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INTEGRATING SQ4R TECHNIQUE WITH GRAPHIC POSTORGANIZERS IN THE SCIENCE LEARNING OF EARTH AND SPACE

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ABSTRACT

This study examined the effect of integrating SQ4R reading technique with graphic post organizers on the students' Earth and Space Science learning achievement and development of metacognitive knowledge. The pretest-posttest non-equivalent control group design was employed in this quasi-experimental method. The sample which consists of 103 seventh grade of secondary school students of SMPN 1 Pontianak was drawn by using intact group random sampling technique. An achievement test and a questionnaire of Reading-Self Awareness were administered. The findings assert that there are significant difference of students' achievement ($F=5.594$, $p < 0.05$) and development of metacognitive knowledge ($F= 13.906$, $p < 0.05$) among groups after having received the three distinctive treatments. Integrating SQ4R reading technique with graphic post organizers reveals an effective impact on the academic achievement (ES= 0.69) and the metacognitive knowledge in reading text (ES = 0.48). It confirms that a science teacher has to execute and model metacognitive strategies intentionally.

Keywords: reading in science, achievement, metacognition

INTRODUCTION

In this twenty-first century, the world is changing rapidly. It is unrealistic to prepare a literate science-information-technology people in the future if based only on facts and concepts of the content areas that students acquired during school years. A new situation and problem they faced in their daily lives required appropriate and satisfactory solutions. Fogarty (1994) confirmed that metacognitive skills are needed when habitual responses are not successful. The hub of school is an ideal place to develop students' metacognitive skills. The task of educators is to acknowledge, cultivate, exploit, and enhance the metacognitive capabilities of all learners. Ellis and Bond (2014) noted that although a large body of literature exists on metacognition, however, there are few studies that summarize specific instructional practices for improving students' metacognitive thinking.

Metacognition is the central aims of current research (Zohar & Barzilai, 2013; Jiang & Grabe, 2017) and the core objectives of science teaching and learning (Coll, et al., 2005; Mitchell, 2015). The call for developing metacognitive skills in the school disciplines is also stated explicitly in the Curriculum 2013 presently implemented in

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Indonesia. Fadel, et.al. (2016) argued that metacognition plays a central role in learning and achievement. Metacognitive strategies are powerful tools for any discipline, inter-discipline or for learning in general. Teachers in classrooms may model and teach as well as teach and encourage metacognitive activity including reading a text and writing notes (Carin & Sund, 1989; Spiegel & Barufaldi, 1994; Glynn & Muth, 1994).

Spiegel & Barufaldi (1994) reported that training students on metacognitive strategies in reading and making self-notes of graphic post organizers during secondary school physics class could enhance recalls and retentions and students' achievement as well. Koch (2001) concluded that the experimental group using the Koch–Eckstein technique with the metacognitive tasks attained significantly higher score on a test of reading-comprehension physycs text than those of the control group after the experimental manipulation. Based on this result, she strongly recommended that the metacognitive technique be developed and applied in teaching reading comprehension of physics texts as an effective self-monitoring device.

Although textbooks are major sources of learning, many students in schools had difficulty to gain a deep understanding of the text they read. The difficulty in understanding textbook was due to a lack of knowledge about techniques of reading and making good notes (Laidlaw, et al., 1993; Spiegel & Barufaldi, 1994). When further explored, the lack of training and guidance provided by teachers at school can be suspected as one of the "roots" of the cause. Tobias (1990) in Halloun (1996) reported that many students in school even in college forgot quickly and did not get much information from the text they read. Students who are not skilled at reading textbooks, according to Holliday et al.(1994), will only spend a lot of time unproductively. In fact, they also can not solve the problems related to the text reading.

Earth and Space is a topic in Secondary School Physics Curricula. Subject matters of this topic are mainly declarative knowledge. The use of symbols, formulas, equations, diagrams, etc during lesson period are few. Kuhn and Dean (2004) characterize declarative knowledge broadly as epistemological understanding, or the student's understanding of thinking and knowing in general. Understanding of subject matters involves the ability to read the text meaningfully.

In the context of this study, students' negative symptoms of seventh grade of public secondary school SMPN 1 Pontianak occurred while learning Earth and Space. They lacked independence and confidence about the subject matters they learned, got bored when reading textbooks, and quickly forgot the essential information they have read or learned. The success of rate in academic achievement of this topic does not reach the minimum standard of passing rate i.e 75 % per class. The percentage of classes with passing rate less than 75 % is still quite low. This issue becomes a focus to the teacher.

