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Cognition and mathematics education: Processing speed and word problem solving performance in children

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Abstract
Learning mathematics is a complex progressive process and a wide range of cognitive skills influences one's success. The present work aims to study the relationship between processing speed and mathematical word problem solving performance in primary school children. The researchers evaluated the performance of 40 children with a mean age of 12.5 years in mathematics word problem solving and their processing speed. This work is theoretically underpinned in Atkinson and Shiffrin's (1968) information processing model and used a quantitative approach. Correlation analysis showed that total processing speed is associated with learners' performance in mathematics word problems. However, out of the two aspects of processing speed like perceptual speed and number facility, it is observed that number facility is significantly correlated with performance in solving word problems. The result of independent t-test indicated that gender does not have any effect on participants' performance in processing speed and mathematics word problem solving. The researcher suggests that educators should design suitable problem-solving strategies with the integration of cognitive tasks to enhance learners' mathematical knowledge.

Keywords: processing speed; cognitive skills; problem solving performance; information processing and mathematical knowledge

1. Introduction

Word problems have a prominent role at all levels of mathematics curriculum, with an objective "to contextualize mathematics in order to help students make better sense of the embedded mathematics concepts, to apply mathematics concepts and procedures to real-world situations, and to motivate students" (Depaepe, & Verschaffel, 2010) [17]. The most difficult kinds of problems that majority of mathematics learners encounter are word problems. Mathematical word problems (Rasmussen & King, 2000; Timmermans et al., 2007) [44] refer to "mathematical exercises that present relevant information on a problem text, rather than in the form of mathematical notation" (Boonen et al., 2016, p.1) [7]. Mathematical word problem solving comprises the integration of several cognitive and meta-cognitive processes such as attention, memory, perception, language, self-questioning, self-monitoring and self-evaluation. In addition to this, understanding or comprehending the text, representing the problem correctly, planning, execution and verifying the obtained solutions are necessary for word problem solving (Hegarty & Monk, 1995; Mayer & Hegarty, 1996) [29, 36]. Thus, effectively solving a mathematical word problem is dependent not only on cognitive abilities but also on learner's ability to accurately understand the text of the word problem.

The influence of cognitive abilities on learners' performance in mathematics was investigated intensively by Abdul Kadir Bahar (2015) [4] in his doctoral thesis. His study was focused on two objectives: firstly, to look at the association between cognitive abilities and mathematical problem-solving performance in both closed and open-ended situations; and secondly, examined whether gender has any influence on the observed relationships. Similarly, Bjork and Bowyer-Crane (2013) [6] conducted a quantitative study, to investigate the cognitive skills that underpin mathematical word problems and numerical operations among sixty children aged 6 to 7 years. A mix of standardized and researcher-designed test was administered to measure the *mathematical ability, reading accuracy, reading comprehension, verbal intelligence and phonological awareness.* The findings suggested that reading comprehension predicted learners' performance in mathematical word problem whereas phonological awareness predicted performance on both types of problems. However, verbal ability and reading accuracy were not emerged as significant predictors of word problems and numerical operations.

A recent work on processing speed, working memory and mathematical cognition was done by Formoso et al., (2018) [19]. The study was carried out in two phases. The aim of the first phase was to determine basic math skills for mathematical cognition among 207 preschoolers of 4, 5 and 6 years of age. This was measured by administering tasks on dot enumeration and dot comparison. Dot enumeration tasks involve subitizing and counting whereas quantity estimation, number line, Arabic numerals, arithmetic word problems and conventional counting sequence were included in dot comparison tasks. Results from exploratory analysis revealed that the two skills that contributed to mathematical cognition are subitizing and counting. Further results from Pearson product correlation showed significant weak, moderate and strong correlations between the variables. The relationship between processing speed, working memory, age and mathematical cognition among 180 preschoolers of 4 to 6 years of age were explored in the second phase. Results from structural equation modeling reported that verbal working memory, visual spatial working memory, and processing speed had a direct effect on math cognition. Additionally, it was found that age had a direct effect over verbal working memory, visual spatial working memory and processing speed, and indirect effect over math cognition.

