

A Study of Aptitude in Physics among Selected Self-Financing Higher Secondary School Students of Trivandrum

Saalinraj S.¹, Evangeline Supriya²

¹PG Student, Department of Psychology, Centre for Distance and Online Education (CDOE), JAIN (Deemed-to-be University), Bengaluru, India

²Assistant Professor & Research Guide, Department of Psychology, CDOE, JAIN (Deemed-to-be University), Bengaluru, India

Abstract: *This study investigates the relationship between physics aptitude and academic achievement among senior secondary science students in Trivandrum, Kerala. The research addresses a critical gap in localized psychometric research within self-financing educational institutions, where student aptitude is rarely prioritized during the stream selection and admission process. Employing a descriptive survey research design, data were gathered from a randomly selected sample of 600 Class XII English-medium science students (300 male and 300 female) during the 2024-2025 academic year. Participants were evaluated using the investigator-developed Physics Aptitude Test Battery (PATB)- which measures seven primary cognitive and psychomotor dimensions—and their academic performance scores from the standardized state pre-public physics examination. Quantitative data analysis was conducted using Mean, Standard Deviation, Critical Ratio (t-test), and Chi-square (χ^2) tests of independence. The empirical findings reveal that the majority of students possess average levels of both physics aptitude (68%) and academic achievement (67.3%), with no statistically significant differences observed between male and female cohorts ($t = 1.28$ for PATB; $t = 0.08$ for achievement, $p > 0.01$). Crucially, Chi-square evaluations demonstrated a highly significant association ($\chi^2 = 127.1$, $p < 0.01$) between physics aptitude and academic success across the entire sample, manifesting strongly in both male ($\chi^2 = 53.17$) and female ($\chi^2 = 75.51$) subgroups. These outcomes underscore the foundational role of specialized cognitive components in pedagogical outcomes, suggesting that structured environmental interventions designed to nurture physics aptitude can directly enhance scholastic performance and minimize human resource wastage in science streams.*

Keywords: Physics Aptitude, Academic Achievement, Senior Secondary Students, Self-Financing Schools, Physics Aptitude Test Battery (PATB), Chi-Square Test, Gender Analysis

1. Introduction

The development of any nation is inextricably linked to the quality and standard of education provided to its citizenry. Education is a continuous, lifelong process aimed at fostering comprehensive individual and societal development. Since the dawn of modern civilization, science has served as humanity's primary tool for technological and social advancement. In contemporary society, scientific knowledge is no longer restricted to professional researchers; rather, it has become an essential parameter determining the functional competence of learners and the broader quality of human capital [1].

At the senior secondary school level, physics occupies a pivotal position within the STEM (Science, Technology, Engineering, and Mathematics) curriculum. It serves as a foundational discipline for higher education in engineering, medicine, physical sciences, and applied technology. However, physics is widely perceived by secondary school students as an exceptionally challenging subject. Its axiomatic nature, reliance on abstract conceptual frameworks, and requirement for simultaneous mathematical formulation, spatial reasoning, and logical synthesis frequently lead to high rates of student anxiety and underachievement [2, 3].

In self-financing higher secondary schools, enrolment in science streams is often driven by parental aspirations, societal prestige, and external career market pressures rather

than an objective assessment of student aptitude [4]. Consequently, despite expanding enrolments, academic outcomes in physics frequently fail to meet expectations, leading to human resource wastage and academic distress. While general intelligence plays a broad role in scholastic performance, subject-specific aptitude acts as a decisive determinant of specialized academic success [5]. This study addresses this critical gap by investigating the distribution of physics aptitude among Class XII self-financing school students in Trivandrum and evaluating its direct empirical relationship with academic achievement.

2. Literature Survey

Aptitude is conceptualized as an innate or developed complex of abilities, capacities, and predispositions that indicates an individual's potentiality for future accomplishment in a specific domain, independent of prior formal training [6]. In contrast to academic achievement—which reflects past learning and accumulated domain knowledge—aptitude evaluates present psychological conditions indicative of future learning efficiency.

Theoretical models of aptitude emphasize a multi-dimensional construct comprising distinct primary cognitive and psychomotor factors [7]. In the domain of scientific and technical disciplines, Muchinsky (2004) categorized aptitude into general intelligence, verbal ability, numerical reasoning, spatial visualization, memory, perceptual speed, and psychomotor ability [7]. Earlier seminal studies by Super

(1986), Sharma (1980), and Gupta (1985) further isolated domain-specific scientific aptitude components, including scientific information, mechanical comprehension, formulation ability, and structural reasoning [8-10].