One of reading techniques which can be used to enhance students' academic achievement in any subject matter (discipline) and to develop metacognitive knowledge in reading text is SQ4R (Survey, Question, Read, Reflect, Recite, Review) developed by E.L Thomas & H.A Robinson in 1972 (Glynn & Muth, 1994). This SQ4R reading technique will be more effective if it is integrated with graphic post organizers made after any reading activity. Spiegel & Barufaldi (1994) explained that any form of two-dimensional graphics, figures, or diagrams, etc. constructed by students after reading texts was called graphic post organizers. Based on the meta-analysis of 23 experimental studies, Moore & Readance (1984) in Spiegel & Barufaldi (1994) reported that making notes in any form of graphic organizers increased students' recall, retention, and concept comprehending or information in texts they read.

The main purpose of this study was to examine the extent of effectiveness of integrating SQ4R reading technique with graphic postorganizers on the students' achievement in learning Earth and Space and development of metacognitive knowledge in reading text.

METHODS

The pretest-posttest, non-equivalent control group design was used in this quasi-experimental method (Creswell, 2008). The target population of this research was the seventh grade (11 until 14 years old) of secondary school students of public junior high school SMPN 1 Pontianak, West Kalimantan, Indonesia (N= 267) enrolled in the academic year 2013/2014 first semester. The intact group random sampling technique was applied to determine groups of sample volunteered students (35 students of class I-H as experimental group 1, 33 students of class I-D as experimental group 2, and 35 students of class I-A as the control group). Data for experimental and control groups were pooled in the same semester. The students who were absent during training or data collection were excluded from data analysis.

The independent variable was treatments which applied to the three groups. The treatments reflected the research questions were as follows : (1) *Treatment 1*: Reading Earth and Space texts by using SQ4R technique and integrating with active construction of graphic postorganizers of the text and/or of mnemonics. This treatment was applied to experimental group 1; (2) *Treatment 2*: Reading Earth and Space texts by using SQ4R technique without training of constructing of graphic postorganizers of the text. This treatment was applied to experimental group 2; (3) *Treatment 3*: Teaching-learning process of Earth and Space text by using lecturing (conventional) method. No training of SQ4R reading technique was employed. This treatment was applied to control group.

To execute operationally the SQ4R reading technique in teaching-learning process of entire materials of Earth and Space in the classroom, the procedures are as follows: (1) *Surveying*, checking title, heading, subheading in textbook they read as guidance; (2) *Questioning*, making or asking her/himself some (written) questions related to contents or material contained in reading text; (3) *Reading*, reading for understanding (that can be assisted or monitored by the questions student made) by signing, underlining, bolding, highlighting, etc on the essential information while reading text; (4) *Reflecting*, considering the information have read for answering questions and relating the information to his/her own prior knowledge; (5) *Reciting*, answering the questions; (6) *Reviewing*, organizing the information of reading text into graphic post organizers and/or mnemonics (e.g: acronym, peg-type, and loci-type).

The first dependent variable was the overall score on pre-and posttest of students' achievement in learning Earth and Space collected by administering 10 items of completion (recall) test, 13 items of four options multiple-choice (comprehending) test and 5 items of essay (application) test. The reliability coefficient of point-biserial correlation for Earth and Space Science learning achievement test was 0.62.

The second dependent variable was the score on pre-and posttest of students' development of metacognitive knowledge in reading text. Costa (1985) argued that metacognitive instruction would include learning how to learn; how to study for a test; how to use strategies of asking before, during, and after reading. It might include how to learn best—visually and diagrammatically. Metacognitive knowledge in reading the text was assessed by using 22 items of Questionnaire of Index of Reading-Self Awareness with four alternative responses (always, often, sometimes, and never) concerning what students do before, during, and after reading (in Appendix 1). This questionnaire was developed by adopting Index of Reading Awareness (McLain, et al., 1991) and Metacognitive Self-Assesment (Gaskin, et al., 1994). The items distinction power were entirely significant ($2.402 < t < 7.538$). The qualitative expert judgments to seek content validity was administered as well.

Comparisons (t-test and F-test, < 0.05) made among the three groups showed a significant difference in the scores of students' Earth and Space Science learning achievement and of metacognitive knowledge in reading the text. The extent of effectiveness of integrating SQ4R reading technique was assessed by using the Effect Size (Cohen, 1988),namely ES = difference between the means, $M_1 - M_2$, divided by standard deviation of either group.

