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Research Paper

The Study on Working Memory and Academic Performance among School Students

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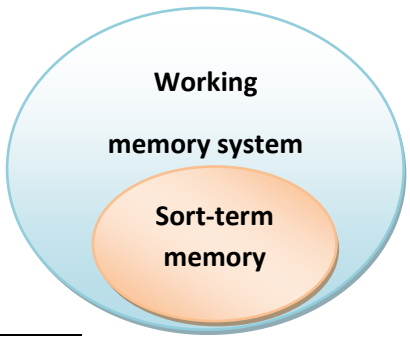
ABSTRACT

A form of short-term memory, which Baddeley named working memory, through which functional processes occur in a person. The amount of its capacity has an impact on every aspect of a person's life, business, mental health, academic performance, etc. Academic performance indicates the student's passing criteria and progress in their education. The purpose of this study is to explore the relationship between working memory how it impacts academic performance. In this study, we took 240 participants (120 female and 120 male) whose age range was 7 to 16 years, and the mean was 13.4 years. In this study, 3 × 2 × 2 ANOVA design has been used. Correlation and regression have also been used. Result of the study, a positive correlation has been found between working memory and mental health and its positive effect on academic performance has been found. So concluded Through training, children's working memory can be enhanced academic performance can be improved.

Keywords: *Working memory, Academic Performance*

Working memory is a cognitive system responsible for temporarily storing and manipulating information essential for tasks like problem-solving and comprehension. Unlike long-term memory, it operates on a temporary basis, holding information for seconds to minutes. It consists of multiple components, including the phonological loop and visuospatial sketchpad, episodic buffer by the central executive. Individual differences in working memory capacity impact cognitive abilities, with higher capacity associated with better academic performance and problem-solving skills. Factors like age, genetics, and environmental influences influence working memory capacity.



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Working memory model

The Working Memory Model proposed by Baddeley and Hitch consists of three main components: the central executive, the phonological loop, and the visuospatial sketchpad. The central executive acts as the supervisory system, coordinating information from the other two components and managing cognitive tasks. The phonological loop stores verbal information through the phonological store (inner ear) and the articulatory control process (inner voice), facilitating tasks like language comprehension and rehearsal. Meanwhile, the visuospatial sketchpad handles visual and spatial information, aiding in tasks such as navigation and mental imagery. These components interact dynamically, with the central executive allocating resources and coordinating their functions. Additionally, the model incorporates an episodic buffer, which integrates information from multiple sources into a single representation. This simplified figure illustrates the interplay between these components in working memory.

New study has revealed that working memory plays an important role in readingand early academic performance among children. The study suggested that children with difficulties might benefit from teaching methods that present working memory overloaded. Several factors which are influence by working memory are Intelligence (Christina S Beck, 2012), Reasoning (kyllonen, P. C & Christal R.E.; 1990), Mathematics ability (H. Lee Swanson, Margaret beebe –Frankenbergez, 2004; Wittmann, W.W & Sub H, 1999) Decision making (Reyne, V F, 2003), Reading (Chaippe, P. Hasherh &Siegel L S, 2000; Crain, S. Shankweiler, D Macaruss, P & Bar shalon E, 1990; Swanson, H L, 2003), and School performance.

Academic performance

Academic performance refers to an individual's performances and outcomes in educational settings. It includes grades, test scores, participation, and overall success in learning endeavours. Academic performance reflects mastery and understanding of academic content and skills within a specific curriculum. Factors influencing academic performance include cognitive abilities, motivation, study habits, and environmental factors such as socioeconomic status and access to resources. Higher academic performance is often associated with better opportunities for future education and employment, highlighting its importance in personal and professional development.

Student with working memory difficulties take much longer time much longer time to process information. They are unable to cope with time activities and fast presentation of information. As a result, they often and up abounding the activities all together out of frustration research studies conducted previously point out that in general working memory was linked with academic performance in India perhaps little research has yet been done in this field. Thus, it would also be relevant to study the effect of working memory on academic performance of student. Against this backdrop this study is planned to investigate of working memory on academic performance of school students.

Objective of the Study:

This research was conducted with following objectives:

- To examine of the effect of academic Performance on working memory.
- To assess the effect of age and gender on working memory.
- To examine the relationship between academic performance and working memory as well as to assess the differential role of demographic characteristics and academic performance in working memory.

Hypothesis:

Based on the above objectives following hypothesis were formulated. It was hypothesized that:

- Academic Performance would exert favourable effect on working memory. More specifically, High academic Performance group of children would be found superior in working memory as compared children with Average and Low academic performance groups.
- The level of working memory would vary in accordance with age level of children. More specifically younger group of children (8-12 year) would be found inferior in working memory than elder group (12-16).
- The level of working memory would differ between boys and girls.
- Academic Performance level, age and gender would play contributing role in working memory and its domains.

METHOD

Design:

Present research would be based on 3x2x2 factorial design with three groups of academic performance (high, average, and low) x two age groups (younger, 8-12yrs & elder, 13-16yrs) x two gender (Boys and Girls). Further, to assess the relationship between working memory and academic performance Correlations and regression analyses were done.

Participants:

A total 240 school students, age ranged 8-16 years (120 boys and 120 girls), studying in different schools of Gorakhpur city, participated in present study. Stratified random sampling technique was be used for selection of participants.

