SSRG International Journal of Humanities and Social Science
ISSN: 2394-2703/ https://doi.org/10.14445/23942703/IJHSS-V11I6P103

Volume 11 Issue 6, 17-42, Nov-Dec 2024
© 2024 Seventh Sense Research Group®

Original Article

Impact of Resource-Driven Infrastructure Optimization on Educational Outcomes: A Study of Indian States (2017-2020)

Kiara Maniar

Dhirubhai Ambani International School, Maharashtra, India.

Corresponding Author : kiara.maniar@gmail.com

Received: 27 September 2024 Revised: 03 November 2024 Accepted: 19 November 2024 Published: 03 December 2024

Abstract *- Despite decades of educational reforms, Indian schools continue to face significant resource deficits that hinder student educational outcomes. Existing policies have not fully bridged these gaps, necessitating a deeper analysis of how various resources impact educational outcomes. This study analyses the impact of 14 explanatory variables and 35 categorical variables on 4 educational outcomes – enrolment, retention, learning outcomes and quality and equity – in 35 States/Union Territories of India from 2017 to 2020. The study employs a random effects model for each of the four analyses, factoring in a total of 4260 observation points. The findings reveal that governance processes regarding transparency improve retention and equity, while technology negatively impacts enrolment and learning outcomes. The study highlights that the role of playgrounds and physical facilities like handrails and ramps is to be carefully assessed, with them having positive and negative impacts on different dependent variables. Supplementary reading materials, supply of functional electricity, and furniture in the classrooms improve the learning outcomes, while rainwater harvesting has a significant positive impact on enrolment. Ultimately, the study emphasizes the need for a nuanced and holistic approach to education policy and attendant infrastructure, offering insights for targeted interventions to optimize educational outcomes in India.*

Keywords *- Enrolment, Equity, Governance processes, Learning outcomes, Regional disparity, Retention.*

1. Introduction

India's educational landscape has evolved significantly over centuries, shaped by cultural, political, and economic factors. During the Vedic period in ancient India (1500-500 BCE), the Gurukul education system was widely prevalent. It was an informal system in which knowledge was primarily imparted through oral traditions and learning focused on the teacher's daily activities (Singh, 2024). However, access to this form of education was only limited to the elites, with minimal women and individuals of the lower castes. During the period of British rule in India (18th to mid-20th century), the education system underwent significant changes as the British introduced a formal and structured system to serve their administrative needs Chutia, 2020). However, access remained limited to urban centers, resulting in rural areas and marginalized communities being neglected with poor resources and facilities. Post-independence, the Indian government considered education crucial for the nation's development. The Constitution of India (1950) recognized education as a fundamental right, and the government implemented numerous schemes and policies to ensure access to quality education (Mahawar, 2022). The First Five-Year Plan (1951-1956) focused on improving infrastructure in rural areas (K. G. Saijndain, 1958). Despite efforts, many schools continued to operate without proper buildings, trained teachers, or necessary learning materials (Nehru, 1951). Recognizing these gaps, the government introduced the National Policy on Education (NPE) in 1986. The NPE aimed to promote and regulate all education in rural and urban India, from primary to higher education. The policy called for a "special emphasis on removing disparities and equalizing educational opportunities, especially for Indian women, Scheduled Tribes (ST), and Scheduled Castes (SC) communities" (Ministry of Human Resource Development, 1986). Additionally, it aimed to implement a uniform educational system, establish a national core curricular framework, and ensure basic facilities and essential infrastructure in all education institutions. While these efforts increased the number of schools, the quality of education remained uneven, as many schools still lacked proper facilities and resources. In 2001, the Sarva Shiksha Abhiyan (SSA) was launched as the Government of India's flagship program for the Universalization of Elementary Education (UEE). It was implemented in partnership with the State Governments to ensure coverage of the entire nation and address the needs of 192 million children (All India Council for Technical

Education, 2017). SSA helped to open new schools in habitations that did not have any facilities, and it strengthened school infrastructure through the provision of additional classrooms, toilets, drinking water, and grants. It also aimed to bridge the digital divide by providing computer education. The Right to Education (RTE) Act of 2009 marked a significant step in Indian education by declaring that children between 6 and 14 years of age will have access to free and compulsory education (Parliament of India, 2009). It also laid down norms and standards regarding Pupil Teacher Ratios (PTRs), buildings and infrastructural facilities, school-working days, and teacher-working hours (Department of School Education and Literacy, 2021). The Act also laid out the requisite academic qualifications for teachers. Hence, it helped to improve access to and the quality of education in schools across India. The Ministry of Human Resource Development, Government of India, initiated the national Swachh Bharat-Swachh Vidalaya (Clean India: Clean Schools) campaign on 25th September 2014 to promote cleanliness drives in schools (Press Information Bureau, 2014).

The campaign aimed to ensure that every school in India had a set of functioning and well-maintained water, sanitation, and hygiene facilities, contributing to a healthy school environment. It also encouraged schools to develop any technical components required, like drinking water, handwash, soap, and rainwater harvesting facilities. Although these governmental schemes, policies, and initiatives addressed the need for basic school infrastructural facilities, they did not emphasize the impact and use of technology in the growing digital age. As a result, in 2020, the Government of India introduced the National Education Policy (NEP) and a comprehensive initiative called PM e-VIDYA to highlight digital learning. The NEP called for investment in digital infrastructure and online teaching platforms while also improving existing pedagogy (Ministry of Human Resource Development, Government of India, 2020). PM e-VIDYA, launched on 17th May 2020, helped unify all efforts related to digital and on-air education to enable multi-mode access to education (Ministry of Education, 2023).

A key component of the initiative was DIKSHA (Digital Infrastructure for Knowledge Sharing) – a digital platform that provided quality e-content for school education in all States/Union Territories as well as QR-coded Textbooks for all grades. Despite significant progress, challenges remain. Schools still face infrastructure deficits, particularly in sanitation and access to technology. It is estimated that around 10.32 lakh (1.032 million) government schools face a significant infrastructure deficit, lacking furniture, electricity, toilets, water tanks, computers, internet facilities, playgrounds, etc. (Empathy Foundation, 2021). Additionally, school buildings are also dilapidated. According to the United Nations Educational, Scientific, and Cultural Organization (2024), 25 percent of teachers were absent from school, and only 50 percent were teaching during unannounced visits to government schools (UNESCO, 2024). As a result, approximately 60 percent of Indian children aged six to fourteen cannot read at the expected level and 70 percent struggle with the expected arithmetic tasks (World Bank, 2022). Moreover, disparities in infrastructure persist between urban and rural schools and between government and private institutions, exacerbating educational inequality. This study aims to identify, understand, and address the ongoing challenges posed by resource deficits and disparities within India's education system. It analyzes how varied infrastructural facilities impact four different educational outcomes – 1) enrolment, 2) retention, 3) learning outcomes and quality, and 4) equity.

2. Literature Review

The following section looks at the existing body of work exploring the impact of the following variables on the 4 educational outcomes considered in this study. The literature review of the variables has been systematically divided into five categories, which are as follows:

Table 1. Literature review divisions

Category	Title
1	Technology
2	Classroom Spacing and Design
3	Water, Sanitation, and Hygiene Facilities
4	Programs and Incentives
5	Furniture, Infrastructural Facilities, and Other Resources

2.1. Technology

Banerjee et al. (2007) presented the results of two randomized experiments conducted in schools in urban India. Impact evaluations of remedial education and a computer-assisted learning program have been thoroughly discussed. Students of the remedial education program benefited by 0.14 standard deviation in the first year and by 0.28 standard deviation in the second year. The computer-assisted program also proved to be very effective, increasing math scores by 0.36 standard deviations in the first year and 0.54 standard deviations in the second year. However, a significant difference was not noted in the language scores.

The study also emphasized that the quality of education can be greatly improved in India through these programs, particularly because of their practicality, cost-effectiveness, and ease of scaling. However, the question of a short-term versus long-term impact prevails. Linden (2008) examined the effectiveness of technology through randomized evaluations through a computer-assisted learning program in India. The program was implemented in in-school and out-of-school models to assess different strategies for integrating technology into existing schools. The model on substituting technology as a replacement for in-school teachers yielded poor results, with students learning significantly less than they otherwise would

(-0.57 standard deviations). The second model, where the program was used to complement the normal system and the out-of-school mode, generated small positive changes (insignificant) by most students and large positive gains by the weakest and older class students. The results emphasized the importance of considering the relative productivity of learning environments when choosing interventions to improve the quality of education.

2.2. Classroom Spacing and Design

Inamdar (2004) investigates whether unsupervised group learning in shared public spaces can improve children's performance in school examinations using "hole-in-the-wall" kiosks. The experiment was conducted in the rural Sindhudurg District of Maharashtra State with 103 children of Grade 8 for the curricular Computer Science examinations. The results showed that the children who learnt through this Minimally Invasive Education technique scored marginally lower than children who had been taught the curriculum in the school, demonstrating the importance of bridging the digital divide. Weinstein (1979) studied the impact of classroom environments on student behavior, attitudes, and achievement. Specifically, the paper examined studies of six environmental variables: seating position, classroom design, density, privacy, noise, and the presence or absence of windows. Weinstein also pays attention to the benefits of open-space school designs. Ultimately, the paper found that class size and school size are the most notable and significant physical variables that directly impact student achievement.

Stennett & Earl (1983) surveyed 131 Canadian elementary school teachers who taught in open areas to discover the extent to which open education concepts were being implemented. The survey asked teachers to rate their personal preferences on 11 scales concerned with planning and organization and 13 scales concerned with providing instruction. Responses to the survey suggested that teachers saw the strengths of open areas to be identified with the sharing of ideas, techniques, and materials; team teaching and cross-grade grouping of students; providing personal and professional support from colleagues; and capitalizing on teachers' special strengths and talents. The weaknesses cited included noise and distraction, limits on spontaneity in teaching, and occasional disagreement between team teachers.

Glass et al. (1982) conducted a meta-analysis of studies to analyze the impact of class size on achievement. The found that reducing class size from 30 to 20 results in a gain of 6 percentage points in achievement scores, whereas a reduction from 20 to 10 students per classroom yields another 13 percentage points in achievement. They also found that reductions in class size begin to make substantial differences in learning achievement, around 15 students per class. Battersby and Edwards (1975) examined whether changes in seating arrangements, individualized instruction, and group contingencies placed on academic work would change the behaviors of an initially disruptive classroom. An intervention was tested in which desks were changed to cluster arrangements, individualized instructional materials were provided, and group contingency rules were initiated. Student behaviors were observed, teacher instruction was coded, academic performance was recorded, and measures were taken pre- and post-intervention. It was found that individualized instruction with group contingencies increased academic performance.

Reinius et al. (2021) examined the meaning and significance that students and teachers associate with various features at the school. The school, located in the Helsinki capital area of Finland, was designed to have Flexible Learning Spaces (FLS) instead of encapsulated traditional classrooms. The study was qualitative in nature, using interviews and observations. The results were primarily of 2 types: the effect of physical space on collaboration activities and the attributed meanings to various features of FLS. With regard to the meaning of the features, while teachers valued approachability and collaboration, students focused on the proximity of their friends and the importance of studying together. The flexibility in physical arrangement not only influenced teachers' practices but also fostered pupils' agency. Overall, particularly according to the interviews, the researchers concluded that collaborative learning is the direct result of the interactive use of space to provide opportunities for mutual learning.

2.3. Water, Sanitation, and Hygiene Facilities

Hayat (2017) analyzed the relationship between access to toilet facilities and school enrolment rates in Pakistan. The study uses annual census data on government schools in the Punjab region of Pakistan to analyze the relationship between changes in school enrollment and changes in the number of usable toilets, controlling numerous other variables such as the school area, number of classrooms in school, number of teachers in school, availability of drinking water, electricity, boundary wall, sewage access, playground, and library. The author used the first difference empirical strategy to assess the given relationship. The study found that the availability of usable toilets is positively and significantly associated with enrollment. This relationship is stronger for schools in rural areas, for female-only schools and for secondary schools. Further, no evidence of a relationship between the availability of toilets and enrollment in boys-only schools was found.