Bull and Johnston (1997) [8] conducted a study among 68 children with mean age 7 years, 5 months. This research examined the role that processing speed, short-term and long-term memory played in arithmetic difficulties of primary students. Learners were divided into high-ability and low-ability groups based on their performance in *the Group Mathematics Test (Young, 1970),* and *the British Ability Scales (BAS) Word Reading Test (Elliott, Murray, & Pearson, 1979).* The following tests were administered: *Digit span, counting span, word span and speech rate* for short-term memory; processing speed was tapped using *cross-out task, visual number matching and pegboard*; and long-term memory was assessed using *letter identification, number identification, sequencing ability and single digit addition*. It was found that processing speed, speed of item identification and short-term memory were significantly correlated with mathematical ability. Regression analysis results reported that processing speed and item identification contributed unique variance in mathematics ability.

Cowan and Midouhas (2017) [12] suggested that development in mathematical ability and general cognitive ability influence each other. Fuchs et al., (2006) [20] examined the relations between cognitive abilities and arithmetic, algorithmic computation and arithmetic word problems. *Language, nonverbal problem solving, concept formation, processing speed, long-term memory, working memory, phonological decoding, and sight word efficiency* were the selected cognitive abilities. Results from Path analysis reported that the independent predictors of arithmetic were phonological decoding and processing speed whereas the independent predictors of arithmetic word problems were nonverbal problem solving, concept formation, sight word efficiency, and language. Another study by Hecht et al. (2001) [28] found that processing speed was correlated to arithmetic skill when vocabulary knowledge was controlled. Similarly, research studies by Burns et al., (2006) [10] and Swanson (2004) [43] also established the relationship between cognitive abilities and learners' performance in mathematics.

Concerning the gender differences in performing mathematics problems, a study done by Royer et al., (1999) [40] reported that "speed of fact retrieval in the field of mathematics contributed to gender differences in mathematical problem solving on timed tests such as SAT-M" (Zhu, 2007, p. 194) [48]. The results further showed that males responded to math-fact retrieval tasks faster than females. On the other hand, no gender differences existed on performance in simple retrieval tasks. On the contrary, compared to males, females were slightly faster in processing verbal tasks than males. It was stated by Gallagher et al., 2000 [22], that the ability to quickly solve problems in unfamiliar circumstances was considered as focal to performance in mathematics on standardized tests such as *SAT-M* (Gallagher et al., 2000) [22]. Similarly, Geary et al., (2000) [23] reported that males out performed females on math-fact retrieval tests and *SAT-M.*

Goldstein, Haldane and Mitchell (1990) [24] found no gender difference on untimed rotation mental rotation test. Despite all these findings, several researchers did not concur with the opinion that speed of responding could contribute to gender differences in mathematical problem solving (Delgado and Prieto, 2004; Masters, 1998) [15, 34]. Thus, the contribution of gender differences in processing speed and mathematical problem-solving performance demands further examination. The evidence discussed above indicates that cognitive abilities have a crucial role in developing mathematical ability, which further assists in performing mathematical problems. However, there is a paucity of literature on how the cognitive abilities are influencing learners' performance in mathematics word problems. Thus, this study intends to examine the relationship between processing speed and seventh-grade students' well-defined mathematics word problem solving performance.

2. Theoretical Framework

Cognition encompasses the scientific study of the human mind and how the mind process information. Cognitive ability outlines "the process and results of information processing, which comprises perception, conceptualization, and problem solving" (Gelbart, 2007, p. 3). These abilities are one of the determining factors of an individual's academic performance. In essence, when cognitive abilities are strong, learning is fast and when it is weak, learning becomes a cumbersome process. Hence, to investigate the relation between processing speed and mathematical word problem solving performance, it would be appropriate to approach this problem through a cognitive lens. In the field of cognitive psychology, the goal of information processing approach is to understand human thinking process. Cognitive psychology studies individual's mental processing and the approach used by cognitive psychologists to study human mental processing is information processing approach. In fact the core of cognitive psychology relies on the idea of information processing. It focuses on how one learns, acquires new information, retains previous information and produces the output.