Measuring Tools:

A set of measuring tools were used. A brief description of these measures is given below:

- **Personal Data Sheet (PDS):** Personal data background characteristics of participants were determining on the basic of personal data sheet (PDS) was used.
- **Academic Performance Questionnaire:** Academic performance Questionnaire developed and standardized by Sharma; T. R. (1971) was used for measuring on the performance of children. Sharma, T.R. (1971) the inventory seeds to range Performance different types of school.
- **Working Memory Task:** To assess the level of working memory in different age group of children. The working memory task as mentioned below was used:
- **Reading Span Task (RSPAN):** RSPAN is originally devised by Deneman and carpenter (1980) and received by Lusting et al (2001). This task was devised to measured the combined processing and storage capacity of working memory during reading. However, in Indian context reading span task was modified by Pandey and Tamta (2010). This contained 30 sentences each on written on a separate card. The length of each sentence given in card is ranged 8 to 12 words. These cards were categorized under five sets basses on increasing the number of sentences. Each card was shown for ½ second.
- **Visual Pattern Recall (VSPAN):** In Indian context Visual Span Recall Task developed by Pandey and Tamta (2010) on the basic of Visual Span Task (Wilson et al., 2010). Visual Pattern Recall Task of 25 geometric designs composed of filled (black) and unfilled (white) part. Each card consisted of one geometric design. The participant was instructed to look carefully at the pattern and try to remember where

black part with design was. The design was printed on the card and there was a half second delay before presentation of empty geometric design of the same size for recall after the presentation of an empty geometric design of the same size for recall. After the presentation of card assigned, immediate memory test was done.

- **Operation Span Task (OSPAN):** This task is based on Operation Span Task (Turner & Engle., 1989). This task is modified by Pandey and Tamta (2010). This task consisted of 30 math equations. Each card contains one math equation and one unrelated word. These cards were categorized under five sets based on increasing the number of math equation along with words. Each card was shown for ½ second. After the presentation of each set, respondent was asked to recall the word in proper order.

Procedure

The study was conducted in multiple phases. In the first phase of study, children were contacted in school setting, and then proper rapport was established. After this, they were given a booklet containing measure of Background information. Firstly, they were requested to fill up background information.

As they completed this portion, they were requested again to respond on academic performance and academic Performance questionnaire. Following instruction were given, "please read each item in questionnaire and put correct response according to your past experiences in front of each item. What you feel in correct in your own case. Think about it and then correct answer. Your response will be kept confidential.

As they completed response on academic performance questionnaire, then again requested in second phase of the study. Furthermore, in the second phase of the study all the children were contacted again. First, children were given one by one responded on working memory task. As completed their responded of this measure, data were collected, and they were thanked for their participation.

Data were scored according to the defined rules given in measure section to facilitate to the defined rule given in measure section to facilitate further statistical analysis.

Data Analys

Responses obtained from the respondents on the various measures were scored according to the defined rules. After the scoring phase, further statistical analysis was planned the scores was treated for computer analysis in terms of univariate, correlation, and regression analysis using SPSS-21 version. Result was interpreted and discussed in the light of relevant empirical and theoretical evidence.

RESULTS AND DISCUSSION

This section contains results obtained from the statistical analysis of responses given by participants on various measures. First section deals with ANOVA results, whereas correlation results are displayed in second section and last section of the results includes step- wise multiple regression analysis (SMRA). Obtained result are reported and interpreted in following section.

Univariate analysis: Scores obtained on various components of working memory in term of Means, S.Ds. and analysis of variance (ANOVA) and obtained results are displayed in table and figures reported below.

Phonological working memory as a function of academic performance, gender, and age: Table 1 displays Means and S.Ds. of phonological working memory scored. Results show that phonological working memory differ across level of academic performance, gender and age (Table -1 and fig. 1)

Table-1: Mean and S.Ds. of phonological working memory by academic performance, gender, and age

Sources of variable	Sum of square	df	Mean of square	F- value
Between A (level of academic performance)	233.82	2	116.91	9.323**
Between B (gender)	20.48	1	20.48	1.634
Between C (age)	582.38	2	291.192	23.221**
A x B	25.37	2	12.68	1.012
A x C	56.57	2	28.207	2.156
B X C	2.02	1	2.02	.161

Table-2: Summary of 3x2x2 ANOVA (level of academic performance x gender x age) of phonological working memory

Variables		High Academic Performance		Average Academic Performance		Low Academic Performance	
		Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
Younger children (8-12yrs)	**Means**	12.55	14.20	11.17	12.13	11.07	10.00
	S. Ds	4.06	2.94	3.33	3.07	3.17	3.38
Elder children (13-16)	**Means**	16.80	16.80	17.60	16.34	11.36	15.55
	S.Ds.	4.09	3.39	3.61	3.99	3.64	3.12

Furthermore, to ascertain the significant differences among groups, a 2x2x2 factorial analysis of variance was computed, summary of ANOVA results is displayed in table (table 1.2). ANOVA results reveled that main effect of level of academic performance was found significant [F=9.232, p<.01]. Results indicate that high academic performance group was found superior on phonological working memory then average and low academic performance group (Fig.1). Further significant main effect of age [F=23.22, p<.01] main effect of age denotes those younger children performed poor on phonological component of working memory as compared to older children (fig. 2)

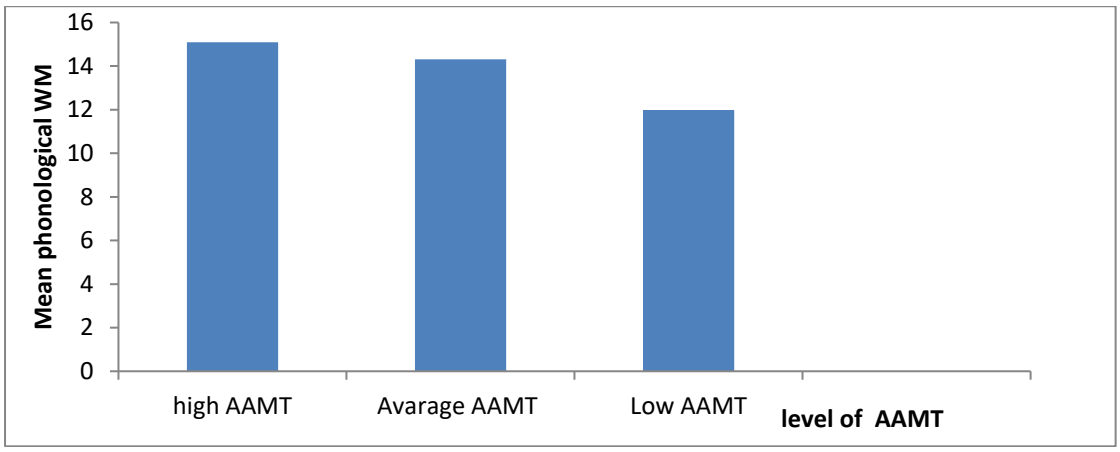

Fig.-1: Phonological working memory as a function of level of academic performance

