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Demographic and Economic Determinants of Educational Equity: A Study on Numeracy and Science Proficiency Across Pakistan's Provinces

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Citation | Mehmood. A, "Demographic and Economic Determinants of Educational Equity: A Study on Numeracy and Science Proficiency Across Pakistan's Provinces", JIRSD, Vol. 3 Issue. 2 pp 75-84, Aug 2024

Received | May 22, 2024 **Revised |** June 26, 2024 **Accepted |** July 15, 2024 **Published |** Aug 03, 2024.

This study explores the impact of demographic and economic factors on the numeracy skills of students across different provinces in Pakistan, with a particular focus on understanding regional disparities and educational equity. The investigation involved a comprehensive survey administered to Grade 4 and Grade 8 students, assessing their mathematical and scientific proficiency alongside demographic data. The findings reveal significant regional disparities in student performance, with Punjab consistently outperforming other provinces, particularly Balochistan and KP & NMD, which exhibit notably lower scores. The results show that Grade 4 students nationally answered 49% of mathematics items correctly, while Grade 8 students demonstrated a decline, with only 41.6% correct responses. This decline suggests increasing challenges in numeracy as students' progress through their education. In science, Grade 8 students performed better overall, with an average score of 51.3%, indicating that science education may be more engaging or effectively taught compared to mathematics. The study underscores the influence of socio-economic status (SES) on academic performance, with students from lower SES backgrounds generally performing worse than their peers. Factors such as parental education, family income, and regional educational resources play a critical role in shaping students' numeracy skills. The research highlights the need for targeted interventions to address educational inequities, particularly in underperforming regions like Balochistan and KP & NMD. Recommendations include improving resource allocation, enhancing teacher training, and providing additional support to students from disadvantaged backgrounds to ensure equitable educational outcomes across Pakistan.

Keywords: Socioeconomic Position, Mathematics, Numeracy, Academic Accomplishment, India.

Introduction:

The influence of the home environment on early literacy and numeracy development has garnered increasing attention, particularly within theoretical frameworks like Neuroconstructivism, which highlight the impact of environmental factors on cognitive growth. Children from low Socio-Economic Status (SES) families often face delays in school readiness, potentially hindering their academic progress and leading to a long-term pattern of underachievement, school dropout, and underemployment, in contrast to their higher SES peers [1]. These delays in school readiness are part of broader disparities linked to low SES, which pose higher risks in various behavioral skills and health outcomes. [2] defines SES as "the individual's or a family's ranking on a hierarchy according to access to or control over some combination of valued commodities such as wealth, power, and social status", while [3]

describe SES as "the position of individuals, families, households, or other aggregates on one or more dimensions of stratification, including income, education, prestige, wealth, or other aspects deemed important by society". The debate on how best to measure SES continues, often including indicators such as education, occupation, and income, as well as possessions (e.g., books and personal computers) and, occasionally, cultural and social capital (e.g., relationships). The choice of SES measures can depend on factors such as the relevance of the concept at the time of the study, its applicability to the population under study, and its comparability with other studies. Parental education is frequently identified as having the strongest link to children's educational outcomes and is closely correlated with other SES indicators. [4] suggest that disadvantage is not inherent in individuals but rather emerges from the interactions between individuals, society, and the educational system. Consequently, literacy practices in disadvantaged families may not align as closely with school literacy as those in more advantaged families. Poverty often strains parents' resources, both material and emotional, which can affect the quantity and quality of home literacy and numeracy activities available to children. Evidence suggests a positive relationship between home literacy and early literacy skills and between home numeracy and early numeracy skills. Nonetheless, past research indicates that the relationship between SES and home literacy is typically moderate, reflecting considerable variability in home learning support within both low- and high-SES families [4] [5].

Mathematics has consistently been regarded as an essential and indispensable subject throughout the history of education. Proficiency in mathematics enables an individual to perform data analysis, derive significant findings, and efficiently tackle practical issues. Furthermore, the exponential expansion of Artificial Intelligence (AI) has resulted in the emergence of numerous novel employment prospects, a significant portion of which require a high level of mathematical aptitude. These occupations encompass computer vision engineers, AI research scientists, and AI product managers. Theories on the replication of human behavior and the advancement of cognitive robots are grounded in mathematical principles and models [6] [7].

