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Exploring the role of innovation in enhancing mathematics achievement in higher secondary students

Jayalekshmi Janardhanan[1*], M. Aron Antony Charles[2]
[1,2]School of Education, Prist Deemed to Be University, Thanjavur, Tamil Nadu, India; jayalekshmijana@outlook.com (J.J.).

Abstract: Mathematics is an essential part of education, important for students' intellectual development and practical application in daily life. Innovative techniques, such as technology integration and project-based learning, are increasingly recognized for improving students' engagement and academic achievement in mathematics. This study examines the effectiveness of modern techniques on the mathematics achievement of higher secondary students in selected schools in Kerala. Using a mixed-methods approach, data were collected from 300 students through interviews, surveys, and classroom observations. The study analyses the factors such as parental involvement, curriculum design, peer interaction, and the availability of technological infrastructure. Statistical tools such as Chi-square tests, ANCOVA, linear regression, and hierarchical regression were utilized to analyze the relationships between these variables and students' academic performance. Results indicate that students exposed to interactive, technology-enhanced lessons demonstrate significant improvements in mathematical achievement. Peer collaboration and high parental involvement positively influence academic outcomes, while access to technological resources enhances learning. Students with lower math anxiety and higher self-efficacy also show greater academic improvements. The study concludes that innovative methods, when combined with supportive learning environments and reduced anxiety levels, significantly improve students' mathematics performance, emphasizing the importance of active participation and modern resources in education.

Keywords: *ANCOVA, Higher secondary students, Kerala, Mathematics achievement, Mixed method approach, Peer interaction.*

1. Introduction

Mathematics has long been regarded as a fundamental component of education, serving not only as a subject of study but also as a critical skill applicable in various facets of life. As the world becomes more dependent on technology and data driven decision making, the necessity for students to attain a robust understanding of mathematical concepts has never been more pressing [1]. In particular, higher secondary school is a crucial time for students to strengthen their mathematical knowledge, preparing them for higher education and the challenges of the modern industry. Research indicates that a significant number of students experience anxiety and reluctance in mathematics. Studies show that about one third of school students have high levels of anxiety in maths, which creates a negative impact on their motivation and performance. Additionally, a lot of students suffer since mathematical ideas are abstract and hard to understand without real-world applications. Traditional approaches, which heavily depend on passive learning, often struggle to engage students in a meaningful way. Therefore, these methods promote only a surface-level understanding of the subject, leading to less interest and motivation in the subject [2].

In the view of these challenges, teachers are using more and more creative methods that encourage participation, teamwork, and deep understanding of mathematics. A more dynamic and interactive learning environment is the goal of these methods, including project-based learning, integration of technology, and collaborative activities [3]. These methods not only make mathematics more relatable

* Correspondence: jayalekshmijana@outlook.com

and enjoyable but also help students develop a deeper understanding of mathematical principles. Innovative strategies are fundamentally rooted in traditional theories emphasizing active learning and a student-centred approach. For example, constructive theories propose that students learn most effectively when they are actively involved in constructing their own understanding through exploration and real-world experiences. By engaging with concepts in a meaningful way, students are better equipped to create problem-solving and critical thinking skills that are essential for success in both academics and life [4].

In recent years, creative learning methods like project-based learning, flipped classrooms, and technology integration have gained significant popularity. Project-based learning focuses on real- world applications, challenging students to use their knowledge to tackle authentic problems. This method not only enhances critical thinking but also promotes teamwork. Flipped classrooms present traditional lecture content outside of class through videos or online resources. Technology integration enhances the learning experience by integrating educational software and interactive tools. It makes lessons more accessible and engaging, allowing students to visualize complex concepts and study at their own pace [5]. Although there is evidence for innovative methods in mathematics education, significant challenges persist in their implementation. Students often struggle with issues like inadequate training, insufficient resources, and resistance to moving away from traditional learning methods. Moreover, access to the technology and materials essential for these innovative practices is not uniform across schools, which can deepen existing achievement gaps among students. Addressing these criteria is essential to ensuring that all learners can take advantage of modern educational practices. The proposed research aims to investigate the effect of creative techniques on the mathematical achievement of higher secondary students. By examining selected schools, the study assesses how different methods affect students' understanding and performance in mathematics.

