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Research Paper

Comparative Study of Working Memory amongst College Students

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ABSTRACT

This study comparatively analysed the impact of academic stream (Science, Social Science, Arts), gender (male, female), and geographical background (urban, rural) on working memory (WM) performance in 300 undergraduate students aged 18–24, selected through convenience sampling with equal representation from each stream. WM was assessed using three subtests—Digit Span, Arithmetic, and Letter-Number Sequencing from the Wechsler Adult Intelligence Scale (WAIS-III), a tool with high reliability and validity. Data were analysed using one-way ANOVA and independent samples t-tests. Results showed a significant difference in WM scores across academic streams ($F = 6.451$, $p < 0.01$). Post hoc comparisons revealed that Social Science students scored significantly higher than Arts students ($p < 0.01$). No significant difference was found between Science and Social Science students. Urban students scored significantly higher than rural students ($p < 0.05$). No significant gender difference was observed, although males had a slightly higher mean score.

Keywords: *Working Memory, College Students*

Working Memory: A Key to Academic and Life Success

Cognition encompasses acquiring, processing, and storing information, with fundamental cognitive function like working memoryplaying a crucial role in everyday tasks and academic success. This cognitive ability not only influence learning but also impact problem-solving, decision-making, and overall mental efficiency.

Working Memory

Working memory (WM) is a vital cognitive ability that helps us hold and work with information for a short period of time. It plays a major role in how we understand, reason through, and solve problems in everyday life as well as in academic settings (Alloway, 2010; Cowan, 2006). The strength of an individual's working memory can vary and often affects their ability to stay focused and ignore distractions, especially during mentally demanding tasks (Engle, Tuholski, Laughlin, & Conway, 1999).

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Role of Working Memory in Academic fields

Working memory plays a key role in enabling students of various disciplines to temporarily hold and manipulate information. In Science, it helps process experimental data, apply formulas, and understand complex theories. In Social science, it supports critical analysis, comparison between concepts and integration of diverse data. In the Arts, working memory aids in creative expression, organizing ideas, and follow sequences in music, drama or poetry. Across various disciplines, it is essential for comprehension, reasoning, and effective performance.

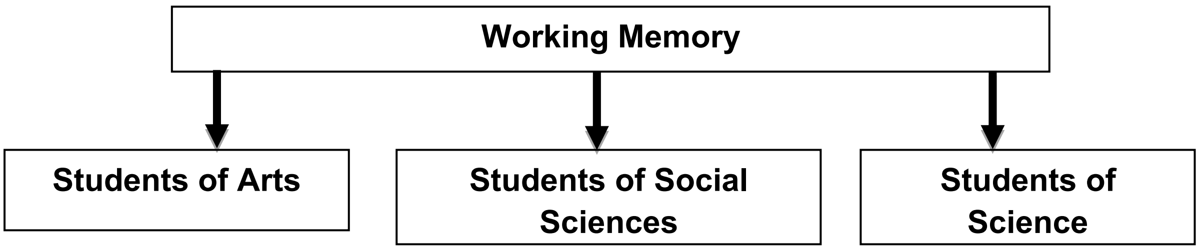
Impaired working memory can significantly affect students' academic performance and overall learning experiences. They may find it challenging to follow multi-step instructions, retain information presented in class, or organize their thoughts effectively for essays and projects. This can result in lower grades, increased frustration, and a sense of helplessness. Additionally, students may experience reduced productivity and higher error rates in tasks requiring quick mental processing, ultimately affecting their confidence and motivation in their studies. Addressing these factors through stress management techniques, healthy lifestyle choices, and structured learning environments can help enhance working memory and improve academic outcomes for students.

Following are the factors that have an effect on the working memory,

1. Age
2. Stress and anxiety
3. Sleep deprivation
4. Nutrition and health
5. Cognitive load

Understanding and improving working memory is essential for both academic achievement and real-world problem-solving as it is deeply interconnected with other cognitive abilities influencing one another in ways that impact learning, task performance, and general cognitive efficiency. Strategies such as cognitive training, healthy lifestyle choices, and optimized learning environments can significantly enhance this function, leading to better academic and professional outcomes.

