

More girls are accessing school, but are they learning? An exploratory study of the factors influencing girls' mathematics achievement in Pakistan

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Although primary school enrollment in Pakistan has increased in the last two decades, schooling quality for girls and boys remains a central challenge. Furthermore, strides made toward gender parity are yet to address pervasive inequities in schooling outcomes. To provide insight on this matter, this paper interrogates girls' achievement in mathematics within the broader context of girls' access to quality schooling, asking: to what extent does gender influence mathematical achievement among grade four students in Pakistan? Building on Sen and Nussbaum's 'capability approach' and 'freedom as development' frameworks, we explore the extent to which girls' educational achievement represents what Nussbaum defines as 'instrumental freedom.' We conducted an OLS regression to analyze Pakistan's TIMSS 2019 data to examine the effect of gender on mathematical achievement. Results show that despite overall inequity in access to education for female students, girls outperform boys. However, while mathematics achievement might contribute to instrumental freedoms via the attainment of numeracy, discriminatory gender norms deny a vast majority of Pakistan's girls and young women the substantive freedoms central to their development. In Pakistan, the reality that young women are still 75 percent more likely to be disengaged from further education or employment presents a missed opportunity and significant cause for concern.

Keywords: Gender equity, girls achievement, sense of belonging, mathematics education, large-scale assessments, quality teaching.

Introduction

Between 1990 and 2019, the expected years of schooling in Pakistan increased from 4.6 to 8.3 years, and the mean years of actual schooling increased from 2.3 to 5.2 years (UNDP, 2019). While 59 percent of the net attendance ratio is obtained at the primary level, this number reduces to 38 percent by the middle and secondary levels (DHS, 2017). Although primary school enrollment in Pakistan has increased overall, schooling quality remains a stubborn challenge. For example, Pakistan experiences 'learning poverty' with approximately 48 percent of all children being unable to read or comprehend written text by age ten (World Bank, 2019). In addition to early-grade reading, mathematics skills are foundational for academic success in upper primary and secondary education as well as adult engagement in political and economic spheres (Sitabkhan & Platas, 2018). The importance of increased mathematics skills is also associated with increased individual earnings later in life (Hanushek, 2015). To date, however, there is limited longitudinal and/or comparable data or analysis on mathematics achievement in Pakistan.

One barrier towards progress is that data on mathematics achievement in lower and upper levels of schooling has been inadequately captured. For example, we have been able to access gender disaggregated data on regional youth reading rates for 15–24-year-olds for some time (indicating a pervasive gender gap in favor of males). However, until Pakistan participated in the 2019 Trends in International Mathematics and Science Study (TIMMS) we lacked gender-disaggregated data on achievement in mathematics at both primary and secondary school levels (UNICEF & UNFPA, 2019). Representing an anomaly in global mathematics achievement trends (Ghasemi & Burley, 2019), we now know that grade four girls in Pakistan perform better on average than boys. Despite boys experiencing more variability in scores and a poorer overall average score, boys are better represented at higher levels of achievement in mathematics than girls (TIMMS, 2019; UNESCO GEM, 2022).

Our ability to meaningfully evaluate the degree to which improved parity of access to schooling for girls in Pakistan - which is 0.90 at the primary level - accompanies comparable academic achievement is limited (UNICEF & UNFPA, 2019). As such, we are interested in the issue of girls' achievement in mathematics within the broader context of girls' access to quality schooling. Specifically, we want to know what this represents regarding broader aspirations for gender parity in global education access and outcomes (see Sustainable Development Goal (SDG) 4.1). This paper uses data from the TIMMS 2019 assessment to produce initial and exploratory insights to focus on the factors influencing girls' mathematics achievement in Pakistan.