2. Literature Review

Onoshakpokaiye (2024) [6] studied the relation amongst academic self-concept, test anxiety, academic performance, and motivation in mathematics among secondary school students. Using a sample of 1650 students from a population of 42,299 senior school students, the study employed a correlational design and observed utilizing Pearson product moment correlation. Findings from the study indicated significant correlations between the psychological variables and academic performance, with gender differences noted in test anxiety, motivation, and self-concept, with differences observed among male and female students in these variables. Obafemi (2024) [7] examined the impact of using brainstorming as a teaching method on the academic performance of pupils in mathematics within Ilorin West Local Government Area, Kwara State, Nigeria. The research utilized a pretest-posttest control group quasi-experimental approach, involving 97 students from two private primary schools. Data was collected using three validated instruments, and the results were analyzed using ANCOVA, revealing that brainstorming significantly improved mathematics performance, though gender had no significant interaction effect.

Abdulkareem et al. (2024) [8] studied the impact of parents' attitudes and socioeconomic status on the academic achievement of middle school students in mathematics in South LGEA. The research used a survey research model with a sample of 100 pupils from 20 private and government schools, gathering parents' perspectives through a validated questionnaire. Multiple regression analysis was employed, revealing that neither socioeconomic status nor attitude of parents significantly influenced pupils' mathematics performance. A limitation noted was that parents with low educational qualifications did not enroll their children in remedial summer coaching, which hinders the efforts to enhance the academic performance. Antipuesto and Tan (2023) [9] studied the effect of blended learning on students' mathematics performance and engagement during the pandemic at Kalilangan National High School. The research utilized students of Grade 10 as participants and performed a one-shot pretest-posttest design to examine the differences in academic performance and engagement before and after exposure to blended learning. Findings revealed that students showed significant improvement in both academic performance and engagement, as indicated by a paired t-test comparing scores of pretests and posttests. Also, the study highlighted a limitation, noting that mathematics teachers have lacked the skills of using technology and printed modules to optimize instruction.

Okibo and Onoshakpokaiye (2023) [10] studied the relation amongst academic motivation and secondary school student efficiency in mathematics in Nigeria. Using a sample of 1,650 senior secondary two (SS2) students selected through multistage sampling, the study employed a correlation survey and Pearson product-moment correlation to examine the data gathered through the Academic Motivation Questionnaire (AMQ). The findings revealed a negative relation between motivation and performance, with no significant relationship between academic motivation and achievement in mathematics. Despite strong levels of motivation reported by most students, the study suggested a difference in performance between highly and poorly motivated students. Bornaa (2023) [11] investigated the relation among mathematics anxiety and academic achievement in students in the municipality area of Sagnarigu, where poor performance in mathematics had persisted for over ten years. The research employed a quantitative method with an analytical cross-sectional approach, selecting 385 pupils from two senior high schools using random sampling. A 20-item math anxiety questionnaire was used to assess students' anxiety levels, while academic reports served as secondary data to measure performance, and Pearson product-moment correlation revealed a negative relation between math performance and anxiety.

In their study, Amjad et al. (2022) [12] investigated the effect of the brain-based learning (BBL) method on the academic achievement of eighth grade pupils in mathematics. They employed a single subject A-B-A research approach, focusing on financial arithmetic, polynomials, and factorization through various engaging activities based on 12 BBL principles. Data were collected nine times using one-tier multiple-choice questions and analyzed with visual analysis and one-way repeated measures ANOVA, revealing a substantial impact of BBL on pupils' academic achievement. Nurbavliyev et al. (2022) [13] aimed to examine the effect of active learning on academic performance, student attitudes, and motivation of 10th grade students at Nurorda School in Kazakhstan. The researchers employed a quasi-experimental approach with two groups: a control group that received conventional lecture-based teaching and an experimental group that used active learning educational platforms. They analyzed the collected data using a multivariate analysis of variance (MANOVA) to evaluate significant differences between the two methods of teaching. The study found that there are no notable changes in the student's attitude or motivation.

Ayeni and Aderinkola (2022) [14] studied the effect of online education on the academic achievement of pupils in mathematics during the era of COVID-19. The research involved 100 students from five secondary schools in Oyo State, using a quasi-experimental approach with control groups that are not equal, through pre- and post-tests. They utilized independent ANCOVA to analyze the data, revealing that virtual learning affected the performance of the students positively and encouraged self-study. Akanmu and Adeniyi (2021) [15] studied the impact of mathematical games on the academic achievement of senior secondary pupils in mathematics in Nigeria. The research involved 73 students, split into two groups: the experimental group, which played mathematical games, and the control group, which did not. Using a mathematics performance test (MPT) and a quasi-experimental research design, the results demonstrated that mathematical games significantly improved student performance in mathematics. The study did not examine the incorporation of mathematical games in the classrooms, which can potentially enhance students' academic achievement in mathematics.

