RESEARCH PAPER

An Experimental Study Of Cognitive Function Among Gurukul (Yogic) And Modern School Students Using Trail Making Test

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Abstract

The Gurukul education system, rooted in traditional Indian pedagogy, emphasizes holistic development, including cognitive discipline and attention. The present study aimed to compare cognitive attention and task-switching abilities among students from two educational systems: the Gurukul education system and modern schools. A total of 140 students aged 8–12 years (70 from each system) were randomly selected for participation. The mean age of Gurukul students was 10.50 ± 1.22 years, while that of modern school students was 10.64 ± 1.19 years. Participants continued their regular academic routines during the observation period. Cognitive functioning was assessed using the Trail Making Test (TMT-A and TMT-B), which evaluates visual attention, processing speed, and cognitive flexibility. Statistical analysis was performed using SPSS (v. 25.0), and multiple linear regression (R^2) was applied. Results revealed that Gurukul students significantly outperformed modern school students in both TMT-A (mean = 49.56 ± 21.41 s; d = −1.27; R^2 = 0.997) and TMT-B (mean = 108.80 ± 39.93 s; d = −1.12; R^2 = 0.790), with $p < 0.001$. These findings indicate enhanced visual attention, faster processing speed, and superior task-switching ability in Gurukul students. It may be concluded that the Gurukul education system fosters improved cognitive functioning, and its pedagogical practices may be beneficially integrated into modern education systems.

Keywords: Gurukul education, Modern education, cognitive function, trail making test, yoga, yogic education

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Introduction

Cognitive function encompasses a range of higher-order mental processes, including attention, memory, reasoning, and executive control, which are essential for effective learning, problem-solving, and daily functioning (Harvey, 2019). These processes enable individuals to acquire, process, and apply information efficiently, thereby playing a critical role in academic achievement and adaptive behaviour. Cognitive strength comprising logical reasoning, analytical thinking, and decision-making is fundamental to intellectual development and long-term educational success (Kumar & Satsangi, 2016).

Educational environments play a crucial role in shaping cognitive development by influencing learning experiences, behavioural patterns, and mental discipline. The traditional Gurukul education system, rooted in ancient Indian pedagogy, emphasizes holistic cognitive development through structured intellectual and contemplative practices (Shanwal, 2024). Students in Gurukul settings engage in activities such as Vedic memorization, logical debates (*Tarka*), grammatical analysis (*Vyākaraṇa*), and astronomical studies (*Jyotiśa*), which collectively enhance memory, reasoning ability, and analytical thinking (Rajguru, 2024). Additionally, contemplative practices such as meditation (*Dhyāna*) and reflective inquiry (*Manana*) are integral components of the Gurukul system and are known to improve attentional control, introspective awareness, and cognitive stability (Dorjee, 2016). These practices promote sustained attention and mental clarity, key elements of executive functioning.

In contrast, the modern education system primarily facilitates cognitive development through structured curricula, problem-solving tasks, and technology-driven learning approaches (Fakhridinovna, 2025). While these methods support knowledge acquisition and innovation, modern lifestyles are often associated with increased screen exposure, multitasking, and environmental distractions, which may adversely affect attention span, cognitive control, and processing efficiency.

A growing body of research highlights the positive impact of mind–body practices on cognitive performance. Meditation has been shown to enhance executive functions, particularly attention regulation and cognitive control (Zainal & Newman, 2024). Similarly, yoga-based interventions have demonstrated improvements in cognitive flexibility, processing speed, and attentional performance among children (Telles et al., 2013). These findings suggest that integrative approaches combining physical, mental, and attentional training may offer advantages in optimizing cognitive outcomes.

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However, despite evidence supporting the cognitive benefits of yoga and meditation, there remains a paucity of empirical studies directly comparing cognitive functioning between students of the Gurukul education system and those of modern schools. Given the fundamental differences in their pedagogical frameworks and daily routines, it is important to examine whether these educational systems differentially influence cognitive development.

The present study aims to compare cognitive attention and task-switching abilities among students from Gurukul and modern education systems using standardized assessment tools, in order to provide empirical insights into the role of educational environments in shaping cognitive performance.

Methodology

Study Design

A comparative cross-sectional research design was used to examine differences between students from the Gurukul and modern school across TMT variables. The target population included 200 students from the Gurukul and 142 from the modern school. From this population, we have randomly selected 70 students from each schools based on inclusion and exclusion criteria. Data were analysed using regression methods to examine relationships and differences between the two educational systems and to test physical fitness in both systems as shown in Figure 1.