We are also motivated by a dearth of evidence on mathematics achievement in the South Asia region more generally (Sitabkhan & Platas, 2018). For this reason, our paper addresses a prevalent knowledge gap in the field and analyzes the extent to which, if at all, gender influences students' mathematics learning outcomes in Pakistan. To better understand the constellation of factors influencing mathematics achievement, we interrogate the extent to which home-life and school-life factors have a bearing on girls' mathematics achievement. To answer this question, we employ an ordinary least squares regression analysis of the dependent variable of 'learning achievement in mathematics'

with four independent variables of 'gender,' 'parental involvement in education,' and 'resources at home' (as proxies for home-life factors), and 'clarity of teaching instruction' and 'student sense of belonging' (as proxies for school-life factors).

Literature review

Over the past two decades, numerous Western governments have positioned girls' education at the forefront of their bilateral aid and development agendas. For example, since 2012, the United Kingdom's Foreign Commonwealth Development Office (FCDO) has funded the Girls' Education Challenge (GEC) to the tune of £400-£600 million per year (The Guardian, 2020). Likewise, multilateral and philanthropic agencies, such as UNICEF, Plan International, and the Malala Fund, have forefronted girls' education to promote and uphold education's promise for girls' lives. Moreover, such agencies broadly promote educated women's role in community and national development, climate change mitigation, and peacebuilding.

As Pakistani scholar Khoja-Moolji (2018) critiques in *"Forging the Ideal Educated Girl: The Production of Desirable Subjects in Muslim South Asia"*, development-sector discourse on girls' education in the Global South places girls "on the precipice of failure" if not saved by the promise of education (p.120). This promise, Khoja-Moolji believes, is accompanied by the economic rationalization that "educated girls will be able to enter the labor force, pull themselves out of poverty, and contribute to national GDP" (p.5). The South Asian girl thus becomes "an actively charged figure" upon whom calls for projects, funds, and reforms are placed for herself, her family, and her community, thereby "legitimizing myriad state and non-state interventions" on their behalf (p.9).

Across South Asia, steady strides have been made toward gender parity in access to education. For example, with only 34 percent of girls in the region attending primary school in the year 2000, by 2020 just over 60 percent attended school, representing a 26 percent increase and a rate of access to primary school comparable to boys (World Bank, 2020). However, in tension with this reality, young women in South Asia are less likely than young men to engage in further employment, education, or training (UNICEF & UNFPA, 2019). Highlighting this fact, only 21.9% of all women participate in Pakistan's formal labor market (UNDP, 2019).

Obscured by regional averages, statistics for girls' and women's low levels of participation in further education or employment are more pronounced in Pakistan due to gender-based discrimination, which is more widespread than in Sri Lanka or the Maldives (UNICEF & UNFPA, 2019). In addition, the scarcity of female teachers at higher levels of Pakistan's education system also means that there is a lack of female role models for girls, which contributes to a poor sense of belonging in school and can "reinforce norms that undermine girls' academic achievement" in higher education or employment (UNICEF & UNFPA, 2019. p. 78). Therefore, girls continue to face barriers in school retention and experience lifelong challenges to fully participate in Pakistan's social and economic development.

With a national population of 220 million and 22.5 million children not enrolled in formal schooling (representing 10.2 percent of the total population), Pakistan has the second highest rate of out-of-school-children (OOSC) in the world, of which 55 percent

or 12.3 million are girls (World Bank, 2019). The Government of Pakistan (GoP) is thus committed to “strengthening human and social capital, which will allow the population to contribute to and effectively benefit from economic growth” (OSF, 2012). Through Article 25A of the Constitution, Pakistan provides “free and compulsory education to all children of the age of five to sixteen years in such manner as may be determined by law” (DHS, 2017).

Across primary, middle, and secondary school levels, children from the highest wealth quintile have the highest net attendance ratio compared to children from the lowest (DHS, 2017). Therefore, Pakistan’s Demographic and Health Services (DHS) (2017) highlights how students in urban areas and wealthier quintiles are more likely to be enrolled in school. For example, 42.3 percent of males from the lowest wealth quintile attend primary school compared to 74.7 percent from the highest quintile. By comparison, only 30.2 percent of females from the lowest quintile attend primary school, and 72.6 of females from the highest (DHS, 2017). With these facts in mind, it is important to note the limited cross-section of Pakistan’s children represented in the TIMSS 2019 survey sample.

