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Working Memory and Academic Performance of High School Students in Chittagong

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Abstract

Working memory (WM) is the ability to retain and process information temporarily in order to complete difficult cognitive tasks which is regarded as one of the most important predictors of academic abilities. Children with poor working memory are more likely to have academic difficulties. However, no studies for high school students in Bangladesh have been found. Thus, the aim of the present study was to investigated the relationship between working memory capacity and academic achievement of high school students. Moreover, it was also investigated the gender difference and academic achievment difference in working memory capacity. Purposive sampling was used to select 128 children (64 high and 64 low achiever) from six schools as participants. There were 32 boys and 32 girls in each group. The digit span backward test was used to assess working memory, and students' academic achievement was assessed using their school's first-term results. Pearson product moment correlation and two-way analysis of variance were used to analyze the data. Working memory capacity was found to have a significant positive relationship with academic achievement. There was also a significant difference in working memory capacity between high and low academic performance. Furthermore, an interaction effect of gener and academic achievement was discovered. However, there was

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no significant gender difference in working memory capacity, indicating that both boys and girls had equal working memory capacity.

Keywords: Working Memory, Academic Performance, High School Students

1. Introduction

Poor academic performance is common and is linked to unfavorable outcomes like grade repetition, behavioral disorders, and unemployment. Children who struggle with memory are more likely to struggle in school. Memory plays a crucial role in information processing. Several memory processes contributed significantly to achievement. Indeed, research in the impact of memory on academic achievement was neglected (DeMarie & López, 2013). Memory deficits cause difficulties in a variety of academic subjects, including reading and mathematics.

Memory is the process by which the past information is retrieved in order to use it in the present time (Sternberg & Sternberg, 2012). It has been demonstrated that Long Term Memory (LTM), the store of knowledge and experiences, is involved in language comprehension, reading, and mathematics (Kutas & Federmeier, 2000; Blankenship et al., 2015). Because the development and functioning of LTM are dependent on working memory (WM), it was inferred that WM controls the rate and scope of learning (Dehn, 2008). Working memory is the tiny quantity of knowledge that can be held in mind and employed in the execution of cognitive activities (Cowan, 2014), as opposed to LTM, which is the large amount of information saved throughout one's life.

According to Cowan (2017) Working memory is a set of components that can hold a finite amount of information for a finite amount of time while still keeping it readily available for ongoing processing (Cowan, 2017). WM appeared to outperform intelligence tests in terms of predicting academic achievement.

Data show that WM influences several educational learnings, including reading and mathematics (Blankenship et al., 2015).

Theoretical concept of working memory is the capability of storing and manipulating information for a short period of time. Working memory has a limited capacity. The memory span of young adults was around seven elements plus or minus (Miller, 1956).

The Short-term memory is a component of working memory but there is a difference between short term memory and working memory. The short-term memory only store information on the other side working memory process and stores information. Working memory is necessary for language comprehension, in arithmetic, reasoning and other cognitive tasks. Working memory is a very useful measure of a student's capability to acquire new information (Alloway & G.Alloway, 2010).

A student's working memory capacity is also a good predictor of the ability to accurately retrieved information that is important because accurate retrieval of acquired information is necessary for learning. Findings from the studies, by Alloway & Alloway (2010) that a child's success in all aspects of learning is down to how good their working memory regardless of IQ score. A noticeable difference also found in academic performance between the visual memory deficit and the non-deficit comparison group (Larsen, 2011).

Al-hamouri and Khasawneh (2011) discovered statistically significant differences in working memory capacity and reading comprehension between males and females, in favor of females. They also discovered that working memory capacity affects reading comprehension, with females performing better than males, while there was no statistically significant interaction between students' working memory capacity and gender on their reading comprehension ability. In a study on university students, Ishak et al. (2011) found no significant differences in working memory scores by gender, year, or program. Sleeping patterns, memorization methods, and study habits did not significantly affect students' working memories either. Additionally, the outcome demonstrated that there was no discernible relationship between working memory performance and CGPA.

Tariq and Noor (2012) in their study depicted that male and female universities science students of Punjab did not differ in working memory, both groups being moderate in the use of working memory. They also noted no significant difference between academic achievement scores of both genders. They also indicates that there is no meaningful relationship between working memory capacity of male and female first year university students to vocabulary learning. Another study by Aghaalikhani & Ahmadi (2013) discovered that there is no meaningful relationship between male and female students' working memory capacity and vocabulary learning (Aghaalikhani & Ahmadi, 2013).

