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VARIATION IN THE EFFECT OF STUDENTS' AGE AND GENDER ON MATHEMETICS ACHIEVEMENT OF GRADE 3 STUDENTS: A MULTILEVEL RANDOM SLOPE ANALYSIS OF NON-FORMAL SCHOOLS IN PAKISTAN

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Abstract
The purpose of this study was to examined whether the effect of age and gender on Mathematics Achievements of grade 3 students vary across non-formal schools in Pakistan. The mathematics achievements of 49,186 third-grade students from 6,706 non-formal schools were analyzed, by employing hierarchical linear modeling (HLM) to account for nested structure of data. While the fixed effects estimated within the multilevel model indicate that age had a statistically significant negative effect on mathematics achievement, suggesting that older students within the same grade level tend to perform worse, while gender had no statistically significant overall effect. Furthermore, random slope analysis showed that both the age and gender slopes differed significantly across schools. The variance components for both slopes were statistically significant; this suggest that the effect of students' characteristics is context dependent and differs by school environment. This finding highlights that gender is not a significant predictor on average, but varies across school contexts, and similarly, the effect of age is not uniform across schools. The results also highlight the importance of school level variables while considering students' achievements in non-formal schools.

Keywords: *Hierarchical linear models, gender slope variance, Fixed effects, Random Effects and school level variables*

Introduction

The process of developing new abilities and skills is named as education, making them responsible citizens and enhancing their social, economic, and cultural performance (Maddox, 2008). It raises awareness and social skills to solve everyday life problems. However, formal educational institutions may not fully meet societal requirements, and even expanded systems may not effectively address community needs. (Kamil et al., 2008). In order to offer people with literacy skills decreasing dropout rates and bring out of school children to schools, non-formal education systems emerged as a result of the difficulties facing modern society and the absence of an efficient formal educational system. Non-formal education programs aim to create a society where everyone can contribute to enhancing their quality of life for themselves and their families. They support integrated, community-based development for marginalized and deprived individuals through organized, systematic education outside the formal education system (Ololube & Egbezor, 2012;

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Romi & Schmida, 2009) Non-formal education can meet the educational needs of all people, regardless of gender or age, and is designed to provide a more inclusive and effective education (Mentz & Barrett, 2011).

Mathematics achievement in early education is necessary for future academic success and cognitive development. Furthermore, Math performance in early age is influenced by a number of factors, including learner characteristics, family background, school processes, and general institutional conditions. According to a growing body of current educational researches, academic success is not determined by a single factor but results from the interplay of cognitive, social, didactic, and contextual influences. Students' performance in mathematics is affected by factors at various levels, as demonstrated by the results of large-scale international studies such as TIMSS and PISA, which reveal differences in performance both within and between schools. For example, TIMSS 2019 illustrates how the home and school environment, including student body composition, resources, school climate, and safety, influences mathematical performance (Mullis et al., 2020).

For non-formal educational contexts, the choice of these variables is both practically and theoretically significant. The effect of age on mathematics achievements has long been a subject of extensive research in both formal and non-formal school settings. Though age has been often used as a measure of success in formal settings, older students within the same grade tend to perform worse on math skills than their younger classmates. In many under developed countries, including Pakistan, children who have not been enrolled in school early due to early childhood issues, repeating a grade, or stopping their schooling are usually older than the mean age for their grade, which is known as age-grade bias (Aslam & Kingdon, 2011). Researches consistently point out fact that age-related disadvantages within formal schooling are not solely based on individual differences in development but are also worsened by individual socio-economic status, the availability of resources, and the school atmosphere. Therefore, analyzing variation in age effect is essential to understand the diversity of student math performance in non-formal settings.

Gender has also found to be an important factor influencing students' math achievements differ depending on the educational setting. Research on gender differences in mathematical achievement in formal schooling environment are plenty of literature, where some of them show that boys outperform than girls in mathematics during their early and secondary schooling (Lu et al., 2023). However, such a finding varies greatly depending on different cultural and institutional context and geographic location. Gender inequality in education remains in many developing countries like Pakistan, especially in rural areas where there are sociocultural barriers for girls to attend quality schooling system, including early marriage, domestic works and gender roles of schooling (Aslam & Kingdon 2011). It has been argued that the teachers unconsciously or consciously give boys more attention and encouragement than girls in subjects such as math, and this causes gender differences in math skills (Hiebert et al., 2017). However, another study conducted by Reilly (2015) indicates that as the gender discrimination has decreased, the gender differences in math performances is reduced or disappeared. While comparing to public education system, the girls dominate in extracurricular education programs, the gender differences in math achievements will thus become larger. Although extracurricular education has been widely recognized as a crucial improvement to girl's future in particular in the rural areas, there still remains some issues, for example the social views and expectations on girls' housework participation continue to undermine their opportunities in both the formal and extracurricular

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education. Therefore, analyzing gender effect is also essential to understanding the variation of student math achievements in non-formal educational programs.

