

# Teachers' Understanding About Executive Function Toward Mathematics

Nani Restati Siregar<sup>1,1\*</sup>, Supra Wimbarti<sup>2,2\*</sup>, Sri Koesrohmaniah<sup>2,3\*</sup>, Yulius Sunardi<sup>3,4\*</sup>

<sup>1</sup>Faculty of Teacher Training, Universitas Halu Oleo, Southeast-Sulawesi, Indonesia

<sup>2</sup>Faculty of Psychology, Universitas GadjahMada, Yogyakarta, Indonesia

<sup>3</sup>Faculty of Psychology, Universitas Sanatha Dharma, Yogyakarta, Indonesia

<sup>1\*</sup>nanirestatiiilham@gmail.com, <sup>2\*</sup>supra@ugm.ac.id, <sup>3\*</sup>koes\_psi@ugm.ac.id, <sup>4\*</sup>nardiiranu@yahoo.com

**Abstract:** This study aims to explore teacher knowledge related to the skills involved in mathematics learning in the classroom and explore teacher knowledge about the important role of executive functions in mathematics learning. The method of this research was using a survey. The participants were 50 elementary school teachers asked to fill out a questionnaire about the importance of skills in several aspects: mathematics-specific (MS); executive function (EF); and other skills (OS) in mathematics learning. The results showed the importance of skills in all three aspects of mathematics learning. Teacher teaching experience has a significant effect on aspects of MS and OS but has no significant effect on aspects of EF's role. The frequency of training has a significant effect on all skills. Especially for EF which comprises items manipulate abstract information (MAI), stores and manipulate information in their head (SMITH), focusing on relevant information and avoiding distractions (FRIAD). It found that teaching experience only affected SMITH and BATF items, while training frequency affected all items. The findings support previous research results that report the important role of executive functions and other mathematical skills. This finding also showed the awareness of primary school teachers regarding the role of executive functions (EF) not based on length of employment but the emergence of an awareness of the importance of these skills after professional training, for example how to improve working memory for students mathematical learning difficulty. The recommendation for future research to design teacher teaching training based on executive function.

**Keywords:** *mathematics learning, mathematics-specific, executive function, other skills*

## INTRODUCTION

Nowadays, studies of mathematical abilities for students in schools have become interdisciplinary concerns. Neuropsychology places an important role in mathematics, namely cognitive skills that support mathematical abilities in students (Geary, 2010). The cognitive skills in question are storing information that is received in a short time and manipulating that information in mind (working memory), inhibiting unwanted responses through ignoring stimulating attention (inhibition control), and thinking flexibly (shifting). These three cognitive skills are components of executive functions (Miyake et al. 2000; Miyake & Friedman, 2012). Executive function is the prefrontal cortex performance that is involved in high-level thinking (Diamond, 2012) and it is a cognitive mechanism in dealing with complex situations and producing novelty (Vardejo-Garcia & Bechara, 2010). Previous study had reported mathematical learning difficulty due to low executive function in the student elementary school (Mulder, Van der Ven, Slot, & Leseman, 2017; Ribner, Willoughby, Blair, & Family Life Project Key Investigator, 2017).

Other abilities that contribute to mathematical achievements include knowing concepts, procedures and understanding concepts (Bisanz Sherman, Rasmussen, & Ho, 2005). Young, Levine and Mix (2018) report on spatial skill also plays an important role in mathematical

abilities that are as good as verbal skills (Hildenbrand, Niklas, Cohrssen, & Tayler, 2017) and creative thinking skills (Kroesbergen & Schoevers, 2017). These skills collaborate with components of executive functions to achieve good abilities in mathematics for students (Gilmore & Cragg, 2014).

Previous studies reported that mathematical achievements influenced by working memory (Cragg, Richardson, Hubber, Keeble, & Gilmore, 2017), inhibition control (Gómez, Jiménez, Bobadilla, Reyes, & Dartnell, 2015) and shifting (Poorghorban, Jabbari, & Chamandar, 2018). Executive function low capacity as a predictor for students' difficulty in learning mathematics. Helping teachers to create the learning strategy based executive processes, such: remembering, organizing, shifting and prioritizing which play an important role in the success of mathematical solutions (Roditi & Steinberg, 2007). Teachers play an important role in supporting students' academic success through the ability to create teaching strategies in the classroom (Agharuwhe & Nikechi, 2009).