Conceptual Framework



REVIEW OF LITERATURE

Author/Year	Variables	Conclusion
Helton & Russell (2011)	Working memory load and Vigilance Decrement	The research studied the effect of working memory (WM) load on vigilance. 745 participants performed continuous target detection tasks along with spatial or verbal WM task. Results showed negative effect of WM load on Vigilance performance.
Fry & Hale (2000)	Impact of age on development of working memory processing speed and fluid intelligence	The research attempted to understand how working memory, processing speed and fluid intelligence evolves with age. It was revealed that age positively affects processing speed which in turn leads to improved working memory hence contributing to efficient fluid intelligence thus indicating a cascading relationship between three of them.
Nettelbeck & Burns (2010)	Impact of aging on processing speed, working memory and reasoning ability	This research examined whether cognitive decline in childhood. Participants aged 8–14 and 18–87 took tests of processing speed, working memory, and reasoning ability. Results indicated that childhood cognitive development conformed to a cascade model such that faster processing speed led to better working memory, which in turn enhanced reasoning. Elderly data (adult studies) showed a cascade model of cognitive decline like the youth model but with an important direct effect of age on working memory after 55 years. This implies that in adulthood, cognitive decline is simply not a reversion of the childhood but is also influenced by other factors of aging.
Mulder, Pitchford & Marlow (2010)	Impact of Working memory and processing speed on academic attainment in very preterm children (born before 31 weeks (about 7 months of pregnancy)	This research explored the performance of 48 very preterm (VPT) children and 17 full term children were compared on various processing speed, working memory tasks involving the usage of math and language. Teachers of these children were also asked to fill questionnaires on their academic performance. Results indicated high Group differences in academic attainment for math, English/literacy overall academic attainment. The findings indicate that VPT children are at a higher risk for academic challenges, mainly due to slower processing speeds. Screening for processing speed and working memory can help identify children who might need extra support in their education.

Author/Year	Variables	Conclusion
Tourva&Spanoudis (2020)	age, processing speed, control of processing, working memory, fluid and crystallized intelligence in a developmental context.	The study aimed to see the effect of age on development of processing speed, control of processing, working memory (WM), fluid and crystallized intelligence. 158 participants between age of 7 to 18 attempted large battery tests measuring the concerned abilities. Results pointed out to cognitive-developmental cascade, confirming that age-related increases in processing speed lead to improvements in control of processing, which enhance working memory. This, in turn, contributes to increases in both fluid and crystallized intelligence, indicating a clear developmental progression among these cognitive factors.
Li, J, Cao, Y., Ou, S, Jiang, T, Wang, L, & Ma, N. (2024)	Working memory, sleep deprivation, information accumulation, and sustained attention.	This research attempted to understand the impact of sleep deprivation on working memory and sustained attention. 37 adult participants performed N-back task and the Psychomotor Vigilance Task (PVT). Results showed that sleep deprivation conditions negatively affected responder's accuracy but response times remained largely unaffected. While accuracy significantly declined under sleep-deprived conditions, response times remained largely unaffected, also sleep deprivation reduced the speed of information accumulation, increased variability in processing, and elevated decision thresholds, particularly in the 1-back condition. These cognitive disruptions degraded performance in both the N-back and PVT tasks, suggesting that sleep deprivation adversely affects working memory by diminishing both information integration and attentional stability.
MoshtaghiSharifzadeh, M, Mansouri, A, & Bagherzadeh Golmakani, Z. (2021).	Working memory, phonological awareness, processing speed, and reading ability in students with specific learning disorders.	The research examined how processing speed influences the relationship between working memory, phonological awareness, and reading ability in students diagnosed with specific learning disorders. 150 children from grades 1 to 5 in Mashhad were chosen for this research. Results indicated that processing speed plays a critical mediating role in the development of both working memory and phonological awareness, which in turn significantly affect reading performance. The findings points out the importance of targeted interventions aimed at enhancing processing speed in conjunction with cognitive skills to support literacy development in children with learning difficulties.