This research is based on Bronfenbrenner's ecological systems theory, which describes child development as the result of ongoing interactions between the individual and the environment. The four main levels of environmental systems microsystem, mesosystem, exosystem, and macrosystem are used by EST to describe human development. Even though EST offers a thorough framework, only one system the microsystem is used directly in this study since they correspond with the variables being examined. Age, gender, and other student-level characteristics are included in the microsystem. Age matters since it has a direct correlation with cognitive development and mathematical comprehension readiness. Students in Grade 3 usually belong to the Concrete Operational Stage, where they start to acquire the capacity for mental processes and logical thinking, according to Piaget (1964).

Previous studies have mostly ignored the non-formal education sector in favour of concentrating on the connection between math achievements and formal education. This study examines how non-formal schools affect math's proficiency in an effort to close this knowledge gap. This study will offer a detailed knowledge of the factors impacting math achievement in non-formal schools by investigating the effect of student level variables and math performance. By providing new perspectives on the complex relationships of math's instruction in non-formal institutions, this study will make a significant contribution to the body of literature

Research Questions

This study addressed the following research questions

(a) Does the effect of students' Gender and mathematics achievement differ significantly between and within non-formal schools?
(b) Does the effect of students' Age and mathematics achievement differ significantly between and within non-formal schools?

Research Methodology

Research Design and Approach

In this study used an ex post facto research design, which was a non-experimental method for examining cause-and-effect relationship that have already happened, including gender, age and mathematical achievements, was investigated by the researcher due to this design.

Population and Sample

All 3rd grade Students from 36 districts' non-formal schools who took math's exams during the 2024-2025 school year comprised the study's population. There were 35301 male and 42829 female students in grade 3. The entire population was selected as sample.

Data Collection

The secondary data was used in this study, which was obtained from the Literacy & NFBE Department, Punjab after getting formal approval.

Data Analysis Procedure

HLM was employed as the analytical method, as the data was nested in structure and it also allows for the partitioning of variance within and between schools, provides more accurate standard

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errors, and permits the investigation of both fixed and random effects across all levels. Consequently, multilevel modeling replaced simple correlation and ANOVA methods in the final analysis to ensure statistically valid conclusions. Furthermore, the following multilevel model were used in line with the research questions:

a) **Random Slope Model:** In this model, it was explored whether the effects of gender and age on mathematics achievement vary from one school to another across schools, assuming the relationship is similar across all schools.

Data Analysis and Findings

Descriptive Statistics for level 1 variables (Students Age & Gender) and outcome variable (Math Score) were computed which is presented in table 1.

Table 1

Descriptive Statists for Level 1(Student level) and Outcome Variable (Math score)

Variable	N	Mean	SD	Minimum	Maximum
Student (level 1)					
Gender	49186	0.46	0.50	0.00	1.00
Age	49186	9.73	1.64	7.00	14.00
Math Score	49186	76.61	16.23	0.00	100.00

Table 1 presents the mean, standard deviation, minimum, maximum, and number of valid cases were calculated for each variable. Descriptive statistics were calculated at Level 1 (Student) included: Student Gender & Age. For categorical variables, frequency distributions and percentages were also investigated. These descriptive studies ensured that the data were suitable for multilevel modeling and provided a summary of the distributional characteristics of the variables.

Table 2

Frequency distribution of Students (Level 1) Variables

Student Gender	Frequency	Percent
Male	22459	45.7
Female	26727	54.3

Table 2 shows the frequency distribution of Level 1 Variables. At the student level (N = 49,186), females constituted a slightly larger proportion of the sample at 54.3% than males at 45.7%, indicating a relatively balanced gender split with a slight predominance of females.

