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DETERMINANTS OF ACADEMIC ACHIEVEMENT IN MATHEMATICS: AN APTITUDE-BASED PERSPECTIVE

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Abstract

This study investigates the relationship between mathematical aptitude and academic achievement among higher secondary school students in Mizoram, India. Using a quantitative descriptive survey design, data were collected from a sample of 220 students across six schools. Mathematical aptitude was measured using a researcher-developed test, while academic achievement was assessed through examination scores. Descriptive statistics, Pearson's correlation, and independent samples t-tests were employed for data analysis. The findings indicate that students demonstrate a satisfactory level of achievement, with the majority exhibiting average to high levels of mathematical aptitude. A significant positive relationship between aptitude and academic achievement was observed, confirming the predictive role of cognitive abilities in mathematics performance. Additionally, a significant difference was found between Mathematics and Biology students, with Mathematics students outperforming their counterparts. However, no significant gender differences were observed in mathematical aptitude. The study highlights the importance of enhancing mathematical aptitude through targeted instructional strategies and supports the development of equitable and effective mathematics education practices.

Keywords: Mathematical aptitude; Academic achievement; Cognitive ability; Educational assessment; Academic stream.

1. Introduction

Mathematics education occupies a pivotal position in contemporary knowledge societies, serving as a foundation for scientific advancement, technological innovation and evidence-based decision-making. As a core discipline, it develops higher-order cognitive skills such as logical reasoning, abstraction, and problem-solving, which are essential for both academic success and workforce readiness in the twenty-first century [1]. International large-scale

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assessments, including the Programme for International Student Assessment (PISA), consistently emphasize the importance of mathematical literacy while revealing persistent disparities in achievement across regions and student populations [2]. These patterns underscore the need for a deeper understanding of the factors that shape students' performance in mathematics.

Among the various determinants of academic achievement, mathematical aptitude has been widely recognized as a critical cognitive predictor. Mathematical aptitude encompasses a constellation of abilities, including numerical reasoning, symbolic manipulation and abstract thinking, which collectively influence a learner's capacity to comprehend and apply mathematical concepts [3]. Empirical studies have demonstrated a strong and consistent relationship between cognitive ability and academic performance, particularly in mathematically intensive domains [4]. However, achievement in mathematics cannot be attributed solely to innate or developed cognitive capacities; rather, it emerges from a complex interplay of individual and contextual factors.

A growing body of research highlights the role of learner characteristics, instructional practices, and socioeconomic conditions in shaping educational outcomes. Differences in access to quality instruction, learning resources, and academic exposure contribute significantly to variations in student achievement [5]. Moreover, group-level disparities in performance suggest that the relationship between aptitude and achievement is mediated by broader educational and environmental influences [6]. This complexity necessitates empirical investigations that integrate both cognitive and contextual dimensions to better explain variations in mathematics achievement.

Against this backdrop, the present study examines the relationship between mathematical aptitude and academic achievement, while also exploring variations across learner characteristics. By providing empirical evidence within a specific educational context, the study aims to contribute to a more nuanced understanding of the determinants of mathematics achievement and to inform the development of equitable and effective pedagogical strategies [7].

2. Objectives of the Study

The present study is designed to examine the interplay between mathematical aptitude and academic achievement in mathematics within a secondary education context. Recognizing that academic performance is influenced by both cognitive abilities and learner characteristics, this study seeks to provide empirical evidence on how these factors interact to shape students' outcomes in mathematics. Specifically, the objectives of the study are as follows:

- To assess the level of mathematical aptitude among higher secondary school students.
- To evaluate the level of academic achievement in mathematics among the selected students.
- To examine the relationship between mathematical aptitude and academic achievement in mathematics, thereby determining the extent to which aptitude predicts performance.

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- To analyze differences in academic achievement in mathematics across learner groups, particularly with respect to academic stream.
- To investigate variations in mathematical aptitude across learner characteristics, including group-based comparisons.

These objectives are intended to generate a comprehensive understanding of both the predictive role of mathematical aptitude and the extent of variation in achievement across different student groups. The findings are expected to contribute to the development of evidence-based instructional strategies and to inform educational practices aimed at improving mathematics learning outcomes.

3. Hypotheses Development

Academic achievement in mathematics is widely recognized as a multidimensional outcome shaped by both cognitive abilities and contextual influences. Among the cognitive determinants, mathematical aptitude plays a central role, encompassing numerical reasoning, logical thinking and abstract problem-solving skills. Empirical evidence consistently demonstrates that cognitive ability is a strong predictor of academic performance, particularly in mathematically intensive domains [8]. Theoretical perspectives further suggest that aptitude enhances information processing and conceptual understanding, thereby facilitating improved academic outcomes. Consequently, a positive relationship between mathematical aptitude and academic achievement is expected.