The information-processing model garnered wide acceptance during the 1960s with the development of computer science. This had greatly influenced psychologists and cognitive approach has become a dominant approach in modern psychology. Cognitive psychologists used computer processing as a metaphor or analogy to compare human thought processing. The information-processing model describes "the flow and processing of information from sensory input to storage and behavioral responses" (Dehn, 2008, p. 11) [16]. According to this model, the "cognitive processing system comprised of a set of separate but interconnected information subsystems, with memory components constituting the core of the system" (Gagne, Yekovich & Yekovich, 1993, p. 12) [21].

From the plethora of memory models emerged between 1960s and 1970s, the widely accepted and enduring model of information processing was the Atkinson-Shiffrin model. This study is theoretically rooted in Atkinson and Shiffrin's (1968) model, which is called as the information-processing model or modal memory model. According to this model, human memory was organized as a system with three kinds of memory storage systems: *sensory store, a short-term store, and a long-term store.* In this model, the process of memorization begins with a sensory input. Firstly, the sense organs collect the sensory information, which passes through the nervous system and enters the brain where the interpretation of the received information takes place. Though, the brain interprets information, the input is held in the nervous system for a very brief time, to give the brain time to interpret the sensory message. This “momentary pause of less than a second, or lingering or persistence of the sensory information, is referred to as sensory register or sensory storage” (Mangal, 2005, p. 259) [33]. This sensory register is associated with each sense, namely, visual, auditory, smell, taste and touch. However, the iconic storage and echoic storage meant for visual and auditory storage systems respectively have been extensively studied so far. The transfer of sensory information to the next stage of processing is of critical importance, hence sensory memory act as a gateway or a portal for all input information. In other words, this storage system decides which information should enter into the next store. The sensory register now transfers the information to the second stage of information processing, which is short-term store. This is a stage of conscious activity, which has a limited capacity to preserve information. The information may hold in short-term store for up to 20 seconds. However, through rehearsal, or repetition, information can be retained in the short-term store as long as an individual wants it in the store. After another brief interval, the information present in the short-term storage proceeds to more durable long-term store for further retrieval of decoded information. The long-term store has unlimited capacity to store currently inactive encoded information or it has the capacity to store information permanently. Atkinson and Shiffrin view “short-term memory as the workspace for long-term learning” (Dehn, 2011, p. 12) [16]. They propose, “learning is dependent on the amount of time information resides in the temporary storage” (Dehn, 2011, p. 13) [16]. Thus, short-term memory has critical role in retaining and retrieving information from long-term memory.

The two major influences on sensory memory to process information are attention and automatic processing. Attention is closely associated to the processes and products of learning. There are external as well as internal factors, which guide and control an individual’s attention. External factors are factors that are present in one’s environment which include nature, intensity, size, contrast, change, repetition and movement of the stimulus. On the other hand, internal factors lie within a person like interest, motives, and mindset. The limitations of our neurological capacity hinder to sense all the external stimuli, even if it got detected, the brain would not be able to process all of the information. This reveal, “our information-processing capacity is too limited” (Solso, 2011, p. 87) [42]. Hence it can be concluded that if the amount of information is within the capability of our sensory system, then it receives, transfers and process information really well; if the input is overloaded then it fails to process the sensory messages.

Another factor linked to information processing is automatic processing, which is a mental cognitive process where the activities require less attention, less cognitive effort and less active control by the subject to perform. This type of processing is the result of “repetitive training on the same task” (Hammer, 2012). Thus, for “automaticity of processing to occur, there must be a free flow of information from memory to the subject’s control of actions” (Solso, 2011, p. 101) [42]. In essence, Atkinson and Shriffrin’s information processing model assumes that one side of processing is storing and the other side is information retrieval.

3. Objectives of the study

The primary objective of this study is to examine the relationship between processing speed and four phases of word problem solving performance, namely; problem translation, problem integration, solution planning and solution execution. The second purpose of this study is to examine whether boys and girls differ in processing speed and four phases of word problem solving performance. The statement of the study is “Exploring the correlation between processing speed and mathematical word problems”.