Numeracy is the mental capacity to understand and manipulate numerical data. This covers a wide range of subjects, including algebra and basic addition. Research has demonstrated that an individual's socioeconomic status exerts a significant impact on this phenomenon. SES, an abbreviation for socioeconomic status, is a numerical assessment derived from the amalgamation of two variables. One of these criteria is economic status, which evaluates an individual's and their family's financial assets and income in relation to others in the community as a whole. Another factor that influences an individual's social position is their occupational status and level of education [8]. This is used to assess an individual's social status in the professional setting as seen by the general public. Research has demonstrated that socioeconomic status is a crucial determinant of various characteristics, including parental education, financial resources, and career, that significantly impact the academic performance of their offspring [9]. If these cognitive deficits are not addressed during the early stages of development, they might result in a gradual and deteriorating decline in mathematical abilities, causing a chain reaction of negative consequences. Students from lower socioeconomic status backgrounds face educational inequalities in comparison to their more affluent peers as they advance through the academic levels. Students from economically impoverished backgrounds may often display diminished focus and attentiveness, which is another prevalent contributing factor. This phenomenon can be ascribed to additional requests or unfinished assignments [10]. Hence, the acquisition of knowledge does not occur solely within the boundaries of the classroom. According to the statistics, children from lower socioeconomic status households were about 1.5 times more likely to experience behavior disorders related to learning compared to children from higher SES households. Research has

shown that persons with lower socioeconomic status also exhibit a notable lack of drive to learn [11].

The primary focus of the current study is on the numerical aptitude of younger children. A comprehensive evaluation has been carried out to gauge the extent of mathematical proficiency among the students enrolled in a government-funded school. An abbreviated assessment was developed to determine the level of numerical competence among children from disadvantaged socioeconomic backgrounds and the factors that lead to their lack of proficiency in this domain [12] [13]. Various studies have shown that children who come from underprivileged socioeconomic backgrounds face challenges when it comes to math's. According to this data, a child's academic performance is impacted by the educational attainment of their mother. This is because the mother fulfills the role of the primary caregiver for the child. Moreover, there is a correlation between young individuals originating from socioeconomically deprived backgrounds and their reduced motivation, which consequently affects their capacity to gain knowledge. This is very apparent, particularly in language and English classes. The aim of this study is to determine the existing deficiencies in numerical proficiency [14].

Study Objective:

The primary aim of this study is to investigate the influence of demographic and economic factors on numeracy skills among students in Pakistan. The focus is on assessing the mathematical and scientific proficiency of students across different provinces, with particular attention to how demographic characteristics and economic conditions impact their performance.

Data Collection:

Survey Design and Administration:

A comprehensive survey was designed to assess students' mathematical and scientific abilities, as well as gather demographic and economic data. The survey consisted of two main sections:

Mathematical and Scientific Proficiency: This section included questions aligned with the national curriculum for Grades 4 and 8, covering a range of topics from basic arithmetic to more complex mathematical concepts and scientific knowledge. The questions were tailored to the appropriate grade levels and included both multiple-choice and open-ended formats to assess a broad spectrum of skills.

Demographic and Economic Data: This section collected information about the students' backgrounds, including their province, socioeconomic status, family structure, and parental education levels. It also gathered data on familial employment and other socio-economic indicators that might influence educational outcomes.

Sample Selection:

The survey was administered to students from Grades 4 and 8 across various provinces of Pakistan. The sample was stratified to ensure representation from different regions, including Punjab, Sindh, Balochistan, KP & NMD, AJK, GB, and ICT. The selection process aimed to capture a diverse range of socio-economic backgrounds and educational environments.

Survey Administration:

The survey was conducted in a controlled environment to ensure the accuracy and reliability of responses. Students completed the survey in small groups, with each group supervised to minimize the risk of dishonesty and to provide assistance if needed. The survey was administered both in paper form and digitally, using Google Forms to facilitate easy distribution and data collection.

Data Analysis:

Data Cleaning and Preparation:

Data collected from the surveys were cleaned and prepared for analysis. This involved checking for incomplete responses, ensuring consistency in data entry, and handling any missing or erroneous data.

Statistical Analysis:

Descriptive Statistics:

Basic descriptive statistics were calculated to summarize the overall performance of students in mathematics and science. This included mean scores, standard deviations, and percentage distributions of correct answers.

Comparative Analysis:

Performance comparisons were made across different provinces to identify regional disparities. Statistical tests, such as t-tests and ANOVA, were employed to assess the impact of various demographic factors, such as socio-economic status and parental education, on student performance.

Correlation Analysis:

Correlations between demographic variables (e.g., family income, parental education) and academic performance were examined to identify significant relationships. This helped in understanding how different factors influence students' numeracy skills.

