RELATIONSHIP BETWEEN VISUAL MEMORY AND ACADEMIC ACHIEVEMENT OF CHILDREN

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Abstract

The main purposes of this study are to develop the Visual Memory Test, to investigate the level of children's visual memory, to compare children's visual memory by gender and regions, and to explore the relationship between visual memory and academic achievement of children. A total of 548 Grade 6 students were selected by using stratified sampling technique. Visual Memory Test developed by the researchers using IRT was used to measure visual memory of children. Then, Myanmar Achievement Test, English Achievement Test, Mathematics Achievement Test, Science Achievement Test, History Achievement Test and Geography Achievement Test developed by the researcher were used to examine academic achievement of children. The findings indicated that female students have higher level of visual memory than male students. Then, the ANOVA results revealed that there was a significant difference in visual memory by regions. Moreover, the findings stated that visual memory of children was positively correlated with their academic achievement. Furthermore, the results indicated that visual memory was a predictor of academic achievement, especially achievement in Myanmar, English, Mathematics and Science subjects. Therefore, it can be concluded that children with higher visual memory will perform better in their academic achievement.

Keywords: Visual Memory, Academic Achievement, Children

Introduction

Memory is a required part of learning. Children spend a majority of their time in school in pursuit of learning and children with poor memories are known to struggle in school. The capacity to process, store, retain, and subsequently recall information is crucial to support learning. It seems likely, therefore, that children with poor memory functioning will struggle to succeed in basic learning activities (Mammarella & Cornoldi, 2005). Academic-based processes rely on the formation and use of representations, a complex process that requires many cognitive skills, including memory. Visual memory and learning are of fundamental importance for normal classroom learning (Aylward, 2002; Bull, Espy, & Wiebe, 2008; Klin & Jones, 2006; Mitchell, 2006; Packiam, Banner, & Smith, 2010; Rourke, 1988, 1993, 1995). Many aspects of visual cognition are sensitive to learning (Green & Bavelier, 2003). Children who have not developed their visual memory skills cannot readily reproduce a sequence of visual stimuli. They frequently experience difficulty in remembering the overall visual appearance of words or the letter sequence of words for reading and spelling (Addie Cusimano, 2001).

In many countries tests of memory in children have been developed for use in educational and clinical contexts, for example, in aiding diagnoses of several learning difficulties. It is possible that more frequent and comprehensive assessment of memory in schools is warranted, since several studies have linked memory performance to academic or achievement performance in children (Gathercole & Baddeley, 1993). In school settings, memory assessment could potentially serve as a useful tool for teachers and school professionals working with children. Memory assessment results could inform teachers and other educational staff of techniques and strategies that could best assist a child in school.

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For children, deficits in the particular system of visual memory could potentially have adverse effects on academic performance by impairing their ability to match symbols, discriminate between different symbols, learn new symbols, and recognize and recall important symbols such as numbers and letters that are used in school learning tasks (Bavin, Wilson, Maruff, & Sleeman, 2005).

Therefore, there has been no satisfactory explanation of the need to consider the relationship between visual memory and academic achievement of children. This study investigated the relationship between visual memory and academic achievement of children.

Purpose of the Study

The main aim of this study was to investigate the effect of visual memory on academic achievement of children.

The specific objectives of this study were described as follows.

- To develop Visual Memory Test
- To investigate the level of children's visual memory
- To compare children's visual memory by gender and regions
- To explore the relationship between visual memory and academic achievement of children

Definitions of Key Terms

Visual memory. Visual memory is generally defined as any memory in which information is acquired and stored via the visual modality (Hollingworth &Luck, 2008).

Academic achievement. Academic achievement indicates the knowledge attained and skill developed of a learner in the school subject, generally designated by test scores (Bhat, 2012).

Review of Related Literature

Visual Memory

Visual memory refers to the ability to remember what the eyes have seen. It is the ability to retain visual information or to remember (for immediate recall) the various characteristics of a given object or form (Borsting, 2006; Sattler, 2002). If the learners are not attentive to the visual stimuli, they cannot process the visual information to recall or recognize it later (Dednam, 2005).