Al-Balushi and Al-Battashi (2013) found that both ninth grade science and mathematics high achievers significantly outperformed than low achievers in terms of working memory capacity. They also added that there was no significant difference between the two genders with regarding their achievement in science and mathematics.

Bos and Weijer-Bergsma (2019) conducted a study on the primary school children to compared how well WM performed in controlled and classroom settings, as well as their ability to predict academic achievement. They found that the best indicators of academic achievement were verbal WM scores obtained from students in a classroom setting.

Binyameen et al. (2022) conducted a study to find out how working memory affects high school students' learning achievement in mathematics. They found that individuals with higher levels of working memory perform better academically than those with average or lower levels. Similar to this, students with average working memory performance demonstrate better learning progress than those with low working memory.

Above research showed that WM is the strong predictor of Academic Achievement for primary school student (Bos & Weijer-Bergsma). University science female student who have higher WM good at reading comprehension than male (Al-hamouri & Khasawneh, 2011). Moreover, science and mathematics high achiever performed well than low achievers in WM (Al-Balushi & Al-Battashi, 2013; Binyameen et al. 2022). However, science university student's working memory did not differe in terms of academic achievement, vocabulary learning, and gender (Tariq & Noor, 2012; Aghaalikhani & Ahmadi, 2013; Al-Balushi & Al-Battashi, 2013). It seems that few researcher claimed that working memory is a good indicator of academic success, particularly in math, reading comprehension, and science. However, some researchers found no gender or academic achievement differences in terms of WM. They also claimed no gender differences in vocabulary learning. But no research examined the effect of WM on overall academic achievement in the context of Bangladeshi high school students. Thus, our goal was to investigate the connection between working memory and overall academic performance of high school students in Bangladesh in order to clear up this misunderstanding.

1.1 Objectives of the study

The main purpose of this study was to investigate the relationship and difference between gender, academic achievement, and working memory capacity of high school children.

The distinct objectives of the present study were-

i. To investigate the relationship between working memory capacity and academic performance.
ii. To determine the difference in working memory capacity between high and low academic achievement.
iii. To determine the difference in working memory capacity between boys and girls.

iv. Determine the interaction effect of gender (boys vs. girls) and academic achievement (high vs. low).

2. Methods and Materials

2.1 Participants

The study included 128 students of class six to nine (64 boys and 64 girls) with a mean age 13.5 who were purposively selected from six different schools of Chittagong City. Participants were divided into groups on the basis of gender and academic achievement. Both high and low achievers were randomly selected following their class roll and acquired grade point. Students who received 3.5 points considered higher achievers and those who received less than 3 considered low achievers. Each class had sixteen students (eight high achievers and eight low achievers). They were all in good physical and mental health. The participants distribution according to their gender and academic achievement is given in Table 1.

Table 1. Participants Distribution according to Academic Achievement and Gender

Academic Achievement	**Gender**		**Total**
	Boys	**Girls**	
High	32	32	64
Low	32	32	64
Total	**64**	**64**	**128**

2.2 Measures

In order to measure working memory of students, digit span backward test was used. Academic performance of students was measured through their 1st term results.

2.2.1 Digit Span Backward Test (DSBT): The DSBT is a widely used measure to estimate working memory capacity (Alloway et al., 2006; Alamolhodaei, 2009). It is individually administered and requires the participants to recall a sequence of spoken digits in the reverse order (e.g., 4, 9, 6, 8 becomes 8, 6, 9, 4). The number of digits in each list increases across trials and the number of correctly recalled list is scored. The largest number of digit that a person can repeat without an error is their backward digit span. The formula used to measure digit span is:

$$Memory\ Span = Basal\ value + \frac{1}{3} \times Excess\ correct\ response$$

2.2.2 Academic Achievement: Academic performance of students were measured through their 1^{st} term results. We counted here student's obtained Grad point and overall Grade. In our study, we divided students into two group based on their grade point, with those who received 3.5 points considered higher achievers and those who received less than 3 points considered low achievers.

2.3 Design

The quasi-experimental design was used in this study.

2.4 Procedure

The aforementioned measures were tested on the study participants individually and data were collected in a quiet room in their school settings. Before collecting the data, permission was taken from the concerned authorities. At first, participants were informed about the purpose and importance of study and initial rapport was established with them. Then, they were told about the basis of working memory capacity and the need to attend to the digit span that was shown by the researcher and to 'rehearse' in their memory before write down the digit span upon the prescribed paper. The test paper contained three list of digits for each span (ranging from 3 to 8). Each digit span was viewed in order starting from three digits then increasing the task up to eight digits. So, every list consisted of six trials. After each digit span was shown, thirty seconds elapsed before participants write down their answers in reverse order. To avoid errors in the experiment (because participants could note down the digits in reverse as they read), they were instructed not to use paper and pencil until thirty seconds after completing the reading of the digit span. In the beginning, a series of digits were administered for practice. After completing the tasks, the DSBT scores were calculated using the aforementioned formula, and participants were thanked for their cooperative efforts.