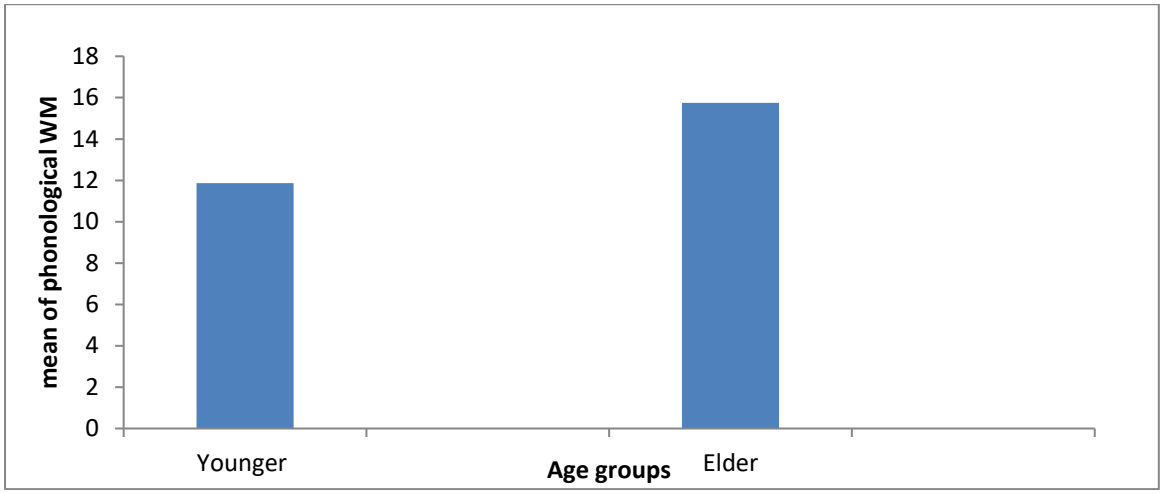

Fig.-2: Phonological working memory as a function of age

Visuo- spatial working memory as a function of academic performance, gender, and age: Table1.3 display Means and S.Ds. of visuo-spatial working memory scored. Result show that visuo spatial working memory scores indicate that differed in accordance level of academic performance, gender, and age (table-3 and Fig.-3& 4).

Table-3: Means and S.Ds. of visuo-spatial working memory, academic performance gender and age

Variables		High academic performance		Average academic performance		Low academic performance	
		Boys	Girls	Boys	Girls	Boys	Girls
Younger group(8-12yr)	Mean	14.778	15.200	12.714	11.827	11.00	11.333
	S. Ds	5.166	2.280	3.397	2.619	4.178	3.661
Elder group (8-12yr)	Mean	18.200	17.400	18.087	14.156	12.454	11.133
	S.Ds.	3.075	3.025	2.372	3.437	3.958	3.64

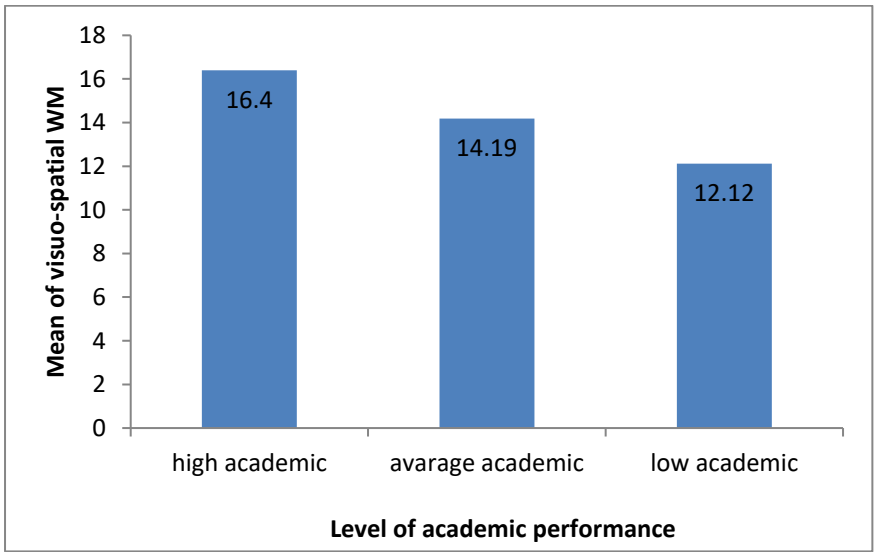

Fig-3: visuo-spatial working memory as a function of academic performance

To ascertain the significant impact of level of academic performance, gender and age on visuo-spatial working memory, ANOVA analysis was done and obtained result are presented in Table 4.