Exploring teacher's understanding of the role of executive functions in mathematics in elementary schools is considered important for several reasons. First, teacher knowledge of the structure and function of brain learners is an important basis for cognitive performance (Dubinsky, 2010). Executive function is the performance of the prefrontal cortex (PFC) to higher-order thinking, including complex mathematical solutions (Amalric & Dehaene, 2016). Second, research has reported the importance of findings in neuroscience and cognitive psychology in educational settings being part of the curriculum in schools (Carew & Magsamen, 2010; Colvin, 2016).

This research is a replication of findings reported by Gilmore and Cragg (2014). Similar research has reported an executive function - based learning design by a teacher for students' academic success (Stockall, 2017). However, the novelty of previous research, namely: first, this research focuses on elementary school teachers in understanding executive functions in mathematics. The reason is that mathematics in basic education plays an important role as a predictor of mathematical success in elementary schools, for example, mathematical word problem solving in elementary schools as predictors of learning algebra (Fuchs, et al. 2014). Teachers involved in professional training, for example workshop, were more understanding about executive function in academic success than teachers not involved. Previous study reported teachers understand well about executive function, even though they were not involved in training teacher yet (Morgan-Borkowsky, 2012). Second, this study does not expand the school level category (up to secondary school) since this study is a pilot for further research related to designing teaching strategies by considering the capacity of executive function students. This study aims: (a) to explore teacher knowledge related to the skills involved in mathematics learning in the classroom; and (b) to explore teacher knowledge about the important role of executive function in mathematics learning.

## **METHOD**

The research was using survey methods to teachers in elementary school. Purposive sampling took teachers as participants. Participants selected based on duration work in years and frequency attending professional training, for example workshop.

The participants in this study were 50 elementary school teachers in the South Konawe District. Teacher teaching experiences vary from the lowest under 5 years to over 20 years. Teacher education comes from several elementary schools. Teacher education not specifically

mathematics education. Participants fill out a questionnaire about the importance of skills in aspects: (a) mathematics-specific; (b) executive function; and (c) other skills.

Measurements using Questionnaire Mathematics Skills can explore teacher understanding of skills that play a role in mathematics learning (Gilmore & Cragg, 2014). This questionnaire comprises aspects, namely: (a) mathematics-specific; (b) executive function; and (c) other skills. Each aspect comprises four items. The questionnaire is a Likert scale with a score of one (not important), score two (less important), score three (neutral), score four (important), score five (very important). The score shows the teacher's understanding of the importance of the three aspects of mathematics learning.

Data analysis uses principal component analysis which aims to examine whether the items in each aspect, namely the mathematics-specific (MS) aspect, aspects of the executive function (EF), and other skills (OS) aspects can measure the same construct. One way ANOVA was used to analyze the differences in understanding of the importance of mathematical skills. Two way ANOVA was used to analyze differences in understanding of the importance of the three aspects based on teaching experience (duration of work in years, 1-10 years, 11-20 years, and > 20 years), and the frequency of attending teacher professional training (0-3 times, 4 -7 times, and > 7 times) as a factor.

## RESULTS AND DISCUSSION

Based on principal component analysis, the results of the Kaiser Meyer Olkin Measure of Sampling (KMO) and Bartlett's test showed that each aspect fulfilled the sample adequacy, namely the MS aspect (MSA =.739; approx chi-square = 50.693; p-value =.000); EF (MSA =.758; approx chi-square = 90.356; p-value =.000), OS (MSA =.761; approx. Chi-square = 75.564; p-value =.000). Table 1 shows the coefficient anti image correlation all items from all three aspects >.50. The commonalities coefficient also shows that the variants of all items in all three aspects >.50, which means that more than 50 percent of the variants of all items can be explained by their respective aspects.

