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Performance of Mathematics Reading and Metacognition on Geometry Text for Fifth Graders

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ABSTRACT

The purpose of this research was to investigate the relationship between mathematics reading and metacognition on geometry text for fifth graders. The theoretical foundation of this study came from three components of text reading and its metacognition along with reading. The three components of mathematics reading were prior knowledge of mathematics, general reading comprehension and mathematics-specific skills. The researcher developed text of mathematics reading with regard to geometry domain. Assessment design in accordance with the text was based on the above three components. Besides, the researcher also built inventory to help examinee reflect their metacognition. According to data analysis, it showed students performed the best in the prior knowledge of mathematics and performed the least in mathematics-specific skills. As to metacognition, the students also had the highest performance in the prior knowledge of mathematics and had the lowest performance in mathematics-specific skills. Moreover, it existed significantly positive correlation between mathematics reading and metacognition. Students who had better metacognition tended to perform better in mathematics reading. Advanced multivariate statistics also indicated the overall relationship between mathematics reading components and its metacognition. In accordance with the results and findings, some recommendations and suggestions for future research and practical instruction were discussed.

Keywords: Geometry, Mathematics Reading, Metacognition, Reading Comprehension

Introduction

The purpose of the current research was to investigate the relationship between mathematics reading and metacognition on geometry text for fifth graders. With respect to the importance of education over the world, reading, mathematics and science are the three major competence fields at testing literacy of PISA (the Programme for International Student Assessment). The research investigated the text reading of mathematics which is an important issue coincide with education in the world. Furthermore, metacognition is one of the major reading activities with the focus on cognitive monitoring, but there are not many studies and references related to metacognition in mathematics text reading. Thus, it is necessary to conduct a study to investigate the connection of the performance of mathematics reading and its metacognition.

Meaning of Mathematics Reading

Brozo, Shield, and Topping (2007) referred to the International Adult Language Literacy Organizations (International Adult Literacy Survey, IALS) that if students in compulsory education did not continue to use reading skills to learn, they would begin to have learning degradation phenomenon. Reading is an important approach to gain knowledge of content, but nowadays the society is a diverse learning environment that knowledge of subjects is obtained through reading activities. According to Organization for Economic Cooperation and Development (OECD), PISA used five levels to describe student performance in reading literacy. In 2001, they also stated that “A country with the number of fifth level reading ability of citizens is an important indicator of the country's future competitiveness.” Therefore, great attention has been paid to students' reading activities over the world, and it also indirectly illustrates the importance of subject reading.

Several major international assessments such as Programme for International Student Assessment (PISA), Trends in International Mathematics and Science Study (TIMSS), and Progress in International Reading Literacy Study (PIRLS) have also begun to pay much attention to the fields of mathematics and reading over the years. Mathematics is an abstract language and an important tool to learn other subjects. Mathematics reading texts feature a variety of sources, including identification characters, mathematical symbols, illustrations, tables, and transformation with the integration of various mathematical representations.

Mathematics is a kind of proven and demonstrated scientific language (Bauers, 2014). Mathematical language has an unique way to represent its sentence and paragraph structure which is different than the usual language structure (Esty, 2014). Thus, mathematics reading is an important proprietary skill when students learn mathematics. According to the definition of subject reading by Mckenna and Robinson (2002), the model of mathematics reading comprehension can be divided into three components: general reading comprehension, prior knowledge of mathematics, and specific skills of mathematics. In which, the current study agreed with such definition to develop related mathematics reading texts and assessments.

Metacognition and Its Importance

The core meaning of "metacognition" is "cognitive awareness" (cognition about cognition) which refers to the individual in the course of cognitive how to monitor, adjust or revise the strategy, that is also subject to self-memory, comprehension, and other cognitive monitoring activities (Flavell, 1979; Flavell, Miller and Miller, 1993). Numerous studies found that there were relationships between metacognition and problem-solving performance and indicated that metacognition affected the effectiveness of learner self-perception and learning. Furthermore, metacognition would affect students’ in problem-solving skills and the abilities of self-learning and self-adjust (Israel, Bauseman and Block, 2005; Mevarech and Kramarski, 2003). In this study, confidence rating method was adopted to measure students’ mathematics reading tasks.