Okafor-Agbala (2021) [16] studied the relation amongst self-efficacy and the academic achievement of secondary school pupils in mathematics in Nigeria. The study utilized a total of 5,096 SS2 students drawn from 261 government-owned secondary schools, employing a correlation research design and data collection through a mathematics self-efficacy questionnaire (MSEQ) and results of students. The reliability of MSEQ was reestablished by Cronbach's alpha method. Pearson r, correlational analysis, and simple regression analysis showed a moderately positive relation amongst students' performance and mathematics self-efficacy. Essuman et al. (2021) [17] performed a study to examine the impact of anxiety in mathematics on the academic achievement of high school pupils in Ghana. The researchers sampled 492 students and used a questionnaire to collect data, applying descriptive statistics and inferential tests such as independent samples t-test, Pearson correlation, and ANOVA for analysis. The research found that anxiety in mathematics affected the pupil's performance negatively, and gender played a significant role in influencing this anxiety.

2.1. Research Gap

The studies reviewed highlighted a consistent focus on various psychological and instructional factors influencing student academic performance in mathematics, including anxiety, motivation, and learning strategies. However, there remained significant gaps in understanding how specific demographic variables, such as socioeconomic status and geographical location, interacted with these factors to affect academic outcomes. Some studies addressed mathematics anxiety and self-efficacy, while few explored how these psychological elements were influenced by external socioeconomic conditions or cultural background. Additionally, there was limited study into the long-term effects of innovative methods on students' performance across different educational settings. The research predominantly concentrated on immediate performance metrics without considering the sustainability of such interventions over time. This underscored the need for comprehensive studies that integrate both psychological variables and external demographic influences to offer a more holistic view of the factors impacting students' academic performance in mathematics.

3. Research Questions

i. How does parental involvement impact the effectiveness of innovative techniques on pupils' achievement in mathematics in Kerala?
ii. What role does curriculum design play in influencing pupils' mathematics achievement when innovative techniques are applied?
iii. To what extent do peer interaction and collaboration during mathematics lessons enhance pupils' achievement when innovative techniques are applied?
iv. How does the availability of technological infrastructure affect the success of innovative techniques on pupils' mathematics performance?
v. What is the relation amongst pupils' mathematics anxiety or self-efficacy and the impact of innovative techniques on their mathematics achievement?

4. Research Objectives

- To analyze the demographic profile of students (e.g., gender, age, socioeconomic status, and academic background) and its influence on the effectiveness of innovative techniques in enhancing pupils' achievement in mathematics.
- To assess the impact of parental involvement on the effectiveness of innovative techniques in improving pupils' achievement in mathematics.
- To evaluate the role of curriculum design in influencing pupils' achievement in mathematics when innovative techniques are applied.
- To examine the extent to which peer interaction and collaboration during mathematics lessons enhance pupils' achievement when innovative techniques are used.
- To analyze how the availability of technological infrastructure affects the effectiveness of innovative techniques in improving pupils' mathematics performance.
- To explore the relationship between students' mathematics anxiety or self-efficacy and the effectiveness of innovative techniques on their achievement in mathematics.

5. Proposed Hypothesis

H_1: There are significant differences in the effectiveness of innovative techniques on pupils' achievement in mathematics based on students' demographic profiles (gender, age, socioeconomic status, and academic background).

H_2: Increased parental involvement positively influences the effectiveness of innovative techniques, leading to pupils' achievement in mathematics.

H_3: A relevant curriculum design significantly enhances the effectiveness of innovative techniques, resulting in improved pupils' achievement in mathematics.

H_4: Higher levels of peer interaction and collaboration during mathematics lessons significantly enhance pupils' achievement when innovative techniques are applied.

H_5: The availability of adequate technological infrastructure significantly improves the effectiveness of innovative techniques, leading to better pupils' performance in mathematics.

H_6: Students with lower levels of mathematical anxiety and higher self-efficacy show significantly greater improvements in their achievement in mathematics when exposed to innovative techniques.

6. Research Methodology

6.1. Conceptual Framework

The study's conceptual framework is grounded in understanding the innovative techniques, along with the factors such as parental involvement, curriculum design, peer interaction and collaboration, and technological infrastructure that impact students' achievement in mathematics. Additionally, it incorporates the influence of psychological aspects like mathematics anxiety and self-efficacy. According to the framework, when these independent variables are appropriately matched and utilized, they can significantly enhance pupils' mathematical performance. The study seeks to understand the interaction of these variables in affecting achievement levels in higher secondary students. The conceptual framework of the study is depicted in Figure 1.