Regression Analysis:

Regression models were used to explore the impact of multiple variables on student performance simultaneously. This included evaluating the influence of socio-economic factors, family structure, and regional educational resources on students' academic achievements.

Results Interpretation:

The findings were interpreted to provide insights into how demographic and economic factors affect students' numeracy skills. Key areas of focus included:

Regional Disparities:

Analysis revealed significant differences in performance across provinces, with Punjab generally outperforming other regions. This disparity is linked to varying levels of educational resources and support.

Socio-Economic Impact:

Students from lower socio-economic backgrounds were found to perform worse on average, highlighting the impact of economic factors on educational outcomes. Factors such as parental education level and family income were significant predictors of student performance.

Educational Equity:

The study emphasized the need for targeted interventions to address educational inequities, especially in underperforming regions. Recommendations included improving resource allocation, enhancing teacher training, and providing additional support to students from disadvantaged backgrounds. This study underscores the critical role of demographic and economic factors in shaping students' numeracy skills in Pakistan. By identifying key influences and regional disparities, the findings provide a basis for developing strategies to improve educational equity and enhance academic outcomes for all students.

Results:

The data from Grade 4 and Grade 8 mathematics and science assessments provides a comprehensive view of educational equity in Pakistan, revealing substantial disparities in student performance across different provinces. In Grade 4 Mathematics, students nationally answered an average of 49% of items correctly, equivalent to 23.7 out of 48 items. This figure indicates a foundational level of numeracy but also exposes significant gaps in student knowledge. The performance distribution is notably bimodal, with a considerable proportion of students scoring around 25% of the maximum marks, suggesting issues either with foundational subject knowledge or student engagement.

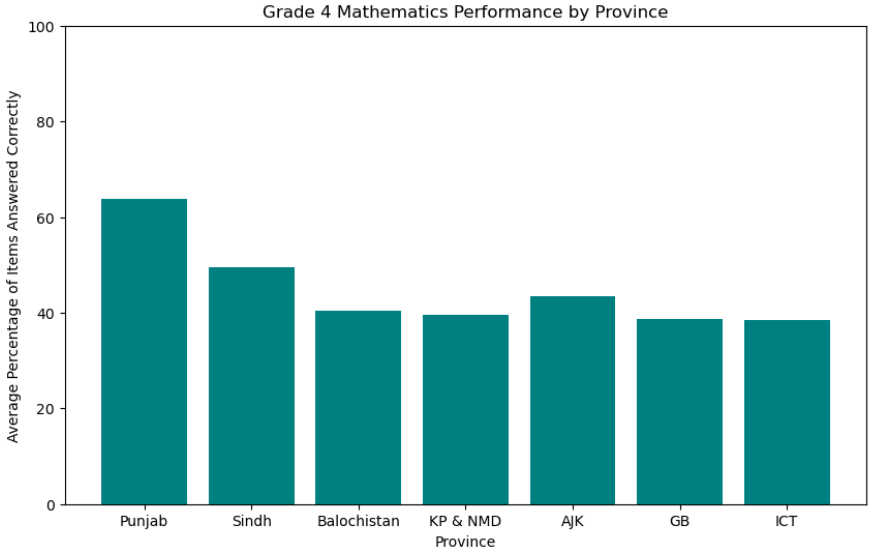

Figure 1: Grade 4 Mathematics Performance.

By province, Punjab stands out with the highest average performance of 63.7%, reflecting a better educational infrastructure and possibly more effective teaching strategies. Conversely, Balochistan and KP & NMD exhibit lower average scores of 40.4% and 39.5%, respectively, highlighting regional challenges such as inadequate resources and limited educational support. Sindh, with an average of 49.4%, aligns closely with the national average, while AJK, GB, and ICT show average scores ranging from 38.5% to 43.5%, indicating moderate performance with room for improvement. Notably, a significant percentage of students in Balochistan (24.0%) and KP & NMD (25.5%) score at or below the 25% guessing benchmark, underscoring persistent educational disparities in these regions.

