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Research Article

Mathematics Anxiety and Academic Performance: A Statistical Analysis of Urban–Rural Differences among Secondary School Students in North-East India

Sabita Mahanta[1*]

[1*]Department of Mathematics, Handique Girls' College, Panbazar, Guwahati, Assam, Pin-781001 Email: sabita.hgc@gmail.com

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ABSTRACT

This paper investigates the relationship between mathematics anxiety and academic performance among secondary school students across urban and rural areas in North-East India. A total of 2,600 students from ten government schools were selected through stratified random sampling. Standardized instruments have been used to measure the mathematics anxiety, self-efficacy and attitude towards mathematics. Further, mathematics scores in the previous academic year and the socio-economic background of the students have been collected. Statistical analysis *t*-tests, Pearson correlations, and hierarchical multiple regression have been used to examine the group differences and to predict the relationships. Results revealed that urban students had significantly lower mathematics anxiety (M = 58.53) and higher performance (M = 63.27) compared to the rural students (M = 60.76; M = 60.89), though the effects were minimal. It has been observed that Mathematics anxiety correlated negatively with achievement ($r = -0.38$, $p < 0.001$), while self-efficacy and attitude correlated positively ($r = 0.46$, $r = 0.33$; $p < 0.001$). Hierarchical regression analysis revealed that self-efficacy and attitude variables together explained 47% of the variance in performance, while demographic factors contributed only a negligible amount of predictive power. The findings highlight the central role of emotional and motivational factors in shaping mathematics achievement, underscoring the importance of anxiety-reduction and confidence-building initiatives, especially for rural learners.

Keywords: mathematics anxiety, self-efficacy, attitude toward mathematics, urban–rural difference, hierarchical regression, secondary education, North-East India.

1. Introduction

Mathematics is a fundamental discipline that develops logical reasoning and problem-solving capabilities in students, which are essential for both academic and professional success. However, a significant number of students have a negative attitude towards mathematics, which becomes a major reason for poor performance in their early education. This emotional reaction, referred to as mathematics anxiety, has a significant role in obstructing performance and limiting their progress [1,2]. Such anxiety reduces the working memory capacity and self-efficacy of students [3].This scenario exhibits a variability across socio-cultural frameworks. In India, the discrepancies between rural and urban educational institutions have a significant effect on how students engage with mathematics [4]. Rural students are mostly content with limited resources and exposure to experiential learning methodologies, whereas their urban counterparts are subjected to pressure driven by competitive academic environments [5]. In the North-Eastern region of India, the educational disparities are characterized by linguistic heterogeneity and geographic remoteness [6,7]. This paper aims to explore mathematics anxiety and its correlation with academic performance among secondary school students in Assam and Arunachal Pradesh, with the intention of comparing mathematics anxiety and achievement levels across urban and rural cohorts. Further, an attempt has been made to analyse the interrelationships among anxiety, self-efficacy, attitudes, and performance outcomes.

2. Literature Review

Mathematics anxiety has long been recognized as a major obstacle to effective learning. Richardson and Suinn described it as a sense of tension and fear that interferes with handling numbers and solving mathematical problems [8]. Hembree [2] and Ma [9], in their major meta-analyses, confirmed a strong and consistent negative link between mathematics anxiety and achievement across educational levels. Ashcraft [10] and Eysenck et al. [11] have shown that anxiety disrupts working memory and cognitive processing, thereby lowering efficiency during problem-solving. Carey et al. further observed that this relationship is cyclic—poor performance increases anxiety, and heightened anxiety, in turn, reduces future performance [3].

Self-belief and confidence play a vital role in mathematics learning. Bandura's self-efficacy theory posits that an individual's belief in their personal capability influences their motivation, effort, and persistence [12]. Pajares and Miller found that self-efficacy predicts mathematical problem-solving even more strongly than prior achievement [13]. Students with low confidence often avoid difficult tasks and interpret setbacks as personal failure, which heightens anxiety. Thus, mathematics anxiety represents not only an emotional reaction but also a blend of affective, cognitive, and motivational elements.