Author/Year	Variables	Conclusion
Mgbedo, N. E., Musa, M. E., Chhikara, P., Chaturvedi, R., Vyas, N., &Zavradashvili, N. (2024	social media use, working memory, academic performance, gender, and social media-related issues (e.g., persistence, escape, conflict).	This research studied the impact of social media usage on working memory and academic performance. 722 undergraduate students from three universities in Georgia were chosen for this study. The study incorporated the Social Media Disorder Scale (SMD), the Academic Performance Scale (APS), and a Working Memory (WM) test, along with socio-demographic data. The findings revealed that higher levels of social media use—particularly among female students—were associated with reduced working memory capacity and lower academic performance. The results indicated the cognitive and academic risks of excessive social media engagement in university students.
Bergman Nutley, S., &Söderqvist, S. (2017)	Impact of working memory training, on reading ability,	This research attempted to see the impact of Working Memory (WM) training on students' academic performance in reading and mathematics. For this the study used the Cogmed WM training program and identified two primary mechanisms by which WM training could enhance academic outcomes: (1) improving long-term learning capacity by increasing attentional control in classroom settings and (2) directly enhancing task performance requiring WM. The results showed that WM supports different stages of reading—initially aiding in word recognition and later in reading comprehension. Importantly, it pointed out the individualized nature of WM training effectiveness, suggesting that tailored interventions based on the specific needs of each child and the appropriate choice of assessment tools are crucial for maximizing benefits. This study supports the idea that customized WM training may be a valuable educational tool, particularly when applied strategically.
Almarzouki, A. F.(2024)	Stress, working memory, and academic performance: a neuroscience perspective	This research explored the intricate relationship between stress, working memory (WM), and academic performance from a neuroscience perspective. The study distinguishes between acute and chronic stress, both of which adversely affect WM by impacting critical brain regions such as the prefrontal cortex and hippocampus. Acute stress affected WM through the release of stress hormones like glucocorticoids and catecholamines, leading to temporary cognitive disruptions. In contrast, chronic stress can lead to structural changes in the brain, resulting in more sustained cognitive impairments. Results also showed that how emotional processing, when negatively influenced by stress, can further negatively impact WM functioning, making academic concentration and task execution more challenging. Hence the

Author/Year	Variables	Conclusion
		study suggests incorporating stress management strategies—such as mindfulness, relaxation techniques, and WM training—into academic settings to support cognitive functioning and enhance student performance. The findings underscore the necessity of fostering supportive learning environments that mitigate stress and optimize cognitive resources.
Kundey, S. M. A., De Los Reyes, A., Rowan, J. D., Lee, B., Delise, J., Molina, S., & Cogdill, L. (2013)	Working memory and sequential pattern learning	This study investigated the importance of working memory (WM) in college students' learning and implementation of sequential patterns through computerized tasks. In three experiments, the research attempted to know whether WM was necessary for the detection and precise reproduction of patterns, especially when patterns involved structural interruptions. The results from the first experiment showed that WM is essential to understand a sequence's overall structure even when the sequence itself is irregular. The second experiment showed that WM was essential for precise performance, namely in patterns that did not follow expected structures. In the third experiment, participants performed an additional cognitive load, causing a reduced capacity to internalize and use sequence rules. The research concluded that WM plays a vital function not just in decoding sequences but also in producing them, particularly under cognitively challenging situations. These findings highlight the active engagement of WM in dealing with difficult and dynamic learning tasks.
Daneman, M., & Carpenter, P. A. (1980).	Individual differences in working memory and reading	This research investigated how individual differences in working memory (WM) capacity contribute to reading comprehension. They predicted that poor readers would not be able to cope with the simultaneous processing and storage functions of WM. Participants read a series of sentences aloud and answered with the last word of each. The number of correctly recalled final words positively correlated with performance on standardized reading comprehension measures, including the verbal section of the Scholastic Aptitude Test (SAT) and fact retrieval and interpretation of pronouns. Importantly, the same pattern also emerged in a listening comprehension test, suggesting that the correlation between WM and comprehension does not exist independently with reading. The study concluded that WM capacity played a central role in language comprehension in different modalities.
Oberauer, Farrell, Jarrold, & Lewandowsky (2016)	Working memory and its capacity	This research attempted to study the limits of working memory (WM) this was done by evaluating critically the three prominent