Regarding the factors that improve girls’ access to quality education, teachers are known to be one of the most important school-level inputs for student learning outcomes and a sense of belonging (Lovenheim & Turner, 2018). However, especially in low- and middle-income country contexts, the quality and uniformity of teaching vary greatly. Teacher effectiveness depends on teachers’ access to pre-service and in-service continued professional development, as well as quality teaching and learning materials (GEEAP, 2020). Since 2016, however, Pakistan’s percentage of fully trained teachers has declined from 88 percent to 77 percent (World Bank, 2021).

In high-income countries, parental involvement in learning is a key home-level determinant in student achievement, which is known to have a positive effect on children’s learning and development outcomes (Coleman, 1966; Muller, 2018). Findings from low- and middle-income settings are more mixed, as this study highlights (Kim, 2018). Children born into households where parents are experiencing poverty or other forms of social instability experience adverse effects of parental involvement (Kim, 2018). To address the challenges above, and as we outline in more detail below, findings from this literature review and the current availability of TIMSS 2019 data for Pakistan inform the thematic focus of our study: *“More girls are accessing school, but are they learning? The factors influencing girls’ mathematics achievement in Pakistan.”*

Research question:

To what extent does gender influence mathematical achievement among grade 4 students in Pakistan?

Dependent Variable: score_math (Mathematics learning outcomes)

Independent: female (gender)

Predictor variables: Parental involvement (par_involve), Home resources (hm_resources), clarity of instruction in schools (clarity_inst), and student sense of belonging (belonging)

Data and methods

Definitions of variables:

The TIMSS assessment data capture grade 4 and 8 student performance in mathematics, science, and other schools, student, and household characteristics. The following definitions represent the specific variables employed for this study:

- Mathematics Learning Outcome: A dependent variable providing the mathematics achievement of grade four students in Pakistan.
- Female: An independent variable identifying students' biological sex as 'male' or 'female.'
- Parental Involvement in Children's Education: A predictor variable describing parents' assistance and support to their children in informal learning.
- Resources at Home: A predictor variable depicting socioeconomic status with the potential to facilitate student learning.
- Clarity of Instruction: A predictor variable capturing teachers' effectiveness and capacity to provide clear instruction.
- Sense of Belonging: A predictor variable referring to students' sense of belonging and connectedness to school.

Table 1

Definitions of variables as described by TIMSS 2019

| Variable | Analytical Category (per our analysis) | Type | Code |
|------------------------------|---|--------------------|--------------------------|
| Mathematics Learning Outcome | - | Dependent variable | ASMMAT01 = score_math |

TIMSS 2019 aims to provide a comprehensive picture of the mathematics achievement of grade four students in each participating country. This includes achievement in each of the content domains (Number = 50%; Measurement and Geometry = 30%; Data = 20%) and cognitive domains (Knowing = 40%; Applying = 40%; Reasoning = 20%) (Martin and Mullins, 2017, p. 14) as overall mathematics achievement.

| | | | |
|--------|----------|--|-------------------|
| Female | Identity | Independent variable (Ordinal variable) | ITSEX = female |
|--------|----------|--|-------------------|

Identification of a student based on their biological sex as either 'male' or 'female.'

| | | | |
|----------------------|-----------|--|--------------------------|
| Parental Involvement | Home life | Predictor variable (Categorical variable) | ACBG14E = par_involve |
|----------------------|-----------|--|--------------------------|

Parental involvement is defined as assistance and support parents give to their children in all forms of informal learning and teaching practice related to school (Alreshidiet al., 2021). It is measured through the *School Questionnaire* specifically under Question 14 where students are asked how they characterize parental involvement in school activities (Fishbein et al., 2020, p. 99).

