frontiers | Frontiers in Education

TYPE Brief Research Report
PUBLISHED 09 May 2025
DOI 10.3389/feduc.2025.1526845



OPEN ACCESS

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RECEIVED 12 November 2024
ACCEPTED 16 April 2025
PUBLISHED 09 May 2025

CITATION
Numajiri T and Kosaka M (2025) Study on the quality of mathematics education in primary schools in Sindh province, Pakistan.
*Front. Educ.* 10:1526845.
doi: 10.3389/feduc.2025.1526845



# Study on the quality of mathematics education in primary schools in Sindh province, Pakistan

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This paper investigates the factors influencing primary school students' mathematics achievement in Sindh province, Pakistan, with a focus on grades 3 to 5. Despite a notable increase in primary school enrollment, challenges persist in delivering high-quality mathematics education. Using the data from the project For Gender Responsive Actions to Ensure Retention Through Community Engagement and School Practices (GRACE), the study aims not only to understand students' basic mathematics knowledge but also to investigate factors that can be associated with the low mathematics achievement of primary school students in Sindh province. The study employs a multiple linear regression analysis and descriptive statistics, to explore the impact of various factors on students' mathematics performance. Key findings reveal gender disparities, with female students exhibiting lower achievement, and significant associations between school location and mathematics proficiency, with suburban students outperforming their rural counterparts. Multi-grade teaching is identified as a challenge, particularly in classrooms with three or more grades, highlighting the need for targeted support for teachers. Moreover, teachers' negative attitudes toward mathematics and low confidence levels present barriers to effective instruction. Addressing these factors is crucial for enhancing students' mathematics achievement and fostering a more equitable and inclusive education system in Sindh province. The findings have important implications for policy and practice, emphasizing the importance of targeted interventions and professional development initiatives to support teachers, and improve students' mathematics learning.

KEYWORDS

**quality of education, mathematics education, Pakistan, primary school education, gender, achievement examinations, fundamental learning, numeracy**

## 1 Introduction

Whilst primary school enrollment has increased in Pakistan, challenges remain in providing high-quality education—particularly in mathematics within the Sindh province, where disparities in access, teacher capacity, and classroom conditions are particularly acute. Results from Trends in International Mathematics and Science Study (TIMSS) in Pakistan suggest that many primary school students had not mastered the fundamental skills in early mathematics. Despite well-intentioned policy efforts to improve primary mathematics education, effective interventions remain elusive. Schools are complex environments (UNICEF, n.d.); thus, low student achievement is considered to be due to multiple and complexly interrelated factors.

In addition, the COVID-19 pandemic led to prolonged school closures in Sindh province, exacerbating learning deficits. Understanding the current state of mathematics education in Sindh is critical for addressing these challenges.

Previous studies have often addressed issues related to access and equity in education in Pakistan. However, recent scholarship highlights that despite progress in enrollment, disparities in instructional quality and student achievement persist (Baron and Bend, 2023; Sheikh et al., 2020). However, fewer have provided a detailed empirical examination of the interplay between student, teacher, and environmental factors in shaping mathematics achievement in the province of Sindh. In particular, there is a gap in research that connects quantitative data with contextual insights to understand why certain groups of students consistently perform worse, despite overall increases in enrollment.

This study aims to explore the factors contributing to low mathematics achievement in Sindh, distinguishing itself from prior research by providing empirical evidence based on recent, region-specific data and drawing comparisons to challenges faced in other South Asian and low-resource global contexts, focusing on early mathematics skills such as number concepts and basic computation. It seeks to fill this gap by analyzing data from the Gender Responsive Actions to Ensure Retention Through Community Engagement and School Practices (GRACE) project, an initiative specifically designed to enhance learning outcomes in the region. The research investigates how gender, school location, and multi-grade teaching influence mathematics achievement.

To guide this investigation, the study is structured around the following research questions:

1. How do student characteristics, particularly gender and grade level, affect mathematics achievement?
2. To what extent does school location (suburban vs. rural) influence student performance in mathematics?
3. How does multi-grade teaching impact the learning outcomes of students in mathematics?

These questions aim to contribute to a deeper understanding of the educational landscape in Sindh and support the development of targeted policy interventions and teacher training programs to improve mathematics outcomes.