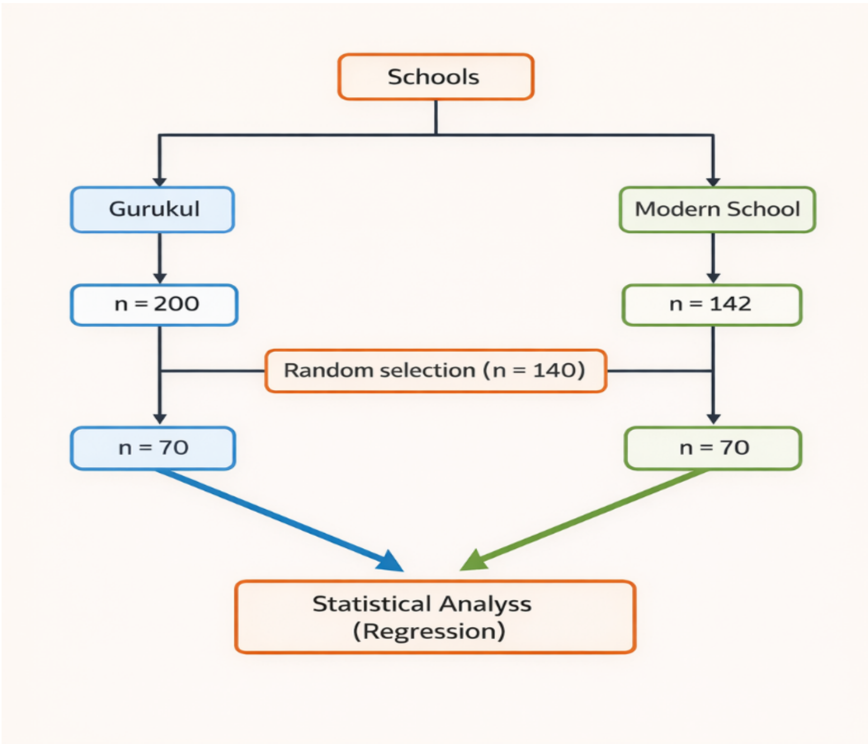

Figure 1: Sampling framework of Gurukul and Modern school students.

The study followed a comparative observational design based on their daily routine practice (DRP) with two parallel groups (Gurukul and Modern School) in a 1:1 ratio. Participants were not subjected to any experimental intervention but were observed under their respective educational environments over a period of 12 weeks. Prior to data collection, informed consent was obtained from parents/guardians through school authorities, and verbal assent was taken from all participants.

Participants

As shown in the study design (Figure 1), a total of 140 school children aged between 8 to 12 years (group mean ± Sd.: Gurukul = 10.50 ± 1.22 years; Modern School = 10.64 ± 1.19 years) were selected as participants. Among them, 70 students belonged to the Gurukul education system, and 70 students were from the Modern school system selected from north India. Both boys and girls were included in the study.

A stratified random sampling method was employed to ensure equal representation from both educational systems and to minimize sampling bias. The participants continued their regular academic and daily school routines during the 12-weeks of observational period, allowing assessment under naturalistic conditions without external intervention. Baseline comparability between the two groups was established, as there was no significant difference in mean age or general characteristics. All participants were from similar socio-economic backgrounds and had comparable exposure to school-level physical activities.

Specific inclusion and exclusion criteria were applied to determine participant eligibility. The inclusion criteria of this study were: (i) students aged between 8 to 12 years (Telles et al., 2013), (ii) participants of both

genders, (iii) continuous enrolment in their respective education system for a minimum period of one year, (iv) physically and mentally healthy and capable of performing the tests, (v) willingness to participate, with written informed consent obtained from parents/guardians and verbal assent from the students. The exclusion criteria of the study were: (i) presence of any physical, neurological, or chronic medical condition affecting the performance, (ii) recent history of injury, surgery, or ongoing medical treatment, (iii) do not want to participate in the study.
Ethical approval for the study was obtained from the Institutional Ethics Committee (Reg. No. EC/NEW/INST/2023/3348).

Assessment
The TMT is a Part of the Halstead-Reitan Neuropsychological Test Battery. It is a widely used neuropsychological assessment tool designed to evaluate an individual's visual attention, processing speed, task-switching ability, sequencing, and cognitive flexibility, essential components of executive functioning. It is particularly useful in identifying impairments related to frontal lobe functioning, attention deficits, dementia, brain injury, and neurodevelopmental disorders.
The TMT test completes in two parts- Part A and Part B-

i. In Part A, the student was instructed to draw lines connecting 25 encircled numbers (1 to 25) arranged randomly on a sheet of paper, in ascending order, as quickly and accurately as possible.
ii. In Part B, the student was instructed to alternate between numbers and letters in a sequential pattern (i.e., 1-A-2-B-3-C.... up to 13-L), which added a level of complexity and assessed divided attention and cognitive flexibility.