3. Results

Pearson's Product Moment correlation coefficient (r) was used to examine the relation between working memory capacity and academic achievement, and two-way analysis of variance (ANOVA) was performed to see whether working memory capacity differed in compliance with academic achievement and gender. All statistical analyses were executed by statistical program SPSS version 25.0 for window. The results are presented in the following.

Table 2. Pearson's Correlation between Academic Achievement and Working Memory

		n	**Pearson's r**	**p**
Grade point	- WMC_score	128	0.475**	< .001

** p < .001

Table 2 showed the Pearson's product moment correlation between academic performance and working memory capacity of school children. Result showed a significant positive correlation between working memory capacity and student's gradepoint (*r=.475*) at the .001 level.

Table 3. Two way analysis of variance of Working Memory Capacity Score Based on Gender (boys and girls) and Academic Achievement (high and low achiever).

Source of Variance	SS	df	MS	F	η^2
Gender (A)	0.38	1	0.38	0.48	0.002
Academic Achievement (B)	47.06	1	47.06	59.28*	0.277
A*B	4.87	1	4.87	6.14*	0.053
Error	98.44	124	0.79		
Total	5374.06	128			

*p<0.01

3.1 Main effect of Gender and Academic Achievement

Table 3 shows there is no significant difference in working memory capacity according to gender $F(1, 124)=.48$, $p > .05$. It has also seen that, there is a significant difference in working memory capacity according to **academic achievement**, $F(1, 124) = 59.28$, $p < .01$. Which indicated that student who have higher academic achievement ($M= 6.92$, $SD=0.74$) have higher working memory capacity than low academic achievement ($M=5.78$, $SD=1.11$) (see Table 4).

Table 4. Overall mean Scores of Working Memory Capacity based on Gender and Academic Achievement.

Variable	Respondents	M (SD)
Gender	Boys	6.44 (±1.08)
	Girls	6.33 (±1.09)
Academic Achievement	High	6.92 (±0.74)
	Low	5.78 (±1.11)

Table 5. Mean Score of Working Memory Capacity According to Gender and Academic Achievement

Gender	Academic Achievement	
	High	**Low**
Boys	6.73 (±0.86)	6.09(±1.23)
Girls	7.13 (±0.51)	5.48 (±0.89)

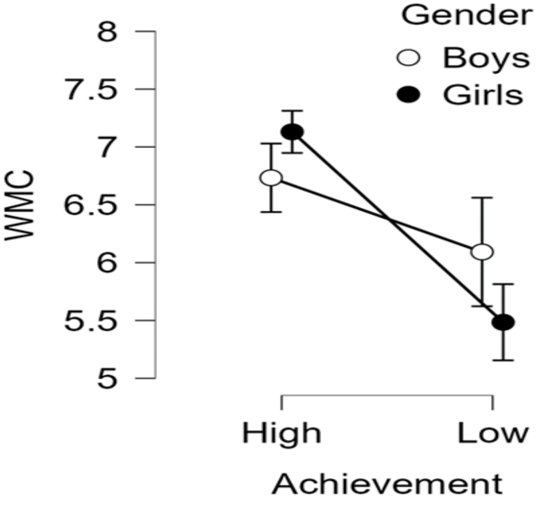

Figure 01: Interaction effect of gender and academic achievement on working

3.2 Interaction Effect of Gender and Academic Achievement

Table 3 and Table 5 showed a significant interaction effect of gender and academic achievement in working memory capacity $F(1, 124)=6.14$, $p<.01$. Post hoc analysis showed a significant difference between high achiever boys (M=6.73, SD=0.86) and higher low achiever boys (M=6.03, SD=1.23) in working memory capacity (see Table 5 and Table 6). Moreover, Post hoc analysis also revealed that high achiever girls (M=7.13, SD=0.51) are higher in working memory capacity score as compared to low achiever girls (*M*=5.53, *SD*=0.89) (see Table 5 and Table 6). Table 5 also showed that high achiever girls were higher in working memory capacity score than high achiever boys but Post hoc analysis showed that this difference was not significant (see Table 6). Contraray, low achiever boys were significantly higher in working memory capacity score than low achiever girls (see Table 6).