# 2 Factors on students' mathematics learning in Pakistan student characteristics

## 2.1 Student characteristics

Student performance in mathematics is influenced by a range of factors, including socio-economic background, health, prior learning, and cultural and gender disparities. In Pakistan, gender and family background, especially in rural areas, create significant barriers. For instance, while enrollment for both boys and girls has improved over the past 15 years, girls' net enrollment remains lower (62%) compared to boys (73%) as of 2018. A large portion of children, particularly girls from low socio-economic backgrounds, are excluded from education due to poverty, lack of school infrastructure, and safety concerns (Sathar et al., 2013). The COVID-19 pandemic and floods have further exacerbated this issue, with 75% of 10-year-olds unable to read a simple text, a rate which may have worsened due to prolonged school closures (Baron and Bend, 2023).

## 2.2 Learning environment in school

Despite efforts to increase access to education, over 20 million children in Pakistan remain out of school. The number of primary schools has risen from 157,900 in 2014 to 187,900 in 2021 (Government of Pakistan Finance Division, 2023), but the rapid expansion has led to multi-grade classrooms, where teachers often struggle to address the needs of different grade levels simultaneously. This is especially problematic in rural areas of Sindh, where many schools have only one teacher for multiple grades. Such conditions can negatively affect learning outcomes (Jamaldini, 2022). Moreover, many teachers are not trained to handle multi-grade teaching, which may hinder their effectiveness in delivering the mathematics curriculum (Nawab, 2018).

## 2.3 Teacher factors

Teachers are pivotal to the quality of education. In Pakistan, efforts to improve teacher quality have been a central focus, but challenges remain. Teachers' confidence in their ability to teach directly impacts student achievement. Studies show that teachers who feel confident in their teaching abilities tend to perform better, enhancing their students' academic performance (Protheroe, 2008) and confidence (Pajares, 2005). However, in Sindh, a lack of professional development and training means many teachers struggle to meet students' needs, particularly in subjects like mathematics.

# 3 Methodology

This study utilizes data collected under the GRACE project (For Gender Responsive Actions to Ensure Retention Through Community Engagement and School Practices), a 4-year technical cooperation initiative conducted by the School Education and Literacy Department (SELD), Government of Sindh, in collaboration with the Japan International Cooperation Agency (JICA). The project aimed to enhance access, retention, and learning outcomes in primary schools. The dataset used in this study was collected in November 2022 from 33 public primary schools, comprising 18 in rural areas and 15 in suburban areas. The survey tools were designed based on international surveys such as TIMSS, TALIS (Teaching and Learning International Survey) and SACMEQ (Southern and Eastern Africa Consortium for Monitoring Educational Quality). The assessment and survey were conducted by a team of 16 trained surveyors who received standardized instructions to ensure data quality and consistency across schools.

The sample consists of 964 Grade 3 to Grade 5 students who took the GRACE mathematics test, as well as 53 teachers, 32 headmasters (HMs), and 33 School Management Committee

(SMC) chairpersons who participated in the survey. The sampling strategy ensured diversity in geographical location and school conditions, providing a broad picture of the educational environment in Sindh. However, it should be noted that the highest priority in selecting sample schools was the security situation. Due to safety concerns in certain areas, school selection was constrained, which limits the representativeness of the sample. As a result, the findings cannot be generalized to the entire province or country. However, while the sample is sizable, it may not fully represent the entire province, and generalizability should be approached with caution.

The mathematics achievement test included 12 items aligned with the national curriculum for Grades 1 to 3, focusing on number concepts and basic computation. Each student's total score, ranging from 0 to 12, was used as the dependent variable for this study.

The following independent variables were analyzed:

- Gender (male/female),
- School location (suburban vs. rural),
- Multi-grade teaching (whether the class comprised three or more grade levels), and
- Grade level (categorical variable for Grades 3, 4, and 5).

These variables were chosen based on literature reviews and field observations, which suggested they significantly influence learning outcomes in low-resource contexts. Multi-grade teaching, in particular, is a widespread practice in rural Sindh due to teacher shortages and infrastructure limitations. Additionally, rural students often face challenges such as inconsistent access to sufficient food (Sheikh et al., 2020).

Descriptive statistics were first used to summarize the characteristics of the sample and the learning environment. Then, multiple linear regression analysis was applied using IBM SPSS software (Version 24). The stepwise method was employed to evaluate the incremental contribution of each predictor while controlling for students' grade levels. Dummy variables were created for categorical predictors to facilitate interpretation.