Nyalusi (2013) studied the factors affecting girls' academic performance in community secondary schools in Mbeya City of, Tanzania. Specifically, it assessed the roles of school matrons and female teachers as role models, physical facilities (sanitary facilities and hostels), social practices and school timetables as key factors affecting girls' academic performance in community secondary schools. The study used descriptive research; two approaches were employed: the qualitative approach and the quantitative approach. Moreover, the study applied four methods: interview, survey, focused group discussion, and documentary analysis. Two instruments, questionnaires and interview guides, were employed to obtain the data needed to achieve the objectives of this study. Finally, the lack of matrons, the shortage of female teachers as role models, and the poor provision of physical facilities, hostels, social practices, and school timetables are found to be great contributors to the poor academic performance among girls in community secondary schools. In order to improve the girls' academic performance, it is recommended that the government and the society should improve school infrastructure for girls, and change attitudes towards girls' education.

Ahiatrogah (2020) investigated the effects of water, sanitation, and hygiene facilities on the academic performance of basic school pupils at Dzodze in Ketu North Municipality of the Volta Region. Through the cross-sectional survey, a total of 100 basic school pupils and 20 teachers were sampled through simple random sampling and purposive sampling techniques. The study found that the presence of WASH facilities helped 98 percent of the students participate in their academic activities and 47 percent of the teachers in their teaching expectations. 28 percent of the students stated that they performed better in their term exams than previously, while 27 percent stated they became more active in class.

2.4. Programs and Incentives

Pandey et al. (2009) examined the impact of community-based information campaigns on school performance using cluster randomized control trials in 610 villages across 3 Indian states. The study concluded that information through structured campaigns to communities had a positive impact in all three states. It is important to note that the most significant impacts occurred on teacher effort, while impacts on learning were more modest.

Improvements also occurred in the benefits given to students, such as stipends, uniforms, and mid-day meals, which then also impacted learning outcomes. Kremer et al. (2004) published "Incentives to Learn" - a randomized evaluation of merit scholarship programs for adolescent girls in Kenya. Cash grants for supplies and school fees were paid for the students who scored well on their academic examinations. Girls eligible for the scholarship showed a significant improvement in exam scores. This also positively impacted boys who were ineligible for the scholarship and girls who didn't score the requirement. Attendance for students and teachers increased, providing the impact of merit scholarships on educational outcomes.

2.5. Furniture, Infrastructural Facilities, and Other Resources

Glewwe et al. (2011) synthesized and stated significant conclusions from 79 "sufficient quality studies" selected from over 9000 papers. Further analyzing the quality of the econometric models utilized, the research conducts an in-depth analysis of 43 studies and eventually finalized 13 randomized studies. For the majority of "high quality" 43 studies evaluated, school and teacher characteristics prove to be statistically insignificant. However, traditional metrics of availability of desks, teacher knowledge of the subject they teach, and teacher absence continue to be significant variables. Ultimately, the impact on time in school and most school and teacher characteristics are insignificant, while the availability of desks, teacher knowledge of subjects, and teacher absence have significant impacts.

Edwards (1991) examined the impact of parental involvement on the overall condition of public-school buildings and their consequent effect, along with other variables, on student achievement. With the use of a regression analysis, the author shows the relationship between building conditions, parental involvement, and student achievement. The results of the study noted that among the 52 schools considered, an increase in the size of a school's Parent Teacher Association (PTA) budget has a positive significant effect on the condition of the school building. The relation between the PTA budget per pupil and the condition of the school building was significant at 7 percent. Further, the improvement in the condition of the building is associated with improvement in achievement scores.

Olufemi et al. (2018) examined the factors affecting students' academic performance in Colleges of Education in Southwest Nigeria. For this study, 480 students were randomly selected from six Colleges of Education. The study analyzed the impact of socio-economic characteristics, parental background, teachers' effectiveness, functionalities and adequacy of school facilities, instructional materials, and reading habits on the academic performance of students. It concluded that students' factors, parental background, school factors, and teachers' factors have a significant impact on students' academic performance. The provision of adequacy and functionality of infrastructural facilities play a crucial role in a student's academic performance. Abdolreza (2016) assessed the impact of educational furniture on the learning and academic achievement of students at the elementary level. It is a cross-sectional study (2015-2016) where a total of 210 students were selected randomly as the sample. Cluster sampling was done using appropriate allocation, and questionnaires were randomly divided among students. Data collection tools used include Hermance's achievement motivation questionnaire, a researcher-constructed questionnaire, and interviews with the students. The data points include school furniture not broken or of sharp and dangerous edges, classroom chairs being single, classroom desk height, convenient location of furniture for placement of school bags, and comfort of chair backrest. The results of the study showed that appropriate educational furniture has a positive impact on the ratio of learning and educational progress of students at the elementary level.

Muralidharan and Sundararaman (2011) studied the impact of contract teachers on improving student learning. Contract teachers are non-civil-service officials who are hired locally by the school and are not professionally trained. The experiment was conducted across a representative sample of 100 randomly selected government-run rural primary schools in the Indian state of Andhra Pradesh. The contract teachers affect the class size pupil-teacher ratio (PTR). After two years, it was observed that students in schools with an extra contract teacher performed significantly better than those in comparison schools by 0.16 and 0.15 in math and language tests, respectively. Surprisingly, they also found out that contract teachers were much less likely to be absent from school than civil-service teachers. Hence, the study concluded that these teachers are as effective at improving educational outcomes as civil-service teachers, although they are not paid as much or professionally trained.

2.6. Research Question

This paper examines the impact of 14 determinants – resource-oriented, infrastructural, as well as government actions – on educational outcomes, including enrolment, retention, learning quality, and equity of the education system across 35 States and Union Territories in India from 2017 to 2020.

How do resource-oriented determinants, infrastructural factors, government actions, and regional State-wise disparities affect enrolment, retention, quality of learning, and equity of the education system in India?

2.7. Knowledge Gap and Rationale of the Study

This paper presents a newer approach, through selected variables and methodology chosen, to studying the impact of resources on education. The study addresses gaps in existing research in several ways:

Firstly, the given research consists of the comprehensive inclusion of 14 independent variables in each regression analysis. The majority of existing research studies focus on individual or small combinations of educational resources, while this paper covers a wide range from sufficient land availability and playgrounds to rainwater harvesting and access to clean drinking water. Hence, it's one of the few studies that addresses the simultaneous effects of diverse resource and infrastructure variables on educational outcomes.

Moreover, the study focuses on specific variables in India, such as clean water, functional female toilets, and rainwater harvesting systems, which have been understudied in the literature, which is another aspect emphasised by this research study. This is particularly important since a majority of studies focus on high-income, developed or cross-country analyses, ignoring developing nations. Secondly, the same comprehensiveness and holistic approach are reflected for the dependent variables as well. The examination of four educational outcomes – total enrolment, retention, learning outcomes and quality, and equity – adds to the existing literature since it usually focuses on only one of these, particularly learning quality or enrolment. This study's inclusion of retention and equity adds new dimensions to the literature. Analysing the students' interest and motivation in continuing school provides insights regarding their long-term engagement, an unexplored aspect of education. Further, the analysis of equity, specifically, adds to the understanding of how infrastructure impacts students from different socio-economic backgrounds, genders, and disabilities.

There is a dearth of studies that highlight this aspect of the education system. Hence, the dependent variables considered for this study add to a more comprehensive understanding of sustainable and inclusive education. Thirdly, the research addresses a critical gap by taking into consideration individual State and Union Territory-level differences, recognizing the profound regional disparities in educational outcomes in India. Prior literature often examines education at the national level without disaggregating regional data. This paper's attention to local heterogeneity provides insights that are often missed in studies treating nations as homogenous entities.

Fourthly, another important contribution of this research study is the use of panel data over a four-year time period. While the majority of studies utilize cross-sectional data, panel data captures changes over time and controls unobserved heterogeneity, thereby providing more reliable and precise estimates. Further, the use of quantitative models – the random effects regression model – compared to qualitative analyses – offers a more objective and generalizable understanding of how changes in resources affect educational outcomes.

3. Data

3.1. Sampling and Data Collection

This research is a quantitative study using secondary data from the Unified District Information System for Education (UDISE) - which presents school, State, Union Territories, and nationwide information about the education system in India – and the Performing Grading Index released by the Department of School Education and Literacy, Ministry of Education, Government of India. The study employs a panel-data analysis, which allows for tracking changes in educational factors over four years. This allows for a certain continuity that enables the analysis to provide a higher-level efficiency with more variability for each variable used. It provides a more nuanced understanding by considering how regional factors and disparities evolve over time. The use of panel data also contributes further to the literature since the majority of studies in this field tend to focus on short-term or static comparisons. The study was conducted using annual data from four years, from 2017 to 2020. The study is a panel data analysis that includes 35 States and Union Territories in total.

The States and Union Territories included are shown in Table 2.

Table 2. Sample Units (N=35)

Andaman & Nicobar Islands	**Goa**	**Madhya Pradesh**	**Rajasthan**
Andhra Pradesh	Gujarat	Maharashtra	Sikkim
Arunachal Pradesh	Haryana	Manipur	Tamil Nadu
Assam	Himachal Pradesh	Meghalaya	Telangana
Bihar	Jammu and Kashmir	Mizoram	Tripura
Chandigarh	Jharkhand	Nagaland	Uttarakhand
Chhatisgarh	Karnataka	Odisha	Uttar Pradesh
Daman and Diu, Dadra and Nagar Haveli	Kerala	Puducherry	West Bengal
Delhi	Lakshadweep	Punjab	

Of all Indian States and Union Territories, Ladakh has been excluded due to the unavailability of data prior to 2019. Additionally, Daman and Diu and Dadra and Nagar Haveli have been combined as one for 2017 and 2018 by taking an average of all values due to the presentation of that format of data for the years 2019 and 2020. The necessary data has been collected for a period of 4 years, from 2017 to 2020, resulting in a total number of 4260 observations.

3.2. Limitations of the Data

One of the limitations of this study is its restricted time period of four years from 2017 to 2020, since complete data was not available before and after this period. Since the analysis is limited to data for four years only, it may not capture long-term variations. Furthermore, this period involved the COVID-19 pandemic, which significantly affected the outcomes.

However, the impact of such external factors is very difficult to eliminate due to the short duration of the study. Second, the study employs Simple Moving Averages to fill in missing data points (as further explained in section 3.3, Data Cleaning). However, this method may not fully account for any patterns or trends forming and may introduce biases if the incomplete data is not entirely random.

3.3. Data Cleaning

During data collection, any missing data points were addressed using the Simple Moving Averages (SMA) technique, which calculates the average of three consecutive data points immediately prior to the missing value. This method provided realistic estimates based on existing trends but did not take into consideration any inconsistencies that may have been present for that specific year.

In the process of data arrangement on STATA 17.1, an important part was the creation of a panel in order to conduct a longitudinal analysis of the variables across the four years. The initial data was repositioned State/Union Territory wise using the order and sort command. After generating a unique ID for each State or Union Territory, the data was converted from a wide to a long format, specifying State as the panel identifier and Year as the time variable.

3.4. Descriptive Statistics

The first independent variable, land availability, averages 29639 schools meeting the required criteria, but numbers vary widely, ranging from 27.75 in State 18 to 168,832.5 in State 34. This stark disparity points to regional differences in infrastructure development. Functional electricity follows a similar pattern, with an average of 32,876 schools.

While states like State 34, 19, and 20 show high numbers of schools with electricity, others, such as State 18 and State 6, have very limited access. Playgrounds are available in 39.5 schools in State 18 compared to 196,546 in State 34, reflecting differences in investment in recreational educational facilities, which may impact student well-being. The average number of schools with reading materials is 193,686, but it is surprising that access remains inconsistent.

Furniture availability shows large disparities, a basic necessity that is still unmet in many schools. Functional toilets and urinals for girls have a slightly higher mean than for boys, showing a focus on gender-specific needs, but large regional differences remain in access. Rainwater harvesting systems are present in an average of 7,457 schools, while pure water is accessible in 9,301 schools. However, some states provide no access to pure water – denoted by a minimum of zero – posing significant risks to student health. Additional physical facilities for students with disabilities, such as ramps and handrails, average 23,896 schools but show wide discrepancies, indicating a lack of emphasis on inclusivity.

The availability of medical facilities, measured through medical and complete medical checkups, averaging 23,603 schools, remains insufficient in many states, with only 14 schools in some cases. Technology resources, averaging 24,520 schools, show considerable variation, with high standard deviations pointing to unequal access across regions.

The governance processes variable, with a mean of 241.88, reflects policy implementation and oversight differences, which is crucial for managing educational outcomes. Overall, these variables underscore significant disparities in educational infrastructure across states, highlighting the need for targeted interventions.