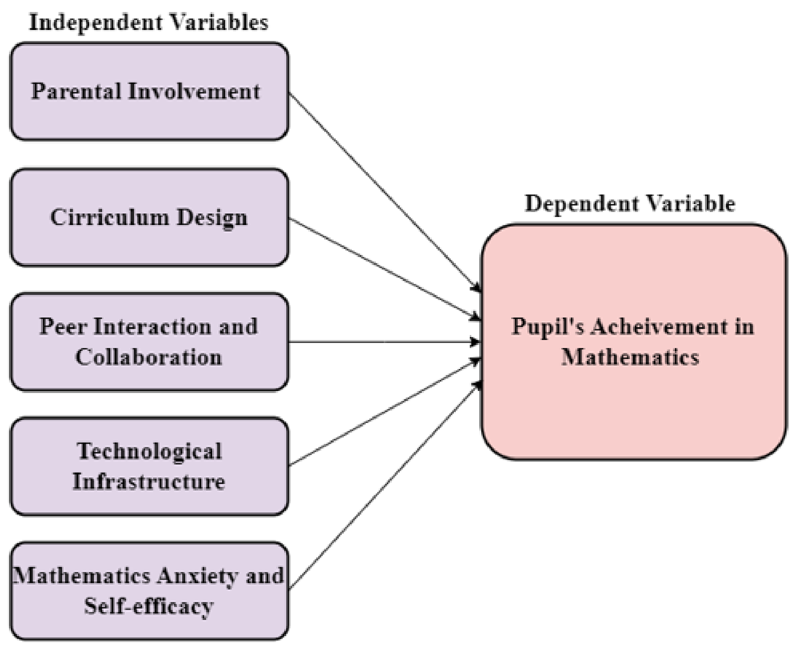

Figure 1.
Conceptual framework of the study.

6.2. Research Design

A mixed-methods approach is used in this study, integrating quantitative and qualitative data to provide a thorough analysis. The quantitative component uses statistical analysis and structured surveys to evaluate the effectiveness of innovative methods on students' achievement in mathematics. Qualitative approaches like focus groups and interviews are used to gather information into students' perceptions and experiences over these methods. By integrating these approaches, the study offers a better understanding of how factors such as parental involvement, curriculum design, peer interaction,

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technological infrastructure, and mathematics anxiety or self-efficacy impact pupils' achievement in mathematics.

6.3. Data Collection

The study utilized a combination of interviews, surveys, and observations from classrooms. Structured questionnaires were distributed to pupils, parents, and teachers to collect quantitative data on demographics, academic performance, parental involvement, and availability of technological resources. It also included items examining the student's mathematical anxiety and self-efficacy. A 5-point Likert scale was utilized within the questionnaires to quantify students' attitudes and perceptions regarding these aspects. Qualitative data was gathered through semi-structured interviews with teachers and students to understand their perceptions of innovative methods and their impact on mathematics achievement. The study also involved direct classroom observations to evaluate the implementation of these methods and their effectiveness.

6.4. Designing of Questionnaire

The questionnaire was designed to capture information on various factors related to the study. It consisted of multiple sections such as demographic information (age, gender, socioeconomic status, academic background) and Likert scale questions related to parental involvement, peer interaction, and curriculum design. Separate scales were used to measure mathematics anxiety and self-efficacy. Additionally, questions were structured to examine the availability and usage of technological infrastructure such as computers, internet access, and educational software.

6.5. Sampling Area and Population

The study took place in selected higher secondary schools located in Kerala. The population was comprised of students enrolled in Grade 11 and Grade 12, as these students were most likely to have encountered advanced mathematical concepts where innovative techniques had a significant impact. Schools with varying levels of technological infrastructure were included to ensure a comprehensive evaluation of the role of technology in learning. The schools selected had diverse student populations, including students from different socioeconomic backgrounds, allowing for examination of demographic influences on academic performance.

6.6. Sampling Technique and Sample Size

A total of 300 students were chosen through a stratified random sampling method to guarantee proportional representation across various demographic groups. The sample consisted of students from varying age groups, socioeconomic statuses, and academic backgrounds. The stratification ensured that students of both genders, along with those from different levels of parental involvement and access to technological infrastructure, were adequately represented. Yamane's formula is used to compute a suitable sample size for the given population as given as:

$$n = \frac{N}{1+Ne^2} \tag{1}$$

Where n stands sample size, N for population, and e for sampling error, which is equal to 0.05.

6.7. Statistical Tools for Analysis

The study utilized a range of statistical tools to analyze the data. Chi-square tests were employed to identify the relationship between parental involvement and student achievement. Analysis of Covariance (ANCOVA) was utilized to assess the impact of curriculum design while controlling for parental involvement. Linear regression analysis was applied to study the influence of peer interaction on mathematics performance. Factor analysis was conducted to explore the role of technological infrastructure, while hierarchical regression was used to determine the combined effect of mathematics anxiety, self-efficacy, and innovative techniques on pupil achievement. All the analysis was performed using the SPSS software.