Visual memory has been defined as "the ability to retain and recall visual experiences" (Todd, 1999). Three processes are fundamental to visual memory:

1. Registration (ability to attend to information for it to be stored),

2. Coding (understanding and structuring information) and

3. Retrieval (finding information stored in long-term memory) (Todd, 1999).

Visual memory can be described as a component of working memory and is often referred to as visual working memory according to Baddeley and Hitch's (1974) theory of the visuo-spatial sketchpad, or a temporary store of visual information. visual working memory capacity increases with age during childhood (Cowan et al., 2005; Heyes, Zokaei, Van der Staaij, Bays, & Husain, 2012; Riggs, McTaggart, Simpson, & Freeman, 2006; Simmering & Perone, 2013). Previous studies have shown that visual working memory storage capacity develops to the adult level by around 10 years of age (Riggs et al., 2006). Adults by around 10 years of age can hold multi-feature

items (e.g., a red square and a yellow rectangle) as well as single-feature items (e.g., a red square and a yellow square) in visual working memory, suggesting that the unit of visual working memory capacity is the integrated object rather than individual features (Luck & Vogel, 1997; but see also Jiang, Makovski, & Shim, 2009; Magnussen, Greenlee, & Thomas, 1996).

Visual Memory and Academic Achievement

Samuels and Anderson (1973) were also interested in the role of visual memory in associational learning and whether children with reading difficulties were more likely to have visual memory deficits. Results of their research found that children who were "good readers" performed significantly higher than "poor readers" on visual recognition tasks. Additionally, the children with high visual recognition scores also tended to perform well on paired associated tasks. Samuels and Anderson (1973) concluded that children's learning is heavily influenced by their perceptual learning abilities. Kulp et al. (2002) conducted a study that specifically examined the relationship of visual memory performance to academic achievement in school age children. Results of their research indicated that there was a positive trend between children's visual memory score and performance on reading decoding, math, and overall academic achievement. Kulp et al. (2002) concluded that poor visual memory scores were associated with an increased likelihood of poor performance globally in academic achievement. Poor visual recall occurs when the learner cannot remember what he or she has seen or read. The learner struggles to remember what the pattern of the word or numbers looks like or is unsuccessful in identifying a similar word or number combination on another page. When the learner is given letters or number combinations to build words, he or she may place them in the wrong order or leave out certain letters or numbers. It is also a challenge to remember the steps to solve mathematical problems (Dednam, 2005).

Method

Research Design

The cross-sectional survey was used in this study.

Participants of the Study

The participants Grade 6 students from Mon State and Ayeyarwady Region (Lower Myanmar) and Mandalay Region, Magway Region and Naypyidaw Union Territory (Upper Myanmar), were selected by using stratified sampling method. A total of 548 children participated in this study. The characteristics of the chosen number of participants are presented in Table 1.

Table 1 Characteristics for Participants of the Study

	Gender		**Total**
	Male	**Female**	
Upper Myanmar Mandalay Region	83	47	130
Magway Region	56	24	80
Naypyidaw Region	46	38	84
Lower Myanmar Ayeyarwady Region	69	45	114
Mon State	58	82	140
Total	**312**	**236**	**548**

Instruments

The Visual Memory Test was developed by the researcher. This instrument consists of 60 items by seven subtests to measure visual memory of children. Then, Myanmar Achievement Test (Cronbach's alpha = 0.683), English Achievement Test (Cronbach's alpha = 0.551), Mathematics Achievement Test (Cronbach's alpha = 0.628), Science Achievement Test (Cronbach's alpha = 0.633), History Achievement Test (Cronbach's alpha = 0.548) and Geography Achievement Test (Cronbach's alpha = 0.542) developed by the researcher were used to examine academic achievement of children.

Data Analysis and Findings

Development of Visual Memory Test

Checking the Assumption of Unidimensionality for IRT

In order to check the assumption of unidimensionality, a principal factor analysis was conducted by using SPSS software package. The scree plot of this test (see Figure 1) clearly showed the dominant of the first factor. According to this figure, the largest eigenvalue of the correlation matrix for 60 items was nearly two times larger than the second largest.