Table 3. Descriptive Statistics for Independent Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
LAND	140.00	29638.82	35939.32	26.00	171610.00
ELEC	140.00	32876.74	38607.20	45.00	200059.00
PLAYG	140.00	32269.45	40613.45	29.00	202465.00
READMAT	140.00	19386.22	22583.94	26.33	97399.34
FURN	140.00	27776.08	30420.76	45.00	182092.00
TOILUR	140.00	21258.76	33074.80	0.00	171966.00
GTU	140.00	30231.20	38718.99	22.50	206086.00
BTU	140.00	29572.49	37998.82	22.50	204511.00
RWHARV	140.00	7456.28	11444.90	0.00	54055.00
PUREW	140.00	9301.10	12464.82	0.00	54620.00
PHYFA	140.00	23896.66	31297.49	14.00	162272.00
MED	140.00	23602.59	28304.86	13.50	152059.50
TECH	140.00	24520.26	29348.09	59.00	124208.00
GP	140.00	241.88	58.09	129.00	348.00

Table 4. Descriptive Statistics for Dependent Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
EnTWPTotal (Enrolment)	140.00	16.47	20.96	0.03	100.00
Ret (Retention)	140.00	76.86	17.33	34.89	100.00
LOQ (Learning Outcomes & Quality)	140.00	76.32	7.50	55.56	93.33
EQ (Equity)	140.00	90.54	4.57	73.48	99.13

The trend of high variation continues extensively with the dependent variables as well. At the same time, the enrolment rate has a mean of only 16.472, which represents that the mean is in the first quadrant of the enrolment rate. This signifies that the majority of States have low rates for enrolment, a cause of concern. However, the extremely low minimum of 0.026 can be explained by the restricted geographic locations and small size since it belongs to Lakshadweep. On the other hand, the mean for retention lies in the fourth quadrant, with an average of 76.858. This indicates that while the mean retention is high, there is still room for improvement, especially with a minimum of 34.89. Learning outcomes and quality also lie in the last quadrant, with an average of 76.317. However, the differences in minimum and maximum reflect inconsistencies in educational delivery. It's particularly interesting to note that the status of equity is better than any of the other dependent variables, with a mean of 90.537. After assessing these estimates, it is evident that there is substantial State and Union Territory-wise variation in the variables discussed. This could potentially lead to differences in State-wise results for the research question, which is as follows:

How do resource-oriented determinants, infrastructural factors, government actions, and regional State-wise disparities affect enrolment, retention, quality of learning, and equity of the education system in India?

To identify the extent of the impact of all variables, including the categorical ones, the next section elaborates on the methodology.

4. Materials and Methods

4.1. Research Aim

The purpose of this study is to identify the impact of fourteen factors, indicators of resources and infrastructural facilities, on the educational outcomes of students in 35 States and Union Territories of India from 2017 to 2020.

The explanatory variables considered are land availability, provision of functional electricity, availability of playground, access to additional reading materials, adequate furniture, functional toilet and urinal facilities, girls' toilets and urinals, boys' toilets and urinals, rain water harvesting systems, availability of pure water, presence of additional physical facilities, medical checkups, access to technology, and government processes. The impact of these variables on educational outcomes has been considered in a multitude of different ways. Educational outcomes have been measured in four fundamental ways: 1) Enrolment, 2) Retention, 3) Learning outcomes and quality, and 4) System Equity.

4.2. Model Specification and Research Design

Panel data regression analysis was conducted to examine the influence of the 14 factors on the educational outcomes and standards in the 35 States and Union Territories in India from 2017 to 2020. Educational outcomes and standards have been examined in terms of four measures: 1) Enrolment of students, 2) Retention, 3) Learning outcomes and quality, and 4) system equity. Four models have been crafted to understand the extent of the impact of the factors on these dependent variables. The given table represents the four models and dependent variable in each model:

Table 5. Model Description

	Dependent Variable
Model 1	EnTWPTotal, Total Enrolment Rate
Model 2	Ret, Retention
Model 3	LOQ, Learning Outcomes and Quality
Model 4	EQ, Equity

In order to identify the regression model – fixed effects regression or random effects regression – that is most suited for each model, the Hausman specification test was utilised for the differentiation. However, the test stated that the difference in coefficients was not systematic. As a result, the random effects regression model has been utilised since, for a vast data set, it would provide more efficient (smaller standard errors) and generalizable results across a broader context by including independent State and Union Territory level characteristics, unlike a fixed effects Model. Further, a random effects model is better suited for a multilevel data structure of states over time, and it fits the available data better. The generalised Random Effects Regression Model used for each of the four models is given as follows:

$$\begin{aligned} y_{it} = {} & \alpha_i + \beta_1 x^1{}_{it} + \beta_2 x^2{}_{it} + \beta_3 x^3{}_{it} + \beta_4 x^4{}_{it} + \beta_5 x^5{}_{it} \\ & + \beta_6 x^6{}_{it} + \beta_7 x^7{}_{it} + \beta_8 x^8{}_{it} + \beta_9 x^9{}_{it} \\ & + \beta_{10} x^{10}{}_{it} + \beta_{11} x^{11}{}_{it} + \beta_{12} x^{12}{}_{it} \\ & + \beta_{13} x^{13}{}_{it} + \beta_{14} x^{14}{}_{it} + \gamma_1 q^1{}_{it} + \gamma_2 q^2{}_{it} \\ & + \gamma_3 q^3{}_{it} + \cdots + \gamma_{33} q^{33}{}_{it} + \gamma_{34} q^{34}{}_{it} \\ & + \gamma_{35} q^{35}{}_{it} + \epsilon_{it} \end{aligned}$$

Here, y_{it} is the dependent variable, α_i is the unobserved effect, β_j is the estimated coefficient of the explanatory variables, x_j represents the fourteen independent variables, γ_j is the estimated coefficient of the 35 categorical variables, q_j represents the 35 categorical variables considered, and e_{it} is the estimated error value in the equation.

4.3. Effectiveness of the Random Effects Model

The random effects model combines the within or fixed – variation of variables with each entity – and the between – differences across entities – estimators. The model assigns a weight to both the fixed and between estimators depending on the variation of each. Mathematically, it can be represented as follows:

$$\widehat{\beta_{RE}} = \lambda \widehat{\beta_{FE}} + (1 - \lambda) \widehat{\beta_{BE}}$$

Here $\widehat{\beta_{RE}}$ is the random effects estimator, $\widehat{\beta_{FE}}$ is the fixed effects estimator, $\widehat{\beta_{BE}}$ is the between estimator, and λ is the weight assigned to the fixed estimator. For this study, the random effects model includes fixed variation – which is how the 14 variables change within each State over time – and between variation – which is the variation between States. Since the model blends both these types of variations, it provides a more flexible, efficient, and generalizable estimate than only the fixed effects model would. However, the model does present certain limitations. The random effects model does not establish clear causality due to potential confounding variables and reverse correlation. Further, while it allows for generalization, it assumes that unobserved variables are uncorrelated with the independent variables, which may not necessarily be true.

4.4. Diagnostic Tests

As previously mentioned, a random effects model will be conducted for all models. However, before presenting these results of the regression equations, the assumptions to carry out such a technique must be met. All models should have an absence of autocorrelation and heteroskedasticity. If these conditions are not met, certain adjustments to the model will have to be made.

4.4.1. Autocorrelation

The presence of autocorrelation suggests that there are underlying relationships between consecutive data points, which can affect the accuracy of statistical models, implying that the data is not purely random. This further leads to inaccurate results, especially regarding the significance levels and coefficients. The Wooldridge Test for autocorrelation in a panel data set has been utilised for all four models. The null hypothesis for the test states the following:

H_0 = There is no first-order autocorrelation

Hence, a P-Value of less than 0.05 indicates the rejection of the null hypothesis and indicates the presence of autocorrelation, while a P-Value greater than 0.05 indicates the acceptance of the null hypothesis and the absence of autocorrelation.

The p-values for all models are given below:

Table 6. Wooldridge Test for autocorrelation in panel data

	P-Value
Model 1	0.0152
Model 2	0.0080
Model 3	0.0031
Model 4	0.0584

Hence, it is observed that Models 1, 2, and 3 reject the null hypothesis and have autocorrelation.

4.4.2. Heteroskedasticity

The presence of heteroskedasticity indicates that the variance of the error term is not constant across all independent variables. Hence, the dispersion of residuals is different for different values, which can result in biased and inconsistent estimates of standard errors, leading to the significance levels and accuracy. Hence, the presence of homoskedasticity is crucial for a regression analysis. White's test for heteroskedasticity has been utilised, which has the following null hypothesis:

H_0 = Presence of homoskedasticity

Hence, a P-Value of less than 0.05 indicates the rejection of the null hypothesis and the presence of heteroskedasticity, while a P-Value greater than 0.05 indicates the acceptance of the null hypothesis and the presence of homoskedasticity. The P-Value and Chi-Square Statistic for all five models are given below: Hence, it is observed that only Model 1 rejects the null hypothesis and has heteroskedasticity.

Table 7. White test for heteroskedasticity

	Chi-Square Statistic	P-Value
Model 1	160.29	0.0418
Model 2	138.83	0.3032
Model 3	110.64	0.9012
Model 4	140.92	0.2615

4.5. Variables and Hypotheses

Table 8 describes the 14 independent (IV), 35 categorical, and 4 dependent variables (DV) used in the study.

Table 8. Description of variables

IV/DV	Symbol	Variable Name	Definition	Measured by (Source, Variable Name or Formula)	Rationale
IV	LAND	Land Available	Total number of schools that provide adequate land to their students.	UDISE, Land Available variable	Land availability plays a critical role in affecting the educational outcome by allowing schools to expand their other facilities, build more classrooms, playgrounds, or other specialised spaces, and increase a school's ability to enrol more students.
IV	ELEC	Functional Electricity	Total number of schools with functional electricity in the given State.	UDISE, Functional Electricity variable	Consistent access to electricity affects attention and retention, as students are more likely to attend schools with basic comfort. Further, digital access and more advanced interactive and technologically abled teaching methods can be used.
IV	PLAYG	Playground	Total number of schools with a playground in the given State.	UDISE, Playground variable	Playgrounds provide a space for physical activity that has shown a correlation with cognitive function and social interaction, which may affect educational outcomes. It helps in the holistic development of students.
IV	READMAT	Reading Materials Available	At least one of the three	UDISE (Library or Reading Corner or Book Bank + Librarian + Newspaper)/3	The availability of numerous reading materials or supplementary resources improves general literacy and furthers academic growth beyond the bounds of the traditional classroom.
IV	FURN	Furniture	Total number of schools with furniture in the given State.	UDISE, Furniture variable	Adequate and comfortable furniture, including desks, chairs, boards, etc., are conducive to a learning environment.
IV	TOILUR	Functional Toilet and Urinal	Students are provided a total number of schools with sufficient toilet and urinal facilities.	UDISE, Functional Toilet and Urinal variable	Proper facilities concerning toilets and urinals are essential and help reduce doubt about enrolling students in schools or absenteeism. Especially with reference to rural parts of India, were sanitation issues yet

					prevail, access to such facilities may directly influence enrolment rates.
IV	GTU	Female Toilet and Urinal	Total number of schools with a functional toilet or urinal for girls in the given State.	UDISE (Girl's Toilet + Functional Urinal Girl's)/2	The availability of functional toilets for girls is critical for their education and gender equity. Lack of privacy or cleanliness may result in a less productive or negative learning environment.
IV	BTU	Male Toilets and Urinal	Total number of schools with a functional toilet or urinal for boys in the given State.	UDISE (Boy's Toilet + Functional Urinal Boy's)/2	Clean and functional toilets help promote a more balanced and healthy learning environment while encouraging attendance and retention due to focus.
IV	RWHARV	Rain Water Harvesting Facilities	Total number of schools with rainwater harvesting facilities in the given State.	UDISE, Rainwater Harvesting variable	Schools with rainwater harvesting systems ensure a consistent water supply for drinking and other sanitation purposes. Additionally, in rural areas in India, rainwater harvesting is considered an essential environmental responsibility, which could make parents more inclined to send their children.
IV	PUREW	Clean Water Provision	Total number of schools with water purifiers or functional drinking water facilities in the given State.	UDISE, (Water Purifier + Water Tested)/2	Access to clean drinking water is important for maintaining student health and concentration. It can result in lesser absenteeism and higher academic performance.
IV	PHYFA	Additional Physical Facilities	Total number of schools with hand rails or ramps in the given State	UDISE, (Hand-Rails + Ramps)/2	Assessing the importance of physical accessibility and inclusivity in schools, especially for students with disabilities or mobility challenges, is essential since it can foster an equitable learning environment, improving outcomes.
IV	MED	Medical Checkups	Total number of schools that conduct medical checkups or complete medical checkups in the given State.	UDISE (Medical Checkup + Complete Medical Checkup)/2	Medical checkups in school help in the early detection of health issues, thereby severely impacting learning outcomes. Additionally, specifically in low-income areas with limited access to healthcare, such facilities may incentivize attendance and enrolment.
IV	TECH	Technology	Total number of schools that provide sufficient internet and computer facilities to students.	UDISE, Internet + Computer Available	Access to the internet allows students and teachers to use online resources and engage in digital platforms, thereby improving the quality of education. Connectivity also helps bridge the digital divide and improves equity in education.
IV	GP	Governance processes	Systematic administration and monitoring are needed to ensure transparency and accountability of	Performance Grading Index, Government Processes	Governance processes improve teacher performance and student attention, ensuring a more responsible education system.