Cross-cultural research indicates that the level and nature of mathematics anxiety vary by educational context. Chinn found that in the United Kingdom, testing and performance pressure are common sources of anxiety [5]. Devine et al. reported that gender differences are largely shaped by social stereotypes rather than ability [14]. Studies such as those by Ashcraft [10] and Carey et al. [3] suggest that improving mastery and confidence is more effective in reducing anxiety than rote-based teaching.

In India, the disparities between rural and urban schools strongly influence the learning experiences of the students in mathematics. Rural schools often lack trained teachers and adequate facilities, resulting in poor conceptual understanding and increased anxiety. Urban schools, though better resourced, create a different kind of stress through competition and examination pressure [4, 5]. Consequently, rural students tend to experience resource-related anxiety, while urban students are more prone to performance-related anxiety.

Gender and socio-economic background also influence these experiences. Devine et al. [14] and Hembree [2] showed that gender differences in mathematics anxiety depend largely on cultural expectations. Singh and Mishra observed that when mathematics teaching in North-East India is connected to real-life contexts, both anxiety levels and gender differences decrease, which highlights the value of culturally responsive teaching [15].

The North-Eastern region of India presents unique challenges. Nanda reported that limited infrastructure, linguistic diversity, and teacher shortages affect mathematics education [6]. Many students study in a language other than their mother tongue, which adds to their anxiety. Baruah noted that a focus on examination-oriented instruction emphasizes rote learning over conceptual clarity, reinforcing fear and avoidance [7].

In cities like Guwahati, high parental expectations and competition often contribute to exam-related stress [7]. Meanwhile, students in Goalpara and rural Arunachal Pradesh experience anxiety due to irregular teaching and inadequate learning resources. Together, these findings suggest that mathematics anxiety in the Northeast is a multifaceted issue influenced by social, cultural, linguistic, and infrastructural factors.

Although many studies have extensively explored mathematics anxiety, systematic and large-scale investigations in India, especially in the Northeast, remain limited. The available research shows that mathematics anxiety is widespread yet deeply context-dependent, and its expression depends upon the learning environment and teaching practices. The present study aims to explore the interaction among anxiety, self-efficacy, attitude, and academic performance among secondary-level students in North East India.

3. Methodology

3.1 Research Design

The study employs a quantitative and cross-sectional approach to investigate the relationship between mathematics anxiety and students' academic performance, with a particular focus on the differences between urban and rural settings in Assam and Arunachal Pradesh. The design integrates both psychological assessments and socio-demographic data to identify the main factors associated with students' achievement in mathematics.

Rather than focusing on experimental control, the research seeks to understand naturally occurring variations among learners. It considers emotional and motivational characteristics—such as anxiety, self-efficacy, and attitude—alongside contextual influences including school location, medium of instruction, parental education, and the learning environment. Together, these elements help explain how students' attitudes towards mathematics and their backgrounds shape their mathematical outcomes. The analysis relies on correlational and inferential statistics to trace meaningful patterns and relationships within the data.

3.2 Study Area and Sample

The research was executed across three districts that exemplify the varied educational contexts of North-East India. Data were gathered from secondary educational institutions situated in:

- Kamrup (Metropolitan) District, Assam, predominantly from Guwahati city, represents urban educational establishments,

- Goalpara District, Assam, is a semi-rural and rural educational environment, and
- Rural regions of Arunachal Pradesh (encompassing East Siang and Papum Pare districts).

A total of 2,600 students from Classes VIII to X participated in the study. The sample was selected through stratified random sampling to ensure fair representation across gender, grade level, and school location (urban and rural). Before data collection, consent was obtained from parents or guardians, and students provided their assent to participate. Participation was entirely voluntary, and all information was kept anonymous to maintain confidentiality and follow ethical research practices.

Students enrolled in Classes VIII to X who completed the questionnaire and maintained a minimum attendance of 75% in the previous academic term were included in the study.

3.3 Instruments and Variables

Data were collected using a structured questionnaire divided into five sections: demographic information, mathematics anxiety, self-efficacy, attitude toward mathematics, and academic performance. The instrument was pilot-tested for contextual clarity and reliability prior to administration.