| | | | |
|-------------------|-----------|--|---------------------------|
| Resources at Home | Home life | Predictor variable (Categorical variable) | ASDGHRL = hm_resources |
|-------------------|-----------|--|---------------------------|

Socioeconomic status is often indicated through proxy variables. TIMSS 2019 developed two scales that expand upon the classic conception of socioeconomic status to home resources with the potential to facilitate student learning. The grade four TIMSS *Home Resources for Learning* scale is based primarily on data derived from the home questionnaire (Martin and Mullins, 2017, p. 64). Students were scored according to their own and their parents' reports regarding the availability of five resources on the scale in Exhibit 5.1 (Martin et al., 2020).

| | | | |
|------------------------|-------------|---|---------------------------|
| Clarity of Instruction | School life | Predictor variable (Continuous variable) | ASBGICM = clarity_inst |
|------------------------|-------------|---|---------------------------|

The TIMSS 2019 student and teacher questionnaires include instructional clarity, which captures a teacher's effectiveness and capacity to provide clear instruction (i.e., the clarity with which teachers convey the curriculum to students). Students were asked about aspects of teachers' mathematics instruction during their mathematics lessons: whether they know what their teacher expects them to do, and whether their teacher is easy to understand, has clear answers to their questions, is good at explaining mathematics, does a variety of things to help the students learn, and explains a topic again when the students do not understand. Responses were combined into the TIMSS *Instructional Clarity in Mathematics Lessons* scale, as described in Exhibit 12.8 (Martin et al., 2020)

| | | | |
|----------------------------|-------------|---|------------------------|
| Student Sense of Belonging | School life | Predictor variable (Continuous variable) | ASBGSSB = belonging |
|----------------------------|-------------|---|------------------------|

Students' sense of belonging, also referred to as school connectedness, by TIMSS 2019, broadly encompasses the notion that students who feel more attached to their school also tend to report greater enjoyment in learning and greater confidence in their capabilities (Martin and Mullins, 2017, p. 68). The items forming the *Sense of School Belonging* scale asked students about their attitudes toward school, including the extent to which they like being in school, feel that they belong, and have good relationships with teachers. Fourth grade students were asked how much they agreed or disagreed with the five statements listed in Exhibit 7.9 (Mullins et al., 2020).

Summary of statistics for variables:

In table 2, we present a summary statistics for the variables: mathematics learning outcome, gender, parental involvement, resources at home, clarity of instruction, and sense of belonging, based on a sample of 3,448 grade four students in Pakistan who participated in TIMSS 2019. Forty-six percent of the students were female. For question items relating to achievement in math, out of a maximum of 1000 points, the mean score was 322.70 with a standard deviation of 99.97. This is the second lowest score among participating nations after the Philippines (mean score = 297). There was a range of 677.42 points between the highest and lowest scores. Finally, for parental involvement, 20 percent of students scored very low parental involvement, 22 percent of students had low involvement, 26 percent of students had medium involvement, 13 percent of students had high involvement, and the remaining 19 percent of students had very high involvement. The standard deviation of parental involvement was 1.38. A minimum score of 1 and a maximum score of 5 provided a range of 4 points in parental involvement. For the variable of resources at home, which was a composite of five

separate socio-economic status question items in the TIMSS student survey, 33 percent had few resources at home, 67 percent had some resources at home, and the remaining 23 percent had many resources at home, with a standard deviation of 0.49. The variable for clarity of instruction scored a mean of 10.20, with a standard deviation of 2.34, with a low score of 2.55 and a high score of 12.75, and a range of 9.70 points. For students' sense of belonging in school, the mean score was 11, with a standard deviation of 2.25. There was a range of 9.61 points, with the lowest score of 3.14 and a high score of 12.75.

