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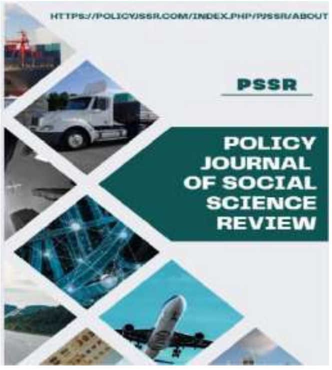

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MATHEMATICS ACHIEVEMENT IN MONOGRADE AND MULTIGRADE CLASSROOMS: A COMPARATIVE STUDY FROM PUBLIC PRIMARY SCHOOLS IN LOWER CHITRAL, PAKISTAN

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ABSTRACT

Multigrade teaching (MTG) – where a single teacher instructs students from more than one grade level simultaneously – is a practical and widespread response to the educational challenges posed by remote, low-density communities. In the mountainous district of Lower Chitral, Khyber Pakhtunkhwa (KP), Pakistan, geographical isolation, sparse populations, and infrastructural deficits have made this model the dominant mode of primary schooling. Yet despite its prevalence, robust empirical evidence comparing student learning outcomes across monograde and multigrade settings remains scarce in this context.

This study addresses that gap through a quantitative, post-test non-equivalent groups design. Sixty Grade 3 and Grade 4 students (30 from each school type) from two public primary schools in Lower Chitral completed a 20-item Mathematics Achievement Test aligned with Pakistan's Single National Curriculum (SNC). Independent samples t-tests and two-way ANOVA were conducted to compare group performance. Results showed no statistically significant difference in mathematics scores between monograde ($M = 15.0$, $SD = 2.5$) and multigrade students ($M = 14.5$, $SD = 3.0$) – a mean gap of 0.50 points ($t(58) = 0.73$, $p = 0.468$, Cohen's $d = 0.18$). Grade 4 students outperformed Grade 3 students in both settings, but classroom type exerted no significant effect on achievement and no significant interaction was found between classroom structure and grade level. These findings align with an expanding global literature suggesting that well-supported multigrade classrooms can produce mathematics

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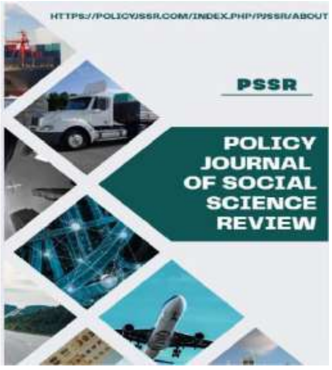

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outcomes equivalent to those of single-grade settings. The study draws on Vygotsky's socio-constructivist framework – including the Zone of Proximal Development (ZPD) and the role of peer-mediated learning – to explain the equivalence. Policy implications for the KP Education Department and directions for future research are discussed.

Keywords: *multigrade teaching; monograde classrooms; mathematics achievement; primary education; Lower Chitral; Pakistan; Zone of Proximal Development; socio-constructivism.*

Introduction

1.1 The Global and Local Context of Multigrade Teaching

In many parts of the world, the familiar image of a single teacher standing before a class of same-age children is a luxury rather than a norm. Across remote, thinly populated regions — from the highlands of sub-Saharan Africa to the mountain valleys of South Asia — the reality is far more complex. Schools in these areas must serve small communities spread across difficult terrain, often with a single teacher managing children from multiple grades at the same time. This arrangement, known as multigrade teaching (MTG), has long been recognised not as an educational experiment but as an operational necessity (Little, 2006).

The district of Lower Chitral, nestled among the Hindu Kush and Karakoram ranges in Khyber Pakhtunkhwa (KP), Pakistan, is a vivid illustration of this reality. Avalanche-prone valleys, unpaved roads, and dispersed hamlets mean that assembling enough children for separate grade-level classrooms is often impossible. A single teacher, frequently the only educator for miles around, must simultaneously guide children who are working towards the Grade 3 and Grade 4 objectives of the Single National Curriculum (SNC). This is not a transitional workaround — it is the permanent structure of primary education for a significant portion of Chitral's children (Nawab et al., 2011).