RESULTS AND DISCUSSION

Pretest

Interval data (scores) gathered from the three groups were analyzed by using F-test (One-Way ANOVA). Pretesting concluded that there were no significant difference scores of academic achievement of Earth and Space topic between experimental groups (group 1 and 2) and control group ($F = 0.074$, sig = 0.929, $p > 0.05$) as shown in table 1. The same results, there was no significant difference scores of metacognitive knowledge in reading the text ($F = 0.039$, sig = 0.962, $p > 0.05$) as shown in table 2.

Table 1. Pretest Mean of the Students' Academic Achievement in Learning Earth and Space

Group	N	Mean	SD	df	F value	Sig
Experimental 1	35	32.84	7.86			
Experimental 2	33	32.49	9.05	2	0.074	0.929
Control	35	32.16	8.58			

Table 2. Pretest Mean of Metacognitive Knowledge

Group	N	Mean	SD	df	F value	Sig
Experimental 1	35	26.29	5.92			
Experimental 2	33	26.37	5.79	2	0.039	0.962
Control	35	26.64	7.18			

The result shows that there were no significant differences between students' academic achievement of Earth and Space topic and metacognition knowledge of the students in reading text before making the manipulation of the treatments in this study. Therefore, post hoc Scheffe-test was not necessary to be carried out by the researcher.

Posttest Means of Students' Achievement on Earth and Space Topic

Comparisons of means in posttest between the experimental groups (group 1 and 2) and control group showed significant differences of students' academic achievement on Earth and Space ($F = 5.594$, sig = 0.005, $p < 0.05$) as shown in table 3.

Table 3. Posttest Means of the Students' Academic Achievement in Learning Earth and Space

Group	N	Mean	SD	df	F value	Sig
Experimental 1	35	66.27	14.66			
Experimental 2	33	63.07	15.32	2	5.594*	0.005
Control	35	56.67	13.60			

* *Significant at the 0.05 level*

The result showed that integrating SQ4R reading technique with graphic post organizers brought the about significant difference in academic achievement in learning Earth and Space between those three distinctive treatments. Due to the significant difference between the three groups were found, post hoc test by using Scheffe-test should be used and shown in table 4.

Table 4. Post Hoc Scheffe-test of Posttest Means of Dependent Variable 1

Dependent Variable 1	Group (I)	Group (J)	Mean difference (I-J)	Sig
Achievement score of Earth and Space Science	Experimental 1	Experimental 2	3.20	0.588
		Control	9.60*	0.006
	Experimental 2	Experimental 1	-3.20	0.588
		Control	6.40	0.092
	Control	Experimental 1	-9.60*	0.006
		Experimental 2	-6.40	0.006

**The mean difference is significant at the 0.05 level*

From tabel 4, the research findings were as follows: (1) There was no significant difference of increasing students' academic achievement in learning Earth and Space topic between experimental group 1 and experimental group 2 (> 0.05); (2) There was significant difference of increasing students' academic achievement in learning Earth and Space topic between experimental group 1 and control group (< 0.05); (3) There was no significant difference of increasing students' academic achievement in learning Earth and Space topic between experimental group 2 and control group (> 0.05)

The result shows that the effectivity of integrating SQ4R reading technique with graphic post organizers on increasing students' academic achievement in learning Earth and Space topic was higher than that of SQ4R reading technique and lecturing (conventional) method. The extent of effectiveness was shown by mean effect size = 0.69 (in effective category).

Spark Student Paper and Academic Research Kit (2014) confirmed that SQ4R is an effective strategy to help all students get the information that they need from textbooks. It works for average, learning disabled, and gifted students whether they are in elementary school or college. There are variations to this strategy, including SQ3R, SRR, and PQ4R, that involve more or fewer steps. This method can be used for reading any type of material at any stage of the research assignment. However, when the text does not appear to be organized according to one of the patterns or text structures, students must create a visual they can use to take notes while or after reading to explore the relationships among the ideas in the text. Using graphic organizers also helps students to see connections as they construct their understanding of science concepts. Using SQ4R methods in language domains was effective to increase students' comprehension of the generic structure of the text and the meaning of words (Yakupoglu, 2012; Raharjo, et al., 2013; Hananiel, et al., 2015). For example, Raharjo et al.(2013) concluded that SQ4R strategy is an appropriate strategy to increase students' achievement in reading comprehension of recount text. The use of semantic and schema mapping was recommended to increase the SQ4R effectivity.