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Table 3
Number of cases, mean math score and standard deviation for Level 1

Variable	Mean Math Score	N	SD	Minimum	Maximum
Gender					
Male	76.14	22459	16.208	0	100
Female	77.02	26727	16.243	0	100
Age in years					
7	76.85	3227	16.005	20	100
8	76.86	8787	16.075	0	100
9	76.97	12158	15.923	0	100
10	76.59	10618	16.151	0	100
11	76.12	7166	16.602	0	100
12	76.15	3980	16.909	0	100
13	75.94	2226	16.800	0	100
14	76.56	1024	16.109	0	100

Table 3 shows the descriptive statistics of math achievement at the student level (Level 1). The overall mean mathematics score of the sample (N = 49,186) was 76.61 with a standard deviation of 16.23, indicating moderate variability in student performance. Separated by gender, female students (F= 77.02, SD = 16.24) performed slightly better than male students (M = 76.14, SD = 16.21), although the difference in mean scores appeared to be small at the descriptive level. Regarding age, the mean mathematics score remains relatively stable across age groups, ranging from 75.94 (age 13) to 76.97 (age 9), suggesting little variation in achievement across age groups at the descriptive stage. The minimum and maximum scores for all categories ranged from 0 to 100, indicating that the full range of possible scores was represented in the data. Overall, descriptive statistics suggested relatively homogenous math performance across gender and age groups prior to multilevel modeling analysis.

Since data analysis through HLM involved the development of model to answer the research questions and the models developed to answer these Research Questions are detailed below:

The research question 1 (a) explore the effect of students' age and mathematics achievement differ significantly between and within non-formal schools. In order to examine if the effect of age and mathematic achievement varies among schools, a random slope model for age was developed.

Level-1 Model

$$Y_{ij} = \beta_{0j} + \beta_1 (Gender_{ij}) + \beta_{2j} (Age_{ij}) + r_{ij}$$

Where;

Y_{ij} = represents mathematics achievement of i^{th} student in J^{th} School

β_{0j}=Intercept (the mean math achievement of all students in the sample that attended school j)

$\beta 1$= Fixed Slope of Gender

β_{2j}= Random slope for age (varies across all schools)

r_{ij} = Student level error

Level-2 Model

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

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$\beta_{2j} = \gamma_{20} + u_{2j}$

$\beta_1 = \gamma_{10}$

Where;

γ_{00} = expected mean math achievement for the reference group students at average age across all schools.

u_{0j} = Random effect of school on intercept

γ_{20} = Average effect of age across all schools

u_{2j} = Random effect of school on age slope

γ_{10} = fixed effect of gender

Table 4

Results from random slope model for age

Predictor	Coefficient	Standard Error	*t*	*p*
Intercept (γ_{00})	74.8520	1.0026	74.657	< .001
Gender(γ_{10})	-0.361704	0.2375	-1.523	.128
Age (γ_{20})	-0.197150	0.77458	-2.545	.011
Random Effect	Variance Component		X^2	*p*
Intercept Variance ($u_{0)}$	167.5375		10829.518	< .001
Age slope variance (u_2	1.40009		2447.1436	< .001
Level-1 Residual	101.405		-	-

In table 4 the fixed effect indicated that age has a statistically significant negative effect on mathematics achievements ($p < .05$), while gender does not have statistically significant effect on mathematics achievement. However, Table 4 shows the results of the Age Random Slope Model, where gender is treated as a fixed effect and age is allowed to vary between schools. Based on the fixed effect result, the estimated grand mean mathematical achievement is $\gamma_{00} = 74.852$ with a standard error of 1.0026. This estimate was statistically significant ($t = 74.657$, $p < .001$). This is the expected math achievement score for a student in the gender category and average age.

The coefficient associated with gender was $\gamma_{10} = -0.3617$ (SE = 0.2375, $t = -1.523$, $p = .128$). This finding suggests that, in this model, gender is not statistically significantly associated with mathematics achievement. Thus, taking age and school level variance into account, there is little evidence that male and female mathematics achievement differs significantly.

On the other hand, age had a statistically significant effect. The estimated coefficient for age was $\gamma_{20} = -0.1972$ (SE = 0.0775, $t = -2.545$, $p = .011$). This indicates that, after adjusting for gender, an average one-year increase in age is associated with a decrease in math achievement of about 0.20 points. Thus, there is a statistically significant negative relationship between age and mathematics achievement.

The variance components showed an important finding that the variance was statistically significant ($\chi2 = 10829.518$, $p < .001$), and the intercept variance (u_0) was 167.5375. This indicates that average math achievement varies between non-formal schools. More significantly, the Age slope (u_2) variance was 1.40009 and statistically significant ($\chi2 = 2447.1436$, $p < .001$). This result shows that there are significant variations in the relationship between age and mathematics achievement between schools. In other words, the strength of the age effect varies; it is weaker in some schools and higher negatively in other schools. After adjusting for age and gender, the Level-1 residual variance, which represents the within-school variation in student mathematical

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achievement, is 101.405. Thus, the relationship between student's age and mathematical achievement differs significantly between and within schools.