**Table 1.** Anti-image correlation and communalities

Aspects	Items	Coefisien anti-image correlation	Communalities	
			Initial	Extraction
Mathematics-specific (MS)	- Know number facts	.732	1,000	.509
	- Understand mathematical concepts	.735	1:000	.689
	- Understand how mathematics is used in the real world	.733	1.000	.518
	- Formulas and procedures	.754	1.000	.666
Executive functions (EF)	- Manipulate abstract information	.771	1.000	.726
	- Store and manipulate information in their head	.760	1.000	.737
	- Focus on relevant information and avoid distractions	.753	1.000	.679
	- Be Able to think flexibly	.748	1.000	.688
Other skills	- Have good verbal skills	.721	1.000	.778
	- Be Able to provide reasons to support Reviews their solutions	.767	1.000	.658
	- Be Able to think creatively	.820	1.000	.647
	- Have good spatial skills	.753	1.000	.586

Table 2 shows that in each aspect (MS, EF, and OS) only one factor is formed (eigenvalue of every single factor  $> 1$ ), which means that each item in each aspect comprises a single factor. This shows that the items in each aspect can measure the same construct. The amount of variance that can be explained by a single factor in each aspect is MS 59.54 percent, EF 70.77 percent, and OS 66.72 percent.

**Table 2.** Total variance expalined

Aspect	Component	Initial Eigenvalues		
		Total	% Of Variance	Cumulative%
Mathematics-specific (MS)	1	2.382	59.542	59.542
Executive functions (EF)	1	2.831	70.768	70.768
Other skills (OS)	1	2.669	66.724	66.724

Table 3 shows the value of the loading factors for each item in each aspect. The loading factor is the magnitude of the correlation between the factors formed with the item. The correlation between the three aspects with each item correlates above 50 percent.

**Table 3.** Component matrix

Aspects	Items	Factor loading
Mathematics-specific (MS)	- Know number facts	.713
	- Understand mathematical concepts	.830
	- Understand how mathematics is used in the real world	.719
	- Know formulas and procedures	.816
Executive Function (EF)	- Manipulate abstract information	.852
	- Store and manipulate information in their head	.859
	- Focus on relevant information and avoid distractions	.824
	- Be Able to think flexibly	.829
Other skills	- Have good verbal skills	.882
	- Be Able to provide reasons to support Reviews their solutions	.811
	- Be Able to think creatively	.805
	- Have good spatial skills	.765

Based on the results of one way ANOVA analysis, the results show that the average MS score is 3.74, EF 3.64, and OS 3.69. Although the average MS score was higher than EF and OS, and the average OS score was higher than EF, there was no significant difference in scores between the three aspects ( $F = .222$ ,  $p\text{-value} = .801$ ).

Table 4 are displaying results of the two ways ANOVA in each of the objectives. Teaching experience (1-10 years, 11-20 years,  $> 20$  years), and the frequency of teacher professional training (0-3, 4-7,  $> 7$ ) as factors, it was found that teaching experience had only a significant effect on the aspects of MS and OS, while in the EF aspect teaching experience had no significant effect. It also appears that the frequency of training and the interaction of teaching experience \* training has a significant effect on all three aspects.

**Table 4.** Tests of between-subjects effects

Aspects	Source	Type III Sum of Squares	F	Sig.
Mathematics-specific (MS)	corrected Model	18.777a	19.371	.000
	Intercept	534.665	4412.519	.000
	Teaching experience	5.158	21.283	.000
	frequency of training	11.759	48.523	.000
	Teaching experience*the frequency of training	1.393	2.873	.035
	Error	4.968		
	Total	723 125		
	corrected Total	23.745		
Executive function (EF)	corrected Model	21.515a	31.540	.000
	Intercept	503.806	5908.326	.000
	Teaching experience	.393	2.306	.112
	teacher training	18.751	109.951	.000
	Teaching experience*the frequency of training	.945	2.771	.040
	Error	3.496		
	Total	689.313		
	corrected Total	25.011		
Other skills	corrected Model	23.870a	58.956	.000
	Intercept	522.451	10323.127	.000
	Teaching experience	7.031	69.465	.000
	frequency of training	14 935	147.554	.000
	Teaching experience*the frequency of training	.552	2.726	.042
	Error	2.075		
	Total	706.750		
	corrected Total	25.945		