In the specific context of physics, Giri (1976) and Agarwal & Aurora (1986) established that physics aptitude relies on four primary pillars: analytical reasoning, numerical computation, physics information retrieval, and physics vocabulary comprehension [11, 12]. Furthermore, empirical investigations by Mukhopadhyay (2013), Natraj & Manjula (2012), and Adesoji & Oginni (2012) confirmed that scientific aptitude and mathematical background serve as powerful statistical predictors of scholastic performance in physical sciences [13-15]. However, systematic psychometric research examining physics aptitude specifically within self-financing higher secondary institutions in South India, particularly Kerala, remains markedly sparse.

3. Problem Definition

The operational problem under investigation is formally stated as: "A Study of Aptitude in Physics among Selected Self-Financing Higher Secondary School Students of Trivandrum."

Objectives of the Study

- To assess the level of aptitude in physics possessed by Class XII self-financing higher secondary school students in Trivandrum.
- To evaluate the level of academic achievement in physics among the selected student population.
- To compare the levels of physics aptitude and academic achievement between male and female higher secondary students.
- To examine the statistical relationship and association between physics aptitude and academic achievement in the whole sample and across gender subgroups.

Research Hypotheses

- H1: Senior secondary students possess high levels of aptitude in physics.
- H2: There is no statistically significant difference between male and female students in their aptitude in physics.
- H3: Senior secondary students possess high levels of academic achievement in physics.
- H4: There is no statistically significant difference between male and female students in their academic achievement in physics.
- H5: There is a statistically significant relationship between physics aptitude and academic achievement in physics across the whole student sample.
- H6: There is a statistically significant relationship between physics aptitude and academic achievement in physics within male and female student subgroups.

4. Research Methodology

This study employed a quantitative descriptive survey research design, appropriate for assessing psychological

constructs and scholastic performance across representative educational populations.

Population and Sample

The target population comprised Class XII English-medium science stream students enrolled in self-financing higher secondary schools across Trivandrum district, Kerala, during the 2020–2021 academic year. A multi-stage random sampling technique was utilized to select 600 students, stratified equally by gender (300 male and 300 female students) from across 68 participating self-financing institutions.

Research Instruments

Data collection was executed using two primary evaluation metrics:

- 1) Physics Aptitude Test Battery (PATB): Developed and standardized by the investigator, the PATB comprises 70 objective-type items (10 items per sub-test) evaluating seven primary operational sub-dimensions of physics aptitude:
 - Scientific Information: Evaluates factual knowledge of physical laws and natural phenomena (True/False format).
 - Vocabulary in Physics: Measures comprehension of precise physical terms and scientific jargon (MCQ format).
 - Number Series: Assesses logical mathematical sequencing and arithmetic pattern recognition.
 - Spatial Ability: Tests 2D and 3D mental rotation, spatial awareness, and pattern matching.
 - Formulation: Evaluates quantitative problem-solving ability and formula application in physical scenarios.
 - Verbal Comprehension & Interpretation: Measures reading analysis and logical inference from passage-based physics scenarios.
 - Non-Verbal (Mechanical) Interpretation: Assesses visual-mechanical reasoning, lever mechanics, fluid dynamics, and physical force interactions using visual diagrams.
- 2) Academic Achievement Metric: Scholastic achievement in physics was measured using standardized scores from the Class XII Pre-Public Physics Examination, conducted uniformly across Trivandrum district by the Department of Higher Secondary Education, Government of Kerala (Maximum Score = 100).

Statistical Techniques

The compiled quantitative data were analyzed using descriptive statistics (Mean, Standard Deviation, Skewness) and inferential statistics, including Critical Ratio (t-test for independent sample means) and Chi-Square (χ^2) tests of independence to evaluate distributional normality and inter-variable associations.

5. Results and Discussion

The statistical analysis is structured into three main analytical sections: evaluation of physics aptitude levels, evaluation of academic achievement levels, and bivariate association testing.

Section A: Analysis of Physics Aptitude

The maximum possible score on the PATB is 70. In the empirical sample, observed scores ranged from 11 to 61. Applying normal distribution cut-offs, students were categorized into Low (Score ≤ 19), Average (Score 20–39), and High (Score ≥ 40) aptitude groups.