Table 2

Summary Statistics for Gender, Resources at Home, Sense of Belonging, Clarity of Instruction, Parental Involvement and Achievement in Mathematics of 4th Grade Students in Pakistan (n = 3, 448)

| Variable | Definition and metrics | Mean | SD |
|---------------------|---|--------|-------|
| Math_score | Mathematics Learning Outcome | 322.70 | 99.97 |
| Female | Female = 1, Male = 0 | 0.46 | |
| <i>Home Life</i> | | | |
| Par_involve | Parental Involvement in children's education | | 1.38 |
| | 1= very low | 0.20 | |
| | 2 = low | 0.22 | |
| | 3 = medium | 0.26 | |
| | 4 = high | 0.13 | |
| | 5 = very high | 0.19 | |
| Resources at Home | Resources at Home | | .49 |
| | 1 = few resources | 0.33 | |
| | 2 = some resources | 0.67 | |
| | 3= many resources | 0.23 | |
| <i>School Life</i> | | | |
| Clarity_instruction | Clarity of Instruction for Teachers Based on a scale from 1-12, with a higher score meaning more clarity of instruction. | 10.20 | 2.34 |
| Belonging | Sense of Belonging Based on a scale of 1-12, with a higher value connoting a sense of belonging. | 11.00 | 2.25 |

Source: TIMSS 2019

Limitations of the study

Due to the quantitative nature of this study there are numerous limitations, which warrants the descriptive presentation and analysis of our findings as well as a call for further research on this topic. First, our study was constrained by the limited number of variables included in Pakistan's 2019 TIMSS dataset. For example, in line with previous studies (Aslam & Kingdon, 2012; Alcott & Rose, 2015) we wanted to evaluate the effect of parental education on girls' learning outcomes. Yet the omission of parental education in the Pakistan survey prevented us from including it as an important predictor variable. Third, the scales used in TIMSS consist of students' self-reported information, meaning the results are limited to students' own reflections and statements, thereby compromising the overall validity of some predictor variables. Fourth, the variable "resources at home" was used as a proxy for students' socioeconomic status. As such, this variable is not a comprehensive or conclusive representation of socio-economic status. Lastly, due to the wealth quintile that grade four girls participating in the Pakistan TIMSS assessment likely belong to, we are careful not to overstate the extent to which our findings represent mathematics learning achievement for all grade four girls in Pakistan.

Analytical strategy

Using STATA, we conducted a statistical analysis with the publicly available TIMSS 2019 data set of grade four students in Pakistan. We conducted a multiple Ordinary Least Squares (OLS) regression analysis to understand the influence of gender on mathematical achievement. Our analysis includes four independent variables: parental involvement, home resources, clarity of instruction, and sense of belonging. We categorized the variables into home life (home resources and parental involvement) and school life (measured by the clarity of instruction and sense of belonging).

To generate an exact copy of the variable with valuable names, we used the *clonevar* command in STATA. By doing this, we generated new variables and labeled them, including math achievement scores, gender, parental involvement, resources at home, clarity of instruction, and sense of belonging. We then employed list-wise deletion to remove missing data for all variables except home resources. Next, we recoded gender as a binary nominal variable, and we recoded and relabeled parental involvement into five ordinal categories starting from 'very low' to 'very high.' Similarly, we recoded and relabeled home resources into three categories starting with 'few resources' to 'many resources.' This process reduced the risk of deviation between variables' definitions and value labeling. Since there were 763 missing observations from the home resources variable, we decided to impute the missing observations. The average value of the home resources variable falls under the 'some resources' category. Hence, we imputed the missing data into that category.

After recoding the variables, we conducted the multiple OLS regression model to examine the effect of gender on mathematical score achievement while controlling for all other variables. With gender as our independent variable, we simultaneously included four predictor variables in the model: parental involvement, resources at home, sense of belonging, clarity of instruction, and sense of belonging. We also created a dummy variable for resources at home to understand whether there is a linear relationship between the categories of resources at home and grade four student performance in mathematics.

Finally, to understand the influence of gender on mathematics achievement scores among grade four students in Pakistan, we analyzed the interaction of our predictor variables to form a more sophisticated understanding of the influence of school life and home life factors on boys' and girls' respective performance in mathematics.