To address internal validity, we considered the possibility of confounding variables. Although the model controls for key factors, some unobserved influences such as parental involvement or students' health could not be measured. Regarding external validity, the study acknowledges limitations in generalizing findings to all primary schools in Sindh, especially private or urban schools not included in the sample.

Potential biases also include response biases from teachers and school administrators, particularly concerning attitudes, and self-reported school conditions. Additionally, infrastructure limitations in rural schools might have affected the consistency of test administration, which could influence student performance outcomes. These factors are noted as methodological limitations in interpreting the results.

# 4 Results

## 4.1 The results of achievement test

The GRACE mathematics test, comprising 12 basic items on number concepts and computation, revealed that the average number of correct responses was 3.1 out of 12. This suggests that many students have not yet mastered fundamental arithmetic skills. Test scores varied by students' grade level, reinforcing the necessity to control for grade level in further analysis.

## 4.2 Visualizing differences by gender and school location

Figure 1 presents a comparative analysis of student performance based on gender and school location using boxplots. The figure shows that the data on test scores of both males ($M = 3.88$, $SD = 3.55$) and females ($M = 3.63$, $SD = 3.06$) in the suburban area are higher than males ($M = 3.12$, $SD = 3.57$) and females ($M = 1.80$, $SD = 2.29$) in the rural area. These plots offer a more detailed view of score distribution, including median, interquartile range, and outliers.

Error bars representing 95% confidence intervals were added to visualize the variability within each group. A two-way ANOVA was also conducted to statistically assess group differences, revealing significant effects of both gender ($p < 0.01$) and school location ($p < 0.001$) on mathematics achievement. An interaction effect between gender and location was not statistically significant.

## 4.3 Regression analysis: factors influencing mathematics performance

A stepwise multiple linear regression was conducted to examine how student gender, school location, multi-grade teaching, and grade level predict mathematics scores (Warner, 2008). Dummy variables were created for categorical predictors, with male, suburban schools, and classrooms with fewer than three grades serving as baseline categories (summarized in Table 1).

Model 1 included only grade levels and explained 8% of the variance in math scores (Adjusted $R^2 = 0.08$). Grade 4 and Grade 5 students scored significantly higher than Grade 3 students.

Model 2 added gender, revealing that female students performed significantly lower than their male counterparts ($\beta = -0.45$, $p < 0.05$).

Model 3 included school location, and results showed that students in rural areas had significantly lower scores than those in suburban schools ($\beta = -0.89$, $p < 0.001$), raising the explained variance to 11% (Adjusted $R^2 = 0.11$).

Model 4 introduced the multi-grade teaching variable. Students in classrooms with three or more grade levels scored nearly one point lower than those in classrooms with fewer grade levels ($\beta = -0.96$, $p < 0.001$), increasing the explained variance to 13% (Adjusted $R^2 = 0.13$).

The results confirm that student performance is influenced by a combination of educational and contextual factors, with multi-grade teaching having the largest negative impact among the predictors tested.

There is a statistically significant effect of Multi-grade teaching on their performance. The model shows that students' scores in the classes that consist of three or more grades are nearly one point lower than those in the classes that consist of single or