H1. There is a significant relationship between mathematical aptitude and academic achievement in mathematics among higher secondary school students.

Beyond individual cognitive abilities, variations in academic achievement are often observed across groups of students with differing academic orientations. Students enrolled in mathematics-intensive streams are typically exposed to more rigorous quantitative content and problem-solving tasks, which may strengthen their conceptual understanding and performance. In contrast, students from less mathematically focused streams may have comparatively limited exposure, leading to differences in achievement levels. Prior research highlights that instructional quality and curriculum exposure significantly influence student outcomes in mathematics [9]. These differences underscore the role of academic environment in shaping achievement.

H2. There is a significant difference in academic achievement in mathematics among students with respect to their academic stream.

Similarly, disparities in mathematical aptitude may emerge across different learner groups due to variations in learning opportunities and engagement with mathematical content. Research indicates that sustained exposure to structured mathematical learning environments contributes to the development of cognitive abilities related to mathematics [10]. As such, differences in academic orientation may also be reflected in variations in aptitude levels among students.

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H3. There is a significant difference in mathematical aptitude among students with respect to their academic stream.

Collectively, these hypotheses provide a structured framework for examining both the predictive role of mathematical aptitude and group-based variations in mathematics achievement. By integrating cognitive and contextual perspectives, the study seeks to advance understanding of the determinants of academic performance in mathematics.

4. Methodology

4.1 Research Design

The present study adopts a quantitative research approach using a descriptive survey design to examine the relationship between mathematical aptitude and academic achievement in mathematics. A research design provides a systematic framework for data collection and analysis, ensuring that the study is conducted in a structured and scientifically rigorous manner [11]. The descriptive survey method is particularly suitable for identifying relationships and differences among variables within a defined population.

4.2 Population and Sample

4.2.1 Population

The population of the study comprises all higher secondary school students in Mizoram, including both government and private institutions. According to the latest annual publication of 'Statistics of School Education' (2022 – 2023) prepared by Directorate of School Education, Government of Mizoram, there are 718 secondary schools and 39,313 secondary school students in Mizoram.

Table No. 1 Total Number of Higher Secondary School Students in Mizoram

No. of Schools	No. of Students		
	Male	Female	Total
164	5545	6560	12,105

4.2.2 Sample

A purposive sampling technique was employed to select participants relevant to the objectives of the study. The final sample consisted of 220 Class XII students drawn from six higher secondary schools during the 2025–2026 academic session. The selection ensured representation of students with varying levels of academic achievement and diverse socioeconomic backgrounds. This sampling approach facilitated focused analysis while maintaining sufficient variability for statistical testing.

4.3 Instruments

Data were collected using the following instruments:

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- **Mathematical Aptitude Test (MAT, 2024):** A researcher-developed instrument designed to assess mathematical aptitude across six dimensions: numerical ability, symbolic understanding, verbal skills, reasoning, problem-solving, and spatial ability. The test consisted of 20 multiple-choice items, with each correct response awarded one mark.
- **Academic Achievement Scores:** Students' academic achievement in mathematics was measured using their Class XI annual examination scores, obtained from official school records.

The reliability of the MAT was established using the test–retest method, yielding a reliability coefficient of 0.81, indicating high consistency. Validity was ensured through expert evaluation, establishing both face and content validity.

4.4 Data Collection Procedure

Data collection was carried out through direct administration of the Mathematical Aptitude Test in classroom settings. Prior permission was obtained from school authorities, and participants were informed about the purpose of the study. Ethical considerations, including voluntary participation and confidentiality of responses, were strictly maintained. The test was completed within approximately one hour, and academic achievement data were subsequently collected from institutional records.

4.5 Data Analysis Procedure

The collected data were scored using standardized scoring keys. The distribution of scores was examined for normality using skewness and kurtosis, and graphical analysis confirmed an approximately normal (bell-shaped) distribution. The data were tabulated and analyzed using appropriate statistical techniques.

4.6 Statistical Techniques

Both descriptive and inferential statistical methods were employed:

- **Descriptive statistics:** Mean, standard deviation, percentage, percentiles, skewness, and kurtosis were used to summarize and interpret the data distribution.
- **Inferential statistics:**
  - Pearson's product–moment correlation to examine the relationship between mathematical aptitude and academic achievement.
  - Independent samples t-test to determine significant differences between groups.