Yet despite this institutional reality, teacher preparation programmes in Pakistan continue to train educators almost exclusively for monograde environments (Mpahla & Makena, 2022). The result is a persistent gap: teachers enter multigrade classrooms equipped with strategies designed for a context they will rarely, if ever, encounter. This mismatch between training and deployment raises a fundamental question for educational policy — one that this study sets out to answer empirically: does it actually matter, in terms of student learning, whether a classroom is multigrade or monograde?

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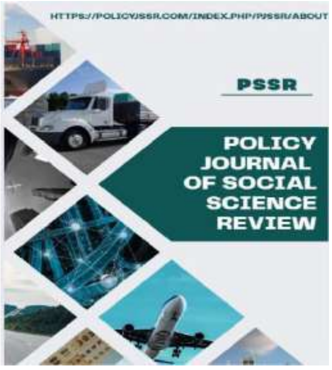

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1.2 Why Mathematics?

This study focuses on mathematics achievement for reasons that go beyond convenience. Mathematics holds a foundational place in the primary curriculum: it develops logical reasoning, numerical fluency, and problem-solving capacities that underpin learning across all subjects (Hussain et al., 2018). More critically, mathematics is deeply sequential in character — each concept builds on what came before. A child who misses the foundational logic of place value in Grade 3 is likely to struggle with operations involving larger numbers in Grade 4. This cumulative structure makes mathematics particularly sensitive to disruptions in instructional consistency and quality, and therefore a strong test case for comparing classroom models (SNC Mathematics, 2020).

The KP Single National Curriculum structures primary mathematics across five domains: Numbers and Operations, Geometry, Measurement, Algebra, and Data Handling. For Grades 3 and 4, these translate into concrete learning objectives around place value, basic arithmetic, geometric shapes, measurement units, and simple data interpretation. These well-defined, assessable outcomes made mathematics the ideal subject for a controlled comparison between classroom types in Lower Chitral.

1.3 Research Problem and Questions

Despite the widespread use of multigrade teaching in rural Pakistan, systematic comparative evidence about its effects on student mathematics achievement in this specific context remains scarce (Ahsan, 2017; Abbas et al., 2018). Policy decisions about resource allocation, school consolidation, and teacher training are therefore often made on the basis of assumptions rather than data. This study is designed to generate the kind of evidence that can ground such decisions in empirical reality.

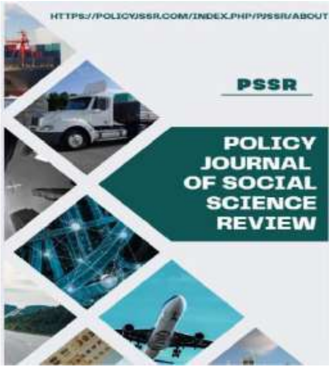
The central question guiding this research is: Is there a statistically significant difference in mathematics achievement between Grade 3 and Grade 4 students in monograde and multigrade public primary classrooms in Lower Chitral? Two subsidiary questions follow: How do average scores compare across the two settings? And do grade-level effects on achievement differ depending on classroom type?

1.4 Hypotheses

Based on the research questions, two competing hypotheses were formulated:

H_0 (Null): There is no statistically significant difference in mathematics achievement between Grade 3 and Grade 4 students in monograde and multigrade classrooms in the public schools of Lower Chitral.

H_1 (Alternative): There is a statistically significant difference in mathematics achievement between Grade 3 and Grade



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4 students in monograde and multigrade classrooms in the public schools of Lower Chitral.

2. LITERATURE REVIEW

2.1 Theoretical Foundation: Socio-Constructivism and Multigrade Learning

The theoretical lens through which this study examines multigrade teaching is rooted in Vygotsky's socio-constructivist framework (Vygotsky, 1978). This perspective holds that learning is not a solitary cognitive process but a social one — knowledge is constructed through meaningful interaction with others, mediated by language and cultural tools. For mathematics education, this means that conceptual understanding develops most robustly when students are required to articulate their thinking, question each other's reasoning, and collaboratively work through problems (Ernest, 1996).

Multigrade classrooms, in this light, are not inherently disadvantaged. They are, in fact, environments where socio-constructivist conditions arise naturally. When children of different ages and abilities share a classroom, they encounter a wider range of perspectives and levels of reasoning than their peers in single-grade settings. Older students regularly explain mathematical ideas to younger ones; younger students ask questions that prompt older peers to revisit and consolidate their understanding. This cross-age dynamic, when appropriately facilitated, can be a powerful engine for learning (Garland et al., 2025).

