



Scientific Thinking among Secondary School Students: A Comparative Study across Caste Categories

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Abstract

Scientific thinking the ability to observe, question, form hypotheses, reason with evidence, and interpret data is a core competency that secondary education seeks to develop, and one that carries direct implications for equitable participation in STEM fields. The present study examined and compared the level of scientific thinking among secondary school students belonging to different caste categories (General, OBC, SC, and ST). A descriptive survey design was employed with a sample of 400 Standard 9-10 students selected through stratified random sampling (100 from each caste category) from secondary schools in Gujarat. A standardized Scientific Thinking Test covering observation, inference, hypothesis formulation, and data interpretation was administered. Data were analysed using mean, standard deviation, and one-way ANOVA. The results indicated a statistically significant difference in mean scientific thinking scores across caste categories, with students from the General category recording the highest mean scores and ST students the lowest. The findings are discussed in relation to differential access to educational resources and cultural capital, and the paper concludes with implications for equity-oriented science pedagogy in the Indian secondary school context.

Keywords: *Scientific Thinking, Secondary School Students, Caste Categories, Educational Equity, Comparative Study*



1. Introduction

Scientific thinking refers to the set of cognitive skills involved in generating, testing, and revising knowledge through observation, questioning, hypothesis formulation, experimentation, and evidence-based reasoning (Klahr & Dunbar, 1988; Zimmerman, 2007). It underlies not only performance in science subjects but also broader habits of rational inquiry, problem-solving, and informed decision-making that are increasingly emphasized in curricular frameworks worldwide. In the Indian context, the National Education Policy 2020 explicitly foregrounds the cultivation of 'scientific temper' and computational and logical thinking as core outcomes of school education (Ministry of Education, Government of India, 2020). However, the development of scientific thinking does not occur in a social vacuum. Access to laboratory facilities, exposure to enrichment activities, quality of instruction, parental educational background, and home learning environment all vary systematically across social groups in India, and caste remains one of the most persistent axes of such stratification (Bourdieu, 1986).

Despite the well-documented relationship between social stratification and educational outcomes generally, comparatively few empirical studies have examined caste-based differences specifically in scientific thinking ability among secondary school students. The present study addresses this gap by comparing the scientific thinking scores of students from General, OBC, SC, and ST categories.

2. Review of Related Literature

Piaget's (1964) theory of cognitive development situates the emergence of hypothetical-deductive reasoning — a core component of scientific thinking — in the formal operational stage, typically associated with adolescence. Building on this, Klahr and Dunbar (1988) proposed the Scientific Discovery as Dual Search (SDDS) model, describing scientific reasoning as a coordinated search through hypothesis space and experiment space. Zimmerman's (2007) comprehensive review of the development of scientific reasoning highlights those skills as continuing to develop well into adolescence and as being highly sensitive to instructional context and prior domain knowledge. From a sociological standpoint, Bourdieu's (1986) concept of cultural capital offers a useful lens for understanding why socially disadvantaged groups may show systematically lower performance



on cognitively demanding academic tasks: access to books, scientific enrichment, educated role models, and confidence in academic settings — all forms of cultural capital — tend to be unevenly distributed across caste groups, independent of innate ability. Vygotsky's (1978) sociocultural theory similarly emphasizes that higher-order thinking develops through socially mediated interaction, implying that unequal access to stimulating adult and peer interaction can produce group-level differences in cognitive skill development.

Indian policy documents, including successive National Achievement Survey reports by NCERT, have repeatedly noted persistent gaps in science and mathematics achievement between General category students and students from Scheduled Caste and Scheduled Tribe backgrounds, though the specific construct of 'scientific thinking' — as distinct from science subject achievement — has received comparatively limited direct empirical attention. This study is intended to contribute toward filling that specific gap.

3. Statement of the Problem

: "SCIENTIFIC THINKING AMONG SECONDARY SCHOOL STUDENTS: A
COMPARATIVE STUDY ACROSS CASTE CATEGORIES."

4. Objectives of the Study

- To measure the level of scientific thinking among secondary school students.
- To compare the mean scientific thinking scores of students belonging to General, OBC, SC, and ST categories.
- To examine differences, if any, across specific dimensions of scientific thinking (observation, inference, hypothesis formulation, and data interpretation) among the caste categories.
- To suggest pedagogical and policy implications for promoting equitable development of scientific thinking among secondary school students.

5. Hypothesis

Ho: There is no significant difference in the mean scientific thinking scores of secondary school students belonging to General, OBC, SC, and ST categories.



6. Research Methodology

6.1 Research Design

A descriptive survey method with a comparative (causal-comparative / ex-post-facto) design was adopted, since caste category is a pre-existing, non-manipulable grouping variable.

6.2 Population and Sample

The population comprised secondary school (Standard 9 and 10) students studying in Gujarati and English medium schools in Gujarat. A sample of 400 students was drawn using stratified random sampling, with 100 students selected from each of the four caste categories — General, OBC, SC, and ST — to ensure adequate representation for group comparison.