			government actions in the education sector by reducing human interference and promoting technology.		
IV	State	State and Union Territory Variable	Accounts for the individual State and Union Territory level differences with State 9, Delhi, being used as the benchmark. Delhi was chosen due to its status as the capital of India.	ib9.State	The varying region-wise factors in terms of governance, socio-economic status, and policy implementation may affect educational outcomes.
DV	EnTWPTotal	Total Enrolment, including preschool	Total number of students enrolled from preschool to Grade 10.	UDISE, (Enrolment by Location, Including Primary)/ (Max Enrolment Rate of the Year) x 100	Provides a clear indicator of the participation and involvement of students in education. Effectively portrays the reach of the education system and inclusivity, which is important as a measure of educational success.
DV	Ret	Retention	Indicates the retention rate of students.	UDISE, (Overall primary retention rate + Overall elementary retention rate + Overall secondary retention rate)/3	Indicates the presence of a supportive and engaging learning environment that encourages continued participation. Helps understand the progression of students through levels without dropping out, thereby indicating active participation.
DV	LOQ	Learning Outcomes and Quality	Measures students' achievement outcomes using language and mathematics scores from Grades 3, 5, and 8.	Performance Grading Index, (Government Processes/180) x 100	Provides a direct assessment of students' academic achievement in foundational subjects like language and mathematics, thereby indicating cognitive development.
DV	EQ	Equity	Indicates whether all students, regardless of their socio-economic background, caste, gender, geographic location, or disabilities, have equal access to education and related opportunities.	Performance Grading Index, (Equity/230) x 100	Understanding whether the educational system addresses and reduces inequalities regarding fair access to education for all is essential.

The following are the hypotheses for Model 1:

1. H_{1M1}: There is an insignificant positive impact of land availability on the total enrolment rate.
2. H_{2M1}: There is a significant positive impact of functional electricity on the total enrolment rate.
3. H_{3M1}: There is a significant positive impact of playgrounds on the total enrolment rate.
4. H_{4M1}: There is a significant positive impact of additional reading materials on the total enrolment rate.
5. H_{5M1}: There is a significant positive impact of furniture on the total enrolment rate.
6. H_{6M1}: There is a significant positive impact of functional toilet and urinal facilities on the total enrolment rate.
7. H_{7M1}: There is a significant positive impact of toilets and urinals for females on the total enrolment rate.

8. H_{8M1}: There is an insignificant positive impact of toilets and urinals for males on the total enrolment rate.
9. H_{9M1}: There is an insignificant positive impact of rainwater harvesting systems on the total enrolment rate.
10. H_{10M1}: There is a significant positive impact of clean water provision on the total enrolment rate.
11. H_{11M1}: There is a significant positive impact of additional physical facilities on the total enrolment rate.
12. H_{12M1}: There is a significant positive impact of the provision of medical checkups on the total enrolment rate.
13. H_{13M1}: There is a significant positive impact of additional technological resources on the total enrolment rate.
14. H_{14M1}: There is a significant positive impact of the implementation of government processes on the total enrolment rate.

The following are the hypotheses for Model 2:

1. H_{1M2}: There is an insignificant positive impact of land availability on the total retention rate.
2. H_{2M2}: There is a significant positive impact of functional electricity on the total retention rate.
3. H_{3M2}: There is an insignificant positive impact of playgrounds on the total retention rate.
4. H_{4M2}: There is an insignificant positive impact of additional reading materials on the total retention rate.
5. H_{5M2}: There is an insignificant positive impact of furniture on the total retention rate.
6. H_{6M2}: There is a significant positive impact of functional toilet and urinal facilities on the total retention rate.
7. H_{7M2}: There is a significant positive impact of toilets and urinals for females on the total retention rate.
8. H_{8M2}: There is an insignificant positive impact of toilets and urinals for males on the total retention rate.
9. H_{9M2}: There is an insignificant positive impact of rainwater harvesting systems on the total retention rate.
10. H_{10M2}: There is a significant positive impact of clean water provision on the total retention rate.
11. H_{11M2}: There is a significant positive impact of additional physical facilities on the total retention rate.
12. H_{12M2}: There is an insignificant positive impact of the provision of medical checkups on the total retention rate.
13. H_{13M2}: There is an insignificant positive impact of additional technological resources on the total retention rate.
14. H_{14M2}: There is an insignificant positive impact of the implementation of government processes on the total retention rate.

The following are the hypotheses for Model 3:

1. H_{1M3}: There is an insignificant positive impact of land availability on the learning outcomes and quality of education.
2. H_{2M3}: There is a significant positive impact of functional electricity on the learning outcomes and quality of education.
3. H_{3M3}: There is a significant positive impact of playgrounds on the learning outcomes and quality of education.
4. H_{4M3}: There is a significant positive impact of additional reading materials on the learning outcomes and quality of education.
5. H_{5M3}: There is an insignificant positive or negative impact of furniture on the learning outcomes and quality of education.
6. H_{6M3}: There is an insignificant positive or negative impact of functional toilet and urinal facilities on the learning outcomes and quality of education.
7. H_{7M3}: There is an insignificant positive impact of toilets and urinals for females on the learning outcomes and quality of education.
8. H_{8M3}: There is an insignificant positive or negative impact of toilets and urinals for males on the learning outcomes and quality of education.
9. H_{9M3}: There is an insignificant positive or negative impact of rainwater harvesting systems on the learning outcomes and quality of education.
10. H_{10M3}: There is an insignificant positive impact of clean water provision on the learning outcomes and quality of education.
11. H_{11M3}: There is an insignificant positive impact of additional physical facilities on the learning outcomes and quality of education.
12. H_{12M3}: There is a significant positive impact of the provision of medical checkups on the learning outcomes and quality of education.
13. H_{13M3}: There is a significant positive impact of additional technological resources on the learning outcomes and quality of education.
14. H_{14M3}: There is a significant positive impact of the implementation of government processes on the learning outcomes and quality of education.

The following are the hypotheses for Model 4:

1. H_{1M4}: There is an insignificant positive or negative impact of land availability on equity.
2. H_{2M4}: There is an insignificant positive impact of functional electricity on equity.
3. H_{3M4}: There is a significant positive impact of playgrounds on equity.
4. H_{4M4}: There is a significant positive impact of additional reading materials on equity.
5. H_{5M4}: There is a significant positive impact of furniture on equity.
6. H_{6M4}: There is a significant positive impact of functional toilet and urinal facilities on equity.
7. H_{7M4}: There is a significant positive impact of toilets and urinals for females on equity.
8. H_{8M4}: There is an insignificant positive impact of toilets and urinals for males on equity.
9. H_{9M4}: There is an insignificant positive impact of rainwater harvesting systems on equity.

10. H_{10M4}: There is a significant positive impact of clean water provision on equity.
11. H_{11M4}: There is a significant positive impact of additional physical facilities on equity.
12. H_{12M4}: There is a significant positive impact of the provision of medical checkups on equity.
13. H_{13M4}: There is a significant positive impact of additional technological resources on equity.
14. H_{14M4}: There is a significant positive impact of the implementation of government processes on equity.

5. Results and Discussion

The diagnostic tests indicate that Models 1, 2 and 3 are plagued with autocorrelation, while only Model 1 has heteroskedasticity. Clustering has been used in Models 1, 2, and 3 to overcome these issues to obtain robust standard errors. The 'vce(cluster id)' function in STATA has been utilised to overcome these challenges, ensuring that the assumptions required for the Random Effects Regression Model are being met.

5.1. Model 1: Enrolment rate

As seen in Table 9, it is observed that the R^2 value is 0.9997, which indicates that 99.97 percent variation in the dependent variable is explained by the 14 variables considered and the categorical variable of State-level differences. It's crucial to note that using State 9 as the base category, all other 35 state-level indicators were significant.

In fact, all of them were significant at 1 percent significance, indicating that they had majorly affected the total enrolment rate. The coefficients for these state-level categorical variables reflect the variations in enrolment across States and the unique regional factors that affect them.

Of the 14 explanatory variables considered, four were significant – Playground, RainWaterHarvesting, AddPhyFac, and Tech. With reference to the beta values or coefficients of the equation, it is concluded that AddPhyFac and Tech had a negative influence on EnTWPTotal at 10 percent significance for both, while Playground and RainWaterHarvesting had a positive influence at 1 and 10 percent significance, respectively. Ultimately, this means that an increase in schools with playgrounds and rainwater harvesting systems will result in an increase in enrolment rate while an increase in schools with additional physical facilities – such as ramps and hand-rails – and technological components – such as computers and internet access – will result in a decrease in enrolment. Overall, this leads to the rejection of the rejection of 4 null hypotheses: H_{3M1}, H_{9M1}, H_{11M1}, and H_{13M1}.

Table 9. Results of Panel Data Regression Using Random Effects Model for Model 1

DV: EnTWPTotal	Coefficient		P-Value
State 3	-16.058		0.000***
State 14	-19.409		0.000***
State 15	-24.749		0.005***
State 22	-19.593		0.000***
State 24	-11.326		0.000***
LAND	6.44e-06		0.905
ELEC	-1.19e-06		0.929
PLAYG	.0000536		0.008***
READMAT	.0000157		0.684
FURN	9.02e-06		0.325
TOILUR	.0000308		0.107
GTU	-.0000237		0.743
BTU	-.0000537		0.406
RWHARV	.0000561		0.097*
PUREW	.0000126		0.438
PHYFA	-.0000281		0.067*
MED	.0000103		0.295
TECH	-.0000288		0.086*
GP	-.0008968		0.410
Constant	9.884588		0.000
R-squared	0.9997	Number of obs	140

****p<0.01, **p<0.05, *p<0.1*

Ultimately, the Random Effects Model follows the given equation:

$$EnTWPTotal_{ij} = \alpha_i + (6.44 \times e^{-6})LAND + (-1.19 \times e^{-6})ELEC + (0.0000536)PLAYG + (0.0000157)READMAT + (9.02 \times e^{-6})FURN + (0.0000308)TOILUR + (-0.0000237)GTU + (-0.0000537)BTU + (0.0000561)RWHARV + (0.0000126)PUREW + (-0.0000281)PHYFA + (0.0000103)MED + (-0.0000288)TECH + (-0.0008968)GP + \gamma_1 q^1{}_{it} + \gamma_2 q^2{}_{it} + \gamma_3 q^3{}_{it} + \cdots + \gamma_{33} q^{33}{}_{it} + \gamma_{34} q^{34}{}_{it} + \gamma_{35} q^{35}{}_{it} + 9.885$$

The significant positive impact of playgrounds can be explained since playgrounds provide a place for physical activity and overall development. Schools that provide these benefits may be considered better for the holistic development of students than those that don't provide these facilities. Hence, enrolment in these schools may be higher due to the students' better overall well-being. Rainwater harvesting systems also have a significant positive impact on enrolment rates. This can be explained by the critical role of water in maintaining hygiene and, hence, a conducive learning environment. Furthermore, numerous parts of rural India face water scarcity, making such schools with a reliable water supply more attractive since water may otherwise be a limited resource. Thirdly, additional physical facilities have a negative impact on enrolment rates. This can be justified by the fact that these facilities are more often implemented in schools serving a specific student population, particularly those with physical disabilities. As a result, the overall enrolment rate would be lower, which appears to have a negative impact. It's surprising to notice that technology significantly negatively impacts enrolment rates. However, it can be explained by the difference in quality and advancement of technology, specifically the availability of computers and access to the internet, between urban and rural areas in India. Furthermore, the mere presence of technology may not be sufficient to attract students – the presence of capable teachers and its integration into the curriculum is necessary to make an impact.