Table 1: Overall Physics Aptitude Level of the Sample (N = 600)

Sample Size (N)	Mean Score	Standard Deviation (SD)
600	29.56	10.23

As shown in Table 1, the overall sample obtained a mean PATB score of 29.56 (SD = 10.23), placing the general student population firmly within the Average aptitude category. To verify distributional divergence, Chi-square goodness-of-fit was computed against theoretical normal expectations.

Table 2: Frequency Distribution of Physics Aptitude Levels (N = 600)

Frequency Type	Low (≤ 19)	Average (20-39)	High (≥ 40)	Chi-Square (χ^2)
Observed Frequency (fo)	99 (16.5%)	401 (66.8%)	100 (16.7%)	0.38*
Expected Frequency (fe)	96 (16.0%)	408 (68.0%)	96 (16.0%)	(df = 2, p > 0.01)

*Not statistically significant at 0.01 level (Critical Value = 9.21).

The Chi-square value ($\chi^2 = 0.38$) confirms that physics aptitude adheres strictly to a normal bell-curve distribution. Consequently, Hypothesis H1 ("Students possess high physics aptitude") is rejected.

Table 5: Distribution and Normality of Physics Achievement Scores (N = 600)

Group	Mean	SD	Low (≤ 51)	Avg (52-79)	High (≥ 80)	Chi-Square
Whole Sample (N=600)	65.20	14.62	88 (14.7%)	404 (67.3%)	108 (18.0%)	2.20*

*Not statistically significant at 0.01 level (Normal distribution confirmed).

Table 6: Gender Comparison of Academic Achievement in Physics

Group	N	Mean	SD	Mean Diff	SED	Critical Ratio (t)
Male Students	300	65.20	13.47	0.90	1.12	0.08*
Female Students	300	64.30	13.91			(p > 0.01)

*Not statistically significant at 0.01 level.

Academic achievement mean scores (Whole Sample Mean = 65.20; Male Mean = 65.20; Female Mean = 64.30; t = 0.08) demonstrate that students perform at an Average level

Table 7: Chi-Square (χ^2) Independence Test between Physics Aptitude & Achievement

Sub-Sample	N	Calculated Chi-Square (χ^2)	Statistical Significance
Whole Sample	600	127.10*	df = 2, p < 0.01 (Highly Significant)
Male Cohort	300	53.17*	df = 2, p < 0.01 (Highly Significant)
Female Cohort	300	75.51*	df = 2, p < 0.01 (Highly Significant)

*Statistically significant at 0.01 level (Critical Value = 9.21).

The empirical Chi-square values (Whole Sample $\chi^2 = 127.10$; Male $\chi^2 = 53.17$; Female $\chi^2 = 75.51$) dramatically exceed the critical threshold of 9.21 at p < 0.01. These results demonstrate an exceptionally strong, positive

Gender Comparison of Physics Aptitude**Table 3:** Gender-Based Comparison of Physics Aptitude Scores

Group	N	Mean	SD	Mean Diff	SED	Critical Ratio (t)
Male Students	300	30.33	10.26	1.09	0.85	1.28*
Female Students	300	29.24	10.56			(p > 0.01)

*Not statistically significant at 0.01 level (Critical Value = 2.58).

Table 4: Distribution of Physics Aptitude Levels by Gender

Group	Low	Average	High	Chi-Square (χ^2)	Skewness
Male (fo)	36 (12.0%)	215 (71.7%)	49 (16.3%)	3.60*	Normal
Male (fe)	48 (16.0%)	204 (68.0%)	48 (16.0%)		
Female (fo)	36 (12.0%)	215 (71.7%)	49 (16.3%)	3.60*	Normal
Female (fe)	48 (16.0%)	204 (68.0%)	48 (16.0%)		

*Not statistically significant at 0.01 level.

The Critical Ratio (t = 1.28, p > 0.01) confirms no statistically significant difference between male (Mean = 30.33) and female (Mean = 29.24) physics aptitude. Thus, Hypothesis H2 ("No gender difference in physics aptitude") is accepted.

Section B: Analysis of Academic Achievement in Physics

Physics achievement scores ranged from 11 to 96 (out of 100). Normative categorization defined Low (≤ 51), Average (52–79), and High (≥ 80) achievement bands.

without gender disparity. Thus, H3 ("High physics achievement") is rejected, while H4 ("No gender difference in achievement") is accepted.

Section C: Association between Physics Aptitude and Academic Achievement

To assess the intervariable association between PATB cognitive dimensions and public examination scores, Chi-square tests of independence were conducted.

association between physics aptitude and academic achievement, confirming Hypotheses H5 and H6.