Table 6. Post Hoc Comparisons of Gender and Academic achievement of working memory.

		Mean Difference	SE	t	p_{tukey}	
Boys High	Girls High	-0.397	0.218	-1.818	0.270	
	Boys Low	0.641	0.226	2.837	0.027	*
	Girls Low	1.249	0.222	5.624	< .001	***
Girls High	Boys Low	1.039	0.229	4.532	< .001	***
	Girls Low	1.646	0.225	7.309	< .001	***
Boys Low	Girls Low	0.608	0.233	2.612	0.049	*

* p < .05, *** p < .001

Note. P-value adjusted for comparing a family of 4

4. Discussion

The purpose of this study was to look into the relationship between working memory capacity and academic achievement in high school students. The findings revealed a significant positive correlation between working memory capacity and grade point. This discovery indicated that students with a high working memory capacity perform better on academic exams. This research supports the findings of Aghaalikhani and Ahmadi (2013), who discovered a link between working memory capacity and academic deficits in reading, mathematics, writing, and other areas of learning. However, this contradicts the findings of Ishak et al. (2011), who discovered that CGPA was not related to WM.

Another goal was to determine the difference in WM capacity between high and low academic performers. Our findings revealed that there was a significant difference in working memory capacity based on academic achievement. That is, high achievers have greater working memory capacity than low achievers among Bangladeshi high school students. This study also found that Bangladeshi high school students with a long memory span process information faster than those with a short memory span. Furthermore, high school students with a high working memory capacity are eager to learn and extremely attentive. Because attention has a significant impact on working memory, particularly when students need to encode information (e.g., when students are listening to a lesson from a variety of sources). The amount of time a student needs to hold information in working memory, specifically visual working memory, is influenced by attention (Makovski et al., 2008). Though it is common for some high school students to struggle, they ultimately fail to process information successfully, which has a negative impact on their academic performance. These high school students perform poorly in subjects such as mathematics and science, where they must perform numerous mental operations.

Another goal was to see if there was a gender difference in WM capacity. There was no significant gender difference in working memory capacity between high achievers and low achievers, according to our findings. Boys and girls have nearly identical working memory capacities. This result was supported by Aghaalikhani and Ahmadi (2013) where they found no significant difference in working memory capacity between boys and girls.

Our ultimate goal was to see if there was any interaction between gender and academic achievement. Working memory capacity was found to have a significant interaction effect of gender and academic achievement. This finding is consistent with the findings of Gathercole and Alloway (2008) but contradicts Al-hamouri and Khasawneh's (2011) findings that there is no significant interaction between WM capacity and gender on reading comprehension ability. According to our findings, high achiever boys have better working memory capacity than low achiever boys in high school. Again, high achiever girls outperform low achiever girls in terms of working memory capacity. Interestingly, our study found no overall gender difference, despite the fact that high achiever girls have better working memory than high achiever boys, but high achiever boys have higher working memory capacity than low achiever girls. This is because high achiever boys and girls in high school may perform better in school exams due to their greater working memory capacity. According to the Baddeley and Hitch (1974) and Atkinson and Shiffrin (1968) memory model high achiever high school student can use various strategies to process information such as concentration degree, mnemonics, chunking, learning strategies.

4.1 Implication

Working memory must be used continuously in order to maintain concentration, purposeful thinking, and mental effort while learning. A better understanding of the nature of human working memory could have significant implications for understanding why people differ in cognitive skills and abilities, as well as why people achieve varying degrees of success in their efforts to achieve real-world goals. In educational setting, one can strive to educate to the learner's working memory level with considering the findings of this study. Training activities can be used to strengthen working memory to the low achiever, allowing them to learn more successfully. Consider the significance of working memory in achieving the most important educational goals.

4.2 Limitation

The current study has only a few limitations. First and foremost, the sample size was extremely small. Second, we only included high school students from urban areas; someone could look into the working memory of primary school students and urban high school students. As a result, these findings cannot be applied to all schoolchildren. Given the limitations, additional research with a representative sample is recommended in order to generalize the findings and gain a better understanding of working memory and its relationship to academic achievement.

4.3 Conclusion

Working memory capacity has a positive influence on academic performance, but there is no overall gender difference. Students with greater working memory capacity perform better academically. Working memory capacity was found to be greater in boys with higher achievement than in boys with lower achievement. High achiever girls outperform high achiever boys in terms of working memory capacity. But, low achiever boys outperform low achiever girls in terms of working memory capacity.

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