Results

As shown in Table 3, a multiple regression analysis was conducted to examine the effect of gender on mathematical achievement among grade 4 students in Pakistan. Using TIMSS data from 2019, we simultaneously entered five predictors into the model: female, parental involvement, resources at home, clarity of instruction, and sense of belonging. Model 1 presents a simple regression with gender as the predictor of mathematical achievement. Here, we observe that girls perform 0.065 standard units higher than males in grade four mathematics, and the relationship is statistically significant ($p < 0.05$, $\beta = 0.065$). We, therefore, accept the alternative hypothesis that student gender is associated with mathematics achievement. The effect of gender is slightly reduced, however, once we adjust for parental involvement, resources at home, clarity of instruction, and sense of belonging (model 5, $\beta = 0.052$, $p < 0.05$).

In model 2, we observe that with each additional unit of parental involvement, there is a decrease in mathematical achievement by 0.024 standard units; however, this association is not statistically significant (Model 2, $\beta = 0.025$, $p > 0.05$). In model 3, we see a 0.006 standard unit increase in mathematical achievement with every additional unit increase of resources at home. This association is also not statistically significant (Model 3, $\beta = 0.006$, $p > 0.05$). When computing dummy variables for resources at home, we found that there is no linear relationship. Students with 'some resources' score 40.02 points higher than students with 'few resources,' and the relationships are statistically significant ($p < 0.05$). Similarly, students with 'many resources' score 40.48 points higher than students with 'some resources'. This relationship is also statistically significant ($p < 0.05$). Model 4 shows that for each unit increase in clarity of instruction, there is a 0.184 standard unit increase in mathematical score achievement; this relationship is also statistically significant (Model 4, $\beta = 0.184$, $p < 0.01$). Lastly, in model 5, for every unit increase in students' sense of belonging, there is a 0.059 standard unit increase in mathematical score achievement. This relationship is also statistically significant (Model 5, $\beta = 0.059$, $p < 0.05$). In total, two out of the five predictor variables are statistically significant ($p < 0.05$). Collectively, all five predictors explained four percent of the variance in mathematical achievement.

Table 3
OLS Regression for TIMSS 2019 Math Scores in Pakistan (n = 3,448)

| Variable | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| Female | 0.065*** (3.434) | 0.068*** (3.464) | 0.068*** (3.464) | 0.052** (3.418) | 0.052** (3.414) |
| <i>Home Life</i> | | | | | |
| Parental Involvement | | -0.024 (1.251) | -0.025 (1.258) | -0.020 (1.237) | -0.016 (1.239) |
| Resources at Home | | | 0.006 (3.625) | 0.005 (3.564) | 0.006 (3.560) |
| 1. Resources at Home | | | | 0.000 (.) | -40.48** (0.257) |
| 2. Resources at Home | | | | 0.46 (0.257) | -40.02** (0.262) |
| 3. Resources at Home | | | | 40.48** (0.262) | 0.000 (.) |
| <i>School Life</i> | | | | | |
| Clarity of Instruction | | | | 0.184*** (0.718) | 0.158*** (0.801) |
| Sense of Belonging | | | | | 0.059** (0.837) |
| R^2 | 0.004 | 0.005 | 0.005 | 0.038 | 0.041 |
| adj. R^2 | 0.004 | 0.004 | 0.004 | 0.037 | 0.040 |

Standardized beta coefficients; Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: TIMSS 2019

We next conducted an interaction effect analysis to understand the effect of home life (measured by parental involvement and resources at home) on females' performance in mathematics compared to males. We observe that for each additional unit in increase for

parental involvement, females perform 10.052 units lower than males ($p < 0.001$). In this sense, compared to boys grade four girls' mathematics performance in Pakistan reduces when there is increased parental involvement. Yet for each additional unit increase of resources at home, females perform 11.333 units higher than males ($p < 0.05$). Thus, despite the insignificant relationship of home resources with overall grade four student performance in Pakistan, it is worth noting that this variable contributes to higher levels of mathematics achievement for girls.