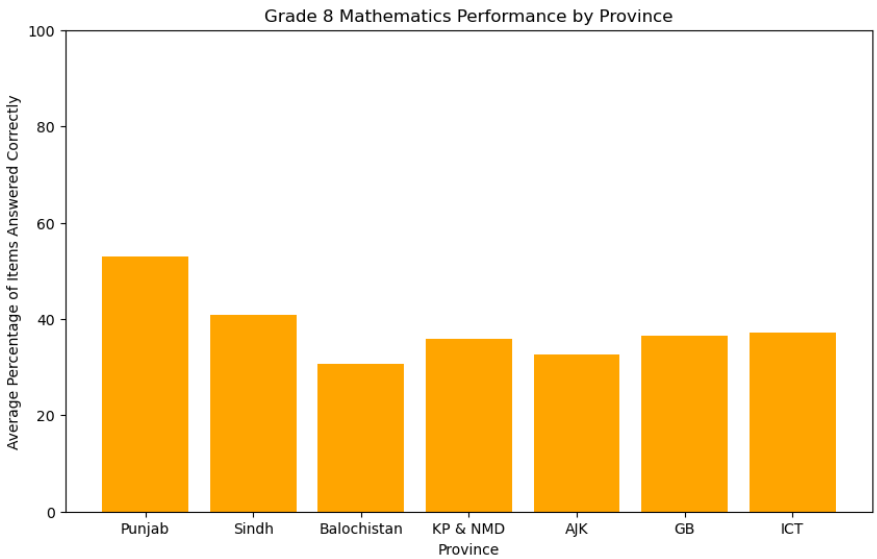

Figure 2: Grade 8 Mathematics performance.

The trend continues into Grade 8 Mathematics, where students answered an average of 41.6% of items correctly, representing a decrease from Grade 4. This decline suggests that numeracy challenges become more pronounced as students advance in their education. The performance distribution shows a single peak at low achievement levels, with fewer students reaching higher scores, which points to growing disparities in numeracy skills. Punjab continues to lead with an average score of 52.9%, but other provinces, such as Balochistan and KP & NMD, perform notably worse, with average scores of 30.6% and 35.8%, respectively.

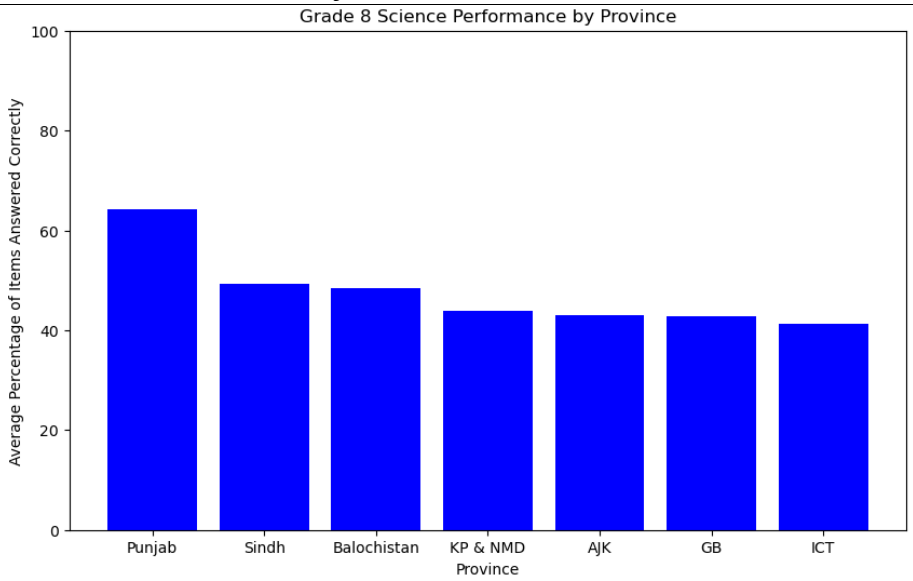

Figure 3: Grade 8 Science performance.

The percentage of students performing at or below the guessing benchmark is highest in Balochistan (36.3%) and lowest in Punjab (6.5%), reflecting significant regional differences in educational outcomes. In Grade 8 Science, students show an average performance of 51.3%, which is generally higher than in Mathematics. This suggests better overall proficiency in science, potentially due to more engaging or effective teaching methods. The performance distribution in science exhibits a single peak at a higher achievement level, indicating better overall outcomes compared to mathematics. Punjab excels with an average score of 64.3%, while other provinces, including Sindh, Balochistan, KP & NMD, AJK, GB, and ICT, show scores ranging from 41.2% to 49.2%. The percentage of students performing at or below the guessing benchmark in science is relatively low at 7%, indicating that fewer students are struggling to the same extent as in mathematics.