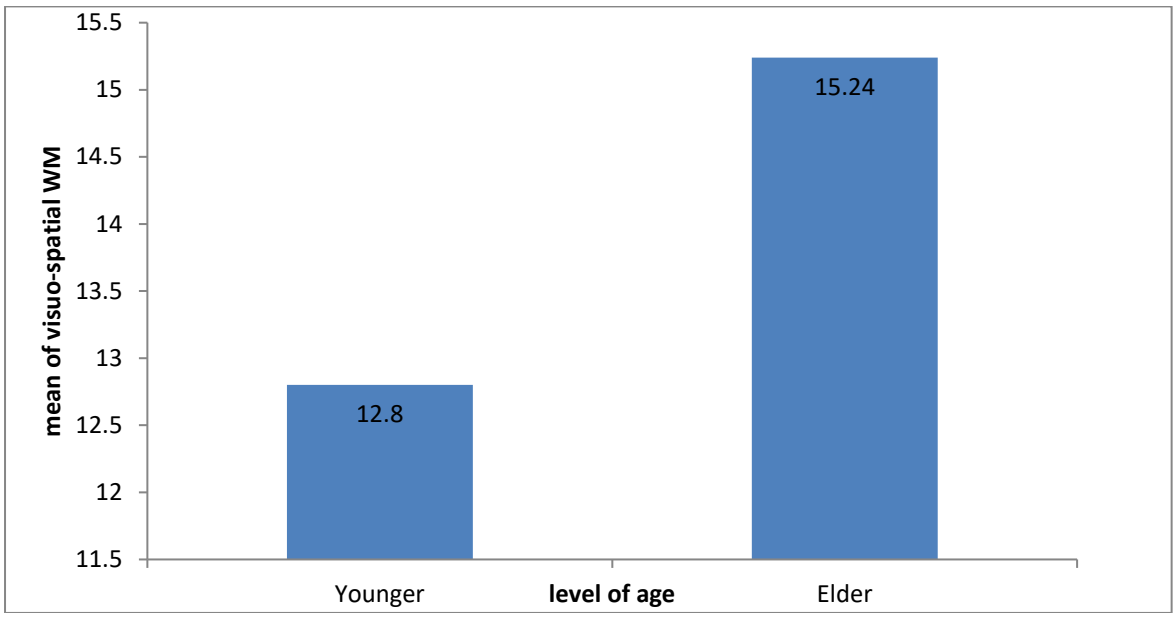

Fig-4: visuo-spatial working memory as a function of age

Table-4: Summary of 3x2x2 ANOVA (Level of academic performance x gender x age) of visuo-spatial working memory

Sources of variable	Sum of square	df	Mean square	F-values
Between A (level of academic performance)	384.732	2	192.366	16.908**
Between B (gender)	18.071	1	18.021	1.588
Between C (age)	297.718	2	148.859	13.084**
A x B	82.012	2	41.006	3.604*
A x C	34.731	2	17.366	1.526
B x C	12.801	1	12.801	1.125
A x B x C	30.125	2	15.062	1.324

N=200, **p<.01, *p<0.05

Further, significant main effect of level of academic performance [F=16.908, P<.01] revealed high AAMT group were (M=16.40) superior on visuo-spatial working memory then average (M=14.19) and low academic performance (M=12.12) group (fig.-3) and significant main effect of age [F=13.084, P< .01] revealed that younger children (M=12.808) performed poorly on visuo-spatial working memory as compared to older children (M=15.24),(fig.-4). A development pattern with increasing age was further identified however, interaction effect of level of academic performance and gender on visuo-spatial working memory was found significant [F=3.604, p>.01] (fig.-5) and interaction effect of

level of academic performance, age and gender on visuo-spatial working memory non-significant.

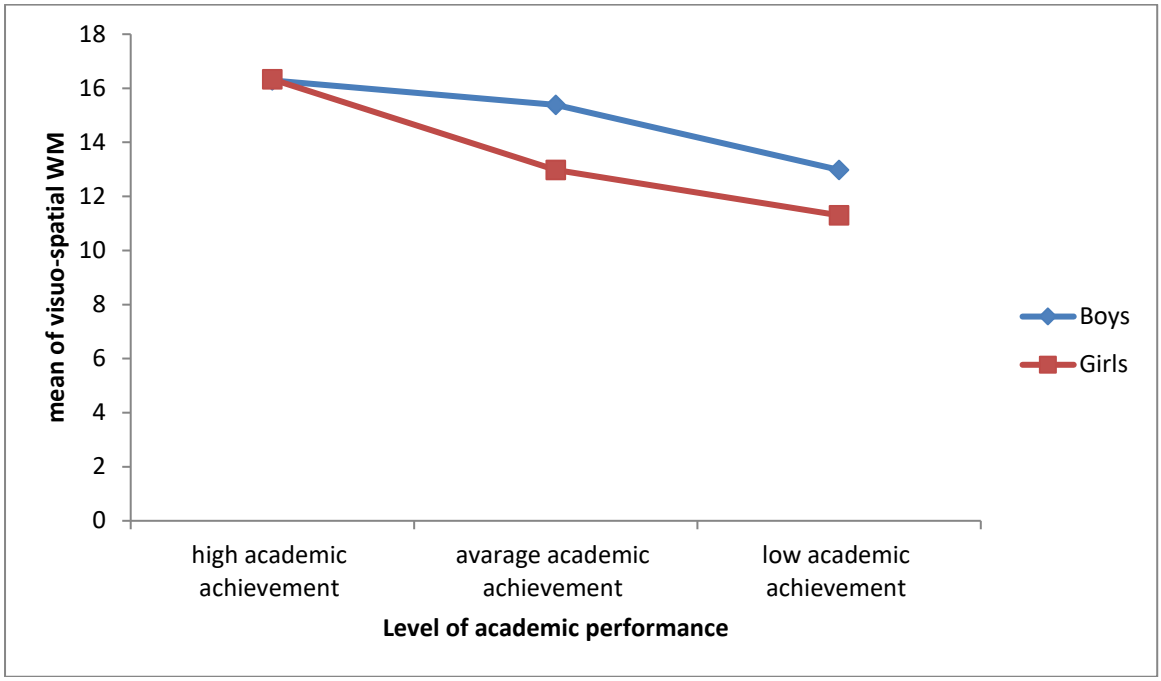

Fig-1.5: visuo-spatial working memory as a function of academic performance & Gender

Central executive working memory as a function of academic performance, gender and age: Table1.5 presents Mean and S.Ds of central executive working memory. Result shown in table-5 and fig.-6 denote that different groups of children varied on central executive working memory.