The test was performed in a quiet, well-lit environment using a pencil and a stopwatch. Before the final test, a brief practical trial was conducted to ensure that the student understood the task. The total time taken to complete each part was recorded in seconds, along with any errors made during the process. Errors were corrected immediately by the student, and both time and error count contributed to the final interpretation. A longer completion time or higher number of errors, particularly in Part B, indicated impairments in executive control, such as those found in attention deficit disorders, brain injury, or neurodegenerative conditions. The difference in completion time between Part B and Part A was analysed to assess the executive functioning component.

Data analysis process
After data collection was completed, all responses were compiled and systematically entered for statistical analysis in SPSS (v. 25.0) software. Comparisons between the Gurukul students (GS) and Modern School (MS) groups were conducted using both descriptive and inferential statistics, including mean, standard deviation, t-tests, and regression analysis. These analyses aimed to determine significant differences between the two educational systems.

Multiple linear regression (R^2)
The Linear Regression method was employed to estimate how well the selected predictors accounted for the variance in the outcome measures, thereby providing insights into the strength and direction of associations across the two educational systems. This method was used in the present study to evaluate the predictive relationship between independent variables (x) and dependent variables (y). The following equations were formulated:
Trial Making Test (TMT):
$y = r_0 + r_1x_1 + r_2x_2$
Where, y = predictor variable for TMT, r_0 = regression constant, and r_1, r_2 = regression coefficients, x_1 = TMT – A, x_2 = TMT – B

Results
The TMT test has two subparts, TMT-A and TMT-B, for which the PRED value was 487.93 ± 127.87 (Table 1). The GS demonstrated superior attention span and processing speed in TMT-A (49.56 ± 21.41 sec) compared to MS (79.73 ± 25.93 sec). Similarly, in TMT-B, which requires task-switching and higher executive functioning, GS again outperformed MS, with a lower mean completion time of 108.80 ± 39.93 sec and 155.97 ± 44.29 sec, respectively.

Table 1: Mean ± SD of TMT-A and TMT-B for GS and MS students

Test	Mean ± SD	
	Gurukul students	**Modern school students**
PRED	487.93 ± 127.87	
TMT-A sec	49.56 ± 21.41	79.73 ± 25.93
TMT-B sec	108.80 ± 39.93	155.97 ±44.29

The R^2 values of the TMT were observed at a significance level of $p < 0.001$. In TMT-A, both groups achieved almost similar values (R^2: GS – 0.997, MS – 0.999), indicating comparable basic processing speed and visual attention. This suggests a very noticeable and systematic difference between the two groups in simple attentional processes, as the school type represented nearly all of the variance in TMT-A performance. In contrast, in TMT-B, GS obtained a lower R^2 (0.790 sec) compared to MS (0.890 sec), reflecting their superior visual attention and higher processing speed. In these tests, lower R^2 values corresponded to shorter completion times (better performance), while higher R^2 values indicated longer completion times (weaker performance). The overall observed difference in R^2 values between the two groups was 112.66 %. The R^2 values of TMT-A and TMT-B for GS and MS are shown in Figure 2.

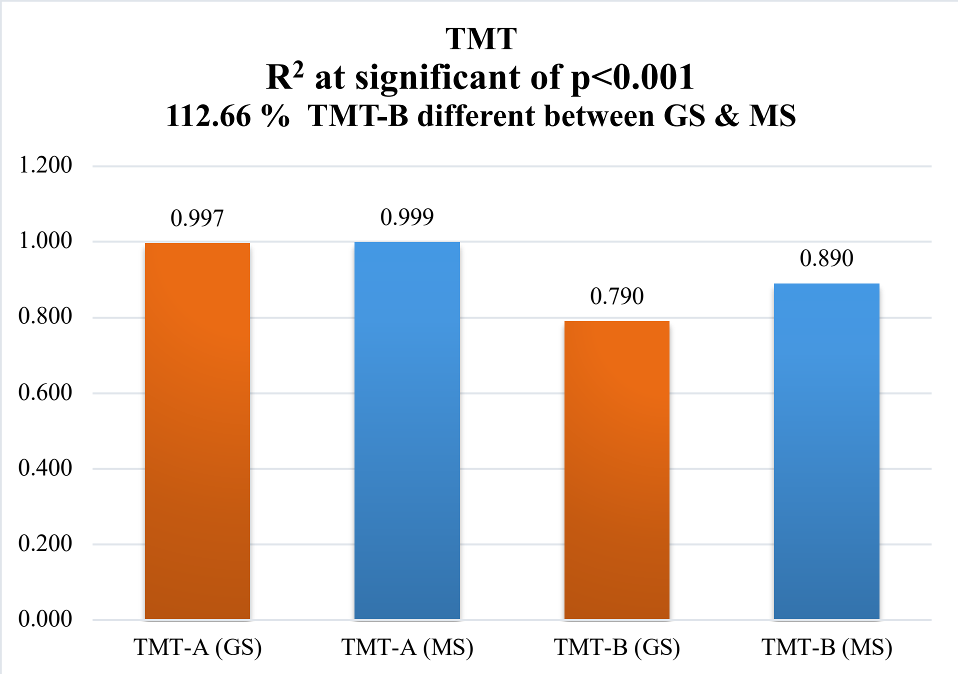

Figure 2: R^2 values of TMT-A and TMT-B for GS and MS.