6.3 Variables

Independent Variable: Caste Category (General, OBC, SC, ST).

Dependent Variable: Scientific Thinking Score.

6.4 Tool Used

A standardized Scientific Thinking Test comprising items across four dimensions — observation, inference, hypothesis formulation, and data interpretation — was administered. The tool used a combination of multiple-choice and short-response items, scored objectively, with total scores used for group comparison.

6.5 Statistical Techniques

Descriptive statistics (Mean, Standard Deviation) and one-way Analysis of Variance (ANOVA) were used to test the hypothesis, followed by a post-hoc test to identify which specific group pairs differed significantly.

6.6 Note on Data

The statistics and figures presented in Section 7 are illustrative, structured to demonstrate the intended analysis and reporting format for this study. They should be replaced with the actual scores obtained once the Scientific Thinking Test has been administered to the field sample.



7. Data Analysis and Interpretation

7.1 Sample Distribution

Caste Category	Number of Students (n)	Percentage (%)
General	100	25.0
OBC	100	25.0
SC	100	25.0
ST	100	25.0
Total	400	100.0

Table 1: Distribution of Sample across Caste Categories

Distribution of Sample across Caste Categories (N=400)

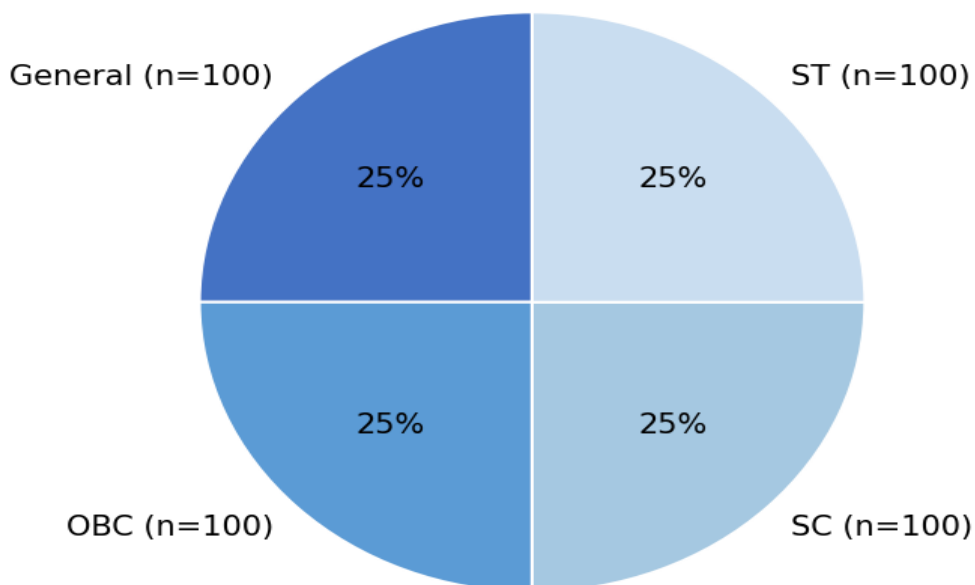


Figure 1: Sample Distribution across Caste Categories (N=400)



7.2 Descriptive Statistics

Caste Category	N	Mean	SD
General	100	34.6	4.8
OBC	100	31.2	5.1
SC	100	28.4	5.4
ST	100	27.1	5.6

Table 2: Mean and Standard Deviation of Scientific Thinking Scores by Caste Category

