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*Corresponding author. E-mail: hhtie@segi.edu.my

THE IMPACT OF SELF-REGULATED LEARNING AND INSTRUCTIONAL METHODS ON STUDENTS' RECALL AND RETENTION PERFORMANCE

***Tie Hui Hui[1], Irfan Naufal Umar[2]**
[1]SEGi College Penang, Penang, Malaysia; [2]Universiti Sains Malaysia, Penang, Malaysia.

ABSTRACT

Self-Regulated Learning (SRL) is the ability of students to set goals for their learning. It has emerged as an important construct in education especially for classroom performance. The first part of this paper discusses the model of memory associated with learning programming and the concept of SRL. The second part of the paper presents the model of SRL. A group of one hundred and twenty three first year computing students was involved in these seven weeks of experimental study. These students from three intact classes were randomly assigned to the two experimental groups and one control group. In the experimental groups, one group received a combination of metaphor and pair programming (MPP), and the other received pair programming method (PP) only. The control group received only the direct instruction method (DI). The participants in both MPP and PP groups worked in pairs, and those of DI group worked individually when solving programming problems. Three computer programming performance tests (CPPT): a pre-test, an immediate post-test and a delayed post-test were administered to measure the students' recall and retention programming performance. The initial results indicated that there is a significant difference between the high and low SRL students taught in three treatment groups. Further analysis revealed that the high SRL students in the MPP group performed significantly better in both recall and retention as compared to those in the PP and DI groups. For the low SRL students, both the MPP and PP groups outperformed the DI group in recall. However, only the MPP group performed significantly better than the DI group in retention. In conclusion, the lecturers should take note of individual differences in students' learning abilities during their course deliveries in order to reinforce the students' engagement and classroom academic performance.

1.0 Introduction

Programming demands complex cognitive skills. Educators involved in teaching the programming concepts to the first year computing students are continually facing difficult challenges in cultivating the students' understanding in the fundamental area of semantics which is the programme comprehension (Oliver & Malone, 1998; Linn, Dalbey, 1985). Miliszewska and Tan (2007) and Dunican (2002) stated that complex cognitive skills such as planning, reasoning, problem solving and analytical thinking play their role in learning to programme. Problem solving skills which include reasoning and analytical thinking are required to analyze a given problem scenario.

SRL is the ability to regulate learning towards a desirable learning outcome. It is also a skill to manage and organize own learning needs, strategy used and learning opportunities (Jossberger *et al.*, 2006; Zimmerman, 2000). Kerka (2000) noted that the learning methods of students and their programming performance are closely related to the different levels of SRL abilities. The use of cooperative learning through PP which consist of students with different SRL abilities theoretically influence the students' proficiency in learning (Song & Hill, 2007; Felder & Brent, 2005).

2.0 Model of Memory for Learning Programming

Similar to any types of learning, the learning of programming involves the use of memory. This memory is classified into the long term, sensory and working memory. Figure 1 shows the model of these three types of memories associated with learning the basic programming concepts. Each memory has its role to play in the process of learning programming.

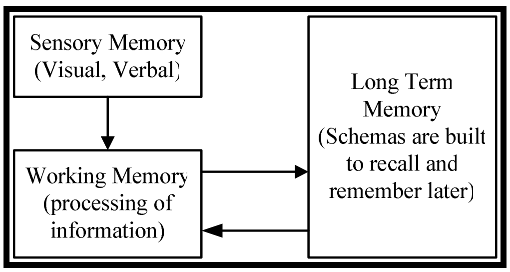

Figure 1: Model of Memory Involved in Learning Programming (Muhammed Yousoff *et al.*, 2006)

The long term memory which is almost permanent stores the information which enables it to be recalled during the process of learning basic programming concepts. Thus, it is also responsible for retaining the stored information until further processing in learning is needed. This long term memory is also subjected to building mental image or schemas. Schema is a network of information formed by the students during the learning process. The working memory processes the information to solve the computer programming problems and has a limited capacity. Miller (1956) has discovered that the working memory is only able to process seven elements at any one time. When more than seven elements are needed to be processed at any one point of time, it becomes overloaded. The learning outcome of the students cannot be achieved whenever overloading occurs.

Lastly, the short term memory, or the sensory memory, receives stimului through the sensory organs (eyes, ear, skin, nose and tongue) which are then processed by this memory which is processed in the working memory. The sensory memory is utilised to reduce or enhance the working memory during the process of the students' learning of basic programming concepts. Metaphors (visualisation representation) can be used to utilise the sensory memory as they help to extend the working memory as visuals presented do not require the memory process (Gerets, 2003). Thus, the understanding of SRL on individual learning process is possible to enhance the students' programming performance. This in turn, develops longer information retention.