The Bonferoni test results showed that in the MS aspect the response scores of teachers with > 20 years of experience (Mean = 4.17) and those with 1-10 years of experience (Mean = 3.28) differed significantly (p-value = .000). Likewise, the experience of 11-20 years (mean = 3.88) with 1 to 10 years is different (p-value = .000). Those with experience of > 20 years with 11 to 20 years' experience did not differ significantly (p-value = .999). In the EF aspect: scores of teachers with experience of > 20 years (Mean = 3.80) with 11 to 20 years experience (mean = 3.67) did not differ significantly (p-value = .525), and experienced 1 to 10 years (mean = 2.75) does not differ significantly (p-value = .093). Likewise, teachers with 11 to 20 years' experience with teachers who have 1 to 10 years' experience are not different (p-value = .999). OS aspects: scores of teachers who experienced > 20 years (mean = 4.25) and 1 to 10 years (mean = 3.17) differed significantly (p-value = .000). Likewise, between 11 to 20 years experienced teachers (Mean = 3.79) with 1 to 10 years different (p-value = .000). Those with experience of > 20 years with 11-20 years did not differ significantly (p-value = .098).

Furthermore, the training factor, the MS aspect the scores of teachers who had attended training with a frequency of > 7 years (Mean = 4.53), and the frequency of training 4-7 (Mean = 3.73) differed significantly (p-value = .000), and different (p-value = .000) with a frequency of 0-3 (mean = 2.93). Then, between the frequency of training 4-7 with 0-3 differed significantly (p-value = .999). In the aspect of EF: scores of teachers who had attended training with a frequency of > 7 years (Mean = 4.57) with training frequency 4-7 (mean = 3.69) differed significantly (p-

value = .000), and differed significantly (p-value = .000) with a frequency of 0-3 (mean = 2.75). Likewise, between the frequency of training 4-7 with 0-3 differed significantly (p-value = .999). On OS aspects: scores of teachers who had attended training with a frequency of > 7 (mean = 4.55) and frequency of training 4-7 (mean = 3.73) differed significantly (p-value = .000), and were significantly different (p-value = .000) with a frequency of 0-3 (mean = 2.93). The frequency of training 4-7 with frequency 0-3 differ significantly (p-value = .098).

Particularly for the EF aspect which comprises item Manipulate Abstract Information (MAI), Store and Manipulate Information In Their Head (SMITH), Focusing On Relevant Information And Avoiding Distractions (FRIAD), and Being Able To Think Flexibly (BATF) and as a factor are teaching experience (1-10 years, 11-20 years, > 20 years), and the frequency of teacher professional training (0-3, 4-7, > 7). It was found that in MAI items, teaching experience did not have a significant effect (p-value = .116), training frequency had a significant effect (p-value = .000), and between teaching experience and training frequency, there was no interaction (p-value = .550). In the SMITH item: teaching experience has a significant effect (p-value = .038), the training frequency has a significant effect (p-value = .000), and there is no interaction between the two factors (p-value = .755). On FRIAD items: teaching experience has no significant effect (p-value = .408), training frequency has a significant effect (p-value = .000), and between teaching experience and training frequency there is no interaction (p-value = .377). In BATF items: teaching experience has a significant effect (p-value = .036), the frequency of training has a significant effect (p-value = .001), and there is no interaction between the two factors (p-value = .862).

The results of the two-way ANOVA on experience factors found that in the MAI items the response scores of teachers with > 20 years experience (mean = 3.83) and 11 to 20 years experience (mean = 3.60) did not differ significantly (p-value = .999), and with experience of 1 to 10 years (mean = 3.42) also did not differ significantly (p-value = .0853). The difference between 11-20 years' experience with 1 to 10 years did not differ significantly (p-value = .256). On items SMITH: experience > 20 years (Mean = 4.00), and experience 11 to 20 years (Mean = 3.80) did not differ significantly (p-value = .999), and with experience 1 to 10 years (Mean = 3.44) not different (p-value = .065). Likewise, between 11 to 20 years of experience with 1 to 10 years did not differ significantly (p-value = .065). On items FRIAD: experience > 20 years (mean = 4.00), and experience 11 to 20 years (mean = 3.76) not different (p-value = .999), and with 1 to 10 years of experience (mean = 3.64) not different (p-value = .999). Likewise, between 11 to 20 years' experience with 1 to 10 years is not different (p-value = .065). On BATF items: experience > 20 years (Mean = 3.81), and experience 11 to 20 years (Mean = 3.58) did not differ significantly (p-value = .999), and with experiences from 1 to 10 years (mean = 3.07) not different (p-value = .999). Likewise, between 11 to 20 years' experience with 1 to 10 years is not different (p-value = .065).

