

4. Experimental results and analysis

This study applied the questionnaire designed by Sweller et al. (1998) to understand cognitive load about students using this exercise system. The questionnaire was filled by students. The results were analyzed through independent samples *t*-test, as shown on Table 1. About mental load, the means of the experimental group and the control group were 3.64 and 2.59, respectively. The results achieved significant differences ($p < 0.001$). About mental effort, the means of the experimental group and the control group were 3.41 and 2.44, respectively. The results also achieved significant differences ($p < 0.01$). Students in Taiwan got used to getting learning goals and strategies from the teachers, therefore they easily felt confused about setting learning goals and strategies by themselves. In this study, students in the experimental group could set their learning goals and strategies, and these might lead to the higher

mental load. The reason of higher mental effort may be that the operating of system for the experimental group is more complicated than the control group.

The learning effectiveness of the experiments is shown on Figure 2. In pre-test, the mean score of the experimental group was lower than that of the control group. After using the system, the mean scores of the two post-tests of the experimental group were both higher than those of the control group.

Table 1: *t*-test results of cognitive load.

Dimension	Group	N	Mean	S.D.	*t*
Mental load	Experimental group	34	3.64	1.11	4.45***
	Control group	41	2.59	0.93	
Mental effort	Experimental group	34	3.41	1.09	3.60**
	Control group	41	2.44	1.24	

***$p < 0.001$;**$p < 0.01$

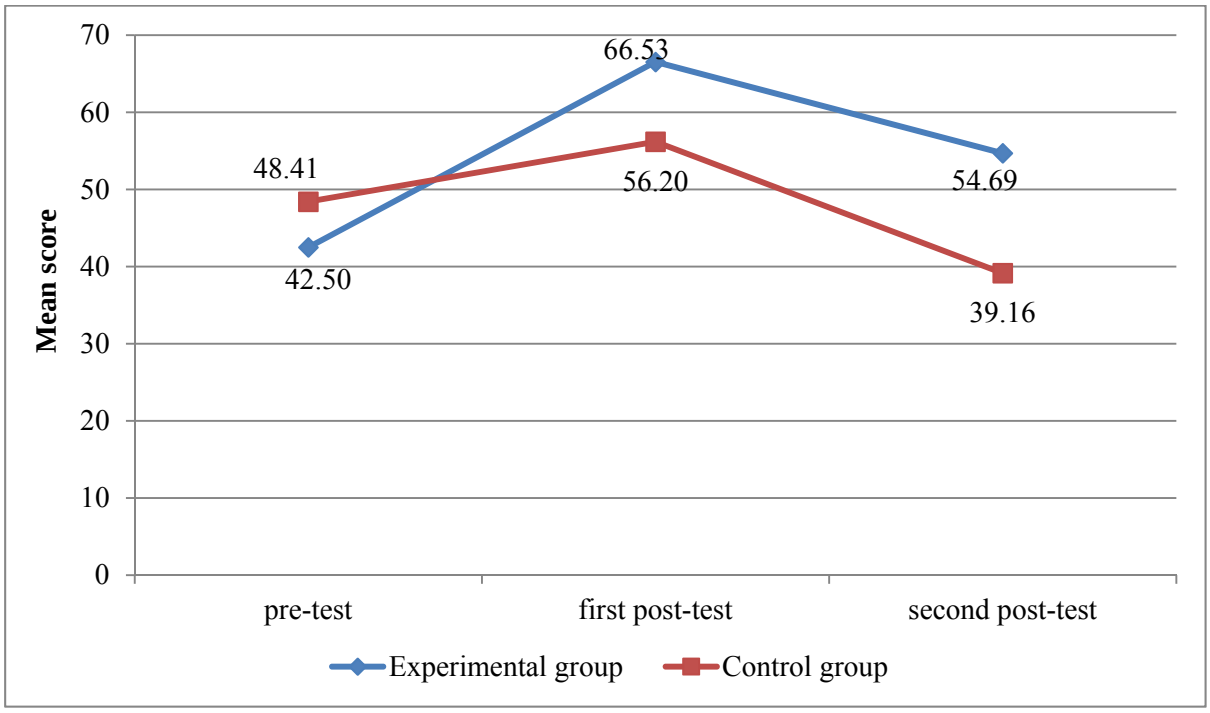

Figure 2. Line chart of the average score about three tests for two groups.

This study used descriptive statistics to analyze pre-test and two post-tests. The results revealed that these three tests were homogeneous (first post-test $p = 0.452$, second post-test $p = 0.147$, $p > 0.05$). Therefore, we further utilized ANCOVA (ANalysis of COVAriance) to excluding the influences of pre-test and post-tests. The results of ANCOVA about the first post-test ($F = 10.78$, $p = 0.002 < 0.01$) achieved significant differences. The adjusted means of the experimental group and the control group achieved significant differences. And the midterm's adjusted mean score (67.45) of the experimental group was better than that (55.44) of the control group. The results of ANCOVA analysis about the second post-test ($F = 18.28$, $p = 0.000 < 0.001$) also achieved significant differences. The adjusted means of the experimental group and the control group still achieved significant differences. And the final examination adjusted mean score (55.83) of the experimental group was higher than that (38.22) of the control group. For the adjusted mean score difference between the experimental group and the

control group, the final examination (67.45 - 55.44 = 12.01) was bigger than that (55.83 - 38.22 = 17.61) of the midterm. The results are shown on Table 2 and Table 3. That is, through the self-regulated learning strategy, the learning effectiveness is effectively enhanced.

Table 2: First post-test results of ANCOVA.

Group	N	Mean	S.D.	Adjusted Mean	Std. Error.	*F value*
Experimental group	34	66.53	16.35	67.45	2.68	10.78**
Control group	41	56.20	15.57	55.44	2.44	

**$p < 0.01$

Table 3: Second post-test results of ANCOVA.

Group	N	Mean	S.D.	Adjusted Mean	Std. Error.	*F value*
Experimental group	34	54.69	18.47	55.83	3.02	18.28***
Control group	41	39.16	17.73	38.22	2.74	

***$p < 0.001$

5. Conclusion and Future work

This study compared the self-regulated learning strategy and non-self-regulated learning strategy in an exercise system to discuss influences of cognitive load and learning effectiveness, via students' pre-test, two post-tests and cognitive load questionnaire. Research results showed cognitive load of the experimental group is higher than that of the control group. This is because that the operating of self-regulated learning system is more complicated. The outcome is the same with research from Tsai, Yang, Hsu, and Chang (2015, May). Therefore, complex operations influence student's cognitive load.

Students using self-regulated learning strategy can make learning effectiveness better than using non-self-regulated learning strategy. The result is the same with research from Chen, Wang, and Chen, (2014), Chen and Huang, (2014), Hackett and Betz, (1989), Malpass, O'Neil, and Hocevar, (1999), Pajares and Miller, (1994), Parker, Marsh, Ciarrochi, Marshall, and Abduljabbar, (2014), Betz and Hackett, (1983), Britner and Pajares, (2006), Chen and Usher, (2013), Hwang, Kuo, and Hsu, (2008), Hwang et al. (2007). Results of the study demonstrate using self-regulated learning strategy can enhance students' learning effectiveness.

In summary, student using self-regulated learning strategy can promote learning effectiveness. However, complex operations for adjusting the learning goals and strategies increase students' cognitive load. In the future, this study will combine a goal recommendation function to help students reducing their cognitive load. Besides, the relation between self-regulated learning strategy and human factors will be discussed.

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