Investigation on Geometry Reading Text

Geometry is an important topic in the elementary curriculum, but the related researches to study mathematics reading and metacognition in geometry are featured less. Therefore, the current study tended to develop a suitable geometry reading text for fifth graders, and to investigate the relationship between mathematics reading and metacognition of students' learning. The purposes of this research study are as following: (1) to develop a suitable geometry reading text for fifth graders; (2) to investigate the relationship between students' mathematics reading and metacognition on geometry text; (3) to investigate explanations with metacognition in mathematics reading on geometry text.

Literature Review

Theoretical Foundation and Content of Mathematics Reading

Wakefield (1993) indicated that mathematics was a language to read consisted several characteristics, for example: the use of language or written symbols to communicate concepts and ideas in terms of representation, a fixed sign and system, to linear or al serial way to represent, a possible approach to translation and interpretation, the process of encoding and decoding to make communication effective, and etc.. In the process of reading mathematics, there must be a "text" to be read in order to have the reading behavior. As shown in Figure 1, McKenna and Robinson (2002) stated that writing to reading from the texts is the meaning of the conversion process. Throughout the process, the writers tended to convey the meaning or the concept through the coding manner. Moreover, readers managed to use their prior knowledge and experience to decode the meaning of the text and then restructure its significance.

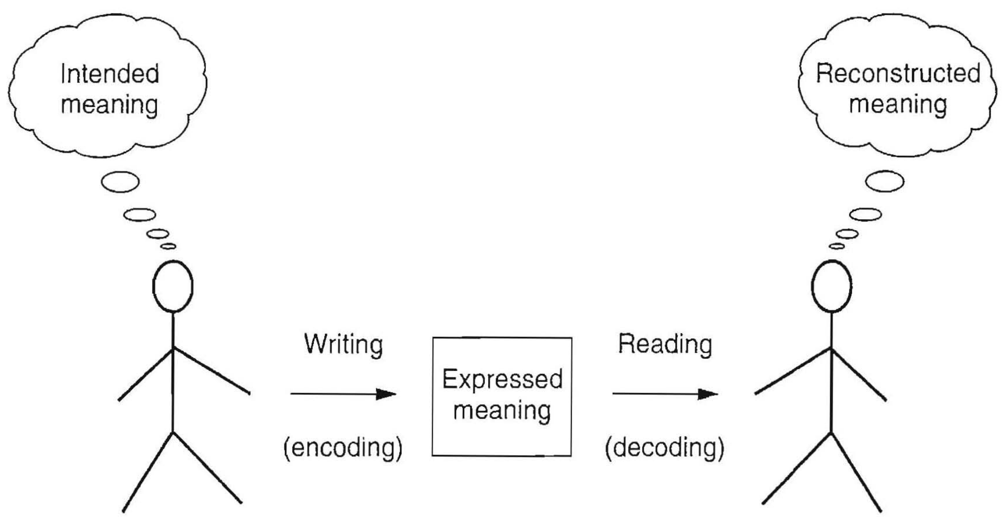

Figure 1. Teaching through Text-Reading and Writing in the Content Area
Source: *Teaching through text-reading and writing in the content area*. (p.16), by M. C. Mckenna, & R. D. Robinson, 2002, Boston: Allyn & Bacon.

Text reading is learning process through the integration of the learners' prior knowledge and the content knowledge of the text in the action based on encoding and decoding approaches (Jan, Roxana, & Roland, 2010; McKenna and Robinson, 2002; Mayer, 1992). National Assessment of Educational Progress (NAEP) conducted a study sought to investigate the relationship between reading comprehension and academic performance, where the study showed that the high level of students' reading engagement and their reading efforts were positively correlated to their academic performance in schools (Brozo, 2008). Flick and Lederman (2002) proposed to allow students to improve the reading comprehension skills to develop the higher-level mathematics cognitive techniques. Borasi and Siegel (2001) proposed the integration of reading equation as of learning mathematics from reading and the social aspects and collaboration with mathematics, which represented in the chronological: (1) setting the stage and the focus of the survey questions; (2) expanding the survey issues; (3) integrating and discussing the results.

According to the definition of subject reading by Mckenna and Robinson (2002), the cognitive components of mathematics reading comprehension can be divided into general reading comprehension, prior knowledge of mathematics, and specific skills of mathematics. It was depicted in Figure 2. With respect to the structure of Figure 2, the current study tented to develop the geometry reading text and related assessments, and discuss the results of data analysis.