3.0 Self-Regulated Learning

SRL has been defined as a process in which the students set goals for their learning, which involves planning and carrying out certain strategies for the achievement of the goals, to independently manage time and effort, and to evaluate the quality of their own learning environment (Guglielmino *et al.*, 2006; Grieve, 2003; Ncrel, 2001). The student's level of SRL ability, high or low, is based on the group mean measured using the Motivated Strategies for Learning Questionnaire (MSLQ) instrument developed by Pintrich and DeGoot (1990).

Studies have shown a significant correlation between an individual student with a high level programming performance and his high-quality involvement in SRL (Ricard, 2007; Van De Wiel *et al.*, 2004; Reder & Strawn, 2001). In fact, the high SRL students are those who are highly involved in independent learning (Song & Hill, 2007; Jossberger *et al.*, 2006; Taylor *et al.*, 2003). These students have the ability to regulate learning towards a desirable learning outcome and the skill to manage and organize their own learning needs, strategies and learning opportunities.

3.1 Model of Self-Regulated Learning

SRL is a self-initiated action whereby students set goals for their learning process which includes monitoring, regulating and controlling of individual metacognition (Chen, 2002; Zimmerman & Risemberg, 1997). At the same time it involves motivation, time management, behaviour and physical and social environment regulation. Boekaerts (1999) proposed a three-layer model of SRL (Figure 2). The innermost layer represents the ways students learn and process information as well as the quality of their self-regulation process. This includes their ability to perceive a choice among alternative cognitive strategies which is a critical aspect of SRL (Winne & Perry, 2000). The middle layer of SRL is the ability of students to direct self-learning. This is the cognitive process on the ability of students to use metacognitive skills such as orientating, planning, monitoring, evaluating and correcting for their learning activities (Boekaerts, 1999; Brown, 1987). The students' personal goals and resources setting (the outer layer) enable them to define priority on the ongoing and upcoming activities based on their own wishes, needs and expectation. Thus, it forms a learning intention by which students find opportunities to communicate and reflect on effect allocation, involvement and commitment in relation to their goals set and to self-demonstrate and evaluate their competency level. This allows the students to initiate, persist and disengage in acquiring new knowledge and skills according to individual learning pace that is oriented towards attaining own goals.

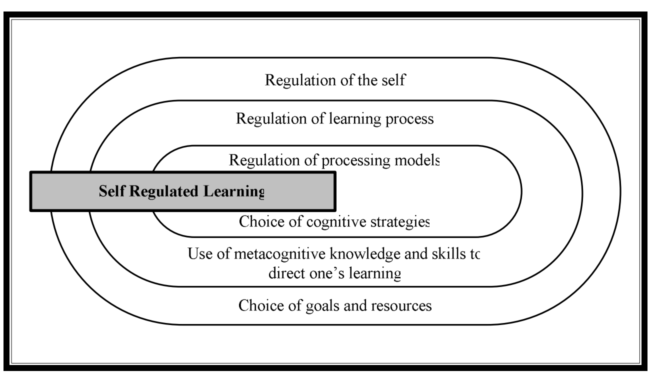

Figure 2: The Three-layered Model of Self-Regulated Learning (Boekaerts, 1999)

4.0 Research Questions

In this study, two main research questions have been formulated to facilitate and address the research outcomes:

1. Are there any significant differences in terms of recall between high and low SRL students who received (i) a combination of MPP treatment, (ii) PP only and (iii) the DI instructional methods?
2. Are there any significant differences in terms of retention between high and low SRL students who received (i) a combination of MPP treatment, (ii) PP only and (iii) the DI instructional methods?

5.0 Research Methodology

The purpose of this study is to investigate the effects of blending the MPP strategy on the programming recall and retention performances among high and low SRL computing students. It aims to examine whether the different levels of SRL could be the moderating factors when an instructional strategy such as (i) metaphors as visualisation techniques, and (ii) PP as cooperative learning, are used in classroom during course delivery.

5.1 Research Design

A 3 x 2 factorial design was used to examine the three independent variables (MPP, PP and DI) on the two dependent variables (recall and retention) with SRL (high and low) being the moderating variables. The students' recall and retention performances were measured based on the immediate and delayed post-test scores obtained from the CPPT.