The following research questions have been framed for the study:

1. Is there any relationships exist between processing speed and mathematics word problem solving performance?
2. Does gender difference exist when processing speed and mathematics word problem solving performance are concerned?

4. Methodological Procedures

The present study considers gender and processing speed as independent variables and the mathematical word problem solving performance as dependent variable. are used to conceptualize The processing speed is construed in terms of perceptual *speed* and *number facility*. Learner’s performance in mathematical word problems in arithmetic and geometry are assessed using four cognitive phases proposed by Mayer (1992) [29]: Problem translation, problem integration, solution planning and solution execution.

In this study, numerical data was analyzed to explore the potential relationships between independent and dependent variables. Therefore, this study used a quantitative approach. The research design chosen for this study was exploratory and descriptive correlation study.

Forty (40) students from grade seven of a CBSE school in the state of Telangana participated in this study. Purposive sampling technique is used for selecting the sample, which comprises of 20 girls and 20 boys with a mean age of 12.5. There are two reasons for choosing this sample. Firstly, according to Piaget’s cognitive development theory, the age group (11 to 15) falls on formal operational stage and secondly, the sample is assumed to possess procedural and conceptual knowledge in mathematics and also have basic reading and writing abilities. The selected subjects are native speakers of Telugu language, however, academic instruction in school happens in English. From the interaction with academic instructors the researcher came to know that though trouble in reading, writing and performing mathematics exists among the children, no children in that class have any kind of learning disabilities.

Learner’s performance in mathematics word problem solving performance is measured by administering a test designed by the researcher. This test constituted 20 multi step word problems covering two areas in mathematics, namely, arithmetic and geometry. Class VI mathematics syllabus was used for preparing the test items. 10 multi step word problems each for arithmetic and geometry are constructed and evaluated using the four cognitive phases proposed by Mayer (1992) [29], namely, problem translation, problem integration, problem planning and problem execution. The items in this test comprises of simple to complex problems. In this test, subjects are instructed to: write appropriate steps; to diagrammatically represent the information; decide appropriate computation; and execution of solution. Based on this criterion a four-point rating scale was prepared to assess the respondent's word problem solving performance and a final score was obtained for overall word problem solving performance. The value of the split-half reliability is 0 .71.

In this study, by administering the tests of perceptual speed and number facility researhers captured the processing speed. Two tests are administered to assess perceptual speed, namely, number comparison test and finding A's test. On the other hand, number facility is measured by addition test, division test, and subtraction and multiplication test (Ekstron et al., 1976, p. 124-126). The researchers using the description given in Manual for Kit of Factor-Referenced Cognitive Tests designed the tests for both perceptual speed and number facility. Number comparison test is a paper-pencil test and a timed test. In this test, participants have to quickly compare the numbers given on two sides of a line. If the numbers on both sides are different, subject has to put a cross mark on the line, if it is same, they have to leave the space blank. This test has two parts with 48 items on each part with a time limit of one and a half minute for each part. Final score is the average of the correct responses. Similarly, Finding A's test which is also a paper pencil test and a timed task, where the learners speed in finding the letter 'a' in the given words are assessed. This test has two parts and the lime limit is 2 minutes for each part. The number of correct responses is the final score. On the other hand, in number facility, speed, fluency and accuracy in completing basic arithmetic are assessed by administering three tests on addition, division, and subtraction and multiplication. This is a timed paper-pencil test. Each test has two parts with 60 items on each part and limited to 2 minutes for each part. Similar procedures are being followed for remaining two tests. The number of correct responses is recorded and average is taken as the final score.

The data related to processing speed were gathered after the mid-term examination. The test was conducted in a small room away from the regular classroom setting. The assessments were carried out on four consecutive days with 10 students per day. On the other hand, data related to mathematical word problems were collected in two phases. Firstly, assessment on arithmetic word problems was carried out on ten groups with four members in each group. The time limit for this test was one hour and administration extended to more than one week. Similar administration procedure was followed in second phase, where assessment on geometric word problems was done.