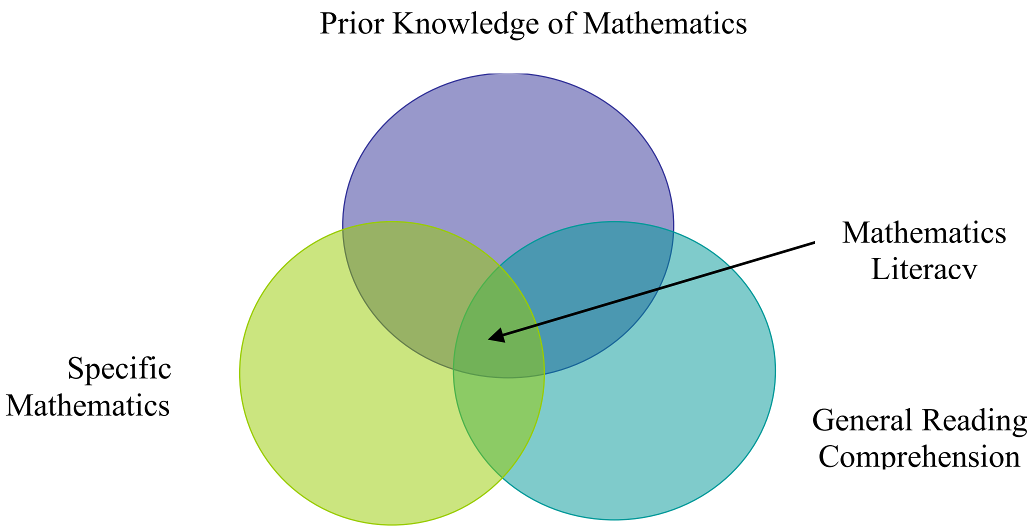

Figure 2. Cognitive Components of Mathematics Reading Comprehension
Adopted from *Teaching through text-reading and writing in the content area*. (p.9), by M. C. Mckenna, & R. D. Robinson, 2002, Boston: Allyn & Bacon.

Metacogntion and Its Measurement

Metacognition is related to effective leaning abilities. This term began to appear during 1970s, and a variety of terms was shown due to different sources. It is shown in Table 1.

Table 1
Metacognition Terms

Authors	Terms
Flavell (1979)	Cognitive monitoring, Cognition about cognition
Meichenbaum and Asarnow (1979)	Self-communication
Brown (1987)	Executive processes, Knowledge about knowledge
Glover and Bruning (1987)	Thinking about thinking

There is a great relevance between metacognition and problem solving in mathematics text. Additionally, a great deal of mathematics problem solving studies from Polya, Mayer, Schoenfeld and Lester et al. are most frequently mentioned. With respect to mathematics problem-solving tasks, Polya's (1957) devise a plan, Mayer's (1992) integration of issues, Schoenfeld's (1985) analysis, exploration, planning, and Lester's (1985) organizational phase had a significant relationship with prior knowledge of mathematics and specific mathematics skills. Furthermore, the problem-solving process showed a relationship with metacognition.

Flavell (1976) referred metacognition to one's knowledge concerning one's own cognitive processes or anything related to them. Cognition could be divided metacognition into two parts: metacognition knowledge and metacognitive experience. Brown (1987) stated that metacognition consisting two domains: knowledge about cognition and regulation of cognition.

Paris and Myers (1981) explored the reading performance of fourth graders, and they confirmed that students with more reading strategies performed better than those students were lack of reading strategies. Mayer (1987) examined the relationship between students' problem solving techniques and their achievement gains in mathematics from third-grade to eight-grade students. Based on their analysis, the findings showed that students' mathematics achievement gains were higher if students adopt metacognition in the process of problem solving. Zabrucky and Ratner (1992) pointed out students with better reading performance were capable of having administered the entire article and with a good ability to recall. Students with better performance in problem solving usually had a relatively numerous self-monitoring tasks and skills. Furthermore, Mevarech and Kramarski (2003) believed that students could enhance better problem thinking skills and metacognitive knowledge through the group cooperative learning. Israel, Bauseman and Block (2005) also showed that student could enhance their reading comprehension ability with the improvement of metacognitive skills.

The metacognition was one set of psychological traits as it cannot be directly observed. Metacognitive assessment can take in many approaches, it included interviews method, thinking aloud method, observation method, confidence rating method, questionnaire survey method and error-detection method, and etc. Confidence rating method is appropriate for conducting a large sample size. Therefore, a confidence rating method was used in the current study.