To answer Research Question 1(b), if the effect of Student Gender and mathematic achievement varies among schools, a random slope model for gender was developed.

Level-1 Model

$Y_{ij} = \beta_{0j} + \beta_{1j}(Gender_{ij}) + \beta_2(Age_{ij}) + r_{ij}$

Level-2 Model

$\beta 0j = \gamma 00 + u0j$

$\beta 1j = \gamma 10 + u1j$

$\beta 2 = \gamma 20$

Table 5

Results from random slope model for gender

Predictor	Coefficient	Standard Error	*t*	*p*
Intercept (γ_{00})	74.7707	1.0062	74.303	< .001
Gender(γ_{10})	-0.3578	0.2376	-1.506	.132
Age (γ_{20})	-0.1929	0.0776	-2.487	.013

Random Effect	Variance Component	X^2	*p*
Intercept Variance (u_0)	172.24421	6880.55763	< .001
Gender slope variance (u_1)	9.03202	1696.30655	< .003
Level-1 Residual	102.18732	-	-

Table 5 shows that the findings of the Gender Random Slope Model, in which the gender slope was allowed to vary between schools, the calculated grand mean math achievement was γ_{00} = 74.7707 (SE = 1.0062, t = 74.303, p < .001), suggesting a statistically significant overall average math score across schools. The fixed effect of gender was $\gamma_{10} = -0.3578$ (SE = 0.2376, t = −1.506, p = 0.132), indicating no statistically significant effect of gender on math achievement. Age, on the other hand, continues to be statistically significant ($\gamma_{20} = -0.1930$, SE = 0.0776, t = −2.487, p = 0.013), suggesting that math achievement decreases slightly with increasing age.

The gender slope was 9.03202, which was statistically significant ($\chi 2$ = 1696.30655, p < .003). The high difference in the gender slope suggests that the effect of gender varies between schools, although the fixed effect of gender is not statistically significant at the overall level. This means that while there may be no or minimal differences between boys and girls in mathematics achievement in some schools, there may be significant differences in others. Consequently, the effect of gender on math score varies by school environment rather than being uniform across schools. The intercept variance (172.24421, p < .001) further confirmed significant differences in mean math achievement between and within non-formal schools.

Conclusion

The study's findings contribute significantly to understanding the structure of achievement variation in non-formal learning environments in several ways. In the model with age random slope, a significant variance in the slope was observed, indicating that the negative relationship between age and mathematical achievements varies depending on the school. This also suggests

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that some schools provide better support for older students than others. Age related disadvantages can be reduced through school-based measures such as remedial instruction, teacher involvement, and a positive learning environment. According to research on school effectiveness (Creemers & Kyriakides, 2018), the quality of the school can reduce individual risk factors. Therefore, the variation in the age effect does not reflect a uniform developmental trend, but rather contextual influences.

The gender slope variance was significant, but the overall effect of gender was not statistically significant. This suggests that the effect of gender on mathematical achievements varies depending on the context. While girls may perform better at some schools, boys may be performed better at others. These differences could be due to different assumptions about gender, teacher expectations, and school culture. In South Asian contexts, as Aslam and Kingdon (2011) have shown, gender-specific learning outcomes can be influenced by teacher biases and teaching practices. This finding is an addition to the growing body of literature showing that contextual factors, rather than biological predispositions, are responsible for gender differences in mathematics. This study provides evidence that the characteristics of teachers and the teaching methods have a significant influence on the learning success of students, and these effects can be differ depending on gender. The variability of the slope highlights the importance of considering contextual variability in educational research.

Hence, the variation in age & gender random slope model is one of the study's key findings that gender differences appear to be context-dependent, even though the average gender effect was not statistically significant. Similarly, the relationship between age and achievement varied between schools. These results are consistent with studies highlighting how certain characteristics, influenced by school processes such as teacher expectations, instructional quality, and school climate, impact academic performance (Leithwood et al., 2008; Leithwood et al., 2020; Thapa et al., 2013).

Policymakers should focus on to overcome these academic gaps to help older students, non-formal educational programs should offer accelerated learning modules or structured support measures. Teachers should regularly assess students' learning progress in class and offer additional support to students showing early signs of learning difficulties. Policy frameworks should also focus on gender-sensitive educational strategies, implementation of teacher training modules that emphasize equal participation in the classroom and used such teaching methods for reducing bias. Furthermore, future research should focus on qualitative and school level factors which may be contributed in student's mathematical performance.

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