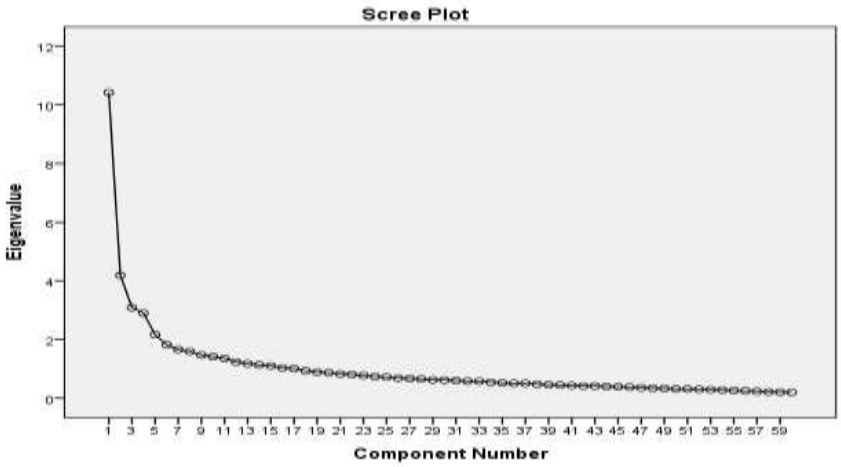

Figure 1 Scree Plot of the Visual Memory Test

Checking the Assumption of Model Data Fit

In this study, the sample of 548 Grade 6 students were administered. According to sample size, 1 PL and 2PL models were selected for checking model data fitness. Goodness of the Model Data Fit was checked by Lord's Chi-square method. Then, there were 22 Misfit items in 1PLM and 13 Misfit items in 2PLM. Therefore, the total numbers of Misfit items in 1PLM was greater than in 2PLM. According to the model data fitness, 2 PL model was used in this study.

Item Analysis of Visual Memory Test

In this section, item analysis and selection procedures of the items will be presented. Scoring scheme is defined as one point for each correct answer for an item and zero point for each incorrect answer per item. In constructing visual memory test by using 2 PL model, the logistics item response model is employed using BILOG-MG 3 and Microsoft Excel. Item parameters and ability parameters were estimated with the BILOG-MG 3 Software package.

Investigation of Item Parameters Using Logistic Item Response Model

In this study, 60 multiple choice items were used according to the table of specifications. The visual memory test was developed by using two-parameter logistics item response model. The item parameters were estimated by IRT after field testing of the test. In the estimation procedure (Phase 2 output), the ability parameter distribution of the examinees was assumed as a standard normal distribution (Mean=0, Standard deviation=1).

The estimation parameter values for item discrimination parameter and item difficulty parameter of 60 items for visual memory test are described in Table 2. It indicates the estimates of item discrimination parameter (slope) *a* and item difficulty parameter (threshold) *b* of the test. The criteria for item selection were decided for item difficulty parameter estimates (*b*) as the range from -2 to +2 and item discrimination parameter estimate (*a*) as the range from 0 to 2. The value of *a* indicates item discriminate between high and low proficiency of students. The high value of *a* shows the higher discrimination power of item between high and low achieves. The value of *b* indicates how the difficult the item is. The negative sign indicates the easier item difficulty and the positive sign indicates the harder item difficulty.

It was observed that item discrimination *a* parameter ranges from 0.086 to 1.235 and the mean of *a* value is 0.431. The range of difficulty *b* parameter of items in the test was from -10.607 to 2.427. The mean of *b* value is -1.537. It was found that item 1, 2, 3, 13, 16, 17, 18, 19, 20, 22, 27, 29, 30, 44, 45, 46, 47, 49, 50, 52, 59 were very easy for examinees due to b values of these items were less than -2. Except these items, all of items had good difficulty level. According to the Phase 2 output, item 1, 2, 3, 13, 16, 17, 18, 19, 20, 22, 27, 29, 30, 44, 45, 46, 47, 49, 50, 52, 59 were not relevant to use in the visual memory test. Finally, 39 items remained in the visual memory test.