2.2 The Zone of Proximal Development in Cross-Age Settings

Central to understanding why peer interaction in multigrade classrooms can support learning is Vygotsky's concept of the Zone of Proximal Development (ZPD). The ZPD describes the gap between what a learner can accomplish independently and what they can achieve with guidance from a More Knowledgeable Other (MKO) — someone with greater expertise, whether a teacher or a peer (Berk & Winsler, 1995). The support provided within this zone is known as scaffolding.

In multigrade classrooms, where teacher attention is inevitably divided across two or more grade levels, older or more able students naturally assume the MKO role. A Grade 4 student who explains a subtraction procedure to a Grade 3 classmate is not simply repeating information — they are encoding that knowledge more deeply through the act of explanation. Simultaneously, the younger student receives guidance that is closer to their own cognitive level and linguistic register than any teacher-led instruction could consistently be (Way, 1979). In this way, the structural constraint of the multigrade setting — limited direct teacher time per grade — can paradoxically activate a distributed scaffolding network that benefits learners across grade levels.

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2.3 Empirical Evidence on Multigrade Outcomes

A substantial body of international research has examined whether students in multigrade classrooms perform differently in core subjects compared to their peers in single-grade settings. The weight of this evidence is striking in its consistency: when teaching quality and resource conditions are reasonably controlled, multigrade instruction tends to produce learning outcomes that are comparable to, and sometimes exceed, those of monograde classrooms.

Thomas (2012) conducted a systematic review of multigrade research across multiple countries and found that well-implemented multigrade programmes produced results comparable to monograde classrooms in most subject areas. Perry et al. (2017) reported no meaningful differences in mathematics achievement between primary students in multigrade and single-grade settings in rural Ireland after accounting for socioeconomic factors. Sharma (2020), studying rural India, similarly found no major differences in mathematics performance and concluded that the quality of classroom processes mattered far more than the structural arrangement. At the global policy level, the World Bank has observed that a properly managed multigrade school can be as effective as a single-grade school in achieving core learning objectives (Psacharopoulos et al., 1993).

Within Pakistan, and particularly in Khyber Pakhtunkhwa, the picture is somewhat more complex. Wajidullah et al. (2022), in a large-scale study across KP, found that the effectiveness of multigrade instruction was strongly mediated by teacher efficacy — schools where teachers felt confident managing mixed-grade classrooms showed no meaningful achievement gap compared to monograde counterparts. Where teacher confidence was low, performance gaps emerged. Nawab (2018) emphasised that the critical bottleneck in rural KP is not the multigrade structure itself but the absence of specialised training for the teachers who work within it.

This pattern — where the quality of the teacher, not the format of the classroom, emerges as the primary predictor of student outcomes — frames the present study's contribution. What happens in Lower Chitral specifically, where the challenges of remoteness and limited teacher preparation are most acute, has not been rigorously examined before.

3. METHODOLOGY

3.1 Research Design

This study adopted a quantitative, post-test only non-equivalent groups design (Campbell & Stanley, 1963). Two groups of students — one from a monograde school and one from a multigrade school — were compared on a standardised mathematics test following a four-week instructional period during which both groups covered the same SNC-aligned learning objectives. Because classroom

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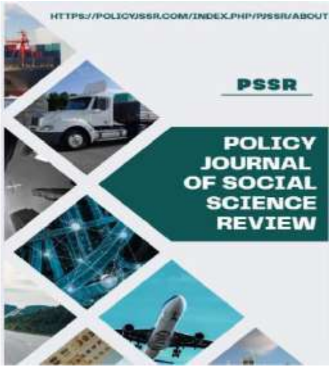

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type is a pre-existing structural condition rather than a variable that can be randomly assigned, random allocation of participants was not possible. The non-equivalent groups design is the appropriate methodological choice in such natural settings, provided that key confounding variables are addressed through careful sampling and procedural controls.

3.2 Participants and Sampling

The study was conducted in two public primary schools in Lower Chitral, KP. The monograde school, located in a more accessible area with separate classes for each grade, was selected as representative of the monograde model in the district. The multigrade school, situated in a more remote location, had a single teacher managing Grade 3 and Grade 4 students simultaneously — a typical arrangement for such communities.