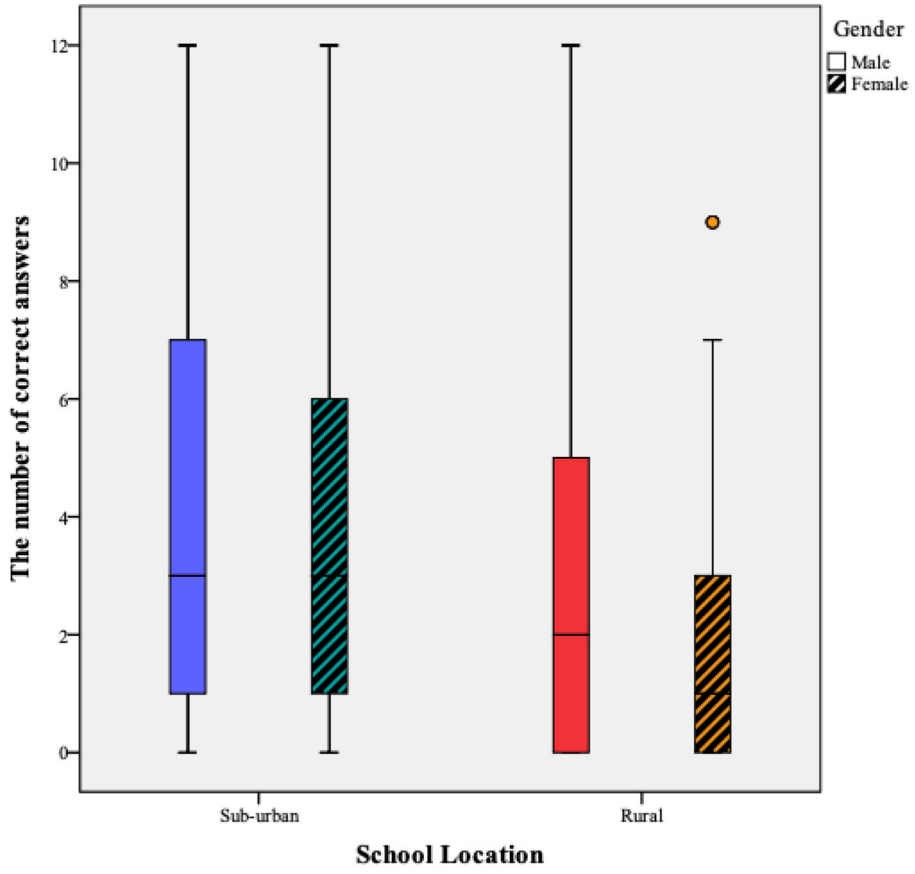


FIGURE 1
Comparison of mathematics scores by gender and school location.

two grades, after controlling for the other variables. Among the three variables, the Multi-grade teaching has the biggest impact on students' outcomes.

## 4.4 Headmaster/mistress and teacher survey findings

In addition to test score analysis, this study incorporated a cross-sectional survey of 53 teachers and 32 headmasters (HMs) from 33 primary schools. The survey aimed to capture stakeholders' perceptions of learning environments, classroom conditions, and teaching practices.

As shown in Table 2, HM perceptions of learning factors: nearly all HMs rated the following as "very important" for improving mathematics education: adequate learning environments, additional teachers, more qualified teachers, and increased teaching resources. While school-community collaboration was seen as less critical, a substantial number of HMs still valued community support for learning.

School infrastructure: large disparities were found between rural and suburban schools in terms of physical infrastructure. Nearly half of the schools lacked electricity, and many rural schools had no boundary walls or adequate sanitation. In smaller rural schools, HMs reported that government education officers visited infrequently, indicating limited external support.

Classroom context: class size varied greatly, with an average of 50.3 students per class and a maximum of 178. Rural schools had significantly larger classes ($M = 60.1$) than suburban ones ($M = 42.6$). Forty of the 53 teachers taught in multi-grade classrooms, and 18 of them taught three or more grade levels simultaneously. Most reported a lack of essential classroom furniture and learning materials.

Teacher characteristics: of the 53 teachers, 35 were male and 18 were female. Thirty teachers taught in suburban schools, while 23 worked in rural schools. Most teachers were employed by SELD, and only six were volunteers. Despite the importance of professional development, more than half of the teachers had not participated in any in-service training over the past 5 years, especially in mathematics-related topics.

According to Table 3, attitudes toward mathematics: teachers generally expressed a positive attitude toward mathematics, with most agreeing that they liked the subject and enjoyed teaching it. However, only 36 out of 53 teachers felt mathematics was easy to teach. Female teachers in rural areas reported lower confidence and more negative attitudes. Gamma statistics showed strong positive relationships between

enjoying mathematics and confidence in teaching it, though all teachers believed that mathematics was essential for everyday life.

These survey results provide important contextual insights and complement the statistical findings, reinforcing the need for improved infrastructure, teacher support, and capacity building in mathematics instruction. In particular, they underscore the urgency of providing targeted support for rural schools, which face more severe resource shortages, larger class sizes, and limited access to professional development opportunities.