Author/Year	Variables	Conclusion
		explanatory theories: temporal decay, cognitive resource theories, and interference-based accounts. The research critiqued how each theory accounts for prominent empirical phenomena, such as the set-size effect, domain-specificity, heterogeneity of memory sets, the effects of unfilled retention intervals, and the consequences of distractor processing. The research generated weak support for the decay hypothesis, particularly within verbal working memory situations, and revealed a number of the resource-based explanation's limitations. The interference model proved to be the strongest framework, producing consistent predictions and explanatory value although with some lingering challenges. The authors concluded that interference between memory representations is the most reasonable explanation of WM capacity constraints, proposing this should inform future empirical research and theory.
Cohen, J. D., Perlstein, W. M., Braver, T. S., Nystrom, L. E., Noll, D. C., Jonides, J., & Smith, E. E. (1997)	Impact of working memory task on brain activation	This research examined the neural substrates of working memory (WM) through the measurement of temporal patterns of brain activation during WM tasks using functional magnetic resonance imaging (fMRI). The study sought to distinguish the neural correlates of two basic WM processes: executive control and active maintenance. The DLPFC was previously assumed to be involved in executive control, while posterior regions, such as the parietal cortex, were assumed to be involved in content-specific maintenance. But the results dismissed this dichotomy. The findings indicated that both the prefrontal and parietal cortices demonstrated active sustained activation throughout delay periods, indicative of their combined contribution to the maintenance of information online. Crucially, the prefrontal cortex was also implicated in active maintenance, contrary to initial claims of regional specialization. This overlapping pattern of activity suggests a more integrated and distributed account of WM, whereby different brain regions work together to facilitate ongoing cognitive load.
Titz, C., & Karbach, J. (2014)	Working memory and executive functions: effects of training on academic achievement	This research strudied the relationship between working memory (WM), executive functions and learning with special emphasis on WM training. The results pointed out that WM training had beneficial effects on reading skills in children, whether or not they were challenged by learning difficulties. Improvement in mathematical capabilities was less uniform, typically varying with the nature of the training protocol, duration, and characteristics of the participants. Interestingly, those children who were under more

Author/Year	Variables	Conclusion
		academic stress gained the most, proposing a compensatory effect of WM and EF training for vulnerable learners. The research highlights the need for individually tailored cognitive training programs for particular academic and cognitive profiles. The research also underscores that WM interventions can serve as a supportive component to standard education practices, especially in developing reading skills.

Research Gap

1. **Lack of Comparative studies among Academic streams**- Most existing studies have focused on how working memory influences academic performance or general intelligence of an individual while there is lack of studies on how this cognitive faculty vary among different academic streams.
2. **Interdisciplinary Streams or Modern Academic Trends**- The rise of interdisciplinary fields and their unique cognitive demands have not been considered enough.