A total of 123 students (n = 123) from the first year semester one undergraduate computing course were involved in this study. These three classes, all intact groups, were randomly assigned to the three treatment groups. Two experimental groups consisting 40 students (n = 40) each received the MPP and PP treatment respectively; and the control group (n = 43) received the DI treatment.

5.2 Research Instruments

The immediate and delayed post-test of CPPTs examining the students' recall and retention on both theory and practical knowledge of the basic programming concepts were administered.

The MSLQ was used to determine the students' level of SRL. A four dimension that consisted of 23 items of the MSLQ that requires 20 minutes to complete was used to classify their SRL levels. In this study, the MSLQ mean score of the sample was 3.50. Subsequently, students who scored 3.50 and above the group mean were categorized as high SRL and those who scored below 3.50 were classified as low SRL.

A set of reliability tests were conducted on the instruments used in order to determine the Cronbach's Alpha reliability coefficients. The reliability values of instruments are: (i) 0.915 for the pre-test, (ii) 0.954 for the immediate post-test, and (iii) 0.947 for the delayed post-test.

5.3 Data Collection Procedures

Three intact classes from the computing programme were selected and they were randomly assigned to the three treatment groups. In the first treatment group (MPP), each student received a programme flowchart and a Pseudocode with the use of MPP instructional strategy in learning the basic programming concepts. The students in the second treatment group (PP) were exposed to PP as the cooperative learning instructional strategy in solving the programming problems. The control group received the DI only teaching method, in which the programme flowchart and Pseudocode were used to explain the basic programming concepts.

The students in both the experimental groups were paired and each member of the pair was randomly assigned with a role, either as driver or navigator. The explanation regarding the roles (driver or navigator) of each member in the pair was given to both the MPP and PP groups. On every programming problem, they were persistently required to cooperate on the same design, algorithm, coding and testing. The role between the driver and the navigator was switched periodically.

The experiment was carried out for seven weeks. The immediate post-test was conducted to the three groups immediately after the treatment. A month later, the delayed post-test was administered. The CPPT instrument was used to measure the students' recall and retention performances of the basic computer programming knowledge.

6.0 Findings

The Multiple Analysis of Covariance (MANCOVA) was used to test the research hypothesis. MANCOVA was chosen as this study involved two dependent variables: recall and retention performances. The pre-test score was used as the covariate in this analysis.

Table 1 and Table 2 revealed the results of the analysis. Table 1 indicates the MANCOVA findings, while the descriptive statistics are shown in Table 2.

Table 1: MANCOVA Results for the Recall and Retention Scores of the Three Treatment Groups

Dependent variable	df	Mean square	F	Sig.
Recall (immediate posttest)	5	1703.22	52.38	0.00*
Retention (delayed posttest)	5	1764.70	43.68	0.00*

*significant at 0.05 level

Table 2: Descriptive Statistics for the Recall and Retention Performances of the Three Treatment Groups with Different SRL Levels

	Groups	SRL	N	Mean	SD
Recall (immediate post-test)	MPP	High	22	74.13	3.92
		Low	18	61.39	5.62
	PP	High	26	69.85	6.95
		Low	14	54.97	6.68
	DI	High	22	66.27	4.79
		Low	21	49.49	6.38

	Groups	SRL	N	Mean	SD
Retention (delayed post-test)	MPP	High	22	65.20	4.47
		Low	18	45.73	4.71
	PP	High	26	57.98	9.65
		Low	14	43.58	5.44
	DI	High	22	59.77	5.94
		Low	21	41.32	5.77

MANCOVA results in Table 1 clearly indicate a statistical significant difference in terms of recall performance between the high SRL and the low SRL students in the three treatment groups (F: 52.38; p: 0.00). Similarly, there is a significant difference in retention performance between the high SRL and low SRL students who received different treatment methods (F: 43.68; p: 0.00). Therefore, these findings have rejected both the first and second hypothesis. The post-hoc test was conducted to further investigate the differences (Table 3 and Table 4).

Table 3: Summary of Post-Hoc Test for Recall Performance between the High and Low SRL Students in the Three Treatment Groups

Level of SRL	Groups	Mean Difference	p-value	Results
High	MPP vs PP	4.28	0.011	Sig.
	MPP vs DI	7.86	0.000	Sig.
	PP vs DI	3.58	0.058	Not Sig.
Low	MPP vs PP	6.42	0.002	Sig.
	MPP vs DI	11.90	0.000	Sig.
	PP vs DI	5.48	0.006	Sig.