5.2. Model 2: Retention

Table 10. Results of Panel Data Regression Using Random Effects Model for Model 2

DV: Ret	Coefficient		P-Value
State 3	-48.1		0.000***
State 15	-44.582		0.000***
State 22	-39.559		0.000***
State 23	-38.315		0.000***
State 24	-36.749		0.000***
LAND	-.000013		0.982
ELEC	.0001079		0.233
PLAYG	.0000666		0.754
READMAT	.0006673		0.172
FURN	.0000381		0.648
TOILUR	.0002397		0.623
GTU	-.0003344		0.618
BTU	-.0002604		0.679
RWHARV	.0003428		0.570
PUREW	.0000165		0.947
PHYFA	.0002471		0.407
MED	-.0000302		0.746
TECH	-.0000473		0.790
GP	.0331305		0.055*
Constant	80.80811		0.000
R-squared	0.9415	Number of obs	140

****p<0.01, **p<0.05, *p<0.1*

Also, the socio-economic challenges in affording schools with such technology may be a barrier to the full realization of the benefits, resulting in a lower enrolment rate in schools focused on tech-based learning. State and Union Territory level differences, accounted for by the categorical variable, significantly impact the enrolment rates due to the different social, economic, and political factors that vary across these regions. Differences in educational policies, funding for resources, the efficacy of governance, cultural attitudes – specifically towards marginalised groups, and regulation of schemes may affect the enrolment rates. In particular, Andaman and Nicobar Islands, Arunachal Pradesh, Chhattisgarh, Goa, Himachal Pradesh, and 11 other states have an enrolment rate lower than that of the base state, Delhi. It is possible that the remaining States have policies that favour the enrolment rate; however, that is beyond the scope of this study.

As seen in Table 10, it is observed that the R^2 value is 0.9415. This signifies that the 94.15 percent variation in the retention rate is explained by the 14 variables considered and the individual State and Union Territory level differences. Of the 34 State level difference indicators, thirteen were significant at 1 percent, five were significant at 5 percent, and seven were significant at 10 percent. This implies that individual state-level differences played an immense role in affecting student retention rates. Of the other 14 independent variables considered, however, only one was significant. Governance processes were significant at 1 percent significance with a positive coefficient of 0.033. Hence, this results in the rejection of the null hypothesis H_{14M2}. The positive significant impact of government processes can easily be explained. Firstly, monitoring teacher attendance and transparent recruitment systems, promoted by the independent variable, helps ensure that schools are constantly well-staffed with committed teachers. It created a stable learning environment, thereby improving the retention rate by increasing the number of students continuing in the education system. Secondly, School Leadership training sessions fostered by the variable positively influence retention. Thirdly, efficient allocation of funds enables schools to maintain operational continuity and provide resources that help retain students further. Lastly, the regular monitoring of schools and inspections ensure that standards are maintained, which makes schools more conducive for long-term student engagement. Ultimately, the Random Effects Model for retention follows the given equation:

This positive impact of Governance processes is highlighted by Khan & Iqbal (2014), who demonstrated that improved governance in school systems, including better leadership and administrative processes, positively impacts both student enrolment and retention. They found that when government processes such as teacher training, transparent recruitment, and fund disbursement are efficient, they directly correlate to better school environments and higher retention rates.

$$
\begin{aligned}
Ret_{ij} = \alpha_i &+ (-0.000013)LAND_{it} + (0.0001079)ELEC \\
&+ (0.0000666)PLAYG \\
&+ (0.0006673)READMAT \\
&+ (0.0000381)FURN \\
&+ (0.0002397)TOILUR \\
&+ (-0.0003344)GTU \\
&+ (-0.0002604)BTU \\
&+ (0.0003428)RWHARV \\
&+ (0.0000165)PUREW \\
&+ (0.0003471)PHYFA \\
&+ (-0.0000302)MED \\
&+ (-0.0000473)TECH \\
&+ (0.0331305)GP + \gamma_1 {q^1}_{it} + \gamma_2 {q^2}_{it} \\
&+ \gamma_3 {q^3}_{it} + \cdots + \gamma_{33} {q^{33}}_{it} + \gamma_{34} {q^{34}}_{it} \\
&+ \gamma_{35} {q^{35}}_{it} + 80.80811
\end{aligned}
$$

Another study by Muralidharan and Sundararaman (2011) supports this finding by highlighting how regular teacher evaluations and performance incentives improve teacher retention, indirectly affecting student retention through improved learning environments. However, Dyer (2015) argues that the impact on retention is minimal or even negative in regions with poor implementation of government processes, such as delayed fund disbursement or inefficient teacher transfers.

This occurs when government inefficiencies lead to resource shortages or staff dissatisfaction, affecting the learning environment and causes students to drop out. Similarly, Kingdon & Teal (2010) found that while government processes theoretically improve retention, in practice, if not effectively monitored, they may fail to deliver significant outcomes, particularly in regions with a high level of bureaucratic delay and weak enforcement of policies. It is surprising to note technology's insignificance in this case. Technology, often considered a major factor with regard to education, enhances learning opportunities, digital literacy, and engagement.

Access to computers and internet services is expected to result in higher retention due to modern advancement. The categorical variable of State and Union Territory level differences have also proved highly significant. Infrastructural development and investment into facilities, which are different according to State policies and decisions, have an important impact on the retention rate.

Furthermore, supportive government policies that emphasise consistent attendance by teachers and students also improve retention, contrary to other States that don't. Moreover, geographically isolated States or generally lesser developed States struggle with retention due to limited access to schools and poor infrastructure, as found by Shani (2020). Hence, it's important to consider these differences.

5.3. Model 3: Learning Outcomes and Quality

Table 11. Results of Panel Data Regression Using Random Effects Model for Model 3

DV: LOQ	Coefficient	P-Value	
State 6	21.921	0.000***	
State 8	7.963	0.000***	
State 17	13.354	0.000***	
State 21	10.199	0.000***	
State 33	9.256	0.000***	
LAND	-.0001628	0.251	
ELEC	.0001341	0.012**	
PLAYG	.0000196	0.897	
READMAT	.0003101	0.017**	
FURN	.0001341	0.000***	
TOILUR	-.0000468	0.458	
GTU	-.0000403	0.834	
BTU	.0001236	0.633	
RWHARV	-.0001047	0.527	
PUREW	.0000651	0.555	
PHYFA	-.0000273	0.609	
MED	.000028	0.165	
TECH	-.0000396	0.081*	
GP	-.0009996	0.880	
Constant	67.17196	0.000	
R-squared	0.9707	Number of obs	140

****p<0.01, **p<0.05, *p<0.1*

As seen in Table 11, it is noticed that the R^2 value is 0.9707, which indicates that 97.07 percent of the dependent variable – Learning Outcomes and Quality – is explained by the 14 independent and 35 categorical State and Union Territory variables considered. It's essential to note that thirteen of the categorical variables were significant at 1 percent, three were significant at 5 percent, and three were significant at 3 percent. This implies that the individual State level differences play a major role in the learning outcomes and quality provided by the education system. Of the 14 explanatory variables considered, four were significant – FunctionalElectricity, ReadMat, Furniture, and Tech.

With reference to the beta values or coefficients of the equation, it is noted that FunctionalElectricity, ReadMat, and Furniture had a positive impact on LOQ at 5 percent, 5 percent, and 1 percent, respectively, while Tech negatively impacted LOQ at 10 percent significance. Thus, the findings indicate that an increase in schools with functional electricity, supplementary reading materials and related facilities – libraries or book-reading corners, librarians, and newspapers – and furniture will help improve the quality of education. On the other hand, however, an increase in schools with internet and computer facilities will worsen the quality of education. Overall, this leads to the rejection of the rejection of 4 null hypotheses: H_{2M3}, H_{4M3}, H_{5M3}, and H_{13M3}. Hence, the Random Effects Model for learning outcomes and quality follows the given equation:

$$\begin{aligned} LOQ_{ij} = \alpha_i &+ (-0.0001628)LAND_{it} + (0.0001341)ELEC \\ &+ (0.0000196)PLAYG \\ &+ (0.0003101)READMAT \\ &+ (0.0001341)FURN \\ &+ (-0.0000468)TOILUR \\ &+ (-0.0000403)GTU \\ &+ (0.0001236)BTU \\ &+ (-0.0001047)RWHARV \\ &+ (0.0000651)PUREW \\ &+ (-0.0000273)PHYFA \\ &+ (0.000028)MED \\ &+ (-0.0000396)TECH \\ &+ (0.0009996)GP + \gamma_1 {q^1}_{it} + \gamma_2 {q^2}_{it} \\ &+ \gamma_3 {q^3}_{it} + \cdots + \gamma_{33} {q^{33}}_{it} + \gamma_{34} {q^{34}}_{it} \\ &+ \gamma_{35} {q^{35}}_{it} + 67.17196 \end{aligned}$$

Functional electricity's positive influence on learning outcomes and quality can be justified since functional electricity directly affects the classroom environment and the physical well-being of students and teachers. The comfortable learning environment helps maintain student focus and attention, improving education quality. Research by Schneider (2002) found that schools with proper lighting and ventilation, both reliant on functional electricity, show higher student achievement and fewer health-related absences. However, other studies, such as one by McGuffey (1982), argue that while electricity is important, the correlation between electricity and academic performance diminishes when other factors, such as socio-economic status or teacher quality, are introduced. This suggests that electricity alone may not be a primary driver of learning outcomes but acts in conjunction with other elements. Another variable that had a positive, significant impact on LOQ was reading materials. Access to such materials through libraries, book-reading corners, and newspapers helps students foster interest in reading and independent learning, sometimes beyond the bounds of their academic needs. Access to resources can help further develop their skills. Krashen (2004) emphasizes the role of reading and comprehension in developing adequate literacy and critical thinking skills. Elley (1992) also found that schools with well-stocked libraries have higher literacy rates, particularly in under-resourced communities where students might not have access to books outside of school.

However, studies like Williams & and Wavell (2001) argue that providing access to reading materials does not automatically result in better learning outcomes unless students are encouraged and guided to use them effectively. In many cases, without proper support from teachers or librarians, the availability of reading materials may be underutilized, thus limiting their impact. Furniture was also found to play a significant role in enhancing learning outcomes. Adequate furniture, such as desks and chairs, improves concentration, allowing students to focus for longer periods without any distractions. Higgins et al. (2005) showed that well-designed furniture reduces physical discomfort, allowing students to concentrate longer. An important aspect to note is the arrangement of furniture, which can promote a collaborative learning environment and interactive activities. Barrett et al. (2015) found that the physical design of learning spaces, including furniture, significantly impacts student engagement and academic performance since such students are more likely to participate actively in lessons. On the other hand, Earthman (2004) argues that while furniture quality is important, other factors like teacher effectiveness and school resources have a greater impact on learning outcomes.

It is interesting to note that technology significantly negatively impacts learning outcomes and quality. In addition to these technological resources possibly posing a distraction for students if used for non-learning purposes, they also have the possibility of students becoming overly reliant on these tools, thereby degrading the quality of learning outcomes. Furthermore, it's important to note that the differences in access to such resources may widen the gap between learning outcomes, causing disparities in academic achievement. Research by Ravizza et al. (2017) demonstrated that students who multitask using laptops during lessons tend to perform worse on exams due to divided attention. However, Means et al. (2010) found that technology can have a positive impact when used as part of a hybrid learning model, where it supplements traditional teaching methods rather than replacing them entirely. This suggests that the negative impact of technology depends on how it is integrated into the curriculum and used by both students and teachers. The State and Union Territory level differences significantly impacted the education quality and learning outcomes possible because of the variations in economic development and differences in governance and policy implementation; different levels of economically developed states invest differently in learning resources and teacher development that enhance the quality of education and student outcomes. For instance, Filmer & Pritchett (2001) emphasize the correlation between household wealth, state resources, and student performance, showing that students in wealthier regions can access better learning environments, contributing to higher academic achievement. Moreover, State governments have varying levels of efficacy in implementing national education policies such as the Right to Education, National Education Policy, or the Midday Meal Scheme. While they have been introduced nationally, the level of implementation and regulation varies, which negatively affects education quality. Studies by Kingdon & Banerji (2009) show that effective policy implementation at the state level is critical for improving student retention, learning outcomes, and access to quality education.