7. Result and Analysis

7.1. Demographic Distribution

Demographic distribution refers to the statistical analysis and visual representation of students' academic achievement in mathematics when taught using innovative techniques. The demographic distribution of the students based on gender, age, socioeconomic status (SES), and academic background was displayed on Table 1, and Figure 2 provides a visual representation of this data.

Table 1.
Demographic distribution.

Demographic variable	Category	Frequency (N)	Percentage (%)
Gender	Male	160	53.3
	Female	140	46.7
Age	15-16 years	120	40.0
	17-18 years	180	60.0
Socioeconomic status	Low	100	33.3
	Middle	140	46.7
	High	60	20.0
Academic background	Below average	150	50.0
	Average	100	33.3
	Above Average	50	16.7

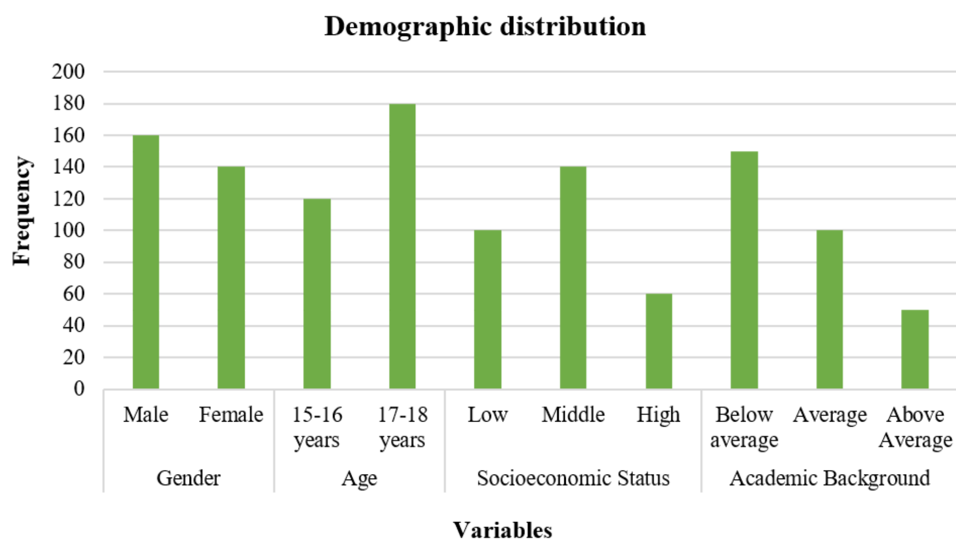

Figure 2.
Demographic distribution of students.

As presented in Table 1, the demographic distribution of the sample revealed that out of 300 students, 53.3% were male and 46.7% were female. Regarding age, 40% of students were between the ages of 15 and 16, while 60% of students were between the ages of 17 and 18. Regarding socioeconomic status, 46.7% of the students belonged to middle-income families, 33.3% belonged to low-income families, and 20% belonged to high-income families. The academic background data revealed that 50% of the students were classified as below average in academic performance, 33.3% were considered average, and 16.7% were classified as above average. This distribution provided a balanced sample to examine the influence of various demographic factors on students' achievement in mathematics when exposed to innovating techniques.

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7.2. Chi-Square Test of Independence

It is an analytical technique utilized to identify whether there is a significant relationship among two categorical variables. In this case, it evaluates the relationship between parental involvement level (high, medium, low) and pupils' achievement in mathematics. The Chi-Square statistic formula is calculated as follows:

$$X^2 = \sum \frac{(O_i - E_i)^2}{E_i} \qquad (2)$$

Where, O_i, denotes the frequencies observed, and E_i, denotes the frequencies expected for each category.

Table 2.
Chi-square test of independence between parental involvement and pupil's achievement in mathematics.

Parental involvement level	High achievement (N)	Medium achievement (N)	Low achievement (N)	Total (N)
High	87	34	9	130
Medium	62	39	19	120
Low	14	18	18	50
Total (N)	163	91	46	300
Chi-square value			38.25	
p-value			0.0001	

The analysis of the Chi-Square Test of Independence presented in Table 2 indicated that among the 300 students surveyed, a total of 87 students with high parental involvement attained high performance in mathematics, while only 14 students with low parental involvement reached the same level. Additionally, 34 and 62 students with high and medium parental involvement, respectively, achieved medium performance. The Chi-Square test yielded a value of 38.25 and a p-value of 0.0001, indicating differences in achievement levels were statistically significant. These findings supported the hypothesis that higher levels of parental involvement positively influenced pupils' academic success in mathematics. Figure 3 illustrates the relationship between parental involvement levels and students' achievement.