Using systematic random sampling from school registers, 30 students were selected from each school — 15 from Grade 3 and 15 from Grade 4 — yielding a total sample of N = 60. Only students enrolled for at least one full academic year were eligible, to minimise the impact of recent transfers on performance. The final sample comprised 32 boys and 28 girls with a mean age of 8.7 years (SD = 0.6). Socioeconomic backgrounds, gathered through a short parental questionnaire, were broadly similar across the two groups, with most families engaged in agriculture or small-scale trade.

3.3 Instrument: Mathematics Achievement Test

The primary data collection instrument was a 20-item Mathematics Achievement Test (MAT) developed by the researcher and aligned with the Grade 3 and 4 SNC mathematics curriculum. All items were multiple-choice, each with one correct answer and three distractors. Test content was drawn from the five core SNC domains: Numbers and Operations (8 items), Geometry and Measurement (7 items), Algebra (3 items), and Data Handling (2 items). Items were structured according to Bloom's Taxonomy: ten items targeted knowledge-level recall, five required comprehension and interpretation, and five assessed procedural application.

The instrument was developed through a rigorous process: curriculum mapping, expert review by three experienced mathematics teachers, and a pilot test administered to 15 students from a school outside the main study sample. Pilot data confirmed that items were clear and appropriate. The final test was scored out of 20, with one mark per correct response.

3.4 Ethical Considerations

The study received ethical approval from the Department of Education, University of Chitral, and operational clearance from the District Education Office of Lower Chitral and the head teachers of both participating schools. Informed consent was obtained from parents and

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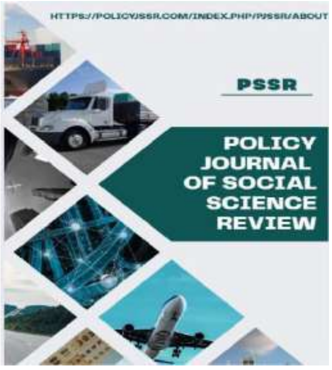

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guardians, and student assent was sought in age-appropriate terms. All participant data were anonymised using codes, with identifying records stored securely and accessible only to the principal researcher. Participation was voluntary, with withdrawal possible at any point without consequence. Both schools received written feedback reports summarising their students' performance and identifying areas for instructional attention.

3.5 Procedure

The study unfolded across four weeks. In the first week, research protocols were finalised, consent was obtained, and participants were selected. The second and third weeks constituted the instructional period, during which both teachers delivered mathematics lessons covering the same SNC-aligned learning outcomes across four domains: Numbers and Operations (place value, addition, and subtraction), Geometry (plane figures and spatial logic), Measurement (length, weight, and time), and Patterns and Algebra (simple patterns and equations). Both teachers were briefed on the curriculum objectives, submitted weekly lesson plans, and were observed once per week using a structured observation protocol. Implementation fidelity was assessed at above 85% compliance in both classrooms. In the final week, the Mathematics Achievement Test was administered under standardised conditions, with consistent verbal instructions, a 30-minute time allocation, and individual desk arrangements to prevent copying.

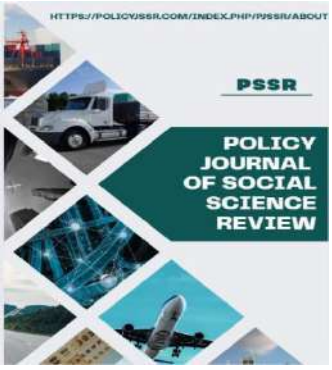
3.6 Data Analysis

Descriptive statistics (mean, standard deviation, median, mode, range, skewness, and kurtosis) were computed for both groups. The primary inferential test was an independent samples t-test, appropriate for comparing the means of two independent groups. A two-way ANOVA was subsequently conducted to assess the main effects of classroom structure (monograde vs. multigrade) and grade level (Grade 3 vs. Grade 4), as well as their interaction. Effect size was estimated using Cohen's d and partial eta-squared (η^2). The significance threshold was set at $\alpha = 0.05$. An item-level content area analysis and an error pattern analysis were also performed to contextualise the overall findings. All analyses were conducted using SPSS Version 27.