The researcher employed both descriptive and inferential statistics to address the research questions. Firstly, missing data analysis for the data set was carried out. This helped to find out the systematic errors in the data set. Under descriptive statistics mean and standard deviation were calculated and in inferential statistics independent t-test and correlation analysis were employed. To answer the first research question, the researcher used correlation analysis to examine the relation between independent and dependent variables. For the second research question, independent t-test was applied to find out the influence of gender factor on the dependent variable.

5. Findings of the study

The researcher assessed the normality of independent and dependent variables by examining the skewness and kurtosis values. These values showed an acceptable normality for the selected variables. Descriptive statistics for the cognitive variable *processing speed* and its two aspects and mathematics word problem solving performance have been presented in the below table.

Table 1: Descriptive statistics for variables

Measure	Gender	N	Min	Max	M	SD
Total Processing Speed	Boys	20	31.66	56.06	46.192	5.893
	Girls	20	34.66	58.50	47.933	6.960
Perceptual Speed	Boys	20	21.500	33.250	26.575	3.665
	Girls	20	23.000	36.750	29.225	4.050
Number Facility	Boys	20	8.666	24.333	19.617	3.762
	Girls	20	10.666	25.500	18.708	4.102
Mathematics word problem solving performance	Boys	20	168	283	234.200	34.910
	Girls	20	92	270	209.500	50.094

The above table shows the descriptive statistics of dependent and independent variables. It can be seen from the mean scores of total processing speed that girls performed slightly greater than boys. This shows that girls have greater speed to quickly and fluently perform simple cognitive tasks such as comparing numbers or symbols than boys. Concerning the two aspects of processing speed, it can be observed from the mean scores that boys displayed slightly greater performance than girls in number facility. On the contrary, girls performed better than boys in perceptual speed tasks. Thus, in this study boys have greater speed, fluency and accuracy in performing basic arithmetic operations than girls. On the other hand, speed and fluency in comparing numbers when presented visually is greater among girls than boys. Concerning overall mathematical word problem solving performance, it can be observed that mean scores of boys are greater than girls. This reveals that compared to girls boys are good at problem translation, problem integration, problem planning and problem execution and also in procedural-conceptual knowledge.

i) Processing Speed and Mathematics Word Problem Solving Performance

The way learners process a mental task, making sense of incoming information and giving response depends on processing speed. Previous studies reported that this is an important cognitive ability, which is related to learning. Following hypothesis is framed and translated into null form to test this assumption.

The cognitive ability, processing speed is significantly correlated with mathematical word problem solving performance of primary school children.

Pearson product moment correlation is applied on the null hypothesis to test the correlation between processing speed and mathematical word problem solving performance. The results are given in table 2.

Table 2: Correlation between total processing speed and mathematical word problem solving performance

		Total Processing Speed	Mathematical word problem solving performance
Total Processing Speed	Pearson Correlation	1	.413**
	Sig. (2-tailed)		.008
	N	40	40
Mathematical word problem solving performance	Pearson Correlation	.413**	1
	Sig. (2-tailed)	.008	
	N	40	40
**. Correlation is significant at the 0.01 level (2-tailed).			

As seen in table 2 that the correlation coefficient (r) equals .413 and the *p*- value is .008, which is less than .01. Thus, null hypothesis is rejected. It is observed that there is significant moderate positive correlations exist between processing speed and mathematics word problem solving performance (r = .413, $p < .01$).

ii) Perceptual Speed, Number Facility and Mathematics Word Problem Solving Performance

The way learners process a mental task, making sense of incoming information and giving response depends on perceptual speed and number facility. Previous studies reported that these are important cognitive abilities, which are related to mathematics word problem solving performance. The following hypotheses are formulated:

There exists significant correlation between perceptual speed and mathematical word problem solving performance.

There exists significant correlation between number facility and mathematical word problem solving performance.

The above hypotheses were translated into null form for the purpose of statistical testing. The results of Pearson product moment correlation are given below.