The difference in scores on the frequency factor of training was found in the MAI items scores of teachers who had attended professional training with a frequency of > 7 (Mean = 4.23) and frequencies of 4-7 (mean = 3.83) did not differ significantly (p-value = .130), and with frequency 03 (mean = 2.80) differed significantly (p-value = .000). Between frequencies 4-7 and 0-3 differ significantly (p-value = .000). On the SMITH item: frequency > 7 (Mean = 4.73) and frequency 4-7 (Mean = 3.72) differed significantly (p-value = .000), and with frequency 03 (mean = 2.80) differ significantly (p-value = .000). Between frequencies 4-7 and 0-3 differ significantly (p-value = .000). On items FRIAD: frequency > 7 (Mean = 4.87) and frequency 4-7 (Mean = 3.76) differed significantly (p-value = .000), and with a frequency of 0-3 (mean = 2.78) differ significantly (p-value = .000). Between frequencies 4-7 and 0-3 differ significantly (p-

value = .000). On BATF items: frequency > 7 (Mean = 4.10) and frequency 4-7 (Mean = 3.47) differed significantly (p-value = .000), and with frequency 03 (mean = 2.88) differ significantly (p-value = .000). Likewise, between frequencies 4-7 with 0-3 differed significantly (p-value = .000).

This study explored the teacher's understanding of the skills needed in mathematics learning. These three aspects play an equally important role in mathematics learning. This supported by previous studies which reported that the executive functions and spatial skills both played important roles in mathematical achievement (Verdine, Irfin, Golinkoff, & Hirs-Pasek, 2015). This finding differs from the previous study that the aspect mathematics (MS) score is different significantly with executive function (EF) and other skills (OS) scores (Gilmore & Camila, 2014). Another study showed that the component of executive function comprising working memory, inhibition control and shifting influences students' mathematical achievements thorough knowledge of facts, procedures, and concepts (Cragg, Keeble, Richardson, & Gilmore, 2017). This shows that the executive function's role is superior to other aspects, namely mathematics-specific (MS) and other skills (OS). This study was a replication of a study conducted by Gilmore and Cragg (2014) that used teacher subjects ranging from elementary school to secondary school. The results of the study showed that mathematics-skills (MS) is more instrumental than an executive function. (EF) This is due to the EF component being more related to problem behavior for middle school students than the EF role for academic achievement in elementary schools (Jacobson, Willford, & Pianta, 2011).

Primary school teachers who were the subjects in this study varied both in teaching experience and involvement in professional training. Teachers who have attended professional training (not limited to teaching experience) consider the executive function skills important in mathematics learning in the classroom. It means that teachers more than understand how executive function works in the brain and how to improve executive function for academic success based on brain training, for example physical training (Egger, Benzing, Conzelman, & Schmidt, 2019). This differs from the research conducted by Gilmore and Cragg (2014) that the longer the teacher's working period, the more important the executive function is. Other experts expressed confidence in the importance of executive functions directing the way teachers teach mathematics in the classroom (Rapoport, Rubinsten, & Katzir, 2016). Therefore, an important indicator lies in the belief, not at the length of the work period of the teacher regarding the important role of the executive function in student academic success.

## CONCLUSION

This study is a replication of the previous findings but differs from the findings regarding the role of executive functions in mathematics learning. In this study, there were no significant differences between the three aspects of skills. This finding also supports previous research results that report the important role of executive function along with other mathematical skills. The contribution of the research will consider designing of training executive function based - learning strategy for teachers to improve students' mathematical performance. For academic reasons, teachers need how brain working based student's academic performance. Executive functions involved in curriculum, teaching and learning strategy are appropriate.

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