4. RESULTS

4.1 Descriptive Statistics

Table 1 presents the descriptive statistics for mathematics achievement scores in both classroom types. The monograde group recorded a mean score of 15.0 (SD = 2.5) out of 20, while the multigrade group achieved a mean of 14.5 (SD = 3.0). The difference in means was 0.50 points. Median scores closely mirrored the means in both groups (MG: 15.0; MTG: 14.5), indicating symmetric score distributions. Both groups achieved a maximum score of 20, while the minimum was 9 in the monograde group



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and 8 in the multigrade group. The slightly wider standard deviation and interquartile range in the multigrade group (IQR = 4.0) compared to the monograde group (IQR = 3.5) suggest marginally greater score variability in the mixed-grade setting.

Table 1. Descriptive Statistics of Mathematics Achievement Scores (N = 60)

Statistic	Monograde (n = 30)	Multigrade (n = 30)
Mean	15.0	14.5
Standard Deviation	2.5	3.0
Median	15.0	14.5
Mode	16	14
Minimum	9	8
Maximum	20	20
Range	11	12
Interquartile Range (IQR)	3.5	4.0
Skewness	-0.32	-0.18
Kurtosis	2.89	2.45
Standard Error of Mean	0.46	0.55

The skewness values for both groups were slightly negative but close to zero (MG: -0.32; MTG: -0.18), indicating approximate normality with a slight concentration of higher scores — a pattern consistent with a test that was accessible to most students. Kurtosis values were also within acceptable ranges. These properties satisfied the parametric assumptions required for the t-test and ANOVA analyses that followed.

4.2 Inferential Statistics: Independent Samples t-Test

An independent samples t-test was conducted to determine whether the 0.50-point mean difference between

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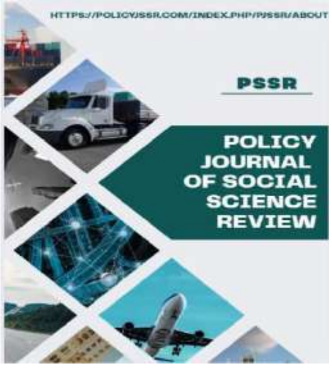

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groups was statistically significant. The results are presented in Table 2.

Table 2. Independent Samples t-Test: Mathematics Achievement by Classroom Type

Variable	Mean Diff.	t	df	p-value	Cohen's d	95% CI
Mathematics Achievement (MG vs. MTG)	0.50	0.73	58	0.468	0.18	[-0.87, 1.87]

The t-test yielded a t-statistic of 0.73 (df = 58, p = 0.468). This p-value substantially exceeds the significance threshold of α = 0.05, indicating that the observed mean difference is not statistically significant and could plausibly arise from random sampling variation in approximately 46.8% of comparable samples. The 95% confidence interval for the mean difference ranged from -0.87 to 1.87 — a range that includes zero, providing additional confirmation that the null hypothesis cannot be rejected. The effect size, calculated as Cohen's d = 0.18, is classified as small, indicating that the structural difference between classroom types has minimal practical impact on mathematics achievement in this context.

On the basis of these results, the null hypothesis (H_0) is accepted: there is no statistically significant difference in mathematics achievement between Grade 3 and Grade 4 students in monograde and multigrade classrooms in the public schools of Lower Chitral.

4.3 Two-Way ANOVA: Classroom Structure × Grade Level

A two-way ANOVA was conducted to examine the independent and joint effects of classroom structure and grade level on mathematics achievement. Results are presented in Table 3.

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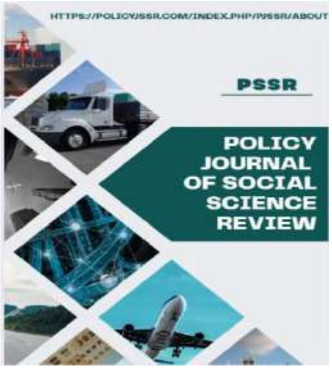

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Table 3. Two-Way ANOVA Results for Mathematics Achievement

Source	SS (Type III)	df	MS	F	p-value	Partial η^2
Classroom Structure	3.75	1	3.75	0.53	0.468	0.009
Grade Level	40.83	1	40.83	5.79	0.020*	0.091
Structure × Grade Level	0.08	1	0.08	0.01	0.920	0.000
Error	407.33	58	7.02	—	—	—