5.4. Model 4: Equity

Table 12. Results of Panel Data Regression Using Random Effects Model for Model 4

DV: EQ	Coefficient	P-Value
State 14	-8.836	0.036**
State 18	-6.298	0.013**
State 21	-8.349	0.001***
State 22	-13.469	0.000***
State 23	-6.576	0.009***
LAND	.0002156	0.371
ELEC	-4.83e-06	0.950
PLAYG	-.0002832	0.056*
READMAT	.0002798	0.273
FURN	-.0000514	0.446
TOILUR	.0000472	0.770
GTU	-.0003111	0.458
BTU	.000246	0.529

DV: EQ	Coefficient		P-Value
RWHARV	-.0001202		0.538
PUREW	-.0000246		0.839
PHYFA	.0001874		0.071*
MED	.0000191		0.651
TECH	.000064		0.402
GP	.0277148		0.001***
Constant	87.29427		0.000
R-squared	0.6737	Number of obs	140

****p<0.01, **p<0.05, *p<0.1*

As seen in Table 12, the R^2 value is 0.6737, which means that 67.37 percent of the dependent variable – Equity – is explained by the 14 independent and 35 categorical State and Union Territory variables considered. It's interesting to note that three categorical variables are significant at 1 percent, three are significant at 5 percent, and two are significant at 2 percent. Also, all significant categorical variables negatively impacted EQ, signifying that the status of educational equity was worse in Arunachal Pradesh, Jammu and Kashmir, Kerala, Lakshadweep, Manipur, Meghalaya, Mizoram, and Odisha compared to State 9, Delhi. Three of the 14 independent variables considered were significant.

While AddPhyFac and GP affected EQ in a positive manner, Playground had a negative impact, as inferred from the coefficients. GP is significant at 1 percent, while AddPhyFac and Playground are significant at 10 percent. Hence, the findings indicated that an increase in schools with the presence of additional physical facilities such as handrails and ramps and better systematic management and administration by the government would improve the state of equity. On the other hand, it's intriguing to observe that an increase in schools with playgrounds will have a negative impact on equity. Ultimately, this leads to rejecting three null hypotheses: H_{3M4}, H_{11M4}, and H_{13M4}.

Finally, the Random Effects Model for equity has the given equation: Additional physical facilities positively impact the state of equity in education. This can easily be explained by the fact that facilities such as ramps and handrails ensure accessible infrastructure for students with disabilities. They help to ensure that all students can fully participate in the education system. Research by Schneider (2002) highlights that improved school facilities correlate with better student outcomes, especially in marginalized communities.

Similarly, WestEd (2017) demonstrates that schools with inclusive infrastructure create more equitable environments by ensuring that students with physical disabilities and girls have the necessary facilities to participate fully in school. These findings are further supported by Barrett et al. (2015), which shows that school infrastructure improvements lead to better academic performance and increased enrolment for underprivileged students

$$\begin{aligned} EQ_{ij} = \alpha_i &+ (0.0002156)LAND + (-4.83 \times e^{-6})ELEC \\ &+ (-0.0002832)PLAYG \\ &+ (0.0002798)READMAT \\ &+ (-0.0000514)FURN \\ &+ (0.0000472)TOILUR \\ &+ (-0.0003111)GTU + (0.000246)BTU \\ &+ (-0.0001202)RWHARV \\ &+ (-0.0000246)PUREW \\ &+ (0.0001874)PHYFA \\ &+ (0.0000191)MED + (0.000064)TECH \\ &+ (0.0277148)GP + \gamma_1 {q^1}_{it} + \gamma_2 {q^2}_{it} \\ &+ \gamma_3 {q^3}_{it} + \cdots + \gamma_{33} {q^{33}}_{it} + \gamma_{34} {q^{34}}_{it} \\ &+ \gamma_{35} {q^{35}}_{it} + 87.29427 \end{aligned}$$

Secondly, the governance processes, referring to the structured management of educational resources, accountability, and monitoring, also positively affect equity. This is because they also promote transparency and accountability to ensure that resources, including funds, facilities, and teachers, are allocated fairly and efficiently, particularly in underserved areas. This helps to reduce the learning gap for those from disadvantaged backgrounds or regions. Moreover, the focus on inclusivity by policies – such as the emphasis on enrolment and performance of marginalised groups – helps ensure that students receive the necessary support to continue their education. Muralidharan & Sundararaman (2011) found that effective governance in teacher attendance and fund allocation directly led to better outcomes for students from disadvantaged communities. Kingdon and Teal (2010) also demonstrated that states with strong governance processes, particularly in teacher recruitment and accountability, witnessed improved educational outcomes among marginalized groups. Playgrounds have a negative impact on equity. Although this is surprising, it can be explained by their disproportionate benefit for students residing in urban areas or from better economic backgrounds. The differences they cause in terms of accessibility and inclusivity may also worsen the equity. Additionally, De et al. (1999) highlight that focusing on non-academic facilities like playgrounds in underfunded schools can divert attention from more pressing needs, such as improving classroom resources and teacher training, thus negatively impacting equity. The individual State and Union Territory level differences accounted for a significant difference in the equity across education. However, comparatively, with reference to the other three outcome variables, their impact was less significant. This indicated that while regional factors, such as State-level governance, may not affect equity, larger nation-wide factors account for a more significant impact. State and Union Territory differences significantly affect equity in education, particularly due to variations in governance, resource allocation, and local implementation of policies, as highlighted by Dahill-Brown (2019). However, research by Wilcox & Lawson (2022) emphasizes that nationwide factors, such as federal funding and standardized programs, often have a broader and more significant impact on educational equity by setting uniform standards across regions. However, Kingdon & Teal (2010) argue that without effective state-level governance, national policies may not produce desired outcomes, suggesting that both levels play critical roles.

6. Conclusion

This study aimed to understand the impact of 14 resource-based determinants and State and Union Territory-level differences on educational outcomes, proxied through four fundamental variables of enrolment, retention, learning outcomes and quality and equity of the education system. The research, conducted using the 35 States of India from 2017 to 2020, underscores educational outcomes' complexity and holistic nature. The summarised outcomes for all the independent variables have been shown below in Table 13.

The study results have important implications for policymakers and academics in this field. Specifically, policymakers should prioritise the government's monitoring and supervision of the education system. This has been shown to have a significant positive impact on retention and equity, indicating its importance to educational outcomes.

Table 13. Summarized Results

	LAND	ELEC	PLA GY	REA DMAT	FURN	TOIL UR	GTU	BTU	RW HARV	PURE W	PHY FA	MED	TECH	GP
EnTWPTotal			INC						INC		DEC		DEC	
Ret														INC
LOQ		INC		INC	INC								DEC	
EQ			DEC								INC			INC

[INC represents a significant positive impact, and DEC symbolises a significant negative]

Policymakers should emphasise upon the implementation of systems, preferably digital, to improve transparency and accountability.This has also been supported by the United Nations Educational, Scientific, and Cultural Organization. Furthermore, the government must realise the precarious nature of playgrounds and additional physical facilities. While playgrounds attempt to improve the enrolment rate by highlighting the multifaceted approach to learning, they also reduce equity in the system.

Moreover, while additional physical facilities often limit the enrolment rate, they help improve equity and inclusivity for all students, particularly designed for those facing physical disabilities. Policymakers should actively recognise the different nature and extent of the impact of each of these variables in order to initiate tangible impact. For instance, introducing regulations and norms about the minimum number of librarians or access to newspapers and supplementary reading materials will help improve learning outcomes and quality. The consistent negative impact of technology – access to computers and internet services – for enrolment and learning outcomes is also important to note. While increased accessibility to computers and the internet reduces enrolment and learning outcomes and quality, as supported by previous research, their integration into the pedagogy supported with a strong teaching background will help facilitate their positive impact. The study also contributes to the existing literature by highlighting the influence of contextual factors recognized through the individual State and Union Territory level differences. The central government needs to ensure that States and Union Territories standardize the base quality of education in accordance with central guidelines, which regional-level forces and policies should further accentuate.

Additionally, the study, by focusing on the different States and Union Territories, lays a strong foundation for policy formulation specific to India's needs and development. Moreover, the methodology of panel-data analysis, compared to a cross-sectional study, allows for a more dynamic understanding of the educational outcomes. Using the random effects regression model accounts for the observable and unobservable differences, and the methodological rigor offers a more accurate understanding of resources over time. Ultimately, this research takes a new take on existing literature by emphasising upon the specificities of infrastructural developments. However, the research has certain limitations.

The vast socio-economic, cultural, and political diversity across India's States and Union Territories implies that findings may have a stronger and more specific impact due to the presence of regional factors in certain areas over others. A more granular regional analysis could provide deeper insights than achievable in a nationwide study. Additionally, data availability posed an obstacle due to which the study's time frame was limited to only 4 years. A longer time frame would provide a more robust understanding of these variables over time. Further, certain external factors, such as the COVID-19 pandemic – that took place during 2020 – have impacted the education system but have not been individually analysed. The study can be strengthened with the inclusion of more independent variables. For instance, governance processes, found to be significant in two models, is a highly composite variable constructed by the Department of School Education and Literacy, Ministry of Education. Deconstructing this variable into individual sub-variables like policies, guidelines, systems, reporting, etc., would help to identify more specific factors, allowing for better-targeted intervention. Moreover, new variables such as teacher-student ratio, distance to school, and gender quotas add to a more comprehensive analysis. In the future, when more data is available, conducting a school-level analysis instead of a State-wise analysis will help provide more detailed insights into issues faced by individual schools. This will also capture the localized variations, helping policymakers understand how State-wide policies are being implemented on the ground. Additionally, in the future, a longer time period in the study would help negate the impact of COVID-19 to provide more reliable results.This study underscores the need for a nuanced and holistic approach to education policy and attendant infrastructure, offering insights for targeted interventions to optimize educational outcomes in India.

References

[1] Mathias Dodzi Ahiatrogah, "*Effects of Water, Sanitation and Hygiene Facilities on Academic Performance of Basic School Pupils in the Ketu North Municipality*," M. Phil Thesis, University of Cape Coast, pp. 1-99, 2020. [Google Scholar] [Publisher Link]

[2] All India Council for Technical Education, Sarva Shiksha Abhiyan, Government of India. [Online]. Available: https://www.aicte-india.org/reports/overview/Sarva-Shiksha-Abhiyan\

[3] Abhijit V. Banerjee et al., "Remedying Education: Evidence from Two Randomized Experiments in India," *The Quarterly Journal of Economics*, vol. 122, no. 3, pp. 1235-1264, 2007. [CrossRef] [Google Scholar] [Publisher Link]

[4] Peter Barrett et al., "The Impact of Classroom Design on Pupils' Learning: Final Results of a Holistic, Multi-Level Analysis", *Building and Environment*, vol. 89, pp. 118-133, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[5] Michael Kremeret al., "Teacher Absence in India: a Snapshot," *Journal of the European Economic Association*, vol. 3, no. 2-3, pp. 658-667, 2005. [CrossRef] [Google Scholar] [Publisher Link]

[6] Manas Chutia, "Growth and Development of Education in India During British Period in a Historical Perspective," *International Journal of Management*, vol. 11, no. 9, pp. 1464-1470, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[7] Anuradha De et al., "*Public Report on Basic Education in India*," Oxford University Press, pp. 1-156, 1999. [Google Scholar] [Publisher Link]

[8] Department of School Education and Literacy, Right to Education, Government of India, Ministry of Education, 2021. [Online]. Available: https://dsel.education.gov.in/rte

[9] Caroline Dyer, "Decentralisation to Improve Teacher Quality? District Institutes of Education and Training in India," *Compare: A Journal of Comparative and International Education*, vol. 35, no. 2, pp. 139–152, 2005. [CrossRef] [Google Scholar] [Publisher Link]

[10] Glen I. Earthman, "*Prioritization of 31 Criteria for School Building Adequacy*," American Civil Liberties Foundation of Maryland, pp. 1-66, 2004. [Google Scholar]

[11] Edwards Maureen, "*Building Conditions, Parental Involvement and Student Achievement in the D.C. Public School System*," Thesis, pp. 1-100, 1991. [Google Scholar] [Publisher Link]