Table 4: Summary of Post-Hoc Test for Retention Performance between the High and Low SRL Students in the Three Treatment Groups

Level of SRL	Groups	Mean Difference	p-value	Results
High	MPP vs PP	7.22	0.000	Sig.
	MPP vs DI	5.43	0.010	Sig.
	PP vs DI	1.79	0.391	Not Sig.
Low	MPP vs PP	2.15	0.344	Not Sig.
	MPP vs DI	4.409	0.033	Sig.
	PP vs DI	2.26	0.306	Not Sig.

Hypothesis 1: There are no significant differences in terms of recall between high and low SRL students taught in the MPP, PP and DI groups

The post-hoc test result (Table 3) indicated a significant difference in recall between the MPP and PP groups for high SRL students, with the former performed significantly better than the latter $\left(\overline{X}_{high\,MPP}:74.13; \overline{X}_{high\,PP}:69.85; \mathit{Mean\ diff}:4.28; p:0.011\right)$. A similar significant difference in recall was also observed between the high SRL students in MPP group and DI groups $\left(\mathit{Mean\ diff}:7.86; p:0.000\right)$ with the MPP group significantly outperforming the DI group $\left(\overline{X}_{high\,MPP}:74.13; \overline{X}_{high\,DI}:66.27\right)$. However, there was no significant difference in recall between the PP group and DI group for the high SRL students.

For the low SRL students, the post-hoc test result in Table 3 indicated a significant difference in recall for low SRL students among all the three groups, namely (i) between MPP and PP groups $(Mean\ diff: 6.42; p: 0.002)$, with the MPP group significantly outperforming the PP group $(\bar{X}_{low\ MPP}: 61.39; \bar{X}_{low\ PP}: 54.97)$, (ii) between MPP and DI, with the MPP group performed significantly better $(\bar{X}_{low\ MPP}: 61.39; \bar{X}_{low\ DI}: 49.49)$ than the DI group $(Mean\ diff: 11.90; p: 0.00)$ and lastly, between the PP and DI groups $(Mean\ diff: 5.48; p: 0.006)$ with the PP group performing significantly higher than the DI group $(\bar{X}_{low PP}: 54.97; \bar{X}_{low DI}: 49.49)$.

Hypothesis 2: There were no significant differences in terms of retention between high and low SRL students taught in the MPP, PP and DI groups

For the high SRL students, the post-hoc test result (Table 4) indicated that there was no significant difference in retention between the students of PP and those of the DI group. However, there was a significant difference in retention between the MPP and PP groups for high SRL students $(Mean\ diff: 7.22; p: 0.000)$, with the MPP group performing significantly higher than the PP group $(\bar{X}_{high\ MPP}: 65.20; \bar{X}_{high\ PP}: 57.98)$. Likewise, there was also a significant difference between the MPP and DI groups $(Mean\ diff: 5.43; p: 0.01)$, where the high SRL students of the MPP group significantly outperforming their peers in DI group $(\bar{X}_{high\ MPP}: 65.20; \bar{X}_{high\ DI}: 59.77)$.

The post-hoc result in Table 4 further revealed that there was no significant difference in retention for the low SRL students between the MPP and PP groups. A similar no significant difference in retention was also observed between the low SRL students of the PP and those of the DI group. However, there was a significant difference between the low SRL students in MPP group and those of the DI group $(Mean\ diff: 4.409; p: 0.033)$, with the MPP group performing significantly better than those in the DI group $(\bar{X}_{low MPP}: 45.73; \bar{X}_{low DI}: 41.32)$.

7.0 Discussions

This study aims to investigate the impact of different SRL levels on the students' recall and retention performances on the instructional methods used in course delivery. These students from the three intact groups were randomly assigned to the different instructional methods (MPP, PP and DI). The research findings indicated that the difference between high and low SRL students among the three instructional methods were significant, both in the recall and retention performances.

Further analysis revealed that the high SRL students taught in MPP method performed significantly better than those taught in both PP and DI for both the recall and retention tests. Regardless of instructional methods, by adopting MPP and PP methods, the low SRL students taught in the MPP and PP groups performed equally well in the recall performance compared to their counterparts in the DI group. However, for retention, the finding showed that only the low SRL students in the MPP group performed significantly better than those of the DI group. The students' learning, in both the recall and retention skills, was significantly correlated with the instructional methods used in course delivery and the level of SRL. Therefore, lecturers need to re-consider the instructional methods used in class lectures, and as well as to take note of the students' SRL levels in order to have significant influence on their programming performance.