Table 2 Item Parameters in IRT Analyses of all items in Visual Memory Test

Item No.	Slope (*a*)	Threshold (*b*)	Item No.	Slope (*a*)	Threshold (*b*)
ITEM0001	0.146	-7.787	ITEM0031	0.819	0.924
ITEM0002	0.197	-3.847	ITEM0032	0.130	1.208
ITEM0003	0.319	-3.091	ITEM0033	0.447	1.088
ITEM0004	0.388	-1.093	ITEM0034	0.274	1.232
ITEM0005	0.453	-1.321	ITEM0035	0.640	2.427
ITEM0006	1.235	-0.092	ITEM0036	0.500	1.568
ITEM0007	0.700	-1.098	ITEM0037	0.091	-1.943
ITEM0008	0.866	-0.857	ITEM0038	0.263	0.104
ITEM0009	0.984	-0.531	ITEM0039	0.391	-0.239
ITEM0010	1.235	-0.275	ITEM0040	0.515	-0.480
ITEM0011	0,404	-1.962	ITEM0041	0.122	-5.981
ITEM0012	0.631	-1.427	ITEM0042	0.358	-0.154

Item No.	Slope (*a*)	Threshold (*b*)	Item No.	Slope (*a*)	Threshold (*b*)
ITEM0013	0.513	-2.051	ITEM0043	0.277	-0.389
ITEM0014	0.388	-1.573	ITEM0044	0.104	-2.173
ITEM0015	0.118	-1.844	ITEM0045	0.383	-2.834
ITEM0016	0.092	-2.555	ITEM0046	0.583	-2.067
ITEM0017	0.492	-2.311	ITEM0047	0.487	-2.928
ITEM0018	0.763	-3.417	ITEM0048	1.210	-0.979
ITEM0019	0.515	-2.955	ITEM0049	0.159	-4.807
ITEM0020	0.699	-2.594	ITEM0050	0.206	-5.412
ITEM0021	0.488	-1.592	ITEM0051	0.896	0.490
ITEM0022	0.255	-4.768	ITEM0052	0.217	-3.901
ITEM0023	0.744	-0.939	ITEM0053	0.654	-0.616
ITEM0024	0.747	-0.735	ITEM0054	0.251	-0.644
ITEM0025	0.481	-0.947	ITEM0055	0.227	-0.685
ITEM0026	0.279	-0.306	ITEM0056	0.193	-1.033
ITEM0027	0.117	-2.804	ITEM0057	0.404	0.038
ITEM0028	0.611	-0.257	ITEM0058	0.266	0.614
ITEM0029	0.086	-10.607	ITEM0059	0.107	-2.076
ITEM0030	0.140	-2.425	ITEM0060	0.720	0.474

Investigation of IRT Graphic Illustration for Visual Memory Test

The matrix plot of Item Characteristics Curve (ICC) for the test items (see Figure 2). The Item characteristics curve (ICC) is a graphical representation of the probability of responding correctly to an item as a function of the latent trait (denoted by θ) underlying performance on the items of the test. The higher the student's ability level (moving from left to right along θ scale, the greater the probability that an examinee corrects the item.

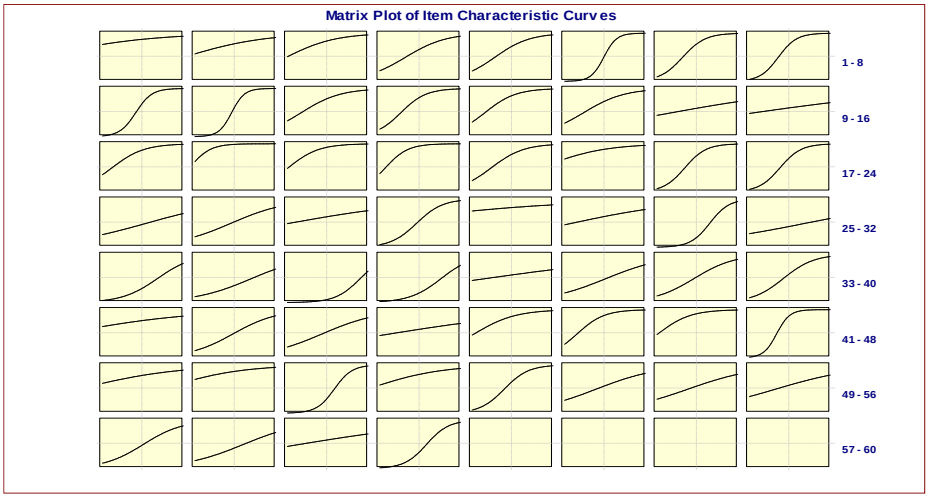

Figure 2 Matrix Plot of Item Characteristics Curves for All Items in Visual Memory Test

The total information curve (TIC) gives the average probability or expected proportion of the correct as a function of the underlying latent trait. According to Demars (2010), the greater information causes, the smaller the standard error and the greater the reliability. TIC is plotted according to the results of parameter estimates of the test.