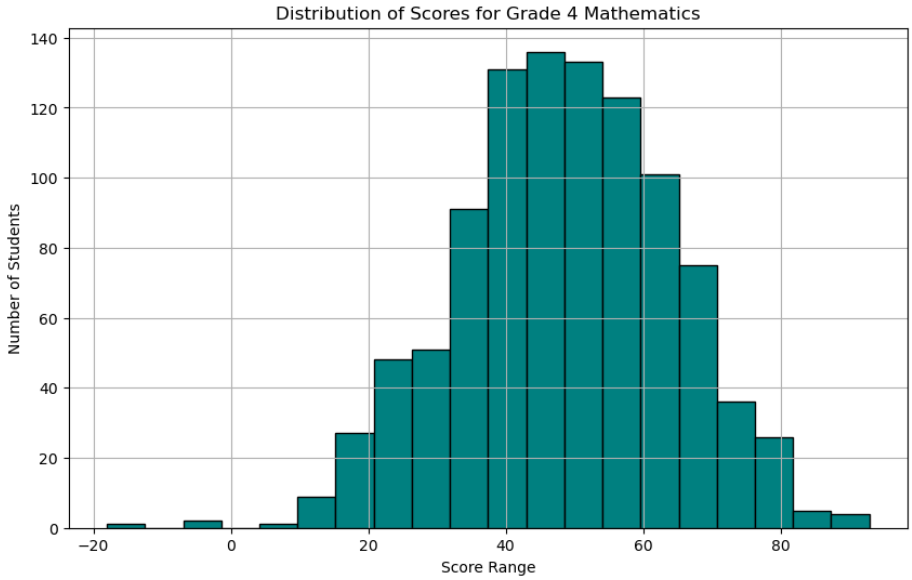

Figure 4: Distrivution of scores for grade 4 Mathematics.

The data highlights significant disparities in educational performance across provinces, which are influenced by various demographic and economic factors. Punjab's consistently higher performance suggests better educational resources and support, while the lower scores in Balochistan, KP & NMD, GB, and ICT reflect ongoing challenges related to economic development and resource allocation. These findings underscore the need for targeted

interventions to address the educational inequities present in less advantaged regions. Improving resource allocation, enhancing teacher training, and developing personalized educational strategies are crucial steps in addressing these disparities and ensuring that all students have the opportunity to succeed. By focusing on these areas, Pakistan can work towards achieving more equitable educational outcomes and bridging the gaps in numeracy skills across its diverse regions.

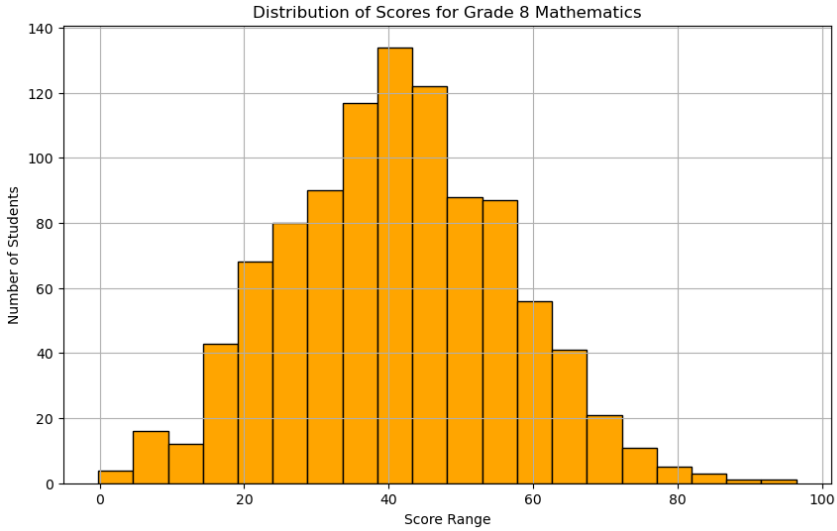

Figure 5: Distribution of scores for grade 8 Mathematics.

Discussion:

The analysis of numeracy and science proficiency among students across Pakistan's provinces has revealed critical insights into the existing educational disparities. The data underscores the significant influence of demographic and economic factors on students' academic performance, highlighting the challenges faced by students from lower socioeconomic backgrounds and under-resourced regions.