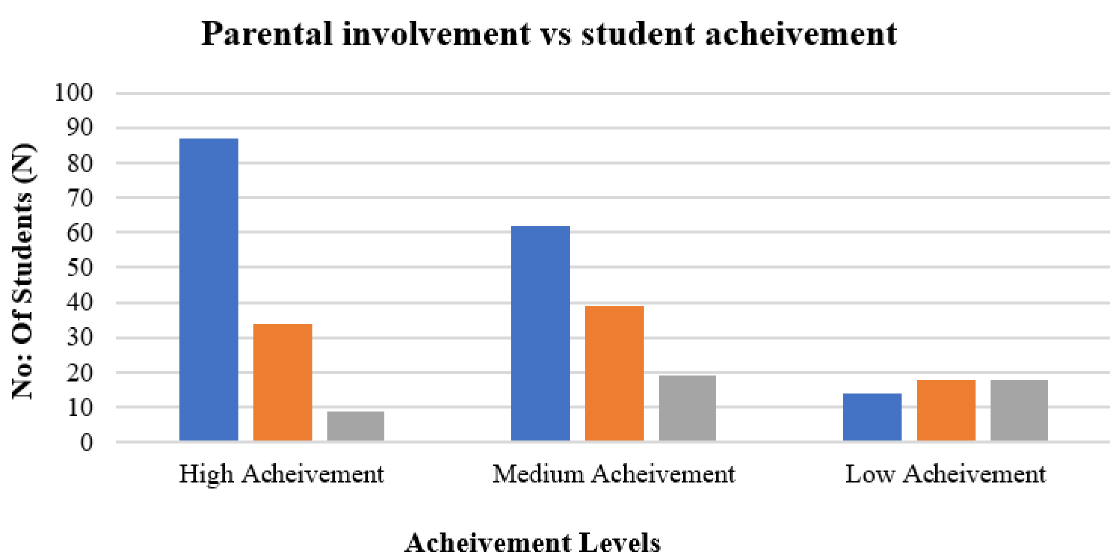

Figure 3.
Relationship between parental involvement levels and student achievement.

7.3. Analysis of Covariance (ANCOVA)

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ANCOVA is an analytical method which combines the ANOVA and regression to evaluate the significant differences in pupil achievement in mathematics across different curriculum designs. The method assesses the source of variation through "Between groups" (differences among curriculum designs), "Covariates" (additional variables influence) and "Within groups" (variability among pupils within each curriculum). The mathematical equation for ANCOVA is expressed as follows:

$$Y_{ij} = \mu + \tau_i + \beta X_{ij} + \epsilon_{ij} \tag{3}$$

Where, Y_{ij}, is the dependent variable, μ, denoting the overall mean, τ_i, effect of the i-th group, β, signifies the regression coefficient of the covariate, X_{ij}, is the covariate and ϵ_{ij}, is the error term representing the variability in Y_{ij}.

Table 3.
ANCOVA for curriculum design and pupils' achievement in mathematics.

Category	Sum of squares	df	Mean square	F	p-value
Between groups	1520.45	2	760.23	16.45	0.0001
Covariates	2450.30	1	2450.30	53.34	0.0001
Within groups	22100.85	297	74.48		
Total	26171.60	300			

Table 3, presents the findings of the ANCOVA conducted to evaluate the impact of curriculum design on pupils' mathematics achievement. The analysis showed a significant impact of curriculum on achievement, with a sum of squares of 1,520.45 and an F value of 16.45, resulting in a p-value of 0.0001, indicating strong statistical significance. Additionally, the covariate had a substantial impact, as evidenced by a sum of squares of 2,450.30 and an F-value of 53.34, also with a p-value of 0.0001, suggesting that parental involvement substantially influenced the relationship between curriculum and pupils' achievement.

7.4. Linear Regression Analysis

It is an analytical method that is utilized to determine the relationship between an independent variable (peer interaction and collaboration) and a dependent variable (pupils' achievement in mathematics). The equation for linear regression analysis is given by:

$$Y = \beta_0 + \beta_1 X + \epsilon \tag{4}$$

Where, Y represents the pupil achievement, X represents peer interaction and collaboration, β_0 is the intercept, β_1 is the coefficient of peer interaction and ϵ is the error term.

Table 4.
Linear regression analysis.