[12] Elley B. Warwick, "*How in the World do Students Read? IEA Study of Reading Literacy*," International Association for the Evaluation of Educational Achievement, Technical Report, pp. 1-136, 1992. [Google Scholar] [Publisher Link]

[13] "*Impact of School Infrastructure Development Program on Learning*," Empathy Foundation, Report, pp. 1-41, 2021 [Publisher Link]

[14] Deon Filmer, and Lant Pritchett, "Estimating Wealth Effects Without Expenditure Data-or Tears: An Application to Educational Enrollments in States of India," *Demography*, vol. 38, no. 1, pp. 115–132, 2001. [CrossRef] [Google Scholar] [Publisher Link]

[15] Abdolreza Gilavand, "The Impact of Educational Furniture of Schools on Learning and Academic Achievement of Students at Elementary Level," *International Journal of Medical Research & Health Sciences*, vol. 5, no. 7, pp. 343-348, 2016. [Google Scholar] [Publisher Link]

[16] Glass V. Gene, "*School Class size: Research and Policy*," Reports, pp.1-160, 1982. [Google Scholar] [Publisher Link]

[17] Paul Glewwe et al., "*School Resources and Educational Outcomes in Developing Countries: A Review of the Literature From 1990 to 2010*," National Bureau of Economics Research, Cambridge, pp. 1-71, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[18] Fatima Akram Hayat, "*The Relationship Between Access to Toilets and School Enrollment in Pakistan*," Thesis, Georgetown University, Washington, pp. 1-41, 2017. [Google Scholar] [Publisher Link]

[19] Steve Higgins et al., "*The Impact of School Environments: A Literature Review*," Design Council, Reports, pp. 1-47, 2005. [Google Scholar] [Publisher Link]

[20] Parimala Inamdar, Computer Skills Development by Children Using 'Hole in the Wall' Facilities in Rural India, "*Australasian Journal of Educational Technology*," vol. 20, no. 3, 2004. [CrossRef] [Google Scholar] [Publisher Link]

[21] Wasal Khan and Mohammad Iqbal, "Role of Co-Curricular Activities in School Effectiveness," *Middle-East Journal of Scientific Research*, vol. 21, no. 11, pp. 2169-2176, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[22] G Kingdon, and R Banerji, "*School Functioning in Rural North India: Evidence From School-TELLS Survey*," Institute of Education, University of London, 2009. [Google Scholar]

[23] Geeta Kingdon and Francis Teal, "Teacher Unions, Teacher Pay and Student Performance in India: A Pupil Fixed Effects Approach," *Journal of Development Economics*, vo. 91, no. 2, pp. 278-288, 2010. [CrossRef] [Google Scholar] [Publisher Link]

[24] Stephen D. Krashen, "*The Power of Reading: Insights from the Research*," ABC-CLIO, pp. 1-180, 2004. [Google Scholar] [Publisher Link]

[25] Michael Kremer, Edward Miguel, and Rebecca Thornton "Incentives To Learn," *The Review of Economics and Statistics*, vol. 91, no. 3, pp. 437-456, 2004. [CrossRef] [Google Scholar] [Publisher Link]

[26] Leigh Linden, "*Complement or Substitute? The Effect of Technology on Student Achievement in India*," Columbia University, Reports, pp. 1-47, 2008. [Google Scholar] [Publisher Link]

[27] Oishika Banerji, iPleaders, Article 21A of the Indian Constitution, 2022. [Online]. Available: https://blog.ipleaders.in/article-21a-of-indian-constitution/

[28] Herbert J. Walberg, "*Improving Educational Standards and Productivity: The Research Basis For Policy*," McCutchan Pub. Corp, 1982. [Google Scholar] [Publisher Link]

[29] Barbara Means et al., "*Evaluation of Evidence-Based Practices in Online Learning A Meta-Analysis and Review of Online Learning Studies*," U.S. Department of Education, Project Reports, pp. 1-93, 2010. [Google Scholar] [Publisher Link]

[30] Samagra Shiksha, Department of School Education and Literacy, Ministry of Education Government of India, 2021. [Online]. Available: https://samagra.education.gov.in/

[31] Azadi ka Amrit Mahotsav Ministry of Education, Steps Taken By The Government to Provide Free of Cost Digital Tools to Marginalised Communities, 2023. [Online]. Available: https://pib.gov.in/PressReleasePage.aspx?PRID=1982424

[32] Ministry of Human Resource Development, National Policy on Education 1986, Programme On Action 1992, 1986. [Online]. Available: https://www.education.gov.in/sites/upload_files/mhrd/files/upload_document/npe.pdf

[33] Ministry of Human Resource Development, Government of India, National Education Policy 2020, 2020. [Online]. Available: https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

[34] Sarva Shiksha Abhiyan, Ministry of Human Resource Development & Department of Elementary Education and Literacy, Universal Elementary Education, 2004. [Online] Available: https://dsel.education.gov.in/sites/default/files/2019-05/Manual_Planning_and_Apprisal.pdf

[35] Karthik Muralidharan and Venkatesh Sundararaman, "Teacher Performance Pay: Experimental Evidence from India," *Journal of Political Economy*, vol. 119, no. 1, pp. 39-77, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[36] Jawaharlal Nehru, *Five Year Plans, Chapter-7*, Ministry of Statistics and Program Implementation, pp. 1-13, 1951. [Publisher Link]

[37] Maria Camila Coronado et al., "*The Impact of School Facilities on Student Learning and Engagement*," The NetZED Laboratory, University of Oregon, pp. 1-83, 2021. [Google Scholar] [Publisher Link]

[38] Angela Nyalusi, "*Factors Affecting Girls' Academic Performance in Community Secondary Schools A Study of Mbeya City*," Master Thesis, The Open University of Tanzania, pp. 1-105, 2013. [Google Scholar] [Publisher Link]

[39] Oladebinu Tokunbo Olufemi, Amos Adekunle Adediran, and Oyediran, "Factors Affecting Students' Academic Performance in Colleges of Education in Southwest, Nigeria," *British Journal of Education*, vol. 6, no. 10, pp. 43-56, 2018. [Google Scholar] [Publisher Link]

[40] Priyanka Pandey, Sangeeta Goyal and Venkatesh Sundararaman, "Community Participation in Public Schools: Impact of Information Campaigns in Three Indian States," *Education Economics*, vol. 17, no.3, pp. 355-375, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[41] The Right of Children to Free and Compulsory Education Act, Indiacode, 2009. [Online]. Available: https://www.indiacode.nic.in/bitstream/123456789/13682/1/rte_act_2009.pdf

[42] Alyssa Perez, "*How School Facilities Impact Student Health and Performance: Advancing Equity With Green Infrastructure*," Western Educational Equity Assistance Center at WestEd, pp. 1-12, 2024. [Google Scholar] [Publisher Link]

[43] Swachh Bharat-Swachh Vidyalaya Campaign, Press Information Bureau Government of India Ministry of Human Resource Development, 2014. [Online]. Available: https://pib.gov.in/newsite/PrintRelease.aspx?relid=110034#:~:text=The%20HRD%20Ministry%20had%20earlier,the%20cleanliness%20drive%20in%20schools.

[44] Susan M. Ravizza, Mitchell G. Uitvlugt, and Kimberly M. Fenn, "Logged In and Zoned Out: How Laptop Internet Use Relates to Classroom Learning," *Psychological Science*, vol. 28, no. 2, pp. 171-180, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[45] Hanna Reinius, Tiina Korhonen, Kai Hakkarainen, "The Design of Learning Spaces Matters: Perceived Impact of the Deskless School on Learning and Teaching," *Learning Environments Research*, vol. 24, no. 3, pp. 339-354, 2021. [CrossRef] [Google Scholar] [Publisher Link]
[46] Schneider Mark, "*Do School Facilities Affect Academic Outcomes?*," Information Analyses, National Clearinghouse for Educational Facilities, Washington, DC. pp. 1-25, 2002. [Google Scholar] [Publisher Link]
[47] Serah Shani, "Education and Human Capital Development among Geographically Isolated Regions and Marginalized Groups in Kenya," *Education and Development*, pp. 131-153, 2020. [CrossRef] [Google Scholar] [Publisher Link]
[48] Jasdev Singh, Vediconcepts, Gurukul Education System, 2024. [Online]. Available: https://vediconcepts.org/gurukul-education-system/
[49] RG Stennett, LM Earl, "*Open Area Elementary Schools: Survey of Teachers' Attitudes and Opinions. Research Report 83-01*," London Board of Education (Ontario). Educational Research Services, Reports, pp. 1-17, 1983. [Google Scholar] [Publisher Link]
[50] Marko Teras, "Education and Technology: Key Issues and Debates," *International Review of Education*, vol. 68, pp. 635–636, 2022. [CrossRef] [Google Scholar] [Publisher Link]
[51] Mira, The impact of School Facilities on Student Learning & Engagement, Institute for Health in the Built Environment, 2022. [Online]. Available: https://buildhealth.uoregon.edu/2022/12/07/the-impact-of-school-facilities-on-student-learning-engagement/
[52] Carol S. Weinstein, "The Physical Environment of the School: A Review of the Research," *Review of Educational Research*, vol. 49, no. 4, pp. 577-610, 1979. [CrossRef] [Google Scholar] [Publisher Link]
[53] Kristen Campbell Wilcox, and Hal A. Lawson, "Advancing Educational Equity Research, Policy, and Practice," *Education Sciences*, vol. 12, no. 12, pp. 1-21, 2022. [CrossRef] [Google Scholar] [Publisher Link]
[54] Dorothy Williams, and Caroline Wavell, "*The Impact of The School Library Resource Centre on Learning*," The Robert Gordon University, Research Report, pp. 1-195, 2001. [Google Scholar] [Publisher Link]
[55] Richard A. Winett, Charles D. Battersby, and Sharon M. Edwards, "The Effects of Architectural Change, Individualized Instruction, and Group Contingencies on the Academic Performance and Social Behavior of Sixth Graders," *Journal of School Psychology*, vol.13, no. 1, pp. 28-40, 1975. [CrossRef] [Google Scholar] [Publisher Link]
[56] World Bank Group, 70% of 10-Year-Olds now in Learning Poverty, Unable to Read and Understand a Simple Text, 2022. [Online]. Available: https://www.worldbank.org/en/news/press-release/2022/06/23/70-of-10-year-olds-now-in-learning-poverty-unable-to-read-and-understand-a-simple-text

Appendices

Appendix I: Results of Panel-Data Analysis Using Random Effects Model For Model 1

EnTWPTotal	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
1	-9.509	.155	-61.20	0	-9.814	-9.204	***
2	6.884	.503	13.68	0	5.898	7.871	***
3	-9.012	.211	-42.69	0	-9.425	-8.598	***
4	5.612	1.6	3.51	0	2.475	8.749	***
5	47.211	.816	57.88	0	45.612	48.809	***
6	-9.035	.177	-50.96	0	-9.383	-8.688	***
7	3.113	.637	4.89	0	1.866	4.361	***
8	-9.497	.151	-62.87	0	-9.793	-9.201	***
: base 9	0	.	.	.	.	.	
10	-9.011	.12	-75.33	0	-9.246	-8.777	***
11	16.846	1.272	13.25	0	14.353	19.338	***
12	2.985	.305	9.80	0	2.388	3.583	***
13	-6.543	.209	-31.26	0	-6.953	-6.133	***
14	-4.106	.385	-10.67	0	-4.86	-3.352	***
15	8.382	.581	14.42	0	7.242	9.522	***
16	14.642	.965	15.18	0	12.752	16.533	***
17	4.674	.35	13.34	0	3.987	5.361	***
18	-9.661	.153	-63.29	0	-9.96	-9.361	***
19	25.26	1.387	18.21	0	22.542	27.978	***
20	41.209	2.435	16.92	0	36.437	45.982	***
21	-8.297	.219	-37.80	0	-8.727	-7.867	***
22	-7.228	.384	-18.82	0	-7.981	-6.476	***
23	-9.154	.202	-45.40	0	-9.549	-8.759	***
24	-8.778	.183	-47.94	0	-9.137	-8.419	***