3.3.1 Mathematics Anxiety Scale

In this study, a revised iteration of the Mathematics Anxiety Rating Scale (MARS), conceptualised by Richardson and Suinn [8], has been utilised. Twenty Likert-type items were designed to assess three distinct domains: anxiety related to testing, anxiety associated with learning, and anxiety in problem-solving contexts. Responses were evaluated on a 5-point scale, ranging from 1 (indicating no anxiety) to 5 (indicating extreme anxiety). Elevated scores were indicative of increased levels of anxiety. The reliability of the instrument, as assessed in a pilot sample, yielded a Cronbach's α of 0.87.

3.3.2 Mathematics Self-Efficacy Scale

Derived from the research conducted by Pajares and Miller [13], the instrument used in this study comprises twelve items that evaluate the students' self-efficacy regarding their proficiency in resolving mathematical problems. The assessment utilized a 5-point Likert scale, where 1 indicated a lack of confidence and 5 denoted a high level of confidence. The reliability of the instrument was evidenced by a Cronbach's α coefficient of 0.82.

3.3.3 Attitude Toward Mathematics Scale

According to Aiken [16], this scale consisting of ten items assessed students' enjoyment, interest, and perceived utility of mathematics. The response format utilized was a 5-point scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). The reliability coefficient was determined to be Cronbach's α = 0.79.

3.3.4 Demographic and Contextual Variables

The dataset encompassed variables such as gender, age, academic grade, parental educational attainment, socioeconomic status as indicated by family income bracket, daily hours dedicated to study, accessibility to digital educational resources, and the language of instruction utilized. The geographical variable distinguishing urban from rural locales was systematically categorized in accordance with the official governmental classification protocols pertinent to each district.

3.3.5 Academic Performance

The annual assessment scores in mathematics of students as documented in official educational records, functioned as the metric for evaluating academic performance. The scores were normalized to a 0–100 scale for the purposes of analysis and subsequently classified into the following categories:

- High performance (≥ 75 marks)
- Medium performance (50–74 marks)
- Low performance (< 50 marks)

3.4 Data Collection Procedure

Data collection took place over four months through planned visits to the selected schools. Questionnaires were administered during regular class hours under the supervision of the research team to minimize response bias. In rural areas, the questions were explained in Assamese, Hindi, or English, depending on the students' language proficiency, to ensure clarity and accurate responses.

Students' academic performance data were verified using official school records and matched with their questionnaire responses. All completed forms were checked for accuracy and completeness, coded systematically, and entered into a central database for statistical analysis.

3.5 Data Analysis

Data analysis comprised both descriptive and inferential statistical procedures.

- Descriptive statistics (mean, standard deviation, skewness, kurtosis) were used to summarize sample characteristics.
- Independent-samples *t*-tests compared mathematics anxiety and achievement across urban and rural groups.
- Pearson's product–moment correlation measured associations among anxiety, self-efficacy, attitude, and performance.
- Hierarchical multiple regression analysis examined the predictive power of affective–motivational variables while controlling for demographic factors (gender, socio-economic status, study habits).

All analyses were performed using the Python Statistical Library (pandas, scipy, statsmodels). Statistical significance was set at $p < 0.05$.

4. Experiment and Results

4.1 Research Design and Sampling

The study followed a quantitative, descriptive–correlational design to investigate how mathematics anxiety affects students' academic performance and to compare patterns between urban and rural learners in the North-Eastern Indian context.

A total of 2,600 students were drawn using stratified random sampling from ten government secondary schools—five from urban Guwahati (Kamrup Metropolitan District), three from semi-rural Goalpara District, and two from rural areas of Arunachal Pradesh. This sampling strategy ensured balanced representation of both urban and rural groups, allowing for meaningful comparison and statistical analysis.

The participants were students from Classes VIII to X, ranging in age from 13 to 17 years. Before data collection, informed consent was obtained from school authorities and students to ensure voluntary participation and ethical compliance.

4.2 Instruments and Data Collection

Four standardized tools were used in this study:

1. Mathematics Anxiety Scale (20-item Likert-type)

Adapted from the *Mathematics Anxiety Rating Scale* developed by Richardson and Suinn [8]. Each item was rated on a 5-point scale (1 = Not at all anxious to 5 = Very anxious).