For the recall performance, the finding indicated that the use of the MPP instructional method significantly influenced the high SRL students' immediate recall. Specifically, high SRL students in the MPP group (receiving a combination of MPP) performed significantly better than their peers in both the PP and DI groups in the recall test. Hence, metaphor aided the creation of memory images of the new concepts being introduced, and it further showed the connection between the existing knowledge and the newly introduced knowledge that helped to enhance the students' programming comprehension as these high SRL students in MPP group were able to develop clearer "mental visualisations" of the novel concepts to reason about abstract situations as compared to those in the PP and DI groups (Flanik, 2008; Cazeaux, 2007; Lakoff & Johnson, 2003). For the low SRL students, there was a significant difference in recall performance among the three groups. In other words, the low SRL students in the MPP and PP significantly outperformed their counterparts in the DI group. Since the students in the MPP and PP groups had to work in pairs, they were able to discuss, find solutions for specific problems, form ideas and opinions with their partners (high SRL), and thus helped to cultivate problem solving skills, higher order thinking skills and improved their attitude towards programming (Gillies, 2007; Bevan *et al.*, 2002). In other words, the low SRL students participated in the discussions by explaining each other's approaches to problem solving thereby creating a higher level of conceptual understanding and promoting critical thinking skills that subsequently improved their recall performance (Felder, 1996). Likewise, these students benefited the most from participation in heterogeneous pairs, specifically by offering further explanations to their peers (Mohd Nasir Ismail *et al.*, 2010; Ballantine & Larres, 2007).

This finding also revealed a significant difference in students' retention performance. The use of metaphors as an instructional strategy assists students to have better programming conceptual understanding by developing clearer "mental schemes" of the novel concepts. As a result, it fostered positive improvement on memory retention. In particular, these high and low SRL students in MPP group were introduced and exposed to new novel concepts by associating the existing knowledge to the newly introduced knowledge that assisted them in better programming comprehension and relating these key ideas, which subsequently promoted meaningful learning and enhance retention. It further showed the connectivity between the known and the unknown by converting tacit knowledge into explicit knowledge that facilitate both SRL students to retain newly gained information much longer than their counterparts in the PP and DI groups; that, in turn, encouraged meaningful learning and longer memory retention. Regardless of their SRL levels, metaphors allowed them to build complex schemas or mental images in the long term memory. These mental schemas, as a network of information, stored permanently in the long term memory can be recalled and retrieved during the process of learning the basic programming concepts (Muhammed Yousoff *et al.*, 2006).

The use of metaphor supported the formation of memory images of the new concepts being introduced and positively influences on memory recall and retention for both high and low SRL students. On the other hand, with a combination of MPP, it significantly aided the memory relation rate especially for the low SRL students taught in the MPP group as compared to those of the PP and DI groups. Therefore, this finding demonstrated that metaphors facilitated and improved learning towards recall and retention (Kovecses, 2005; Zhang, 1997) and PP by itself did help low SRL students in their immediate recall as these students preferred to learn and work in groups (Melissa Ng, 2010). Likewise, these low SRL students working in pairs within an active learning environment as well as learning from their high SRL partners, constantly received constructive criticisms during pair discussions and were reported to develop higher cognitive knowledge that led to a higher programming recall performance than those in the DI group (Simon & Hanks, 2007; Pintrich, 2000). Furthermore, the MPP method developed clearer "mental schemas and images" of the novel concepts that enabled both high and low SRL students to retain information longer compared to the DI group. In the pair activities, normally the discussions were dominated by the high SRL students. As such, information stored over extended period of time had affected the SRL students in their programming comprehension and retention performances, and did not show significant improvement for students who participated in pair activities. Thus, this finding revealed that there was no significant difference in retention performance between both high and low SRL students taught in the PP and DI groups. Several researchers have reported similar results (Ricard, 2007; Shih & Alessi, 1994). However, the finding of this research contradicted the findings in Meseka *et al*. (2010) and Bevan *et al*. (2002) that the PP approach itself did not significantly influence students' programming performance as self-regulation strategies encouraged students to self regulate their own learning in programming environment.

8.0 Conclusion

The study has emphasised the importance of considering SRL components in learning the basic programming concepts for classroom academic performance. Self-regulation is the predictor of programming performance that uses the self-regulating strategies such as goal setting, planning, time management, self monitoring and evaluation for enhancing the students' programming knowledge and increasing academic performance. Thus, the students' programming performance is correlated with the instructional methods used in course delivery and the different levels of self-regulation learning of students. When used effectively, these self-regulatory strategies could stimulate students' recall and retention performances. It is suggested the lecturers should encourage their students to apply SRL in programming contexts.

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