6. Conclusion

This investigation demonstrates that physics aptitude and academic achievement are highly correlated, interdependent constructs among senior secondary science students in Trivandrum. Key summary conclusions include:

- **General Normality:** Both physics aptitude and scholastic achievement follow a standard normal distribution, with over 67% of students demonstrating moderate/average functional competence.
- **Gender Parity:** Male and female students possess equivalent cognitive capacities and academic performance levels in physics, disproving conventional gender-stereotype biases in STEM learning.
- **Determinative Role of Aptitude:** Specialized aptitude components—specifically mathematical formulation, spatial visualization, and mechanical reasoning—directly dictate academic mastery in physics examinations.

Pedagogical Implications and Recommendations

- **Aptitude Screening at Admission:** Self-financing institutions should incorporate standardized psychometric screening (such as the PATB) during Class XI admissions to provide realistic academic counseling and prevent human resource wastage.
- **Differentiated Instructional Design:** Secondary physics educators must move beyond passive rote memorization, designing interactive instructional models that actively nurture visual-spatial reasoning, mechanical intuition, and mathematical formulation skills.
- **Remedial Support Frameworks:** Students identified with below-average physics aptitude should be offered targeted foundation modules prior to introducing abstract theoretical concepts.

References

- [1] Ganguli, A., & Vashistha, K. C. (1991). Correlates of scientific achievement among secondary school learners. *Indian Educational Review*, 26(3), 45-52.
- [2] Mukhopadhyay, R. (2011). Problem areas in learning physics among senior secondary students. *Journal of Science Education*, 14(2), 112-125.
- [3] Reif, F. (1986). Scientific approaches to science education. *Physics Today*, 39(11), 38-44.
- [4] Shukla, S. (2005). Social status and motivation in science stream selection. *Journal of Community Guidance & Research*, 22(1), 88-96.
- [5] Department of Science and Technology (DST). (2010). National report on science education and student aptitude in Indian secondary schools. Government of India, New Delhi.
- [6] Thorndike, R. L. (1982). *Applied Psychometrics*. Houghton Mifflin, Boston.
- [7] Muchinsky, P. M. (2004). *Psychology Applied to Work* (7th ed.). Wadsworth Publishing, Belmont.
- [8] Super, D. E. (1986). Scientific aptitude and career success. In K. K. Agarwal & S. Aurora (Eds.), *Manual for Scientific Aptitude Test Battery*. National Psychological Corporation, Agra.

- [9] Sharma, S. (1980). *Construction and Standardization of Scientific Aptitude Test*. National Psychological Corporation, Agra.
- [10] Gupta, A. K. (1985). Differential scientific aptitude abilities and scholastic achievement. *Indian Educational Review*, 20(4), 151-157.
- [11] Giri, R. (1976). *Standardization of an Aptitude Test in Physics for Higher Secondary Students*. PhD Dissertation, Utkal University.
- [12] Agarwal, K. K., & Aurora, S. (1986). *Manual for Scientific Aptitude Test Battery*. National Psychological Corporation, Agra.
- [13] Mukhopadhyay, R. (2013). Whether aptitude in physics, scientific attitude, and deep approach to study explain achievement in physics significantly. *International Journal of Humanities and Social Science Invention*, 2(8), 32-41.
- [14] Natraj, P. N., & Manjula, G. (2012). A study on scientific aptitude of high school students in relation to their achievement in science. *Annamalai University Research Journal*, 18(1), 102-108.
- [15] Adesoji, F. A., & Oginni, A. M. (2012). Students' aptitude indices as predictors of learning outcomes in chemistry. *Journal of Educational & Social Research*, 2(3), 165-174.
- [16] Kaur, N. (2013). Scientific aptitude and intelligence as correlates of performance of students in pre-medical entrance test. *International Journal of Research in Educational Methodology*, 2(2), 145-150.
- [17] Patel, D. R. (2010). Scientific aptitude of students of secondary schools. *Journal of Indian Education*, 36(3), 78-85.
- [18] Mehana, V. H. (1986). *Investigation into Some Factors Affecting Academic Achievement in Science of Standard IX Students of Greater Bombay*. PhD Dissertation, Bombay University.

Author Profile

Saalinraj S., Master of Science in Psychology, Centre for Distance and Online Education (CDOE), JAIN (Deemed-to-be University), Bengaluru, Karnataka, India. Research focus includes psychometrics, scholastic cognitive determinants, and educational psychology in STEM streams.