* $p < 0.05$

As anticipated from the t-test results, classroom structure exerted no significant main effect on mathematics achievement ($F(1,58) = 0.53$, $p = 0.468$, partial $\eta^2 = 0.009$). Grade level, however, showed a significant main effect ($F(1,58) = 5.79$, $p = 0.020$, partial $\eta^2 = 0.091$): Grade 4 students ($M = 15.7$, $SD = 2.6$) outperformed Grade 3 students ($M = 13.8$, $SD = 2.7$) across both classroom types. This is a developmentally expected finding, reflecting the cumulative nature of mathematical skill acquisition. Crucially, the interaction between classroom structure and grade level was not significant ($F(1,58) = 0.01$, $p = 0.920$, partial $\eta^2 = 0.000$), indicating that the performance advantage of Grade 4 over Grade 3 operated identically in both classroom types. Multigrade organisation did not disadvantage either grade relative to its performance in the monograde setting.

4.4 Content Area and Error Pattern Analysis

Item-level analysis across the four content domains revealed a consistent pattern: performance differences between the two groups were minimal across all areas (see Table 4). Both groups performed most strongly in Data Handling and most weakly in Algebra — a pattern consistent with typical developmental trajectories in early mathematics education.

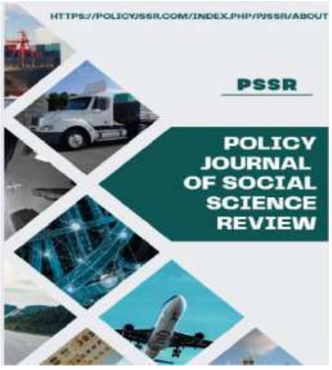

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Table 4. Performance Comparison by Mathematics Content Area

Content Area	Items	Monograde % Correct	Multigrade % Correct	Difference
Numbers and Operations	8	78.3%	76.7%	1.6%
Geometry and Measurement	7	72.6%	70.5%	2.1%
Algebra	3	65.0%	63.3%	1.7%
Data Handling	2	80.0%	78.3%	1.7%

Error pattern analysis revealed four recurring misconceptions distributed evenly across both classroom types: confusion about place value in larger numbers (hundreds and thousands), systematic errors in carrying and borrowing during addition and subtraction, misclassification of quadrilaterals based on visual similarity, and uncertainty about measurement units (particularly confusion between centimetres and metres). The similarity of these error patterns across classroom types suggests that they reflect the inherent complexity of the underlying mathematical concepts rather than any differential effect of classroom organisation on conceptual understanding.

5. DISCUSSION

5.1 The Null Result and Its Significance

The central finding of this study — that mathematics achievement does not differ significantly between monograde and multigrade classrooms in the public schools of Lower Chitral — carries implications that extend well beyond a single district. The null result is not a non-finding; it is an empirically grounded refutation of the assumption that multigrade teaching is inherently inferior and that its structural complexity necessarily translates into lower student achievement.

This finding is consistent with a broad international literature (Perry et al., 2017; Thomas, 2012; Mariano & Kirby, 2009; Sharma, 2020) and with World Bank observations that well-managed multigrade schools can achieve outcomes comparable to single-grade institutions (Psacharopoulos et al., 1993). What makes it particularly meaningful in the Lower Chitral context is the challenging conditions under which it was obtained: the multigrade school was in a more

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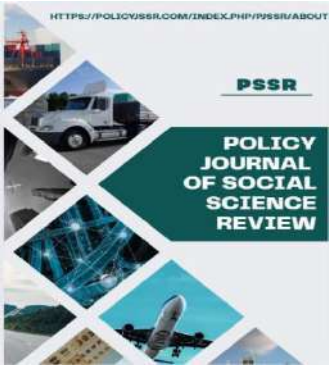
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remote location, served by a single teacher with no specialised multigrade training, and had fewer physical resources than its monograde counterpart. Despite these structural disadvantages, students performed at broadly equivalent levels. This points to significant untapped capacity within the multigrade system — a capacity that is likely sustained, in large part, by the informal peer-learning ecosystems that naturally develop in mixed-grade settings.

5.2 Theoretical Explanations for Outcome Equivalence

5.2.1 Peer Scaffolding and the ZPD

From a Vygotskian perspective, the equivalence in outcomes is best explained by the operation of the Zone of Proximal Development through peer interaction. In the multigrade school, where the teacher's direct instructional time was divided between two grade levels, older students naturally took on the MKO role for their younger peers. When a Grade 4 student explains a place value concept to a Grade 3 classmate, both parties benefit: the younger child receives support pitched at a more accessible level than teacher-directed instruction, while the older student deepens their own understanding through the cognitive effort of explanation (Way, 1979; Ahmed & Raza, 2019). The result is a distributed scaffolding network that compensates for reduced teacher contact time.