Table-5: Means, and S.Ds. of central executive working memory by academic performance academic performance gender and age

Variable		High academic performance		Average academic performance		Low academic performance	
		Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
Younger children (8-12yrs)	**Means**	11.22	11.00	10.142	11.241	9.69	8.200
	S.Ds.	2.27	1.87	3.285	4.111	3.838	2.305
Elder children (13-16yrs)	**Means**	17.53	18.500	17.304	14.250	9.545	12.555
	S.Ds.	3.77	3.171	3.308	3.57	4.251	4.275

ANOVA results displayed in Table-4 showed that central executive differed significantly across the level of academic performance academic performance, gender, and age.

Table-6: Summary of 3x2x2 ANOVA (Level of academic performance x gender x age) of central executive working memory

Sources of variation	Sum of square	Df	Means square	F value
Between A (level of academic performance)	485.738	2	242.869	19.53
Between B (Gender)	.097	1	.o97	.008
Between C (age)	937.763	2	468.882	37.704
A x B	29.430	2	14.715	1.183
A x C	122.776	2	61.388	4.936*
B x C	2.444	1	2.444	.197
A x B x C	166.090	2	83.045	6.678*

N=200 **p<.01, *p<0.05

Significant interaction effect of level academic performance x age [F=4.936, p<0.05]. Interaction graphs show that in case of high academic performance group very little improved was observed in central executive working memory with developing age. On the other hand, in case of low academic performance group, older children were found far superior in central executive working memory then younger children. Level of academic performance x gender x age interaction effect (Table-6 & fig.-7) was also found significant [F=6.678, p<0.05].

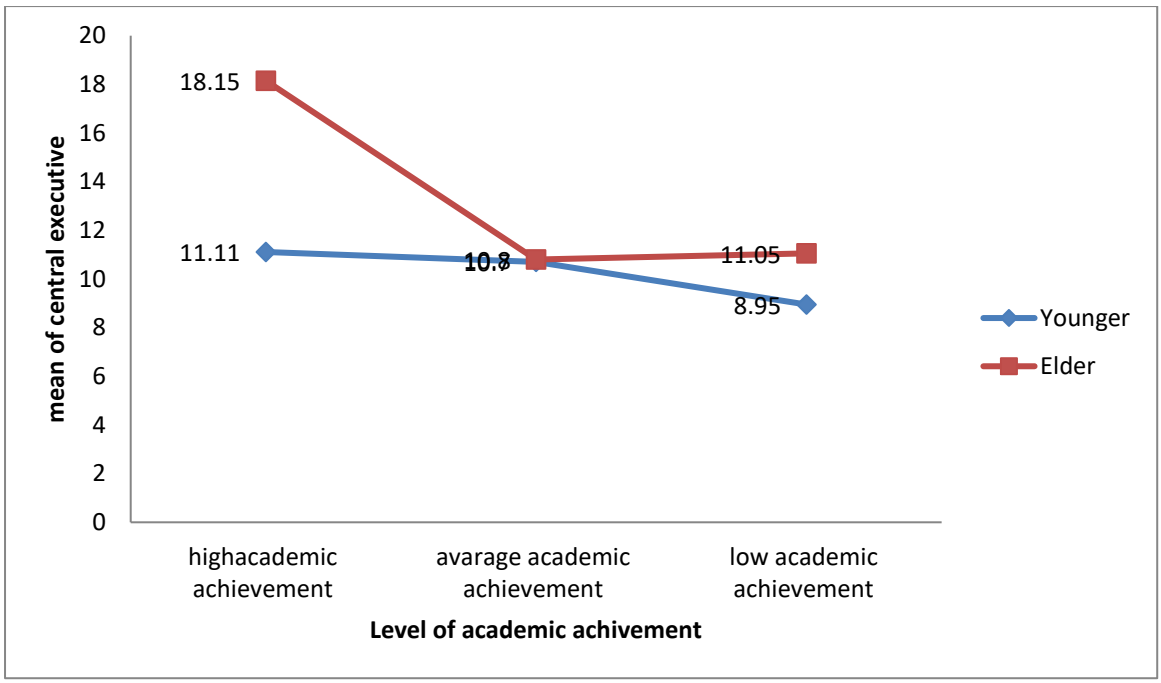

Fig.-6: Central executive working memory as a function of interaction of academic performance academic performance & age