25	8.241	.943	8.74	0	6.392	10.09	***
26	-9.044	.157	-57.72	0	-9.351	-8.737	***
27	3.844	.748	5.14	0	2.379	5.31	***
28	28.828	1.21	23.82	0	26.455	31.2	***
29	-9.378	.147	-63.63	0	-9.667	-9.089	***
30	17.211	1.121	15.35	0	15.014	19.408	***
31	4.737	.344	13.79	0	4.064	5.411	***
32	-8.142	.234	-34.84	0	-8.6	-7.684	***
33	-4.437	.231	-19.17	0	-4.891	-3.984	***
34	90.369	2.481	36.43	0	85.507	95.231	***
35	32.221	1.299	24.81	0	29.675	34.766	***
LAND	0	0	0.12	.905	0	0	
ELEC	0	0	-0.09	.929	0	0	
PLAYG	0	0	2.64	.008	0	0	***
READMAT	0	0	0.41	.684	0	0	
FURN	0	0	0.98	.325	0	0	
TOILUR	0	0	1.61	.107	0	0	
GTU	0	0	-0.33	.743	0	0	
BTU	0	0	-0.83	.406	0	0	
RWHARV	0	0	1.66	.097	0	0	*
PUREW	0	0	0.78	.438	0	0	
PHYFA	0	0	-1.83	.067	0	0	*
MED	0	0	1.05	.295	0	0	
TECH	0	0	-1.72	.086	0	0	*
GP	-.001	.001	-0.82	.41	-.003	.001	
Constant	9.885	.263	37.58	0	9.369	10.4	***

Mean dependent var	16.472	**SD dependent var**	20.962
Overall r-squared	1.000	**Number of obs**	140
Chi-square	.	**Prob > chi2**	.
R-squared within	0.351	**R-squared between**	1.000
**** p<.01, ** p<.05, * p<.1*			

Appendix II: Results of Panel-Data Analysis Using Random Effects Model For Model 2

Ret	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
1	-4.124	2.181	-1.89	.059	-8.399	.15	*
2	-38.004	14.869	-2.56	.011	-67.147	-8.862	**
3	-48.1	2.66	-18.08	0	-53.314	-42.886	***
4	-43.305	20.989	-2.06	.039	-84.443	-2.167	**
5	-40.964	20.274	-2.02	.043	-80.7	-1.228	**
6	8.832	1.619	5.46	0	5.66	12.004	***
7	-28.962	16.928	-1.71	.087	-62.141	4.217	*
8	1.032	2.232	0.46	.644	-3.342	5.407	
: base 9	0	.	.	.	.	.	
10	7.627	2.547	2.99	.003	2.634	12.619	***
11	-28.221	14.081	-2.00	.045	-55.82	-.623	**
12	-2.425	5.969	-0.41	.685	-14.124	9.274	
13	-.492	3.365	-0.15	.884	-7.086	6.103	
14	-27.499	5.683	-4.84	0	-38.638	-16.36	***
15	-44.582	11.547	-3.86	0	-67.214	-21.949	***
16	-37.935	21.552	-1.76	.078	-80.176	4.307	*
17	1.611	4.279	0.38	.707	-6.776	9.997	
18	2.583	2.546	1.01	.31	-2.407	7.573	

19	-60.911	39.402	-1.55	.122	-138.138	16.316	
20	-49.491	28.764	-1.72	.085	-105.867	6.885	*
21	-33.945	1.79	-18.96	0	-37.453	-30.437	***
22	-39.559	2.569	-15.40	0	-44.595	-34.523	***
23	-38.315	1.453	-26.37	0	-41.162	-35.467	***
24	-36.749	2.657	-13.83	0	-41.957	-31.54	***
25	-32.935	21.855	-1.51	.132	-75.771	9.9	
26	5.438	1.679	3.24	.001	2.149	8.728	***
27	-11.984	7.304	-1.64	.101	-26.3	2.332	
28	-58.663	31.785	-1.85	.065	-120.96	3.634	*
29	-11.528	2.247	-5.13	0	-15.932	-7.125	***
30	-36.038	18.848	-1.91	.056	-72.98	.904	*
31	-23.123	9.853	-2.35	.019	-42.434	-3.812	**
32	-12.334	1.354	-9.11	0	-14.987	-9.681	***
33	-12.59	4.668	-2.70	.007	-21.738	-3.441	***
34	-72.258	56.888	-1.27	.204	-183.757	39.241	
35	-37.606	21.23	-1.77	.076	-79.216	4.004	*
LAND	0	.001	-0.02	.982	-.001	.001	
ELEC	0	0	1.19	.233	0	0	
PLAYG	0	0	0.31	.754	0	0	
READMAT	.001	0	1.37	.172	0	.002	
FURN	0	0	0.46	.648	0	0	
TOILUR	0	0	0.49	.623	-.001	.001	
GTU	0	.001	-0.50	.618	-.002	.001	
BTU	0	.001	-0.41	.679	-.001	.001	
RWHARV	0	.001	0.57	.57	-.001	.002	
PUREW	0	0	0.07	.947	0	.001	
PHYFA	0	0	0.83	.407	0	.001	
MED	0	0	-0.32	.746	0	0	
TECH	0	0	-0.27	.79	0	0	
GP	.033	.017	1.92	.055	-.001	.067	*
Constant	80.808	6.02	13.42	0	69.01	92.606	***

Mean dependent var	76.858	**SD dependent var**	17.325
Overall r-squared	0.941	**Number of obs**	140
Chi-square	.	**Prob > chi2**	.
R-squared within	0.307	**R-squared between**	1.000

**** p<.01, ** p<.05, * p<.1*

Appendix III: Results of Panel-Data Analysis Using Random Effects Model for Model 3

LOQ	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
1	5.146	.556	9.25	0	4.056	6.237	***
2	3.841	4.674	0.82	.411	-5.319	13.001	
3	-7.468	.882	-8.47	0	-9.196	-5.739	***
4	6.286	5.633	1.12	.264	-4.754	17.326	
5	-11.312	6.311	-1.79	.073	-23.681	1.057	*
6	21.921	.658	33.32	0	20.632	23.211	***
7	-3.219	3.833	-0.84	.401	-10.732	4.294	
8	7.963	.583	13.67	0	6.821	9.105	***
: base 9	0	.	.	.	.	.	
10	5.761	.478	12.05	0	4.824	6.698	***
11	1.199	5.886	0.20	.839	-10.337	12.735	
12	.348	1.954	0.18	.859	-3.481	4.177	

13	5.187	1.633	3.18	.001	1.987	8.388	***
14	.799	1.821	0.44	.661	-2.77	4.368	
15	5.802	3.814	1.52	.128	-1.673	13.276	
16	-5.39	8.229	-0.66	.512	-21.519	10.739	
17	13.354	1.353	9.87	0	10.701	16.006	***
18	.809	.615	1.32	.188	-.396	2.013	
19	-11.128	9.443	-1.18	.239	-29.636	7.38	
20	-22.896	13.534	-1.69	.091	-49.422	3.631	*
21	10.199	.772	13.22	0	8.686	11.711	***
22	1.659	1.417	1.17	.242	-1.119	4.437	
23	2.216	.701	3.16	.002	.841	3.59	***
24	2.563	.876	2.93	.003	.847	4.279	***
25	-4.556	4.475	-1.02	.309	-13.327	4.215	
26	1.719	.538	3.20	.001	.665	2.773	***
27	-6.588	3.682	-1.79	.074	-13.805	.628	*
28	2.17	7.209	0.30	.763	-11.959	16.299	
29	-.686	.51	-1.35	.178	-1.684	.313	
30	-10.339	4.278	-2.42	.016	-18.724	-1.954	**
31	.314	3.293	0.10	.924	-6.141	6.768	
32	7.058	.541	13.05	0	5.998	8.118	***
33	9.256	2.048	4.52	0	5.241	13.27	***
34	-44.984	20.185	-2.23	.026	-84.546	-5.422	**
35	-17.543	8.713	-2.01	.044	-34.62	-.466	**
LAND	0	0	-1.15	.251	0	0	
ELEC	0	0	2.52	.012	0	0	**
PLAYG	0	0	0.13	.897	0	0	
READMAT	0	0	2.38	.017	0	.001	**
FURN	0	0	4.31	0	0	0	***
TOILUR	0	0	-0.74	.458	0	0	
GTU	0	0	-0.21	.834	0	0	
BTU	0	0	0.48	.633	0	.001	
RWHARV	0	0	-0.63	.527	0	0	
PUREW	0	0	0.59	.555	0	0	
PHYFA	0	0	-0.51	.609	0	0	
MED	0	0	1.39	.165	0	0	
TECH	0	0	-1.75	.081	0	0	*
GP	-.001	.007	-0.15	.88	-.014	.012	
Constant	67.172	1.715	39.16	0	63.81	70.534	***

Mean dependent var	76.317	**SD dependent var**	7.497
Overall r-squared	0.971	**Number of obs**	140
Chi-square	.	**Prob > chi2**	.
R-squared within	0.365	**R-squared between**	1.000

**** p<.01, ** p<.05, * p<.1*

Appendix IV: Results of Panel-Data Analysis Using Random Effects Model for Model 4

EQ	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
1	-1.901	2.51	-0.76	.449	-6.82	3.018	
2	-11.13	8.555	-1.30	.193	-27.897	5.637	
3	-5.827	2.669	-2.18	.029	-11.057	-.596	**
4	-10.565	10.532	-1.00	.316	-31.207	10.076	
5	-16.421	12.744	-1.29	.198	-41.398	8.556	
6	-.879	2.545	-0.35	.73	-5.867	4.109	

7	-8.798	8.628	-1.02	.308	-25.709	8.113	
8	1.747	2.513	0.70	.487	-3.178	6.672	
: base 9	0	.	.	.	.	.	
10	-2.392	2.464	-0.97	.332	-7.221	2.436	
11	-12.816	9.964	-1.29	.198	-32.345	6.713	
12	-5.912	4.146	-1.43	.154	-14.037	2.213	
13	-4.219	3.331	-1.27	.205	-10.749	2.31	
14	-8.836	4.211	-2.10	.036	-17.089	-.582	**
15	-11.12	7.385	-1.51	.132	-25.595	3.354	
16	-11.364	12.913	-0.88	.379	-36.672	13.944	
17	-5.892	3.477	-1.69	.09	-12.708	.923	*
18	-6.298	2.536	-2.48	.013	-11.269	-1.328	**
19	-18.785	19.993	-0.94	.347	-57.97	20.4	
20	-18.268	19.879	-0.92	.358	-57.23	20.695	
21	-8.349	2.625	-3.18	.001	-13.494	-3.204	***
22	-13.469	3.245	-4.15	0	-19.83	-7.109	***
23	-6.576	2.535	-2.59	.009	-11.545	-1.607	***
24	-3.514	2.612	-1.34	.179	-8.634	1.607	
25	-17.793	10.054	-1.77	.077	-37.498	1.913	*
26	-3.169	2.488	-1.27	.203	-8.045	1.707	
27	-7.916	5.755	-1.38	.169	-19.195	3.362	
28	-19.155	16.273	-1.18	.239	-51.05	12.74	
29	-3.825	2.481	-1.54	.123	-8.687	1.037	
30	-4.133	9.647	-0.43	.668	-23.041	14.774	
31	-8.018	6.184	-1.30	.195	-20.139	4.102	
32	-3.847	2.549	-1.51	.131	-8.844	1.149	
33	-5.732	3.886	-1.48	.14	-13.348	1.884	
34	-27.344	35.867	-0.76	.446	-97.643	42.954	
35	-15.261	15.181	-1.01	.315	-45.016	14.494	
LAND	0	0	0.90	.371	0	.001	
ELEC	0	0	-0.06	.95	0	0	
PLAYG	0	0	-1.91	.056	-.001	0	*
READMAT	0	0	1.10	.273	0	.001	
FURN	0	0	-0.76	.446	0	0	
TOILUR	0	0	0.29	.77	0	0	
GTU	0	0	-0.74	.458	-.001	.001	
BTU	0	0	0.63	.529	-.001	.001	
RWHARV	0	0	-0.62	.538	-.001	0	
PUREW	0	0	-0.20	.839	0	0	
PHYFA	0	0	1.80	.071	0	0	*
MED	0	0	0.45	.651	0	0	
TECH	0	0	0.84	.402	0	0	
GP	.028	.008	3.43	.001	.012	.044	***
Constant	87.294	2.768	31.53	0	81.868	92.72	***

Mean dependent var	90.537	**SD dependent var**	4.573
Overall r-squared	0.674	**Number of obs**	140
Chi-square	187.871	**Prob > chi2**	0.000
R-squared within	0.320	**R-squared between**	1.000

*** *p<.01*, ** *p<.05*, * *p<.1*