Reading comprehension of texts is a neglected area in physics curricula. Rote learning is the only one learning strategy commonly employed by many teachers. I found that just a few science teachers trained their students explicitly the reading strategy and making graphic post organizers to gain deep understanding and retention. In addition, they did not intentionally model the learning strategy for developing students' metacognition in their classroom. Many science teachers assume that how to read textbooks meaningfully for gaining comprehension and increasing students' academic achievement should be trained by language teachers. Many are unaware of the importance of metacognitive knowledge development in the teaching-learning as well. Painscar et al. (1996) stated that for students to gain understanding, teachers need to use a variety of reading strategies, including those that involve manipulative, interactive, and physical materials, to address science content in depth and avoid focusing on isolated or disconnected facts" (p.123). Rasinki and Padak (2004) confirmed that most students arrive at the science teacher's classroom knowing how to read, but few understand how to use reading for learning science content.

Barton & Jordan (2001) confirmed that reading is not only a crucial way for students to learn science content, it is also an important part of what professional scientists actually do. One study found that scientists and engineers spend over half of their working time reading, interpreting, and producing text. Without research, there is no science; but without communication, research would grind to a halt. Literacy enables vital inputs and outputs for research: read; research; write; repeat. Armbruster et al. (1989) supported this notion. He said that many educators contend that when students *do* science, they are more engaged in learning than when they read science text. In fact, reading science text and textbooks requires the same critical thinking, analysis, and active engagement as performing hands-on science activities. Science and reading have many process skills in common. The same skills that make good scientists also make good readers: engaging prior knowledge, forming hypotheses, establishing plans, evaluating understanding, determining the relative importance of information, describing patterns, comparing and contrasting, making inferences, drawing conclusions, generalizing, evaluating sources, and so on.

Students in science classrooms are given numerous opportunities to read the text in a variety of formats and for a variety of purposes. They read to solve a problem, understand the steps in an experiment, gain basic knowledge about a concept, answer their own questions, compare their inquiry results with what others have found, expand their basic understanding of a concept, and for enjoyment. The reading tasks going on in science classrooms today are quite extensive and do complement efforts being made in schools to improve reading achievement. However, science teachers need to support struggling readers with strategies that will enhance their comprehension of science reading materials.

Posttest Means of Metacognitive Knowledge

Comparisons of means in posttest between the experimental groups (group 1 and 2) and control group showed significant differences of students' metacognitive knowledge in reading the text ($F = 13.906$, sig = 0.000, $p < 0.05$) as shown in table 5.

Table 5. Posttest Means of Metacognitive Knowledge

Group	N	Mean	SD	df	F value	Sig
Experimental 1	35	34.18	7.21			
Experimental 2	33	33.07	6.65	2	13.906*	0.000
Control	35	30.12	6.82			

** Significant at the 0.05 level*

The results show that integrating SQ4R reading technique with graphic post organizers brought a significant difference in the development of metacognitive knowledge between those three distinctive treatments. Due to the significant difference between the three groups were found, post hoc test by using Scheffe-test should be used and shown in table 6.

Table 6. Post Hoc Test of Posttest Means of Dependent Variable 2

Dependent Variable 2	Group (I)	Group (J)	Mean difference (I-J)	Sig
Score of Metacognitive Knowledge	Experimental 1	Experimental 2	1.11	0.734
		Control	4.06*	0.045
	Experimental 2	Experimental 1	-1.11	0.734
		Control	2.95	0.045
	Control	Experimental 1	-4.06*	0.045
		Experimental 2	1.11	0.734

**The mean difference is significant at the 0.05 level*

From table 6, the research findings were as follows: (1) There was no significant difference of development of metacognitive knowledge in reading text between experimental group 1 and experimental group 2 (> 0.05); (2) There was significant difference of development of metacognitive knowledge in reading text between experimental group 1 and control group (< 0.05); (3) There was no significant difference of development of metacognitive knowledge in reading text between experimental group 2 and control group (> 0.05).

The results show that the effectivity of integrating SQ4R reading technique with graphic postorganizers on development of metacognitive knowledge in reading text was higher than that of lecturing (conventional) method. The extent of effectiveness was shown by mean effect size = 0.48 (in effective category).

Glynn & Muth (1994) argued that SQ4R reading techniques will be more effective if it is integrated with graphic postorganizers made after any reading activity. Reading and writing involve thinking process (Tierney, et al., 1980; Ridley, et al., 1992). Bond et al. (1995) confirmed that learning to read and reading to learn should develop together throughout the school years. Many researchers demonstrated that writing provided a vehicle for teachers to follow students' changes in thinking as they moved from topic to topic and expressed their understanding of concepts. Students' written ideas provided a window into their thinking processes. Flavell (1987), a pioneer in the field of metacognition, mentioned a number of experiences or activities that might assist metacognitive development. Teachers in schools may sometimes model, teach and encourage metacognitive activity including reading and writing any text.