Significance of the study

1. **Exploration of Cognitive Differences between Streams**- This research will try to analyse and understand the differences among Arts, Social Science, and Science streams in terms of the working memory of students. It may therefore help in understanding how this cognitive ability might vary on the basis of selection of academic stream.
2. **Intervention Design for Improvement-** If any stream is endowed with a weaker cognitive ability set-up, then specific programs, or strategies can be especially designed to improve them. This will, in itself, be directly productive for the students at a learning level.
3. **Creating Stream-Sensitive Teaching Styles-** This research may inform teachers to come up with particular teaching skills that fit into the cognitive ability and strength of students from every academic stream.
4. **Career Guidance-** This research can prove to be helpful in career advising, and thus students may make informed decisions about where they can apply their strengths based on proper academic and career development**.**
5. **Promoting School and Workplace Success-** By enabling discovery and rectification of a student's cognitive deficiencies, the research will make students learn better in their academics and perform better in their respective professional lives.

RESEARCH METHOD

Objectives

- To find out if there is any difference in working memory of students among academic streams of science, social science and arts.
- To find out if there is any difference in working memory of male and female students.
- To find out if there is any difference in working memory of rural and urban students.
- To find out if there is any correlation between working memory and academic achievement.

Hypotheses

- **Ho:** There is no significant difference in working memory among the students of science, social sciences and arts.
- **Ho:** There is no significant difference in working memory of male and female students.
- **Ho:** There is no significant difference in working memory of rural and urban students.
- **Ho:** There is no significant difference in working memory and academic achievement.

Sample

1. Sampling technique: Convenient
2. Sampling size: 100 from each type of stream (total 300)

Inclusion criteria

i) Age- The subjects will be between the age group of 18-24 years
ii) Nationality- Indian
iii) Language- The subjects should know either Hindi or English
iv) Gender- any
v) Educational qualification- At least Intermediate

Exclusion criteria

- The subject should not have any history of psychological, psychiatric or serious medical illness.
- Subject should not be under any kind of medication.

Variables

Independent Variable

- Academic Stream (Science, Social Sciences, Arts)
- Gender - Male/Female
- Location- Rural/Urban

Dependent Variable

- Working memory

Operational definitions

Working memory- is the part of short-term memory (STM) and material from LTM, concerned with immediate conscious perceptual and linguistic processing. It is the thinking and reasoning skill focusing on memory in action, the ability to remember and use relevant information, while in the middle of an activity.

Tools

- **Working Memory: Wechsler Adult Intelligence Scale** (WAIS III) - This test was developed by Wechsler in 1997 consisting of 14 sub-tests (seven verbal and seven non-verbal). Out of these 14 sub-tests, only three tests i.e., digit span, arithmetic and letter-number sequencing, measuring working memory were used in the present research. Test-retest reliability of the scale is 0.85 to 0.95 (within a span of few weeks to few months), the criterion validity (0.80 to 0.95) and the predictive validity (0.50 to 0.70) sufficiently make the scale (sub tests) standardized.

Statistical Technique- The study employed one-way ANOVA.

RESULTS

Not only the overall data of working memory normally distributed, but also its normally distributed across all the three faculties, area wise (rural/urban) and gender wise (male/ female). The data also fulfills the conditions of homogeneity of variance.

Table 1: Results of the one-way ANOVA conducted to assess mean differences across groups:

		Sum of Squares	Df	Mean Square	F	Sig.
WM	Between Groups	2304.420	2	1152.210	6.451	.002*
	Within Groups	53044.260	297	178.600		
	Total	55348.680	299			

The F value is significant ($p<0.01$) therefore, there is a significant difference between the mean scores of working memory scores of students of Science, Social Sciences and Arts.

Since the F value is significant, therefore the post-hoc analysis was done. The result of post-hoc analysis is given below.

Post hoc test

Table 2: Post hoc test results identifying specific group differences following the ANOVA.