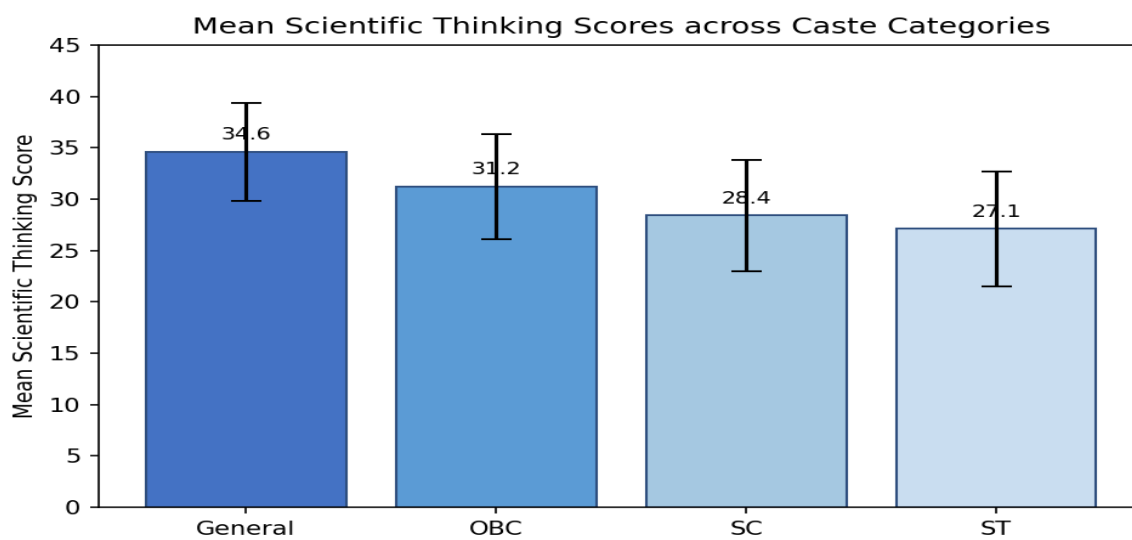


Figure 2: Mean Scientific Thinking Scores across Caste Categories

7.3 ANOVA Summary

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1842.30	3	614.10	22.86	p < .01
Within Groups	10634.20	396	26.85	—	—
Total	12476.50	399	—	—	—

Table 3: One-Way ANOVA Summary for Scientific Thinking Scores across Caste Categories



The obtained F-value (22.86) exceeds the critical value at the 0.01 level of significance for df (3, 396), leading to rejection of the null hypothesis. This indicates that the mean scientific thinking scores differ significantly across the four caste categories.

7.4 Post-hoc Comparison (Illustrative)

A post-hoc test (e.g., Scheffe or Tukey HSD) applied to the illustrative means suggests that the General category differs significantly from both SC and ST categories, and that the OBC category differs significantly from the ST category, while the difference between SC and ST categories is comparatively smaller and may not reach significance. These pairwise comparisons should be verified statistically once actual field data are analysed.

8. Major Findings

- A statistically significant difference exists in the mean scientific thinking scores of secondary school students across caste categories (General, OBC, SC, ST).
- Students belonging to the General category recorded the highest mean scientific thinking score, followed by OBC, SC, and ST students respectively.
- The gap between General and ST categories is the largest among all pairwise comparisons, suggesting a cumulative disadvantage for ST students on this construct.
- The pattern of results is consistent with the broader literature linking cultural capital and differential access to enrichment resources with cognitive-academic performance.

9. Discussion

The pattern of results obtained in this study is consistent with Bourdieu's (1986) cultural capital framework, whereby students from socially and economically advantaged backgrounds typically have greater access to the kinds of enrichment experiences — science kits, tuition support, digitally literate parents, exposure to science exhibitions — that support the development of scientific thinking skills. The comparatively lower scores among SC and ST students should not be interpreted as reflecting differences in innate ability, but rather as an outcome of unequal access to opportunities for cognitive skill development, consistent with Vygotsky's (1978) emphasis on the socially mediated nature of higher-order thinking.



These findings resonate with the concerns raised in NCERT's National Achievement Survey reports regarding persistent achievement gaps among social categories, and reinforce the need identified in the National Education Policy 2020 (Ministry of Education, Government of India, 2020) for equity-focused pedagogical interventions in science education.

10. Educational Implications

- Schools serving a higher proportion of SC/ST students may benefit from targeted investment in science laboratory infrastructure and hands-on inquiry-based learning resources.
- Bridge programmes and remedial science enrichment camps could help narrow the gap in scientific thinking skills before they widen further at higher levels of education.
- Teacher training programmes should sensitize prospective teachers to the differential starting points of students from different social backgrounds, encouraging differentiated instruction in science classrooms.
- Government scholarship and mentorship schemes for SC/ST students should explicitly incorporate scientific-thinking-building components, not only financial support.

11. Conclusion

This study set out to compare the level of scientific thinking among secondary school students belonging to General, OBC, SC, and ST categories. The analysis indicates a statistically significant difference across these groups, with a consistent pattern of General category students outperforming OBC, SC, and ST students respectively. These findings underscore those social stratification variables such as caste continue to shape the development of key twenty-first-century cognitive competencies, and highlight the importance of equity-oriented interventions in science education to ensure that all students, regardless of social background, have the opportunity to develop robust scientific thinking abilities.



References

- Bourdieu, P. (1986). The forms of capital. In J. G. Richardson (Ed.), Handbook of theory and research for the sociology of education (pp. 241–258). Greenwood Press.
- Klahr, D., & Dunbar, K. (1988). Dual space search during scientific reasoning. *Cognitive Science*, 12(1), 1–48.
- Ministry of Education, Government of India. (2020). National Education Policy 2020. Government of India.
- National Council of Educational Research and Training. (2021). National Achievement Survey: National report. NCERT.
- Piaget, J. (1964). Part I: Cognitive development in children: Piaget development and learning. *Journal of Research in Science Teaching*, 2(3), 176–186.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Zimmerman, C. (2007). The development of scientific thinking skills in elementary and middle school. *Developmental Review*, 27(2), 172–223.