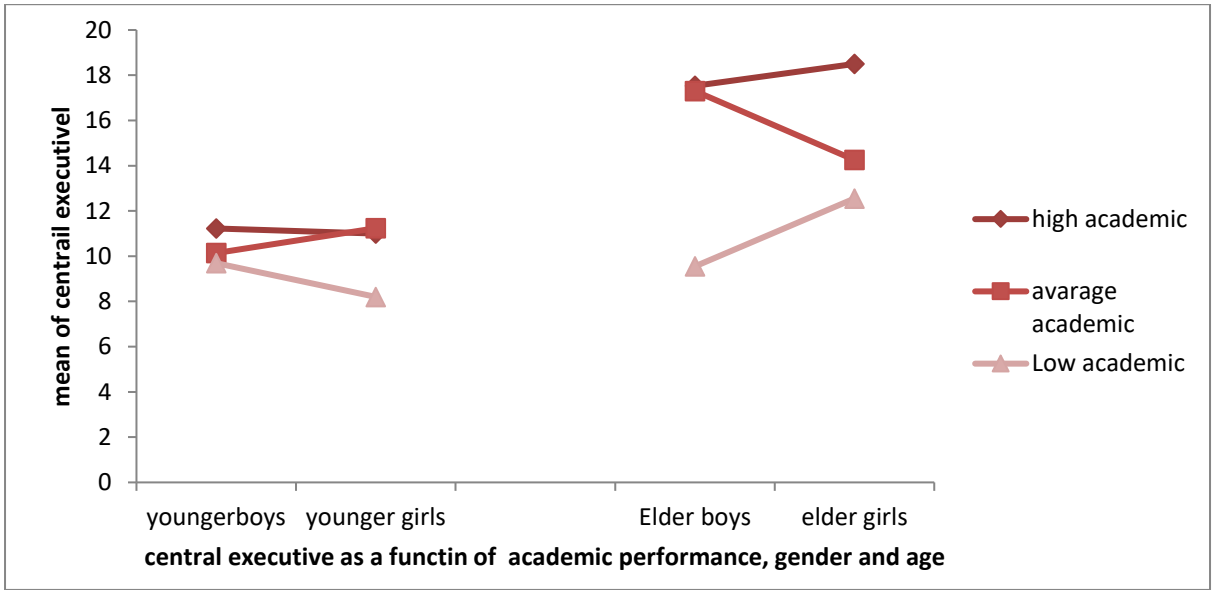

Fig.-7: Central executive working memory as a function of interaction of academic performance, gender and age.

Effect of level of academic performance, Gender and Age on working memory (overall): Table1.7 displays Means and S.Ds. of working memory (overall) different group of children.

Table-7: Mean and S.Ds. of working memory (overall) by academic performance, Gender and Age.

Variable		High academic performance		Average academic performance		Low academic performance	
		Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
Younger children (8-12yrs)	**Means**	38.555	40.400	34.035	35.206	31.769	29..333
	S.Ds.	8.819	5.504	6.362	7.148	10.401	7.499
Elder children (13-16yrs)	**Means**	52.533	52.700	53.000	44.750	33.363	41.444
	S.Ds.	9.553	8.246	8.129	8.721	9.800	8.048

ANOVA results (Table-7, 8, fig.9-10, 11, 12) show that magnitude of working memory different across level of academic performance gender and age. ANOVA results are show in table 8.

Table-8: Summary of 3x2x2 ANOVA (Level of academic performance academic performance x gender x age) of working memory (overall)

Source of variation	Sum of square	Df	Means square	F value
Between A (level of AAMT)	3169.460	2	1584.730	23.644
Between B (gender)	.344	1	.344	.005
Between C (age)	5085.785	2	2542.892	37.940
A x B	.350	1	.350	.005*
A x C	454.569	2	227.284	3.391
B x C	379.039	2	189.519	2.828*
A x B x C	816.299	2	408.150	6.090*

N=200 **p>.01 *p>0.05

As table -8 display, significant level of academic performance x gender interaction effect (fig. 9) was found be significant [F =. OO5, P> .05]. Interaction graphs show that high academic performance girls children performed superior on working memory (overall as compared to boys' children. Similarly, a consistent pattern of increment was observed. Contrary to this in case of low academic performance group very slow improvement on working memory found from girls to boys' group of children. Gender x age interaction effect (fig. 8) was found be significant (F=2.828, P >0.05] interaction graph shows that in high academic performance children performed superior in working memory (overall)as compared to younger children. Similarly, as consistent pattern of increment was observed in case of high academic performance children contrary to this in case of average and low academic performance group very slow improvement on working memory was found younger to older age group of children. Level of academic performance x gender x age interaction effect (Fig.-10) be found significant [F =6.090, P < .05].

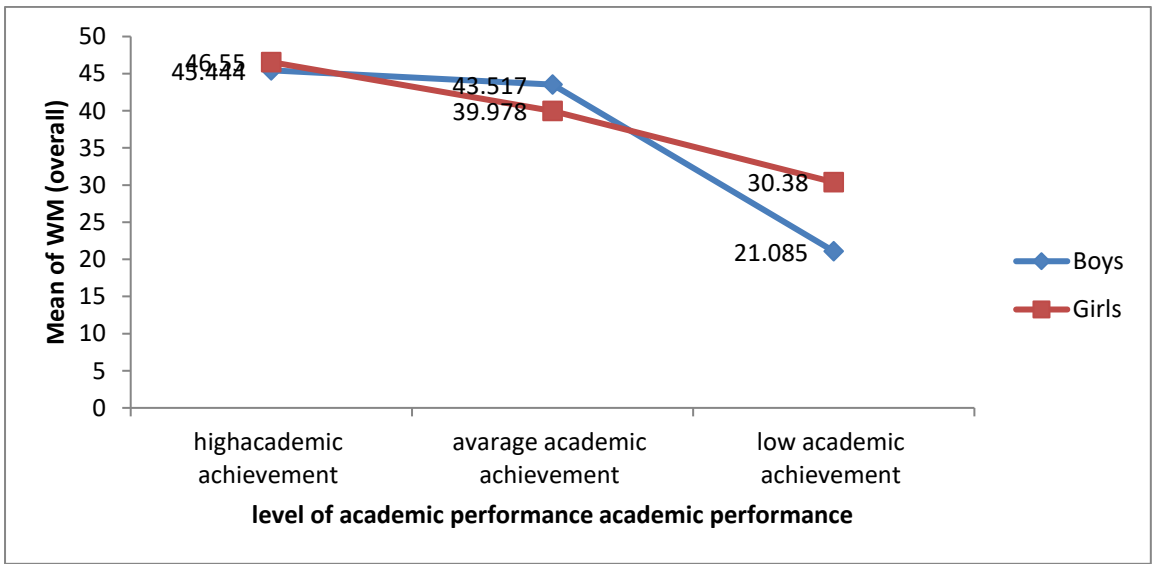

Fig.-8: Overall working memory as a function of interaction of academic performance and gender