Table 3: Correlation between two aspect of processing speed and word problems

Correlations				
		Perceptual Speed	Number Facility	Mathematical word problem solving performance
Perceptual Speed	Pearson Correlation	1	.306	.251
	Sig. (2-tailed)		.055	.119
	N	40	40	40
Number Facility	Pearson Correlation	.306	1	.420**
	Sig. (2-tailed)	.055		.007
	N	40	40	40
Mathematical word problem solving performance	Pearson Correlation	.251	.420**	1
	Sig. (2-tailed)	.119	.007	
	N	40	40	40
**. Correlation is significant at the 0.01 level (2-tailed).				

It can be observed from table 3, that there is a weak insignificant but positive correlation exist between perceptual speed and mathematical word problem solving performance (r = .251, $p > .01$). Thus, failed to reject the null hypothesis. However, a moderate positive significant correlation is reported between number facility and mathematical word problem solving performance (r = .420, $p < .01$). Thus, rejecting the null hypothesis.

iii) Gender Vs. Processing Speed and Mathematics Word Problem Solving Performance

The speed with which a person receives a stimuli or information, processes that information and produces output varies from person to person, whether the information is in visual or auditory form. To test this assumption, the following hypothesis was framed. Independent t-test was computed to find out whether gender factor in learners performance in processing speed tasks.

There is statistically significant difference in mean scores of girls and boys in processing speed (H_0: $\mu_{boys} = \mu_{girls}$).

Table 4: Gender differences in processing speed

Variable	Gender	Mean	Standard Deviation	SE difference between means	df	t-value	p-value
Processing Speed	Boys	46.192	5.893	2.039	38	0.854	.398
	Girls	47.933	6.960				

It can be observed that the *p* – value is .398, which is greater than the chosen significance level $\alpha = 0.05$. This means that the mean scores between the two groups is not significant. Therefore, the null hypothesis is accepted at 5% significance level and concluded that there exists no significant difference in the mean scores of boys (M = 46.192, SD = 5.893) and girls (M = 47.933, SD = 6.960) performance in processing speed; t (38) = .854, $p > .05$. This result suggests that gender does not have any effect on learners' performance in processing speed.

iv) Gender differences in overall mathematical word problem solving performance.

Previous studies had reported that the performance in mathematics word problems differs in boys and girls. To test this assumption, the following hypothesis was formulated.

Mean scores of boys and girls performances in overall mathematical word problems are statistically insignificant (H_0: $\mu_{boys} = \mu_{girls}$).

The table below reports the result of Independent samples t-test:

Table 5: Gender differences in Mathematical Word Problem Solving Performance.

Variable	Gender	Mean	Standard Deviation	SE difference between means	df	t-value	p-value
Mathematics word problems	Boys	234.2	34.910	13.653	38	1.809	.078
	Girls	209.5	50.094				

It can be observed that the *p* – value is greater than .05 level of significance. This means that the mean scores between the two groups is not significant. Therefore, the null hypothesis is accepted at 5% significance level and concluded that there exists no significant difference in the mean scores of boys (M =

234.200, SD = 34.910) and girls (M = 209.500, SD = 50.094) performance in mathematics word problems; t (38) = 1.809, $p > .05$. This result suggests that gender does not have any effect on learners' performance in mathematics word problems. In other words, it can be interpreted that gender has no effect on VII class students overall performance in mathematics word problems.

6. Discussion & Conclusions

Using correlation analysis, the researchers found significant correlation between processing speed and mathematical word problems. This finding concurs with previous studies, which found correlation between processing speed, and mathematical ability, which includes arithmetic operations and arithmetic word problems (Berg, 2008; Bull & Johnston, 1997) [8]. The cognitive ability, processing speed is the time taken by a person to complete a mental task and it depends on the speed in which an individual understand, react, and respond to the information whether it is visual, auditory or kinesthetic. Significant correlation between processing speed and mathematical word problems indicated that learners are capable to perform word problems quickly and fluently with high accuracy. If learners' performance in word problems increases, time taken to complete the processing speed tasks decreases. In this study, processing speed scoring was recorded in terms of correct responses because the tasks were time based. Hence, it can be interpreted that as the learners respond to the tasks correctly, their performance in word problems also increases. Two aspects focusing in the current study are perceptual speed and number facility and learners' performance on tasks associated to these two aspects reflects their processing speed.