Higher scores indicated greater anxiety. The reliability coefficient for the present study was Cronbach's $\alpha = 0.91$.

2. Mathematics Self-Efficacy Scale

A 10-item instrument assessing students' confidence in handling mathematical tasks.

Reliability coefficient: $\alpha = 0.88$.

3. Attitude Toward Mathematics Scale

A 10-item scale measuring students' interest, enjoyment, and perceived usefulness of mathematics. Reliability coefficient: $\alpha = 0.86$.

4. Academic Performance

Students' annual mathematics examination scores were obtained from official school records and expressed as percentage scores.

Data has been collected during regular school hours under supervision to minimize response bias.

4.3 Data Analysis

Data were analysed using descriptive statistics, independent-samples t-tests, Pearson Product–Moment Correlations (PPMC), and hierarchical multiple regression analysis.

All statistical computations were conducted using Python (packages: pandas, scipy, statsmodels).

The main objectives of the analysis are:

1. Examine urban–rural differences in mathematics anxiety and achievement.
2. Determine the relationships among mathematics anxiety, self-efficacy, attitude, and performance.
3. Assess the predictive power of affective–motivational factors, namely self-efficacy and attitude towards mathematics, on academic performance beyond demographic variables.

4.4 Urban–Rural Comparison

Table 1 represents the mean differences between urban and rural students.

Urban students exhibited significantly lower mathematics anxiety ($M = 58.53$, $SD = 14.15$) compared to rural students ($M = 60.76$, $SD = 14.21$), $t(2362.6) = -3.96$, $p = 0.0001$, $d = -0.16$.

Conversely, urban students scored higher in mathematics performance ($M = 63.27$, $SD = 13.81$) than rural students ($M = 60.89$, $SD = 14.85$), $t(2266.6) = 4.14$, $p < 0.001$, $d = 0.17$

Although both effects were small, the results indicate consistent urban advantages in both emotional and academic domains.

Table 1. Group Means and *t*-Test Results (Urban vs. Rural)

Variable	Location	*N*	*M*	*SD*	*t*(df)	*p*	*d*	Interpretation
Mathematics Anxiety	Urban Vs Rural	2600	58.53 vs 60.76	14.15 vs 14.21	−3.96 (2362.6)	0.0001	– 0.16	Rural > Urban (small)
Mathematics Performance	Urban Vs Rural	2600	63.27 vs 60.89	13.81 vs 14.85	4.14 (2266.6)	<0.001	0.17	Urban > Rural (small)

***Note.** p values two-tailed; d = Cohen's d.*

Fig. 1 illustrates the distribution of mathematics anxiety and performance by location. Rural students displayed slightly higher anxiety and lower performance compared to their urban counterparts. The interquartile ranges indicate comparable variability in anxiety but greater dispersion in rural performance scores. The visual pattern aligns with the statistical analysis, confirming small yet consistent urban advantages.

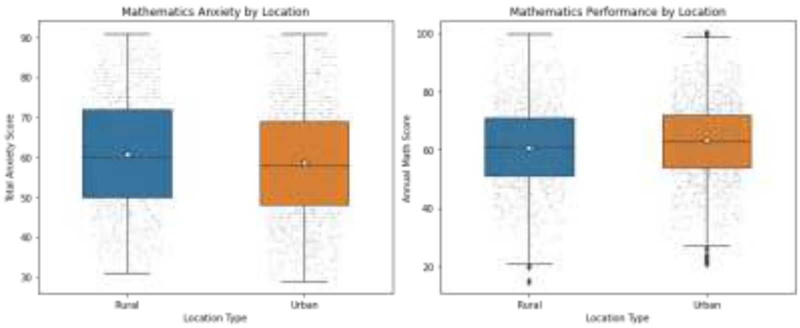

Fig 1. Comparison of Mathematics Anxiety and Performance Across Urban and Rural Students

4.5 Correlation and Regression Analysis

4.5.1 Correlation Analysis

The Pearson correlation results (Table 2) revealed a clear negative relationship between mathematics anxiety and performance ($r = -0.38, p < 0.001$). In contrast, both self-efficacy ($r = 0.46, p < 0.001$) and attitude toward mathematics ($r = 0.33, p < 0.001$) showed positive correlations with students' performance. Mathematics anxiety and self-efficacy were also found to be inversely related ($r = -0.42, p < 0.001$).