5.2.2 Socio-Constructivist Knowledge Building

Beyond the ZPD, socio-constructivist theory offers a broader lens. The multigrade classroom is, by definition, a heterogeneous social learning environment — one in which students encounter mathematical thinking across a wider range of developmental levels than any single-grade classroom could provide. Where the monograde classroom offers instructional efficiency, the multigrade setting offers something different: cognitive diversity. When younger students articulate their reasoning to older peers, they force themselves to organise their thinking. When older students hear approaches they once used themselves, they are prompted to reflect on their own conceptual growth. This reciprocal dynamic, described by Ernest (1996) as a core feature of socio-constructivist mathematics pedagogy, helps explain why the structural limitation of the multigrade classroom does not produce a corresponding limitation in mathematical understanding.

5.3 Implications for Educational Practice

The findings suggest a clear reframing of how multigrade classrooms should be understood and supported. Rather than treating them as an unfortunate compromise to be tolerated until better infrastructure arrives, educational authorities and school leaders should recognise them as legitimate and, in certain respects, pedagogically distinctive learning environments. The peer

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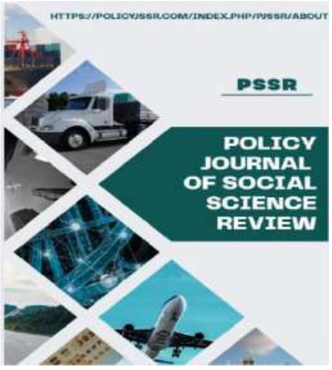

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dynamics that make multigrade classrooms effective cannot simply be replicated in monograde settings — they are a function of age mixing itself.

For teachers in multigrade settings, the practical implication is to formalise and structure what currently happens informally. Older students can be designated as peer tutors for specific mathematical concepts, with the teacher providing them with brief, focused guidance on the explanation task before turning to the other grade group. Integrated lesson designs — where a shared concept such as measurement is taught simultaneously at differentiated levels — can reduce the fragmentation that characterises less effective multigrade instruction. Station-based organisation, where different grade groups work on different tasks simultaneously, can allow the teacher to provide targeted direct instruction to one group while the other progresses independently or in peer pairs.

For school administrators, the priority is creating the conditions for these practices to take hold: ensuring that multigrade teachers have access to differentiated learning materials, building schedules that accommodate integrated mathematics blocks, and establishing professional learning communities where multigrade teachers can share strategies and problem-solve together.

5.4 Policy Implications

At the provincial level, the KP Education Department should consider three interconnected policy responses grounded in the evidence from this and related studies.

First, multigrade teaching should be formally recognised in provincial education policy as a legitimate and necessary educational model — not a second-best alternative, but a valid structural response to the demographic and geographic realities of rural KP. This recognition should be accompanied by dedicated budget lines for multigrade-specific resources, realistic teacher allocation formulae, and assessment frameworks that acknowledge the context of mixed-grade classrooms.

Second, and most urgently, teacher preparation and professional development must be redesigned to include substantive, practical training in multigrade pedagogy. The current practice of training all teachers exclusively for single-grade environments, and then deploying many of them into multigrade schools, is a structural inefficiency that undermines the potential of these classrooms. Building on initiatives such as the School Improvement in Multigrade Situations (SIMS) programme previously piloted in Chitral (Nawab & Baig, 2011), the government should institutionalise multigrade-focused professional development as a standard component of both pre-service and in-service training.

Third, targeted curriculum support materials should be developed and

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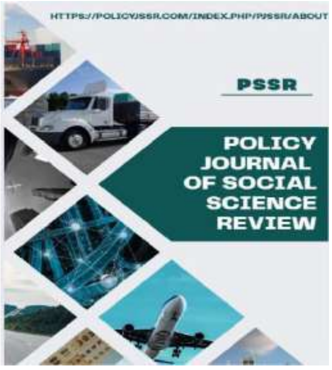

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distributed specifically for multigrade mathematics instruction. These should include self-directed learning cards aligned with SNC outcomes, differentiated work at two grade levels on shared conceptual themes, hands-on manipulatives, and simple formative assessment tools that help teachers track progress across multiple grades efficiently.

6. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

The study's findings should be interpreted in the context of several limitations. The sample was drawn from two schools — one of each type — in a single district, limiting the external generalisability of the results. The post-test only design, while appropriate for the context, does not allow for pre-test controls on baseline differences, though the broadly similar socioeconomic profiles of the two groups provide some basis for assuming initial equivalence. The four-week instructional window is relatively short, and long-term effects of classroom structure on mathematical development cannot be assessed from this design. Additionally, the instrument measured mathematics achievement as defined by correct responses to SNC-aligned items; it did not capture related outcomes such as mathematical reasoning, attitude towards mathematics, or the quality of student-to-student discourse.

These limitations point to several valuable directions for future research. A multi-school, multi-district study — ideally spanning different regions of KP or other multigrade-intensive provinces of Pakistan — would substantially enhance the external validity of these findings. Longitudinal tracking of the same cohort across multiple years would illuminate whether the equivalence observed in Grades 3 and 4 persists as mathematical content becomes more abstract and demanding. Qualitative methods — classroom observation, teacher interviews, and student focus groups — would bring depth to the quantitative findings, illuminating precisely how peer learning dynamics operate in practice. Studies comparing the specific effects of specialised multigrade professional development on teacher practice and student outcomes would directly inform the training-related policy recommendations made here. Finally, cost-effectiveness analyses comparing multigrade and monograde models would provide decision-makers with the evidence needed to optimise resource allocation in rural educational contexts.

7. CONCLUSION

This study demonstrates that, in the public primary schools of Lower Chitral, the type of classroom organisation — multigrade or monograde — does not significantly determine how well Grade 3 and Grade 4 children learn mathematics. A gap of half a mark on a 20-item test, a t-value that falls well short of significance, and a small effect size together tell a clear story: students in both settings are learning mathematics at broadly

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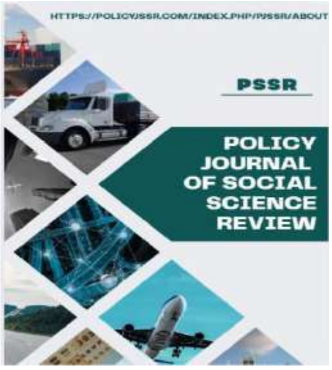

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equivalent levels. Grade 4 students outperform Grade 3 students in both environments, as expected — but the classroom structure adds nothing to this prediction.

This is not a trivial finding. In a policy environment where multigrade teaching is often treated as a deficiency to be corrected rather than a reality to be supported, evidence that its students are keeping pace with their single-grade peers carries real weight. It challenges the assumption that the route to educational improvement in rural Pakistan runs through school consolidation or the wholesale replacement of multigrade structures. It suggests, instead, that the more tractable and more urgent intervention is in the quality of teacher preparation and the adequacy of instructional support for the multigrade classrooms that already exist.

The peer-learning dynamics that socio-constructivist theory predicts, and that Vygotsky's framework of the ZPD illuminates, appear to be operating in Lower Chitral's multigrade classrooms with enough effect to offset the limitations of divided teacher time. That is a resource — human and social — that is present in these classrooms right now, without any additional investment. The task for policy, practice, and future research is to understand it more fully and support it more deliberately, so that the children who study in these mountain valley schools have every opportunity to build the mathematical foundations they will need for the rest of their education and their lives.

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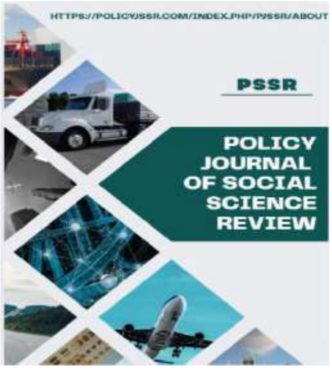

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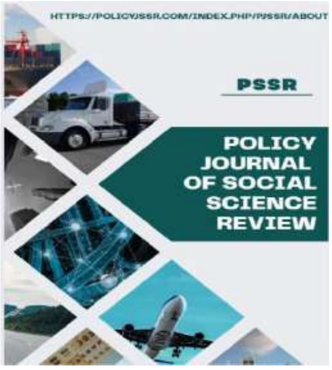

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