Multiple Comparisons

Dependent Variable: WMI

Tukey HSD

Faculty (I)	Faculty (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Arts	Social Science	-6.78*	1.89	.001*	-11.23	-2.33
	Science	-3.69	1.89	.126	-8.14	.76
Social Sciences	Arts	6.78*	1.89	.001*	2.33	11.23
	Science	3.09	1.89	.233	-1.36	7.54
Science	Arts	3.69	1.89	.126	-.76	8.14
	Social Sciences	-3.09	1.89	.233	-7.54	1.36

*p<0.01

Table 3 Independent Samples Test for working memory scores across Location

		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper
WM	Equal variances assumed	-2.290	298	.023	-4.008	1.750	-7.453	-.564
	Equal variances not assumed	-2.183	133.238	.031	-4.008	1.836	-7.640	-.377

Since the difference of mean is significant (p>0.05), there is significant difference between the working memory scores of urban (M=97.72) and rural (M=93.71) students.

Table 4: Independent Samples Test for working memory scores across Gender

		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
WM	Equal variances assumed	1.852	298	.065	3.16	1.71	-.20	6.52
	Equal variances not assumed	1.917	182.51	.057	3.16	1.65	-.09	6.41

There is no significant difference between the means of scores of working memory scores of males and females (p>0.05)).

Table 5: Correlation between working memory and academic achievement

Stream	WM & academic achievement
Science	r = .227*
Social Science	r = .351**
Arts	r = .324**

**Significant at 0.05 level; *Significant at 0.01 level*

The table shows that working memory is significantly correlated with 12th-grade performance across all streams.

DISCUSSION

1. **ANOVA (F test):** Since the F-value (6.451) is significant (p<0.01), it indicates that there is a statistically significant difference in working memory scores among the three groups. (mean of science faculty is 96.82, mean of social science faculty is 99.91, mean of arts faculty is 93.13), this shows that social science faculty performed relatively higher in working memory in comparison to other faculties.

2. Therefore, a post hoc test was conducted to identify between which groups the differences exist.
   i) There is no significant difference between the scores of Working Memory of faculty of Social Science (M=99.91) and the faculty of Science (M=96.82).
   ii) There is no significant difference between the scores of Working Memory of faculty of Science (M=96.82) and the faculty of Arts (M=93.13).
   iii) There is a significant difference between the scores of Working Memory of faculty of Social Science, M=99.91, and the faculty of Arts, M=93.13 (p<0.01).

3. Since the t-value of -2.290 is significant (p<0.05), it indicates that there is a statistically significant difference in working memory scores among students of Rural and Urban areas. Urban students (mean=97.72) scored higher than rural students (mean=93.71).

4. Since the t-value of 1.852is not significant ($p>0.05$), it indicates that there is no statistically significant difference in the working memory scores ofmale and female students, although mean score of male students (M=98.83) is higher than the mean score of female students (M=95.67).

5. The correlation between working memory and 12th-grade marks is significant in all streams—Science ($r = .227$, $p< .05$), Social Science ($r = .351$, $p< .01$), and Arts ($r = .324$, $p< .01$)—indicating a positive association between working memory and academic achievement.

CONCLUSION

- There is no significant difference between the working memory of students of faculty of social sciences and students of faculty of science.
- There is no significant difference between the working memory of students of faculty of science and faculty of arts.
- There is a significant difference between the working memory of students of faculty of social sciences and faculty of arts ($p<0.01$).
- There is a significant difference ($p<0.01$) in the working memory of urban students and rural students
- There is no significant difference between the working memory of males and females ($p>0.05$).
- The correlation analysis reveals that working memory is significantly and positively related to 12th-grade performance across all streams—Science, Social Science, and Arts, indicating that working memory positively relates to academic achievement. ($p<0.05$)

Limitations

- The sampling method used was convenient sampling, simple random sampling can give better representative sample.
- The sample was limited to only one college of Agra district.

Scope for future studies

- A longitudinal study can be conducted on the students to monitor the correlation between academic performance and working memory.
- Intervention in the form of cognitive training can be given to students who are found average and below average in working memory to improve their working memory and the impact of cognitive training on working memory.
- Sample from wider geographical area can be taken to make the results generalisable.

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Conflict of Interest

The author(s) declared no conflict of interest.

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