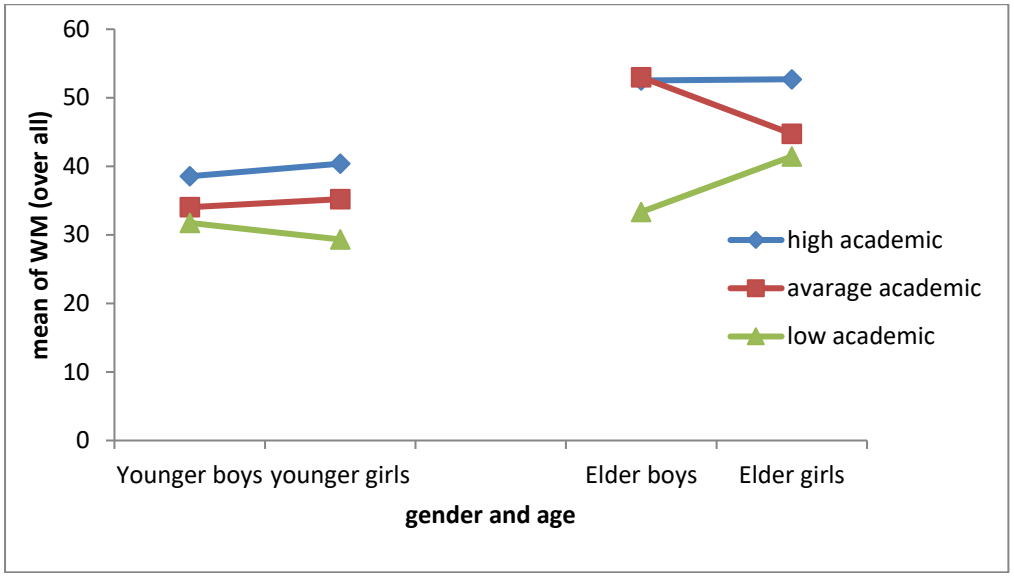

Fig.-10: Overall working memory as a function of interaction of academic performance, gender, and age.

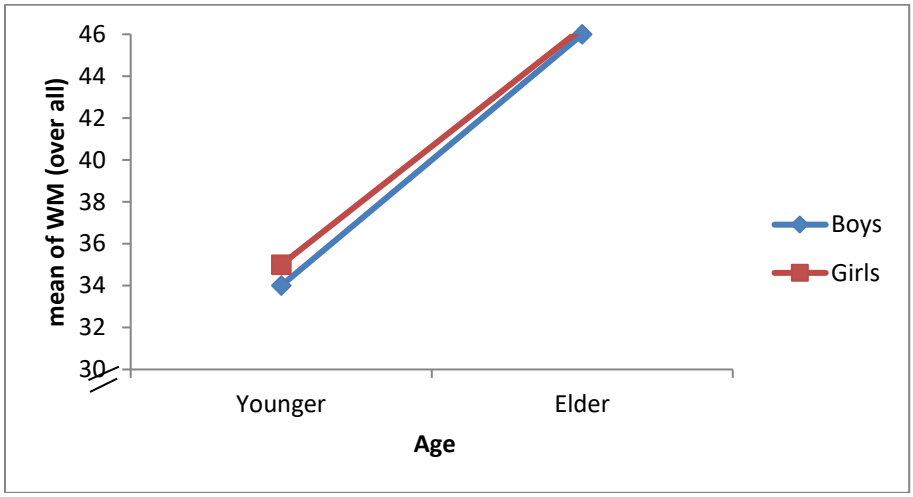

Fig.-9: Overall working memory as a function of gender and age.

ANOVA result thus evinced that with developed academic performance, age gradual improvement in working memory was found. However, level of academic performance excised positive impact on various component of working memory. More specifically, high AAMT children performed very superior on various component of working memory whereas, gradual decrease in working memory was found in case of low academic performance academic performance group of children.

Correlation Results-

- To obtain further insight into the relationship among studied variables correlational analysis was undertaken to examine the
- Relationship between age and working memory and its components.
- Relationship between different levels of academic performance and components of working memory and
- Linkage between different level of academic performance, gender, age and working memory.

- Correlations were calculated and obtained results are displayed in table.

Table-9: Relationship between age, gender, academic performance, and component of working memory

Variable	Working Memory Component			
	Phonological working memory	**Visuo-spatial working memory**	**Central executive working memory**	**Overall working memory**
Age	.289**	.290**	.220**	.307**
Gender	.042	-.166	-.042	-.061
AAMT	.364**	.433**	.388**	.457**

Relation between Age and Working memory: Age was positive correlated with working memory (Table-9). Result indicate that the phonological working memory was found to be positive related with age (r = .289). Central executive was also found to be positive related with age (r=.290) followed by visuo-spatial working memory (r=.220) and overall working memory (r=.307).

Relation between Gender and Working memory: As above table shows, gender was positively related with phonological working memory(r=.042). Further visuo-spatial component of working memory was negatively correlated with gender (r=-.166) followed by central executive working memory(r=-.042) and overall working memory(r=-.061).

Relation between AAMT and Working memory: Academic performance was positively correlated with working memory (Table-1.9) result indicate that the phonological working memory was found to be positively correlated with academic performance (r=.364). visuo-spatial working memory was found to be positive related with academic performance (r=.433,). Central executive working memory was found to be positive related with academic performance (r=.388,). Overall w m was found to be positive related with academic performance (r=.457).