Methodologies and Design

Research Design

The purpose of the current research was to investigate the relationship between mathematics reading and metacognition on geometry text. A discussion and research purpose of the current study in accordance with the research structure is shown in Figure 3.

Figure 3. Research Structure of the Study

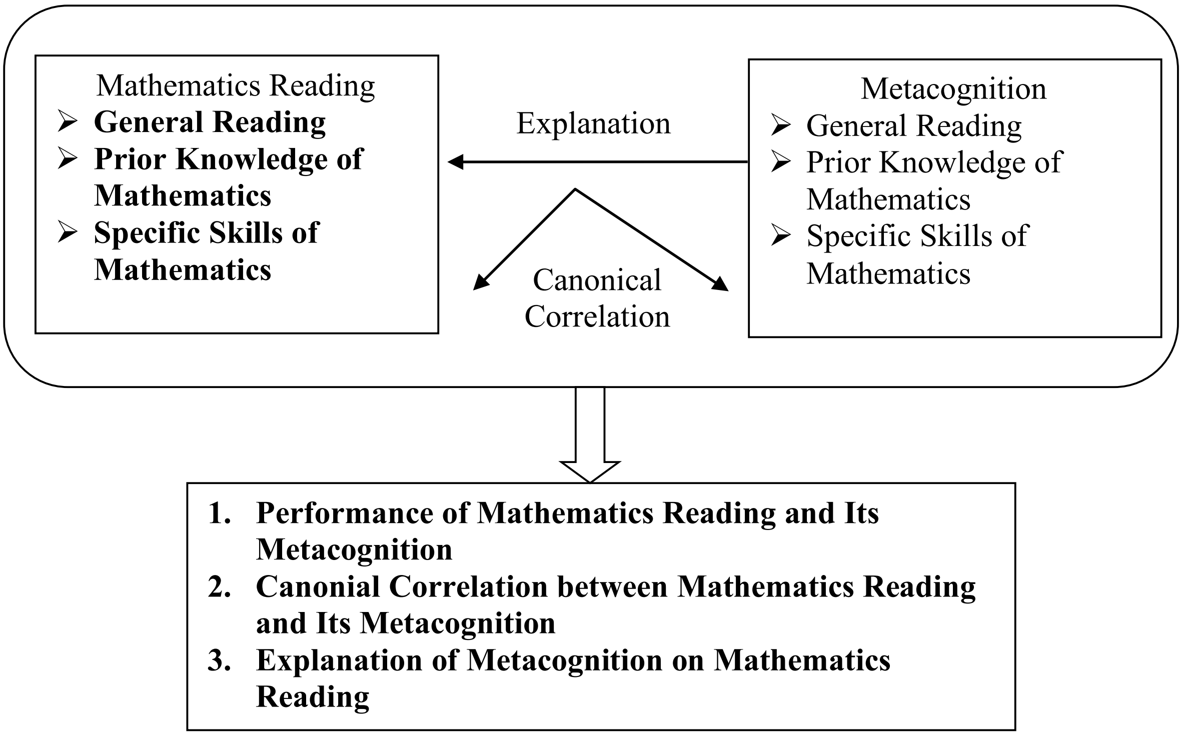

Figure 3. Research Structure of the Study

Subjects

A total of 261 fifth-grade students in central area in Taiwan was participated in the current study. A sample allocation scenario was shown in Table 2.

Table 2

Sample of Fifth-Grade Students

School	Number of Class	Gender		Total
		Male	Female	
A	2	26	16	42
B	3	25	39	64
C	2	27	23	50
D	2	26	27	53
E	2	28	24	52
Total	11	132	129	261

Assessment

The research tools contained in this study were self-made materials of mathematics reading texts and tests, and the corresponding metacognition assessment. The researchers compiled two self-made geometry reading texts for fifth-graders. Based on suggestion from McKenna and Robinson's (2002) three cognitive component (General Reading, Prior Knowledge of Mathematics, Specific Skills of Mathematics), the researchers also compiled the assessment materials.

After the pre-test and screening questions, the first text consisted of 21 questions and the second test consisted of 19 questions. Cronbach α reliability of these tests was .87. With regard to the assessment approach of metacognition assessment, the current study used the confident rating method. Question of "Are you sure the answer is correct?" was added to each item of the mathematics reading. Also, four answer options were presented "very sure, a little sure, not sure, very unsure", to assess the amount of students' metacognition level. The scoring of metacognition is shown in Table 3. The Cronbach α reliablity of metacogntion assessment was .87.