Predictor variables	Coefficients	Standard error	t-value	p-value
Constant	50.12	4.56	10.99	0.000
Peer interaction and collaboration	2.15	0.31	6.94	0.000
R^2	0.42			
Adjusted R^2	0.41			

The linear regression analysis in Table 4 revealed a significant positive relationship between peer interaction and collaboration and pupil achievement in mathematics. The constant coefficient was 50.12, indicating the base level of pupil achievement when there was no peer interaction. The regression coefficient for peer interaction and collaboration was 2.15, were for each one unit increase in peer interaction, pupil achievement increased by 2.15 units. The increase in the t-value (6.94) showed that this effect was statistically significant. The R^2 value of 0.42 indicated that 42% of the difference in pupil achievement could be clarified by per interaction and collaboration during lessons, supporting the hypothesis that higher levels of peer interaction significantly enhance pupils' achievement in mathematics.

7.5. Factor Analysis

Factor analysis is a statistical method utilized to identify the relationship among various aspects of technological infrastructure and their impact on pupils' mathematics performance. Grouping the multiple observed variables into distinct factors enhances innovative techniques. It reduces data complexity, providing a clear understanding of specific elements of technological infrastructure that influence students' academic achievement in mathematics.

Table 5.
Factor analysis for technological infrastructure and pupil's mathematics performance.

Variable	Factor loading	Communality	Eigenvalue	Percentage of variance	Cumulative percentage
Availability of computers	0.85	0.75	3.56	44.5	44.5
Access to high-speed internet	0.90	0.82			
Use of educational software	0.78	0.70			
Training on technology usage	0.76	0.65	1.25	15.6	60.1
Maintenance of technological equipment	0.72	0.55			
Availability of interactive whiteboards	0.68	0.50	1.02	12.8	72.9
Access to online learning resources	0.80	0.64			

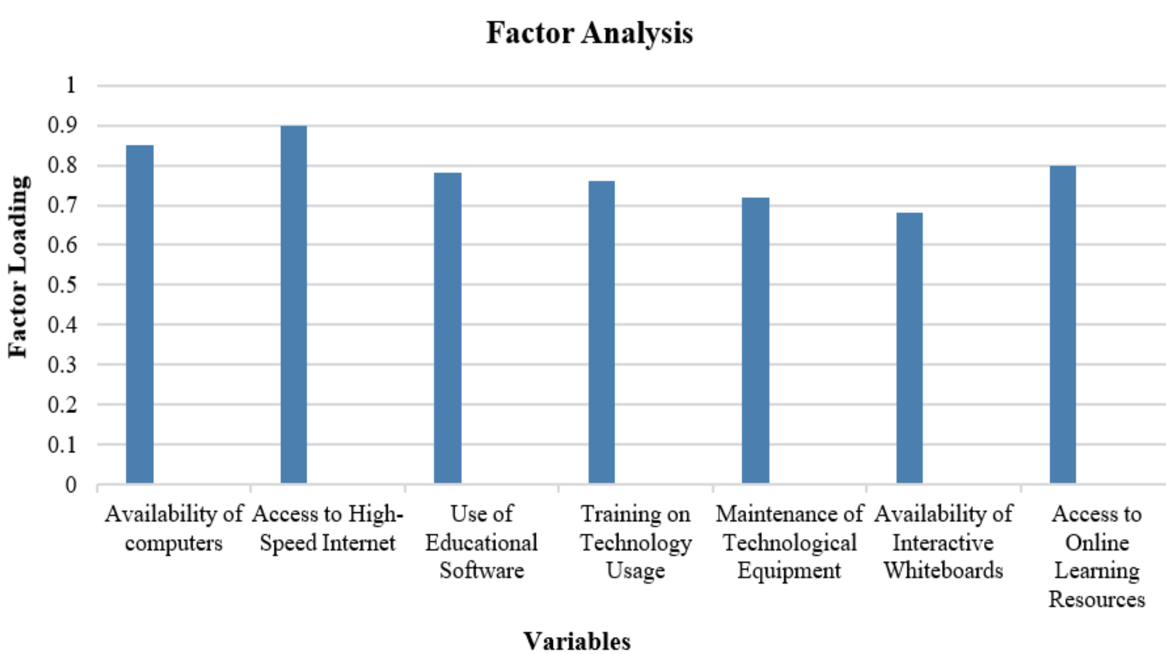

Figure 4.
Factor analysis for technological infrastructure and pupil's mathematics performance.

The findings of factor analysis performed in Table 5 indicated that "Access to High-Speed Internet" exhibited the highest factor loading of 0.90, suggesting it was the most influential variable contributing to students' performance. Other notable variables included "Availability of Computers" (0.85) and "Use of Educational Software" (0.78), which also demonstrated strong connections. The analysis showed that the "Training on technology usage" variable had an eigenvalue of 1.25, accounting for 15.6% of the variance, while "Availability of Interactive Whiteboards" contributed 12.8% to the cumulative percentage of 72.9%. These findings highlight the critical role of technological infrastructure in enhancing pupils' achievements in mathematics, underscoring the importance of access to resources and training in the effective application of innovative techniques. Figure 4 illustrates the relationship between technological infrastructure and pupils' performance in mathematics.