DISCUSSION

The purpose of the present study was to investigate the effect of academic performance, gender, and age on the development of working memory. Result obtained based on ANOVA, correlation and regression analysis have been reported in earlier section and interpreted in this section. Present finding evinced that academic performance, and age exerted on the development of working memory and its components. A clear-cut development change with age in working memory and its component i.e., the phonological loop, visuo-spatial sketchpad and central executive was found. These changes were found to be very similar showing linear increases in performance from younger to older age children various component of working memory.

Consequences of Academic performance on working memory and its components

Finding of this study evinced facilitating effect of academic performance on development of working memory in children. High academic performance group was found superior on

working memory as compared to low academic performance group. More specifically, high academic performance children were found superior on phonological working memory and visuo-spatial working memory (Table,1, 2, 3,4). Furthermore, level of academic performance x age interaction effect indicated that high academic performance older group children were found far superior on central executive working memory and over all working memory (fig.4, 6). It is apparent from this result that academic performance improved with the proper development of working memory capacity. High academic performance older age group of children were superior on central executive and over all working memory then younger children whereas in case of low academic performance group older children were found superior on central executive working memory then younger children. So, improvement with age was found in high academic performance academic performance group but pattern was change in case of low academic performance group of children. Similarly, correlation and regression results have also proved the predicting role of AAMT in the development of working memory (Table, 9, 10, 11, 12, 13).

Present finding has supported by many researchers (Gropper R J & Tannock R, 2009). High academic performance elder children were found far superior on working memory and its component as compared to low academic performance younger children (Pascale M. J. Engel de Abreu, Neander Abreu, Carolina C. Nikaedo, Monica C. Miranda, Debora M. Befi-Lopes, Orlando F.A. Beuno, Romain Martin, 2014). Neuroscience studies also indicate the children who experience low AAMT show deficits on central executive memory (Nolin & Ethier, 2007)

However, contextual factors mediate exposure and consequences of working memory. Cognitive functioning like perception, attention, and intelligence may be closely related to the quality of care taken in home environment.

(2) Gender Difference in Working Memory and its components

Another objective of the present study was to investigate the role of gender in working memory.

Result revealed that difference between boys and girls on working memory was found non-significant (Table,2, 4, 6, 8) however, gender and age interaction effect was found significant (Table, 4, 8 & Fig.5, 8). This result denoted a clear-cut improvement from younger to older age group in girls but such improvement was found slow and steady in case of boys. Present results have been supported by several studies (Pickering et al., 2001; Vuontela et al., 2003).

Research evidence on role of gender in cognitive functioning are equivocal. Tende et al. (2012) found no difference in working memory using n back task. Result obtained the n-back scored showed that there was no statistically significant difference in working memory with boys and girls subject. Other researches also confirm no gender differences in working memory span (Minor & Park., 1999). Lewin el al (2001) did not find a significant difference between man and women in recalling a route between various object within a room. Contrary to this, several studies report gender differences on spatial memory task (Miller & Santoni, 1986; Sharps et al., 1993). Lewin, et al (2001) report that women have higher verbal and non- verbal episodic memory scored, whereas men tended to be batter on visuo-spatial memory tests. Correlation and regression result indicate that gender has contribute negatively development of working memory component i.e., visuo-spatial, central executive and overall working memory (Table-9). In present study, boys and girls did not differ

significantly on working memory and its components. These results have ample empirical support (Bucci et al., 1995; Dabbs et al., 1998).

Effect of Age on Working Memory and its components

Finding of the present study indicated that age exercised significant influence on working memory. As finding indicate that older children performed better on working memory and its component as compared to younger children (Table-13). More specifically, older children expressed superior on phonological, visuo-spatial working memory as a compared to younger children. Correlation and regression result indicate that age has contributed positively in development of working memory component i.e., phonological, visuo-spatial, central executive and over all working memory (Table-12, 13 & Fig. 8, 9, 10).

Present finding has plenty of empirical and theoretical support. Working memory capacity shows a steady development increase across the early a middle childhood year (Pickering & Gathercole, 2001). Children's verbal working memory span increased substantially throughout early and middle childhood. Hulme et al, (1984) studied the digit span and other serial recall spans in groups of children aged 4, 7, and 10 years and reported an average two-to three-fold increase in span from between 2 and 3 items at the age of 4 years to about 6 items at the age 12 years.

Similarly, the improvement in visuo-spatial working memory has also been identified in present results which have been supported by numerous studies (Khetrapal et al., 2008; Logic & Pearson, 1997; Miler, et. al., 1996). Some studies on Indian population have also shown age related improvement up to 10 years of age for 1-back task followed by a plateau until 15 years of age whereas 2-back performance showed improvement only for older children across the age levels of 11-15 years (Khetrapal et. al., 2008).

However, age related improvements in working memory process are moderated by many factors like parenting style (Mishra, 2010), pattern of parent-children interaction (Malviya, 2006).

The present study clearly showed that although developmental trend in various component of working memory has been found. However, academic performance academic performance has causal detrimental impact on proper development of working memory.

Significance

The field of working memory is a very wide-ranging and covers a broad variety of education outcomes. In developed societies, academic performance play an important role in every person life academic performance in important for the wealth of nation and a prosperity. Academic performance is important because it prepares student for future career. It also helps shaping the mind of student. Working memory is active, immediate memory. It helps use in receiving information actively from our environment. Age and socioeconomic status play an important role in process of working memory. Working memory is a relatively stable construct that may have powerful implication for academic performance. Though very little attention has been paid to study the impact of academic performance on working memory. Since, the present study intends to present study intends to provide conceptual clarity to examine the impact of working memory on academic performance and the finding will provide to develop strategies for the proper development of academic performance of school children when student have highly academic performance, so we found highly working memory. Thus, this study will provide its theoretical practical significance.

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Conflict of Interest

The author(s) declared no conflict of interest.

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