TABLE 1 Multiple linear regression coefficients predicting the average maths score in the midlien survey [Standard Error (SE) in parentheses].

| Variable | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| | B (SE) | B (SE) | B (SE) | B (SE) |
| (Constant) | 2.03*** | 2.27*** | 2.92*** | 2.96*** |
| | (0.17) | (0.20) | (0.23) | (0.23) |
| Grade (ref. Grade 3) | | | | |
| Grade 4 | 1.45*** | 1.44*** | 1.42*** | 1.46*** |
| | (0.24) | (0.24) | (0.24) | (0.23) |
| Grade 5 | 2.30*** | 2.23*** | 2.19*** | 2.20*** |
| | (0.26) | (0.26) | (0.25) | (0.25) |
| Student gender (ref. Male) | | | | |
| Female | | −0.45* (0.20) | −0.64** (0.20) | −0.58** (0.20) |
| School location (ref. Sub-urban) | | | | |
| Rural | | | −1.18*** (0.20) | −0.89*** (0.22) |
| Multi-grade teaching | | | | |
| Multi-grade teaching classes that consist of three or more grades | | | | −0.96*** (0.25) |
| Adjusted $R^2$ | **0.08** | **0.08** | **0.11** | **0.13** |

*Significant at 0.05 level.
**Significant at 0.01 level.
***Significant at 0.001 level.

## 5 Discussion

The findings of this study reinforce existing research on the challenges of mathematics education in low-resource contexts, while also offering context-specific insights from Sindh province. Using data from the GRACE project, the analysis identified several key predictors of student achievement in mathematics: student gender, school location, and multi-grade teaching structures.

A significant gender gap in mathematics performance was observed, with female students scoring lower than male students. This disparity was especially pronounced in rural areas, where females had the lowest average scores. These results align with previous findings that girls in Pakistan face disproportionate barriers to educational success, including household responsibilities, early marriage, and limited parental support (Baron and Bend, 2023; Sathar et al., 2013). However, the statistical findings alone cannot fully explain the underlying causes. Further research—particularly qualitative studies—should

TABLE 3 Teacher's attitude toward mathematics and teaching mathematics.

| Item | b) | c) | d) |
|---|---|---|---|
| a) I like mathematics | 0.963*** | 0.519** | 0.517 |
| b) I enjoy teaching mathematics | – | 0.669*** | 0.729** |
| c) Mathematics is easy to teach | – | – | 0.356 |
| d) Mathematics is essential in daily life | – | – | – |

**Significant at 0.01 level.
***Significant at 0.001 level.

TABLE 2 HM's perceptions on factors affecting mathematics education in schools ($N = 32$).

| Which factors would improve the learning and teaching in your school? | Mean | SD | Responses (label) | | | |
|---|---|---|---|---|---|---|
| | | | Not important (1) | Slightly important (2) | Important (3) | Very important (4) |
| Adequate learning environment | 3.75 | 0.76 | 2 | 0 | 2 | 28 |
| More teaching resources | 3.72 | 0.77 | 2 | 0 | 3 | 27 |
| Additional number of teachers | 3.72 | 0.81 | 2 | 1 | 1 | 28 |
| More qualified teachers | 3.69 | 0.82 | 2 | 1 | 2 | 27 |
| More teachers' professional development services | 3.66 | 0.83 | 2 | 1 | 3 | 26 |
| More support from students' parents/guardians to schooling and learning | 3.53 | 0.84 | 2 | 1 | 7 | 22 |
| Higher teachers' attendance rate | 3.53 | 0.95 | 3 | 1 | 4 | 24 |
| More opportunity for learning of students | 3.53 | 1.02 | 4 | 0 | 3 | 25 |
| More support from SMC and communities to children's schooling and learning | 3.47 | 0.84 | 2 | 1 | 9 | 20 |

investigate gender-specific attitudes, classroom practices, and community-level expectations that may contribute to this gap.

The results also highlight the disadvantages faced by students in rural schools. Rural students performed significantly worse than their suburban peers, likely due to poorer infrastructure, larger class sizes, and limited instructional support. These findings mirror previous research by UNESCO (2004) and UNICEF (n.d.), which found that low-resource learning environments strongly correlate with lower student achievement. In particular, the regression results confirm that school location remains a significant predictor even when controlling for student grade and gender.

Among all predictors, multi-grade teaching had the largest negative impact on math achievement. This reflects challenges documented by Jamaldini (2022), who noted that teaching more than two grade levels simultaneously can hinder effective instruction. Most teachers in these contexts lack specialized training in differentiated instruction, which further compounds learning disparities. Interventions aimed at reducing multi-grade teaching or equipping teachers with tools to manage such settings are urgently needed.