7.6. Hierarchical Regression Analysis

It is a statistical approach used to identify the relation among multiple predictor variables and a single outcome variable, which allows to evaluate the incremental value of adding each predictor to the model. The analysis evaluates the variance in the dependent variable, which can be explained by the independent variables at each step, typically expressed as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ \dots\dots\dots.. + \beta_n X_n \tag{5}$$

Where, Y denotes the dependent variable, β_0 denotes the intercept, and β_n denotes the coefficients of the independent variables X_n.

Table 6.
Hierarchical regression analysis.

Variables	R	R2	Adjusted R2	F	p-value
Mathematics anxiety	0.32	0.10	0.09	12.85	0.0004
Mathematics anxiety + Self-efficacy	0.52	0.27	0.26	36.79	0.0001
Mathematics anxiety + Self-efficacy+ Innovative techniques	0.63	0.39	0.38	56.04	0.0001

The analysis in Table 6, examined the relationship between students' mathematics anxiety, self-efficacy, and the effectiveness of innovative techniques on their achievements in mathematics. In the first step, mathematics anxiety alone accounted for 10% of the variance in achievement, with a significant F-value (12.85, p = 0.0004), indicating that higher anxiety negatively affected performance. Adding self-efficacy in the second step allowed the model to explain 27% of the variance (F = 36.79, p = 0.0001), indicating a positive contribution of self-efficacy to improved outcomes. In the final step, incorporating innovative methods further enhances the explanatory power of the model to 39% (F = 56.04, p = 0.0001), confirming that these methods, alongside allowing anxiety and high self-efficacy, significantly enhanced student achievement in mathematics.

8. Discussions

The findings reveal significant information into the effectiveness of innovative methods on pupils' achievement in mathematics among higher secondary students. Analysis showed that demographic factors significantly influenced the achievement levels, with male students showing better achievement in mathematics compared to female students. Students from high socioeconomic backgrounds outperformed their peers from lower SES. The study found a positive correlation between parental involvement and students' mathematics achievement. The Chi-square test confirmed a significant relationship between parental involvement levels and student achievement, supporting the hypothesis that active parental engagement can enhance educational outcomes.

The evaluation of curriculum design indicated that well-structured curriculum incorporating innovative methodologies significantly enhanced students' performance in mathematics. ANCOVA analysis revealed that integration of innovative methods like integrating project-based learning and technology into the curriculum engages students more effectively. These findings underscored the

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significance of aligning curriculum with innovative approaches, which can engage students and make learning more relevant. Peer interaction and collaboration during mathematics lessons increase pupil achievement when innovative methods are used. Regression analysis demonstrated that increased peer interaction positively influences student academic performance. By promoting group work and collaborative learning environments, teachers utilize the power of peer interactions to enhance mathematical understanding and problem-solving skills.

The study highlighted the importance of technological infrastructure in improving pupil performance with innovative techniques. Students who had access to technological resources, like computers and educational software, performed significantly better in mathematics. These results highlight the positive impact of technology on student engagement and learning. The psychological factors explored the relationship between students' anxiety in mathematics or self-efficacy and the effectiveness of innovative techniques on their achievement in mathematics. Students with lower levels of mathematics anxiety and higher self-efficacy experienced greater improvements in their achievement, emphasizing the requirement for strategies to reduce anxiety. Educators create a supportive environment that promotes self-efficacy and encourages a positive mindset towards mathematics.

9. Conclusion

This study examines the effect of innovative techniques on higher secondary students' mathematics achievement in selected schools in Kerala. The study utilized a mixed-methods approach, integrating quantitative data from structured questionnaires and qualitative data from classroom observations and interviews. Findings from the study show that modern techniques such as project-based learning and technology integration enhance the understanding and engagement of students. A Chi-square test ($x^2 = 38.25, p = 0.0001$) confirmed the strong influence of parental involvement on student performance. ANCOVA revealed the significant impact of innovative curriculum design ($F = 16.45, p = 0.0001$) and peer interaction positively influenced performance, explaining 42% of the variance ($R^2 = 0.42$). Hierarchical regression showed that self-efficacy and mathematics anxiety explained 39% of the variance in achievement ($F = 56.04,\ p = 0.0001$) showing greater improvements, confirming the effectiveness of these techniques in addressing both academic and psychological challenges. Overall, the findings highlight the positive influence of innovative strategies on pupils' mathematics achievement, emphasizing supporting environments that promote collaborative learning and reduce anxiety.

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