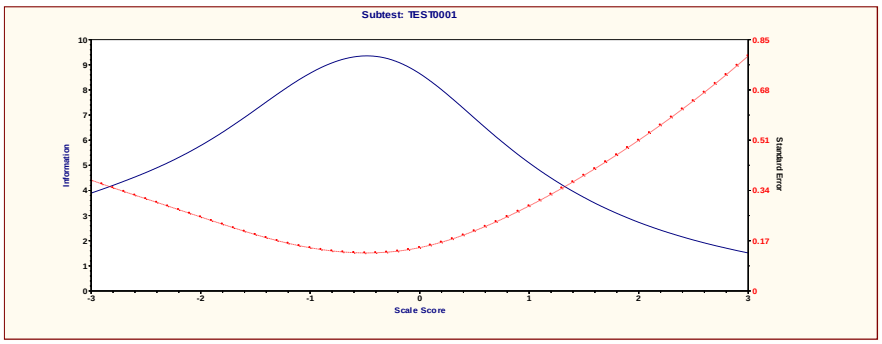

Figure 3 Total Information Curve of Visual Memory Test

The finding indicated that the test had smaller standard error across the ability scale from -2.8 to 1.4 and larger standard error had low and high ends of the scale (see Figure 3). The maximum amount of information was I (θ) = 9.4 at -0.4. Ability estimates are more precise across the ability scale from -2.8 to 1.4. Therefore, it can be interpreted that the test can be used to measure visual memory of children with θ = -0.4.

Investigation of Ability Parameter for Visual Memory Test

Raw scores of each examinee who participated in this study and their ability scores were investigated in scoring output (Phase 3). The range of ability estimation was from -0.0337 (the lowest ability score) to 1.8516 (the highest ability score) and the mean of ability was 0.017 (see Table 3).

Table 3 Ability Parameter of Grade 6 Students

Mean	0.017
Standard Deviation	1.0056
Empirical Reliability	0.8608

Reliability of Visual Memory Test

To examine the internal consistency of visual memory test, Cronbach's alpha was calculated. Cronbach's alpha of the test was 0.773. This result can conclude that the test has high reliability.

Visual Memory Level of Children

By using the statistical analysis, the collected data were analyzed and the results will be described in the following session. The mean score and standard deviation of visual memory was 39.03 and 6.72. Based on descriptive statistics of visual memory, children in this study were identified into three groups: 21.8% of students with scored one standard deviation above the sample mean were considered as high group; 63.8% of students with scores between (+1) and (-1) standard deviation from the sample mean were grouped into moderate group; and the remaining students of 14.4% who scored one standard deviation lower than the sample mean were identified as low group (see Figure 4).

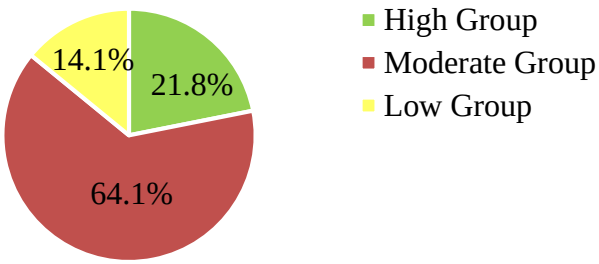

Figure 4 Three Different Groups of Visual Memory of Children

Comparison for Visual Memory of Children by Gender

In order to investigate whether there was a gender difference in visual memory of children. The mean scores of males and females in visual memory were analyzed in Table 4.

Table 4 The Mean, Standard Deviation and Independent Sample *t*-test Results of Visual Memory by Gender

Variable	Gender	*N*	Mean	*SD*	*t*	*p*
Visual Memory	Male	312	38.20	6.63	-3.376**	0.009
	Female	236	40.14	6.69		

Note. ** p < 0.01

The results of independent samples *t*-test confirmed that there was significant difference in visual memory of children by gender. The mean score of female students was higher than the mean score of male students in visual memory.