Table 4

Interaction Effect of Parental Involvement and Resources at Home with Gender on Mathematical Achievement (n=3,448)

| Math Score | Coefficient | Std. Error | t | P> t |
|-------------------------------|-------------|------------|-------|-------|
| Parental Involvement | 3.499 | 1.81 | 1.94 | 0.053 |
| Female x Parental involvement | -10.052 | 2.49 | 5.34 | 0.00 |
| Resources at Home | - 4.511 | 4.89 | -0.92 | 0.356 |
| Female x Resources at Home | 11.333 | 7.23 | 1.57 | 0.117 |

Source: TIMSS 2019

Discussion and conclusion

Results from this study show that despite overall inequity in access to education for female students in Pakistan, girls are performing better than boys as measured through mathematics achievement. In particular, girls' 'sense of belonging' at school had a significant positive effect on 'math achievement'. Furthermore, 'clarity of teaching instruction' in schools showed the most positive and significant effect on math achievement compared to the other predictor variables considered in the study. On the other hand, 'parental involvement' in school activities was shown to have a significantly negative effect. 'Home resources' were also shown to have a statistically insignificant effect on 'math achievement' for grade four students in Pakistan. While girls outperform boys, overall mathematics achievement in Pakistan is considerably low compared to other TIMMS participating countries. Thus, considering the critical value of early-grade mathematics skills as a broad predictor for later mathematics achievement and academic success, this reality is a cause for concern (Aunio et al., 2021).

Identity

Despite inequitable rates of access to education, Pakistan's girls are still performing better than boys in early-grade math achievement (Farooq, 2020; TIMMS, 2019). This is a notable finding because an overwhelming array of sociocultural and economic factors discourage girls' full and equal participation in schooling in Pakistan (Azhar, 2008; Batool et al., 2003). Moreover, within a broader landscape of discriminatory gender norms, males with sufficient financial means have comparatively unimpeded access to school. However, as we have discovered, this does not correlate with better achievement

in mathematics overall (Rehman et al., 2013). Therefore, considering girls' limited opportunities and often inhospitable learning environments, there is a pressing need for more comprehensive research on the factors contributing to girls' higher-on-average rates of mathematics achievement compared to boys (Ali et al., 2012; Batool et al., 2013).

Due to discriminatory gender norms and the extent to which women are much less likely to be engaged in further education or employment than men, our research should prompt Pakistan to leverage girls' early-grade mathematics achievement, support and reinforce higher-level cognitive skills in later grades and continue to advocate for and fund lifelong access to learning for all (UNICEF & UNFPA, 2019). Positively, Pakistan's 'Vision 2025' puts forth a commitment to advancing education reform and pledges to increase public expenditure for education from 0.2% of Gross Domestic Product (GDP) to 1.4% of GDP (GoP, n.d.). As indicated in our findings, however, the GoP must adopt gender-responsive budgeting, prioritize home and school-life factors that best determine girls' engagement and achievement at school, and engage systems-level research that informs gender-responsive policy. Our concluding analysis below provides further guidance.

Home-life factors

The 'parental involvement' variable is shown to have a statistically insignificant effect on math achievement in Pakistan. Poor parental education levels and low literacy attainment are compounding factors (DHS, 2017). However, this finding is inconsistent with global studies whereby parents' involvement in children's education has been a statistically significant and positive factor in students' achievement at school (Shah et al., 2012; Suleman et al., 2012a). At the nexus of home environment and academic achievement, parents who take additional responsibility for their children's learning have traditionally corresponded with increased interest in academic achievement among children (Khan, 2019). As such, further research on why and how the variable of parental involvement in the TIMMS 2019 dataset has an insignificant effect on girls' achievement is required. Although our findings show a statistically insignificant influence, in line with the studies mentioned above we still advocate that children of illiterate or under-educated parents require improved access to remedial or accelerated education within formal and non-formal educational settings. Moreover, parents require access to adult education programs targeted toward home-support strategies for their children's learning (Shah et al., 2012; Suleman et al., 2012a; Khan, 2019).