The survey data also revealed that teachers in both suburban and rural areas have limited access to in-service training, particularly in mathematics education. This lack of professional development can result in lower teacher confidence and reduced instructional quality (Protheroe, 2008; Cornell, 1999). Also, the teachers with low confidence of teaching mathematics tend to employ traditional teacher-controlled pedagogy (Stipek et al., 2001). The results show that teachers' attitudes toward mathematics—especially among females in rural schools—were less positive, which may influence student engagement and achievement. Although not in Pakistan, according to Arends et al. (2017), teachers in South Africa with higher levels of confidence tended to engage students actively, use an interesting way to teach, and be willing to answer questions from their students. These findings suggest the need for systemic investment in teacher training that targets content knowledge and pedagogical skills in mathematics.

While this study has offered empirical insights, its implications extend to education policy. There is a clear need for more equitable resource allocation, improved teacher training programs, and targeted support for rural schools. Moreover, forming professional learning communities across schools could mitigate isolation and help teachers share effective practices (Révai, 2020). Reviewing existing professional development programs in Sindh and aligning them with identified gaps—especially in multi-grade teaching and gender-sensitive pedagogy—would be a meaningful next step.

Future research should consider longitudinal and mixed-method designs to better understand causal relationships and context-specific challenges. Comparative studies between provinces or countries with similar socioeconomic profiles could also enrich the discourse on effective education reforms.

## 6 Conclusion

This study contributes to the growing body of research on the quality of mathematics education in low-resource contexts by examining the case of primary schools in Sindh province, Pakistan. Drawing on data from the GRACE project, the study identified student gender, school location, and multi-grade teaching as significant factors influencing mathematics achievement. In addition, survey data revealed structural challenges faced by schools, especially in rural areas, and highlighted the limited opportunities for teacher training and professional growth.

The findings have several important implications for education policy and practice. First, targeted support is needed to address the gender gap in mathematics, including the development of gender-sensitive pedagogical approaches and community-based interventions to support girls' education. Second, addressing inequities between rural and suburban schools will require investments in infrastructure, teacher staffing, and oversight mechanisms. Third, interventions to improve multi-grade teaching, such as teacher training in differentiated instruction and the recruitment of additional staff, are essential.

Furthermore, building professional learning communities and offering regular, subject-specific in-service training can enhance teacher confidence and instructional quality. Teachers' attitudes toward mathematics, particularly among rural female teachers, should be addressed through both motivational and skills-based training programs.

Considerations: this study is based on a cross-sectional dataset from a sample of 33 schools. This limitation affects the study's external validity and should be considered when interpreting the findings. Moreover, while the regression models control for several key variables, unmeasured factors such as home learning environments, student motivation, and parental support may also influence outcomes.

Future research should adopt longitudinal and mixed-method designs to explore how changes in teacher practices and school environments influence student achievement over time. Comparative studies across provinces or with other countries facing similar challenges could offer broader insights for improving foundational learning outcomes.

In conclusion, improving mathematics education in Sindh requires a holistic approach that integrates data-driven decision-making, teacher development, and policy reforms that are sensitive to local contexts and constraints.

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## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Ethics statement

The studies involving humans were approved by Japan International Cooperation Agecy (JICA); Sindh Education and Literacy Department, Govermnet of Sindh; The University of Fukui. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin because this study

uses the secondary data from Gender Responsive Actions to Ensure Retention Through Community Engagement and School Practices (GRACE) project. The project was operated by JICA and SELD. The authors got permissions to analyse the data and to publish the results.

## Author contributions

TN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MK: Conceptualization, Formal analysis, Funding acquisition, Investigation, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.

## Funding

The author(s) declare that no financial support was received for the research and/or publication of this article.

## Acknowledgments

The authors wish to thank Dr. Fouzia Khan and Mr. Zahoor Khazi for their support for this study. We are also grateful to a International Development Center of Japan Inc. (IDCJ) team (Dr. Takako Yuki, Mr. Kiyofumi Tanaka, Mr. Masafumi Nagao, and Mr. Daigo Ito) for providing the data and their thoughtful feedback on multiple drafts throughout the writing process. This study uses the data from GRACE project which is a technical cooperation project agreed upon between the School Education and Literacy Department, Government of Sindh (SELD), and the Japan International Cooperation Agency (JICA).

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

## Publisher's note



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