Comparison for Visual Memory of Children by Region

To make more detailed information on the difference of children's visual memory by regions, one-way Analysis of Variance (ANOVA) was conducted (see Table 5). ANOVA results

indicated that there was significant difference of visual memory by regions, F (4, 543) = 7.616, p < .001.

Table 5 ANOVA Results of Mean Comparison for Visual Memory by Regions

Variable	Regions	*N*	*M*	*SD*	*F*	*p*
Visual Memory	Region 1	114	36.04	6.7	7.616***	0.000
	Region 2	140	40.16	6.1		
	Region 3	130	39.53	6.1		
	Region 4	80	39.85	7.04		
	Region 5	84	39.65	7.5		

Note. *** $p < 0.001$

To obtain more detailed information for regions, post hoc test was carried out by Tukey HSD multiple comparison procedure for Region 1, Region 2, Region 3, Region 4 and Region 5 (see Table 6). The findings revealed that children's visual memory from Region 1 was significantly lower than other regions (Region 2, Region 3, Region 4 and Region 5).

Table 6 Results of Tukey HSD Multiple Comparisons for Visual Memory by Regions

Variable	(I)Region	(J)Region	Mean difference(I-J)	*p*
Visual Memory	Region 1	Region 2	-4.113***	.000
		Region 3	-3.487***	.000
		Region 4	-3.806**	.001
		Region 5	-3.611**	.001

Note. ** p < 0.01, *** p < 0.001

Relationship Between Visual Memory and Academic Achievement of Children

As one of the objectives of this study, the correlational analysis was conducted to find out whether there is a relationship between visual memory and academic achievement (Myanmar achievement, English achievement, Mathematics achievement, Science achievement, Geography achievement, History achievement) of children (see Table 7).

Table 7 Correlation Between Visual Memory and Academic Achievement (Myanmar Achievement, English Achievement, Mathematics Achievement, Science Achievement, Geography Achievement, History Achievement) of Children

Variables	Academic Achievement	Myanmar Achievement	English Achievement	Mathematic Achievement	Science Achievement	Geography Achievement	History Achievement
Visual Memory	.745**	.560**	.486**	.745**	.557**	.029	-.034

Note. ** p < 0.01

According to the Table 7, the result revealed that there was a significant relationship between visual memory and academic achievement of children because the correlation coefficient was statistically significant (r = .745, p < 0.01). So, it can be said that visual memory of children

was positively correlated with their academic achievement. In other words, the higher children's visual memory, the higher their academic achievement. Moreover, there is a significant relationship between visual memory and Myanmar achievement, English achievement, mathematics achievement, science achievement at 0.01 significance level. But there is no significant relationship between visual memory and history achievement. Similarly, there is no significant relationship between visual memory and geography achievement (see Table 7)

Regression Analysis for the Prediction of Visual Memory

To make more detailed investigation, further detail analyses and computations were undertaken by using regression analyses.

Predictive Power of Visual Memory on Academic Achievement

To examine the predictive contribution of visual memory on academic achievement, linear regression analysis was conducted. The results of linear regression analysis pointed out that the visual memory made predictive contribution to academic achievement; F (1, 547) = 399.714, p < 0.001 and explained for 42.2% (adjusted R^2) of the variance in academic achievement (see Table 8).

Table 8 Simple Linear Regression Analysis Predicting Academic Achievement from Visual Memory

Predictor	B	Std. Error	β	*t*	*R*	R^2	Adjusted R^2	*F*
Constant	41.00	.777			.745	.555	.555	399.714***
Visual Memory	.883	.034	.745	19.993				

Note. *** p < 0.001

The resultant model for this relationship can be identified as the following equation;

AA = 41 + 0.883 VM

Note. AA = Academic Achievement**,** VM = Visual Memory

Predictive Power of Visual Memory on Myanmar Achievement

To examine the predictive contribution of visual memory on Myanmar achievement, linear regression analysis was conducted. The results of linear regression analysis pointed out that the visual memory made predictive contribution to Myanmar achievement; F (1, 547) = 399.714, p < 0.001 and explained for 42.2% (adjusted R^2) of the variance in Myanmar achievement (see Table 9).