Surprisingly, the 'resources at home' variable also showed a statistically insignificant effect on math achievement for grade four girls in Pakistan. Like 'parental involvement,' this finding is inconsistent with previous research whereby 'home environment' and 'home resources' are statistically significant factors in Pakistani students' academic achievement (Parveen, 2007; Muola, 2010). As much as we have employed the 'resources at home' variable as a proxy for students' socioeconomic status, the factors that constitute this variable may differ across studies. Typically, the socioeconomic status of a child is broadly determined by parental educational level, parental occupation, and income level, with previous studies finding that low socio-economic status or few resources at home have negatively influenced academic performance and have traditionally been a powerful predictor of students' academic under-performance (Jeyne, 2002; Suleman et al., 2012b).

School-life factors

Compared to our other predictor variables, 'clarity of instruction' positively and significantly influenced math achievement. 'Instructional clarity' represents the ability of teachers to organize the teaching and learning environment effectively and to carry out the teaching process in ways that cater to students' specific cultural, learning, and development needs (Yagan, 2021). As stated earlier, teachers are known to be the most important school-level factor influencing student achievement (Lovenheim & Turner, 2018). Therefore, our findings suggest that to continue strengthening mathematics achievement for girls in Pakistan, ongoing investment in the development of gender-responsive pedagogies through pre-service and in-service teacher professional learning programs is paramount.

The 'sense of belonging' variable also had a positive and significant effect on mathematics achievement for girls in Pakistan. This finding is corroborated by previous research where a positive correlation has been observed between a 'sense of belonging' and academic success among students in low-income countries (McMahon et al., 2008). This is an important finding for Pakistan, especially due to the aforementioned barriers to girls' access to and retention within Pakistan's school system. Pakistan spends far less on education than is recommended by UNESCO's guidance on girls' education; as such, the Government of Pakistan has not yet established an education system responsive to the unique needs of girls and young women (HRW, 2018). Moreover, due to an upward bottleneck in the education system - meaning fewer girls and young women progress to higher levels of schooling as they get older - our findings emphasize the importance of further investments in the school-level factors that promote retention, such as girls' 'sense of belonging' and teachers' 'clarity of instruction'.

In light of the evidence presented above, we strongly recommend that the GoP participates in the next round of TIMSS grade four *and* grade eight assessments. This will contribute towards the availability of longitudinal and comparable data on girls' mathematics achievement and inform policy iterations that improve equitable access to quality learning for all girls. Additionally, to reduce the need for proxy variables - like those we have depended on in this study - we recommend that Pakistan's Ministry of Education prioritizes the inclusion of question items contributing to variables such as 'parental education,' 'socioeconomic status,' and 'effective teaching instruction.'

Since Pakistan is party to several international treaties on inclusive and equitable education, the measures related to Sustainable Development Goals (SDGs) are yet to reach wide-scale policy implementation (Iqbal & Ashraf, 2023). In this view, to better align with the aspirations of SDG 4: Quality Education, substantive steps should be taken to introduce an all-inclusive education policy and impartial curriculum free from materials that promote gender-based discrimination (Arsha & Khanam, 2023). Furthermore, as Pakistan works towards ensuring the SDG 4 goal of inclusive and equitable quality education and lifelong opportunities for all, a more nuanced understanding of the impact that barriers to access and inadequate quality of education have on girls' long-term educational engagement and achievement is needed. Finally, not forgetting Pakistan's 22.8 million out-of-school children and youth (55% of whom

are girls), non-formal education providers also need to take stock of the home-life and school-life factors that enable out-of-school girls' engagement and retention; by forefronting these factors, we hope that effective pathways are put in place to enable an accelerated transition from non-formal to formal schooling and future employment for all.

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