The result showed that integrating SQ4R reading technique with graphic post organizers brought a significant difference in the development of metacognitive knowledge between those three distinctive treatments. Due to the significant difference between the three groups were found, post hoc test by using Scheffe-test should be used and shown in table 6.

Thinking process involves cognition and metacognition (Costa, 1985; Livington, 1997). Nelson (1999) stated that cognitive strategies are different from metacognitive strategies. It is often difficult to distinguish metacognitive and cognitive. There is also much debate over what metacognition is. These terms are sometimes confusing. According to Weinert and Kluwe (1987), cognitive and metacognitive strategies may overlap in that the same strategy could be regarded as either cognitive or metacognitive depending on what the purpose of using that strategy. Maybe sometimes one reads things slowly simply to learn the contents (cognitive strategy); other times one reads through things quickly to get an idea of how difficult or easy it is going to learn the content (metacognitive strategy).

Metacognition is thinking about your thinking as you are thinking to improve your thinking (Glynn & Muth, 1994). According to Flavell (1979) in Mahdavi (2014), metacognitive knowledge refers to one's knowledge or beliefs about a person, task, and strategy variables. Metacognitive knowledge can be added, deleted, or revised through metacognitive experiences. Ertmer and Newby (1996) described that the novice learners don't stop to evaluate their comprehension of the material. They generally don't examine the quality of their work or don't stop to make revisions as they go along, and are satisfied with just scratching the surface as well. They also don't attempt to examine a problem in depth. Novice learners don't make connections or see the relevance of the material in their lives. On the contrary, expert learners are more aware than novices of when they need to check for errors, why they fail to comprehend, and how they need to redirect their efforts. Taking reading for example. We have all experienced the phenomenon of reading a page or a whole of the chapter in the textbook and then realizing we haven't comprehended a single thing. A novice learner would go on to the next page, thinking that merely reading the words on a page is enough. An expert learner would re-read the page until the main concept is understood, or flag a difficult passage to ask for clarification from teacher or peers later.

Several researchers offer evidence that metacognition is teachable (Flavell, 1987; Winn & Snyder, 1996; Kramarski & Mevarech, 2003; Schraw, et al., 2006). For example, Schraw, et. al. (2006) described an intervention targeted at improving the metacognitive skills and reading comprehension of 171 students in third and fifth grades. Simpson & Nist (2000) emphasized that instructors need to provide explicit instruction on the use of study strategies. In the course of learning to read, the child gets practice in scrutinizing messages in isolation from context, and in evaluating the possible intended meanings and implications. Mitchell (2015) recommended some strategies to improve students' metacognitive skills in the classroom. One of them is that teacher should be a "wrapper" to increase students' monitoring skills. A "wrapper" is a short intervention (give a few tips) that surrounds an existing activity and integrates a metacognitive practice. When used often, this activity not only increases learning but also improves metacognitive monitoring skills.

As students become more skilled at using metacognitive strategies, they gain confidence and become more strategic, more independent as learners. Independence leads to ownership as students realize they pursue their own intellectual needs and discover a world of information at their fingertips (Abromitis, 2009). Because learning how to learn, developing a repertoire of thinking processes to solve a problem, is a major goal of education, the metacognitive strategies will be a critical ingredient to successful learning. In addition, by using metacognitive strategies, students can truly learn. Teachers who use metacognitive strategies can positively impact students who have learning disabilities by helping them to develop an appropriate plan for learning information, which can be memorized and eventually routine. As students become aware of how they learn, they will use these processes to efficiently acquire new information, and consequently, become more of an independent thinker.

CONCLUSION

It is concluded that integrating SQ4R reading technique with graphic post organizers has an effective impact on the students' academic achievement of Earth and Space topic and the development of metacognition knowledge in reading the text (mean effect size respectively 0.69 and 0.48). Reading activities of SQ4R such as constructing graphic post organizers e.g. concept maps, mnemonics, and any two-dimensional diagrams and the replete examples of their application in the Earth and Space learning bear consideration for promoting students' metacognitive knowledge. One of the important ideas this study showed was that writing or constructing notes of graphic organizers was a window for students' knowledge changes. The integrating of two learning activities may be as a mechanism for stimulating the reflection and feedback that facilitates the increase of academic achievement and development of metacognitive knowledge.

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