Table 9 Simple Linear Regression Analysis Predicting Myanmar Achievement from Visual Memory

Predictor	B	Std. Error	β	*t*	*R*	R^2	Adjusted R^2	*F*
Constant	4.258	.292			.65	.423	.422	399.714***
Visual Memory	.254	.013	.650	19.993				

Note. *** p < 0.001

The resultant model for this relationship can be identified as the following equation;

MA = 4.258 + 0.25 VM

Note. MA = Myanmar Achievement, VM = Visual Memory

Predictive Power of Visual Memory on English Achievement

To examine the predictive contribution of visual memory on English achievement, linear regression analysis was conducted. The results of linear regression analysis pointed out that the visual memory made predictive contribution to English achievement; F (1, 547) = 169.204, p = .000 and explained for 31.9% (adjusted R^2) of the variance in English achievement (see Table 10).

Table 10 Simple Linear Regression Analysis Predicting English Achievement from Visual Memory

Predictor	B	Std. Error	β	*t*	*R*	R^2	Adjusted R^2	*F*
Constant	6.546	.295			.586	.321	.319	169.204***
Visual Memory	.167	.013	.586	13.008				

Note. *** p < 0.001

The resultant model for this relationship can be identified as the following equation;

EA = 6.546 + 0.167 VM

Note. EA = English Achievement, VM = Visual Memory

Predictive Power of Visual Memory on Mathematics Achievement

To examine the predictive contribution of visual memory on mathematics achievement, linear regression analysis was conducted. The results of linear regression analysis pointed out that the visual memory made predictive contribution to mathematics achievement; F (1, 547) = 681.486, p = .000 and explained for 55.4% (adjusted R^2) of the variance in mathematics achievement (see Table 11).

Table 11Simple Linear Regression Analysis Predicting Mathematics Achievement from Visual Memory

Predictor	B	Std. Error	β	*t*	*R*	R^2	Adjusted R^2	*F*
Constant	5.472	.242			.745	.555	.554	681.486***
Visual Memory	.275	.011	.745	26.105				

Note. *** p < 0.001

The resultant model for this relationship can be identified as the following equation;

MA = 5.472 + 0.275 VM

Note. MA = Mathematics Achievement, VM = Visual Memory

Predictive Power of Visual Memory on Science Achievement

To examine the predictive contribution of visual memory on science achievement, linear regression analysis was conducted. The results of linear regression analysis pointed out that the

visual memory made predictive contribution to science achievement; F (1, 547) = 246.217, p = .000 and explained for 31% (adjusted R^2) of the variance in science achievement (see Table 12).

Table 12 Simple Linear Regression Analysis Predicting Science Achievement from Visual Memory

Predictor	B	Std. Error	β	*t*	*R*	R^2	Adjusted R^2	*F*
Constant	4.546	.284			.557	.311	.310	246.217***
Visual Memory	.194	.012	.557	15.691				

Note. *** p < 0.001

The resultant model for this relationship can be identified as the following equation;

SA = 4.546 + 0.194 VM

Note. SA = Science Achievement, VM = Visual Memory

According to the results, visual memory was a predictor to Myanmar achievement, English achievement, Mathematics achievement and Science achievement. However, visual memory did not contribute to geography achievement and history achievement.

Discussion

Firstly, this study confirmed that the Visual Memory Test can be measured to examine visual memory for Myanmar children.

Secondly, the findings indicated that female students have higher level of visual memory than male students. The results of this study are consistent with a male advantage in visual-spatial working memory although age and specific task modulate the magnitude and direction of the effects (Voyer, 2017). Moreover, the results revealed that there was a significant difference in visual memory by regions.

In addition, the findings stated that visual memory of children was positively correlated with their academic achievement. Furthermore, the results indicated that visual memory was a predictor of academic achievement, especially in Myanmar achievement, English achievement, Mathematics achievement and Science achievement. Therefore, it can be concluded that children with higher visual memory will perform better in their academic achievement.

Therefore, visual memory can affect academic achievement of children. Teachers and parents should help children to improve their visual memory. Teachers should help children by teaching using visual teaching aids. When the teachers use the teaching learning materials (e.g., using pictures and objects), children will interest in their learning. So, teaching-learning process is effective and visual memory of children will improve and they will perform better in their academic learning.

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