Interpretation of t-values and d-values

The t-values and p-value for each variable were highly significant (t = -7.52 to -6.62 and p <0.001) in GS compare to MS. On the other hand, the calculated d-values for TMT-A (-1.27) and TMT-B (-1.12) indicated very large effect sizes (Table 2). This reflected the stronger visual attention and faster processing speed of GS than MS.

Table 2: t-value, p-value and d-value of TMT for GS and MS.

Test	**t-value**	**p-value**	**d-value**
TMT-A (sec)	-7.52	p < 0.001	-1.27
TMT-B (sec)	-6.62	p < 0.001	-1.12

Note: p < 0.05 (Significant), p < 0.01 (Highly Significant), p < 0.001 (Extremely Significant), p > 0.05 (Not Significant), t should be greater than 1.

Discussion

The TMT consists of two subtests, viz. TMT-A and TMT-B. This test is particularly useful for examining the relationship between emotional intelligence and academic performance, social behaviour, mental health, and school adjustment (Llinas-Regla et al., 2017; Waggestad, 2023). It is also used in comparative studies, such as evaluating differences in emotional traits among students from different educational backgrounds, making it a suitable tool for studies focusing on socio-emotional development in middle childhood (Mohta & Halder, 2021). In the present study, GS performed faster completion in both of the tests, TMT-A (GS = 49.56 ± 21.41 sec vs. MS = 79.73 ± 25.93 sec) and TMT-B (GS = 108.80 ± 39.93 sec vs. MS = 155.97 ± 44.29 sec), with the large effect sizes (d = – 1.27 to – 1.12), as compared to MS (Table 1; Figure 2).

The better cognitive function of GS could be due to the yogic education system of Gurukul education. Some of the research performed on cognitive function shows that yogic practices such as pranayama, meditation, and mantra chanting improve the mental health and function of children and adolescents. Short-term interventions using yogic practices show that pranayama and meditation reduce stress and anxiety and enhance attention, memory, and emotional regulation (Kanchibhotla & Subramanian, 2021; Sinha & Kumari, 2021; Parajuli et al., 2022; Khunti et al., 2023). The studies of Shetty et al. (2022) and Ozgun et al. (2020) also report improvements in working efficiency and academic-related cognitive skills after performing yogic practices. According to Verma et al. (2015), Kaligal et al. (2023), and Kerekes et al. (2024), long-term, school-based practices promote emotional stability, cognitive development, and overall academic performance.

The overall findings of the present study suggest that the Gurukul education system plays a significant role in enhancing cognitive function, particularly in areas such as attention, processing speed, and executive functioning. This cognitive advantage may be attributed to the incorporation of meditation, yogic practices, memorization, and disciplined daily routines, which are known to improve mental concentration, cognitive flexibility, and neural efficiency. In contrast, modern school education primarily emphasizes academic learning and technological skills, with comparatively less focus on practices that directly strengthen attentional control and executive regulation. As a result, differences in cognitive outcomes may emerge between the two systems. Therefore, an integrated educational model that combines the cognitive-strengthening practices of the Gurukul system with the structured academic curriculum and technological resources of modern education may be highly beneficial. Such an approach could promote optimal cognitive development by enhancing not only intellectual performance but also mental discipline, cognitive resilience, and higher executive functioning.

Conclusion

The outcomes of this study show that the Gurukul education method significantly enhances cognitive skills, including attention, processing speed, and executive functioning. This cognitive advantage is most likely the result of combining meditation, yogic practices, memorisation, and disciplined daily routines, all of which have been shown to improve mental focus, cognitive flexibility, and brain efficiency. Modern school education, on the other hand, focuses primarily on academic knowledge and technology abilities, with relatively little emphasis on exercises that improve attentional control and executive functions. As a result, the two systems may provide different cognitive consequences. Thus, an integrated educational paradigm that blends the Gurukul system's cognitive-strengthening techniques with the structured academic curriculum and technical resources of modern school could be extremely beneficial. This approach would promote optimum cognitive growth by enhancing not only intellectual performance but also mental discipline, cognitive resilience, and higher-order executive functions.

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