Regional Disparities in Educational Outcomes:

The results consistently show that students in Punjab outperform their peers in other provinces in both mathematics and science. For instance, in Grade 4 Mathematics, Punjab students answered 63.7% of items correctly, significantly higher than the national average of 49%. This trend continues in Grade 8, where Punjab students achieved an average score of 52.9% in Mathematics and 64.3% in Science [15]. These findings suggest that Punjab benefits from better educational infrastructure, resources, and teaching methodologies, which contribute to its students' higher academic performance. In contrast, students in Balochistan, KP & NMD, and GB consistently scored lower across all subjects and grades. Balochistan, in particular, exhibited some of the poorest results, with only 40.4% of items answered correctly in Grade 4 Mathematics and 30.6% in Grade 8 Mathematics. The high percentage of students in these provinces scoring at or below the guessing benchmark (e.g., 24.0% in Grade 4 Mathematics and 36.3% in Grade 8 Mathematics in Balochistan) further emphasizes the severe educational disadvantages in these regions. These results reflect the impact of regional disparities in resource allocation, access to quality education, and socio-economic conditions [16].

Impact of Socio-Economic Status on Student Performance:

The data clearly indicates a correlation between socio-economic status (SES) and student performance in numeracy and science. Students from lower SES backgrounds, particularly those in economically disadvantaged provinces like Balochistan and KP & NMD, consistently performed worse than their peers from more affluent regions. This disparity can be attributed to several factors associated with lower SES, including limited access to

educational resources, lower parental education levels, and the need for children to contribute to household income, which can detract from their focus on academics. In Punjab, where socio-economic conditions are generally better, students benefit from more educational support, both at home and in school [9] [14]. The higher parental education levels and better access to educational materials in this province likely contribute to the superior performance of students in mathematics and science. In contrast, in provinces like Balochistan, where socio-economic challenges are more pronounced, students face significant barriers to academic success, including inadequate school facilities, poorly trained teachers, and a lack of extracurricular support [17].

The Role of Educational Resources and Support:

The disparities in educational outcomes across provinces highlight the crucial role of educational resources and support in determining student performance. Punjab's relatively high scores suggest that better-resourced schools, effective teaching strategies, and supportive learning environments are key to improving student outcomes. The province's investment in education, including teacher training and curriculum development, appears to have paid off, as evidenced by the superior performance of its students. On the other hand, the low scores in Balochistan, KP & NMD, and GB suggest that students in these regions are not receiving the same level of educational support. The lack of trained teachers, insufficient school supplies, and poor infrastructure likely contribute to the poor academic performance in these areas. These findings underscore the need for targeted investments in educational resources and teacher training in these underperforming regions to bridge the gap in student performance [18].

Gender and Educational Performance:

While the study did not explicitly focus on gender differences, the influence of gender on educational outcomes is a critical area that warrants further exploration. In many socio-economically disadvantaged regions, cultural factors may further exacerbate educational disparities, particularly for girls. Gender biases and societal expectations can limit girls' access to education, leading to lower performance in numeracy and science. Future research should investigate these dynamics to develop gender-sensitive educational policies that promote equity for all students.

Policy Implications and Recommendations:

The findings from this study have significant policy implications for addressing educational inequities in Pakistan. To promote educational equity, especially in underperforming regions, several key actions are recommended:

Targeted Resource Allocation:

There is a pressing need to allocate more educational resources to provinces like Balochistan, KP & NMD, and GB. This includes investments in school infrastructure, teaching materials, and the recruitment and training of qualified teachers.

Enhancing Teacher Training:

Improving the quality of education in underperforming regions requires a focus on teacher training. Teachers need to be equipped with effective teaching strategies, particularly in numeracy and science, to improve student outcomes.

Parental and Community Engagement:

Encouraging greater parental involvement in education, particularly in lower SES regions, can have a positive impact on student performance. Community programs that raise awareness about the importance of education and provide support to families can help bridge the gap in educational outcomes.

Addressing Socio-Economic Barriers:

Policymakers must also address the broader socio-economic factors that contribute to educational disparities. Initiatives that reduce poverty, improve healthcare, and provide social

safety nets can indirectly enhance educational outcomes by creating a more stable and supportive environment for students.

Monitoring and Evaluation:

Ongoing monitoring and evaluation of educational outcomes are essential to assess the effectiveness of these interventions. Data-driven decision-making will allow for the refinement of strategies and ensure that resources are being used effectively to promote educational equity.

Conclusion:

The disparities in numeracy and science proficiency across Pakistan's provinces reflect deep-rooted socio-economic and demographic inequities. While Punjab's students consistently outperform their peers, regions like Balochistan and KP & NMD lag behind, highlighting the urgent need for targeted interventions. By addressing the underlying socio-economic factors and improving educational resources, Pakistan can work towards achieving more equitable educational outcomes and ensuring that all students, regardless of their background or region, have the opportunity to succeed in mathematics and science. This study provides a foundation for future research and policy development aimed at closing the educational gap and fostering a more inclusive and equitable educational system in Pakistan.

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