Table 3
Scoring of Metacognition on Mathematics Reading

Confident Rating Options	Score on Mathematics Reading Item	Metacognition Score
Very sure	1	4
A little sure	1	3
Not sure	1	2
Very unsure	1	1
Very sure	0	1
A little sure	0	2
Not sure	0	3
Very unsure	0	4

Results and Discussions

Metacognitive Reading and Mathematics Performance

With respect to students' mathematics reading performance in three cognitive components, the mean test for repeated measure in terms of general reading comprehension, prior knowledge of mathematics, and specific mathematics skills was shown in Table 4.

Table 4
Description and Mean Comparisons on Mathematics Reading

Cognitive Components	Mean	Standard Deviation	t-test		
			Cognitive Components	General Reading Comprehension	Prior Knowledge of Mathematics
General Reading Comprehension	.74	.41	General Reading Comprehension		
Prior Knowledge of Mathematics	.77	.38	Prior Knowledge of Mathematics	6.91***	
Specific Mathematics Skills	.63	.44	Specific Mathematics Skills	-30.77***	-30.29***

***p<.001

As shown in Table 4, the mean differences were all statistically significant. In particular, the results indicated that students performed the best in the domain of "prior knowledge of mathematics", and followed by "general reading comprehension" and "specific mathematical skills", respectively.

Table 5
Description and Mean Comparisons on Metacognition

Metacognition	Mean	Standard Deviation	t-test Metacognition	General Reading Comprehension	Prior Knowledge of Mathematics
General Reading Comprehension	3.10	.97	General Reading Comprehension		
Prior Knowledge of Mathematics	3.27	.93	Prior Knowledge of Mathematics	8.56***	
Specific Mathematics Skills	3.09	1.04	Specific Mathematics Skills	-30.67***	-28.66***

***p<.001

Table 5 provided description and mean comparisons on metacognition of mathematics reading. It indicated that students performed the best in the domain of "prior knowledge of mathematics", and followed by "general reading comprehension" and "specific mathematical skills", respectively.

Mathematical Reading and Metacognition

Pearson product-moment correlation coefficient of mathematics reading and metacognition was shown in Table 6.

Table 6
Correlation between Mathematics Reading and Metacognition

Metacognition	Mathematics Reading: Metacognition	General Reading Comprehension	Prior Knowledge of Mathematics
General Reading Comprehension	.63***	.47***	.45***
Prior Knowledge of Mathematics	.38***	.59***	.47***
Specific Mathematics Skills	.31***	.37***	.55***

***p<.001

It indicated the cognitive components of mathematics reading and its metacognition were positively correlated. In other words, students obtained better metacognitive strategies could perform better on mathemaitics reading tasks. The current study exploited general reading comprehension, prior knowledge of mathematics and specific mathematics skills as dependent variables (Y variables); on the other hand, Metacognition of reading comprehension, prior knowledge of mathematics and specific mathematics skills were covariates (X variables). Canonical corrrelation analysis was conducted and indicated the Wilk's Λ values of .35, .62 and .83, respectively, and F values of 37.10, 34.85 and 54.12, respectively (p <.001). The relevant summary was shown in Table 7, and canonical correlation analysis path was shown in Figure 4.

Table 7
Canonical Correlation Analysis

X variable (Metacogntion)	Canonical Factor χ_1	χ_2	χ_3	Y variables (Mathematics Reading)	Canonical Factor η_1	η_2	η_3
Reading Comprehension	.982	.187	-.038	Reading Comprehension	.933	.361	.008
Prior knowledge of Mathematics	.784	-.562	-.262	Prior Knowledge of Mathematics	.800	-.501	-.330
Specific Mathematics Skills	.642	-.455	.618	Specific Mathematics Skills	.777	-.437	.453
Variation (%)	66.34	18.59	15.07	Variation (%)	70.43	19.10	10.47
Redundancy (%)	28.74	4.70	2.63	Redundancy (%)	30.51	4.83	1.83
Canonical Correlation	.66***	.50***	.42***				
Canonical Correlation Square	.43	.25	.17				