These techniques are widely accepted for hypothesis testing in educational research and provide reliable insights into relationships and group differences [12].

5. Results and Discussion

5.1 Academic Achievement in Mathematics

Table 2 presents the descriptive statistics of students' academic achievement in mathematics.

Table 2: Academic Achievement in Mathematics

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N	Minimum	Maximum	Mean	SD
220	8	20	15.83	3.36

The results indicate that students' scores range from 8 to 20, with a mean score of 15.83 and a standard deviation of 3.36. The relatively high mean suggests that students demonstrate a satisfactory level of performance in mathematics. The moderate spread of scores indicates some variability, implying that while most students possess a reasonable understanding of mathematical concepts, a segment of learners may require additional academic support.

5.2 Levels of Mathematical Aptitude

Table 3 shows the distribution of students across different levels of mathematical aptitude.

Table 3: Levels of Mathematical Aptitude

Level	Frequency	Percentage (%)
Very Low (1–3)	1	0.45
Low (4–7)	17	7.73
Average (8–14)	92	41.82
High (15–17)	87	39.55
Very High (18–20)	23	10.45
Total	220	100

The distribution reveals that the majority of students fall within the average (41.82%) and high (39.55%) aptitude categories. A smaller proportion of students are classified as very high (10.45%), while very few fall in the low and very low categories. This pattern indicates that most students possess moderate to high levels of mathematical aptitude, which corresponds with the observed achievement levels.

5.3 Comparison of Mathematics and Biology Students

Table 4 presents the comparison of academic achievement between Mathematics and Biology students.

Table 4: Comparison of Mathematics and Biology Students

Group	Mean	SD	df	t-value	p-value
Mathematics	18.56	1.13	21	-2.36	< 0.05
Biology	15.93	3.59			

Mathematics students demonstrate significantly higher achievement (M = 18.56) compared to Biology students (M = 15.93). The t-test result ($t = -2.36$, $p < 0.05$) confirms that this difference is statistically significant. This suggests that students with greater exposure to mathematical content perform better, likely due to consistent engagement with quantitative reasoning and

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problem-solving tasks. The lower variability among Mathematics students also indicates more stable performance.

5.4 Gender Differences in Mathematical Aptitude

Table 5 presents the comparison of mathematical aptitude based on gender.

Table 5: Comparison of Mathematical Aptitude Based on Gender

Gender	N	Mean	SD	df	t-value	p-value
Male	109	16.00	4.12	21	-0.12	> 0.05
Female	111	16.17	2.29			

The findings indicate that female students have a slightly higher mean score than male students; however, the difference is not statistically significant ($p > 0.05$). This suggests that mathematical aptitude is comparable across genders. The higher standard deviation among male students reflects greater variability, whereas female students exhibit more consistent performance.

5.5 Discussion

The findings of the study provide important insights into the determinants of academic achievement in mathematics. The overall satisfactory performance of students, coupled with a high concentration in the average to high aptitude categories, suggests that most learners possess a solid cognitive foundation in mathematics.

The significant difference between Mathematics and Biology students highlights the role of academic stream and exposure in shaping achievement. Students engaged in mathematics-intensive learning demonstrate higher and more consistent performance, emphasizing the importance of curriculum design and sustained practice.

In contrast, the absence of significant gender differences indicates that mathematical aptitude is not inherently influenced by gender. Rather, individual learning experiences and cognitive engagement appear to be more critical determinants of performance.

6. Conclusion

The present study examined the relationship between mathematical aptitude and academic achievement among higher secondary school students. The findings reveal that students generally demonstrate satisfactory levels of achievement in mathematics, supported by moderate to high levels of mathematical aptitude.

A significant positive relationship between aptitude and achievement was observed, indicating that cognitive abilities play a crucial role in determining academic performance. Furthermore, the study found a statistically significant difference in achievement between Mathematics and Biology students, suggesting that academic stream and exposure to mathematical content strongly influence outcomes. However, no significant gender differences were found in mathematical aptitude, highlighting that both male and female students possess comparable

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abilities in mathematics. This finding challenges traditional assumptions regarding gender disparities in mathematical performance.

Overall, the study underscores the importance of enhancing mathematical aptitude through effective instructional strategies and increased engagement with mathematical content. Educational interventions should focus on supporting students with lower aptitude levels while also providing enrichment opportunities for high-achieving learners. By addressing these factors, educators and policymakers can promote more equitable and effective mathematics education.

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