According to information processing theory, the sense organs pick up the sensory information, and then it travels through the nervous system and reaches the brain. This information is in then transferred to the short-term store and then move into the long-term store, if the short-term store is capable to hold the information up to 20 seconds. In essence, processing of information depends not only on sensory memory but also on short-term and long-term memory. The first component in the Atkinson-Shiffrin *Information Processing Memory Model* is sensory memory, which is "closely associated with visual and auditory perceptual processing" (Dehn, 2011) [16]. The visual and auditory information present in iconic and echoic memory, respectively, last only for "a matter of milliseconds, just long enough to create a trace or activate some form of representational code from long-term memory for further processing in short-term memory" (Dehn, 2011, p. 13) [16]. Thus, capacity to hold input information varies from person to person, which subsequently hinders the mental processing, if it is not registered. Association of processing speed to short-term memory and long-term memory and how it influence learning can be interpreted in many ways. From the learning perspective, Atkinson and Shiffrin view "short-term memory as the workspace for long-term learning" (Dehn,2011, p.12) [16]. Information in short-term store fades quickly if it is not maintained through *rehearsal* or *sub-vocal repetition*. If it is preserved in the temporary store through rehearsal, it will be encoded or transferred to long-term storage. In fact, long-term retention of information relies on short-term memory or in other words, learning is contingent on the amount of time information resides in temporary storage. It was proposed by Garnett and Fleischner (1983) that the major difficulty children confront while solving arithmetic problems is associated to slow execution of operations, particularly with regard to long-term memory access. These children may be "slower in general information processing and specifically failed to automate arithmetical operations" (Bull & Johnston, 1997, p. 19) [8]. As a result, these children may also likely to suffer from performing complex mathematical tasks, as "performance on such tasks is contingent upon the fluency of carrying out the simple operations underlying them" (ibid). Relating these explanations to this study, it can be stated that slow processing speed, lack of fluency and accuracy in performing word problems can be attributed to deficits in short term as well as long-term memory. It was pointed out by Bull and Johnston (1997) [8] that lack of automaticity or automatic processing as another reason for low performance in mathematics or decreased mathematics ability. As compared to higher achievers, low scorers were slow to recognize numbers, arithmetic computation and problem solving. Additionally, they use "direct memory retrieval" of mathematical knowledge less frequently than higher achievers. The slow automatic processing may be due to "lack of experience, lack of practice and lack of familiarity with the subject area" (Hitch & McAuley, 1991, as cited in Bull & Johnston, p. 19) [8]. Hence, it can be interpreted that learners' knowledge in arithmetic operations, mathematical knowledge, namely, procedural and conceptual knowledge influences their processing speed. The correlation results of this study reported significant correlation between processing speed and mathematical word problems. Thus, it can be stated that participants of this study possess good fluency, accuracy and automaticity in processing information associated with word problems, which occur through the active involvement of memory stores. The substantial influence of processing speed on mathematical word problems supports the theoretical framework of the study. However, further research is required to identify the cognitive abilities that account for mathematical word problems.

Mathematics has a wider scope, which has been reflecting in human life, which encompasses personal, social or wider community. Witnessing its greater role in human life, it is essential to explore the factors that assist students to learn mathematics. It is established in previous studies that learners' success in mathematics problem solving is influenced by several cognitive factors such as perception, attention, memory, and logical reasoning. The word cognition is defined as the "the act or process of knowing". According to Wahyudi and Waluya (2018) "one of the factors that can make students able to learn and understand mathematics well and correctly is cognitive psychology" (p.4). It comprises variety of "psychological process- from sensation to perception, neuroscience, pattern recognition, attention, consciousness, learning, memory, concept formation, thinking, imaging, remembering, language, intelligence, emotions, and developmental processes" (Solso, 2011, p. 2) [42]. These cognitive factors help learners to receive, store and process information when they encounter any kind of problems. Thus, it is important to understand and unveil the role of cognitive abilities in solving mathematical problems, specifically word problems. This study intends to understand how mathematical word problem solving performance in children relates to processing speed, as current literature regarding this issue is sparse.

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