***p<.001

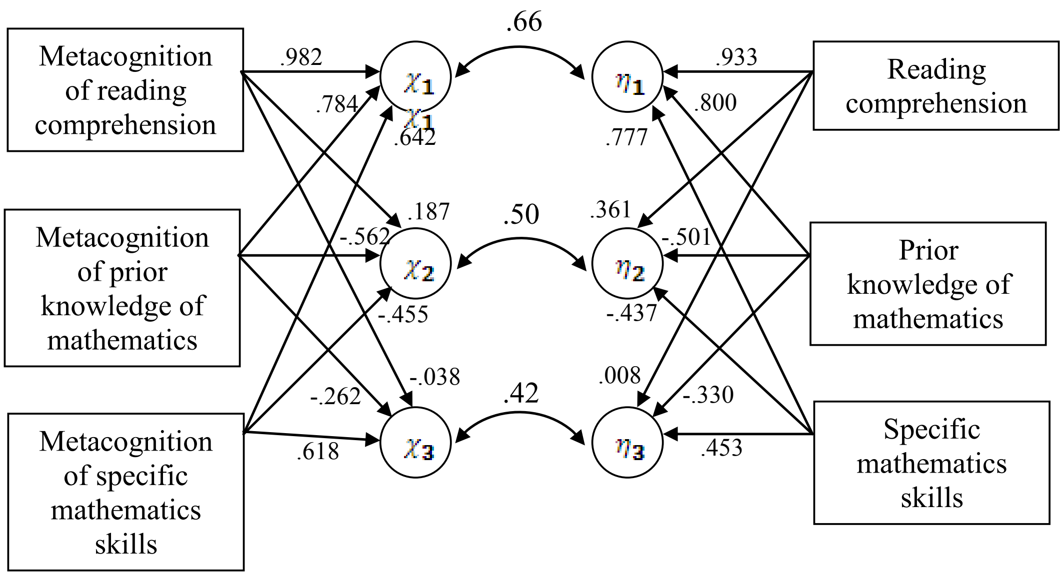

Figure 4. Canonical Correlation Analysis Path

The study found the canonical factor correlation value of χ_1 and η_1 was .66, and squared canonical correlation value was .43 which explained 43% between the relevant group. Similarly, the canonical factor correlation value of χ_2 and η_2 was .50, and squared canonical correlation value was .25 which explained 25% between the relevant group. Furthermore, the canonical factor correlation value of ted η_3 and χ_3 was .42, and squared canonical correlation value was .17 which explained 17% between the relevant group.

Moreover, the results of this study also showed that the percentage of the canonical factors in variables of η_1, η_2, η_3 with regard to reading comprehension, prior knowledge of mathematics and specific mathematical skills were 86.96%, 13.03%, 0.01%; 63.99 %, 25.14%, 10.87%; 60.32%, 19.13%, 20.55%, respectively. The first set of canonical factors showed highly correlation coefficient of .982 with metacognitive reading comprehension and .933 with reading comprehension, hence named such set as “reading comprehension factors”. Similarly, the second set of canonical factors showed highly correlation coefficient of -.562 with metacognitive prior knowledge of mathematics and -.501 with prior knowledge of mathematics, hence named such set as “prior knowledge of mathematics factors”. Furthermore, the third set of canonical factors showed highly correlation coefficient of .618 with metacognitve specific mathematics skills and .453 with specific mathematics skills, hence named such set as “specific mathematics skills factor” "

Conclusions

According to the data analysis and discussion of this study, the main conclusions are as following: (1) students performed the best in the domain of “prior knowledge of mathematics”, and followed by “general reading comprehension” and “specific mathematical skills”, respectively; (2) the cognitive components of mathematics reading and its metacognition were positively correlated. In other words, students performed better on mathematics reading tasks could obtain better metacognitive strategies; (3) Mathematics reading comprehension, prior knowlege of mathematics, and specific mathematics skills can present three canonical factors. Students obtained better mathematics metacognion could perform better in mathematics reading tasks.

Based on the results of this study, some suggestions are as following: (1) the results of this study showed that students’ mathematics reading and their metacognition were significantly related. Addition to teaching mathematics in the classroom, teachers can employ students to adopt metacognitive abilities so that students themselves are able to develop self-awareness during mathematics reading activities. (2) future research can be extended the current study by applying into students of different age, and explore the differences between mathematics reading and metacognitive performance. (3)the related assessment of mathematics reading and metacognition were through written tests, in which it cannot provide deep information of how students apply problem-solving and metacognition techniques. Therefore, the future research can be adopted the way through the interviews to understand students’ problem-solving and metacognitive psychological process.

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