Interestingly, the negative link between anxiety and achievement was stronger among rural students, suggesting that environmental and contextual challenges may intensify emotional barriers to learning.

Table 2. Correlation Matrix (N = 2600)

Variable	1	2	3	4
1. Mathematics Anxiety	—	−0.42	−0.28	−0.38
2. Self-Efficacy		—	0.37	0.46
3. Attitude Toward Mathematics			—	0.33
4. Mathematics Performance				—

4.5.2 Hierarchical Regression Analysis

A hierarchical regression analysis has been conducted to understand how affective and motivational factors influence mathematics achievement.

- Model 1 included only mathematics anxiety and explained about 21% of the variance in students' performance ($R^2 = 0.21, p < 0.001$).
- Model 2 added self-efficacy and attitude toward mathematics, raising the explained variance to 47% ($R^2 = 0.47, p < 0.001$), which represents a substantial improvement of 26%.
- Model 3, which further incorporated demographic controls such as socio-economic status, gender, and study habits, did not significantly improve prediction ($R^2 = 0.47, p < 0.001$).

These results suggest that emotional and motivational factors—particularly self-efficacy—play a much stronger role in predicting mathematics achievement than demographic or contextual variables.

Table 3. Summary of Hierarchical Regression Models

Model	Predictor Block	R^2	ΔR^2	Interpretation
1	Mathematics Anxiety	0.21	—	Anxiety alone predicts performance
2	+ Self-Efficacy, Attitude	0.47	+0.26	Major improvement; motivational variables matter most
3	+ SES, Gender, Study Habits	0.47	+0.00	Minimal contribution of demographics

4.6 Interpretation and Summary

The final regression model explained about 47% of the variance in mathematics performance, showing that students' emotional and motivational traits—such as anxiety, confidence, and attitude—account for nearly half of the observable differences in achievement. This highlights that affective and motivational aspects are not secondary but central to successful mathematics learning. From the educational standpoint, the following observations have been made:

- Reducing mathematics anxiety can directly improve student performance.
- Strengthening self-efficacy and fostering positive attitudes can help bridge socio-economic and contextual gaps.
- Emotional and motivational support may be more impactful than purely structural or demographic measures.

Overall, the findings align with the objectives of the study and suggest clear practical implications for improving mathematics outcomes. They indicate that creating emotionally safe, confidence-building, and engaging classroom environments can significantly enhance students' performance, especially among those from rural and low socio-economic backgrounds.

5. Discussion and Conclusion

The findings of this study reaffirm that mathematics anxiety, self-efficacy, and attitude toward mathematics are closely connected and have a strong influence on students' academic achievement. The results indicate that although urban students tend to report slightly lower anxiety and somewhat higher performance than rural students, these differences are modest. This suggests that psychological and motivational factors play a more decisive role in mathematics learning than geographical location alone.

The hierarchical regression analysis showed that affective and motivational factors together explained about 47% of the variance in mathematics performance—a remarkably high proportion for field-based educational research. This means that students' confidence, emotional stability, and positive attitude toward mathematics account for nearly half of the observed differences in achievement. Once these internal factors are considered, variables such as gender, socio-economic background, and study habits add very little explanatory value. These findings highlight the importance of students' emotional and motivational readiness, which often has a greater impact on performance than material resources.

Overall, the study concludes that mathematics achievement is influenced not only by cognitive ability but also by emotional preparedness and motivation. Students who feel confident, supported, and engaged are more likely to perform well, regardless of their background. Addressing affective barriers—particularly anxiety—through empathetic teaching and supportive classroom environments can significantly enhance learning and promote a more inclusive mathematics culture across both urban and rural settings.
Future research should examine how classroom climate, parental attitudes, and peer support jointly shape mathematical confidence. Longitudinal or mixed-method studies could also track how anxiety and self-belief evolve over time and influence students' later academic choices.

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