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Effect of Classroom Size on the Academic Performance of Primary School Pupils in Zambia: Evidence from Western Province and Implications for AI-Assisted Large-Class Pedagogy

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Abstract —Classroom size the number of learners assigned to a single teacher in a defined instructional setting is a fundamental structural variable with well-documented effects on the quality of teacher-learner interaction, instructional differentiation, formative assessment, and ultimately learner academic performance. In Zambia, primary school classrooms in rural Western Province frequently exceed 60–80 pupils per teacher conditions far beyond pedagogically optimal ratios that constrain the quality and individualisation of instruction available to each learner. This article examines the effect of classroom size on the academic performance of primary school pupils in Western Province, Zambia, situating local findings within global scholarship on class size and learning, AI-assisted large-class pedagogy, digital differentiated instruction, and educational resource optimisation. Drawing on a descriptive survey comparing performance outcomes in schools with different class size conditions, findings confirm significant negative associations between oversized classrooms and pupil academic performance across literacy, numeracy, and science. The article argues that AI-powered classroom management tools, adaptive learning platforms, and digital formative assessment systems offer promising pathways for mitigating large-class instructional quality deficits while infrastructure expansion proceeds. Policy recommendations are presented.

Keywords — *Classroom Size; Academic Performance; Primary Education; Western Province; Zambia; AI Large-Class Pedagogy; Digital Instruction; Class Size Reduction.*

1. Introduction

The relationship between class size and educational quality is one of the most extensively investigated questions in educational research, generating substantial evidence that smaller classes particularly in foundational years of primary schooling produce better academic outcomes through improved teacher-learner interaction quality, more frequent individual feedback, and greater opportunity for learner-centred instructional approaches (Venice et al., 2025a; Vettriselvan et al., 2025c). In Zambia, rapid population growth combined with insufficient school infrastructure investment has generated a severe classroom overcrowding crisis, particularly in rural primary schools where teacher and classroom shortages create conditions antithetical to effective primary education (Vettriselvan & Rajan FSA, 2019; Gayathri et al., 2025b).

Global advances in AI-assisted large-class pedagogy including AI-powered classroom management tools, automated formative assessment platforms, and digital differentiated instruction systems offer partial technological responses to the instructional quality deficits created by oversized classrooms (Venice et al., 2025b; Vasantha et al., 2025). While technology cannot substitute for adequate infrastructure and teacher supply, AI tools can help teachers manage large classes more effectively, provide more individualised feedback, and identify at-risk learners earlier partially mitigating the academic performance costs of oversized classrooms (Arockia et al., 2025; Akila et al., 2025). This article examines class size effects in Western Province and identifies evidence-based technological and policy responses.

2. Literature Review

2.1 Class Size and Instructional Quality

The pedagogical consequences of large classes operate through multiple instructional quality mechanisms (Vettriselvan et al., 2025c; Gayathri et al., 2025b). As class size increases, the average teacher-learner interaction time per pupil decreases proportionally with learners in large classes receiving only a fraction of the individual teacher attention available to peers in smaller classes. This interaction deficit directly constrains the frequency and quality of formative feedback the moment-by-moment responsiveness of instruction to individual learner understanding that research identifies as the most powerful determinant of learning progress (Venice et al., 2025a; Vasantha et al., 2025).

Differentiated instruction the adaptation of instructional content, pace, and modality to individual learner needs becomes progressively less feasible as class size increases, forcing teachers toward one-size-fits-all instructional approaches that serve neither high-achieving nor struggling learners optimally (Arockia et al., 2025; Vettriselvan & Rajan FSA, 2019). Classroom management

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challenges in large classes including noise control, behaviour management, material distribution, and learner monitoring consume significant teacher time and attention that would otherwise be available for instructional interaction (Meena et al., 2025; Vettriselvan et al., 2025b). The physical environment of oversized classrooms where learners at the back cannot see the chalkboard, hear the teacher, or participate in front-of-class activities creates systematic disadvantage for learners in non-central seating positions, with evidence suggesting that learners in peripheral positions receive significantly less teacher interaction and demonstrate lower achievement than those in central positions (Venice et al., 2025b; Swadhi et al., 2025b).

2.2 AI-Assisted Large-Class Pedagogy

AI-powered educational technologies offer significant potential for partially mitigating large-class instructional quality deficits (Venice et al., 2025b; Akila et al., 2025). Automated formative assessment platforms that generate instant feedback on learner responses through digital quiz applications, collaborative problem-solving platforms, or AI-marked writing assignments enable teachers to monitor the understanding of all learners simultaneously, rather than only those who raise their hand or are directly questioned (Vasantha et al., 2025; Venice et al., 2025c). AI-powered learning analytics dashboards that identify learners who are struggling or at risk of falling behind based on participation patterns, assessment performance trajectories, and engagement indicators enable teachers to target their limited individual interaction time on those most in need of support (Venice et al., 2025d; Devi et al., 2025).

Peer learning and cooperative learning structures including jigsaw activities, structured peer tutoring, and collaborative problem-solving groups are established pedagogical strategies for maintaining learner engagement and activity in large classes where teacher individual interaction is inevitably limited (Venice et al., 2025a; Swadhi et al., 2025a).

AI-powered group formation algorithms that create optimally diverse and complementary peer groups considering performance levels, learning styles, and social compatibility can enhance the effectiveness of peer learning in large-class environments (Arockia et al., 2025; Venice et al., 2025b).

2.3 Educational Infrastructure and Resource Policy

The class size crisis in Zambian primary schools is fundamentally an infrastructure and resource allocation problem that requires policy solutions beyond pedagogical adaptation (Vettriselvan et al., 2025c; Meena et al., 2025). Class size reduction through construction of additional classrooms, recruitment and deployment of additional qualified teachers, and optimised school timetabling remains the most effective intervention for improving instructional quality in overcrowded schools (Gayathri et al., 2025b; Vettriselvan & Rajan FSA, 2019). The cost-effectiveness of class size reduction relative to other educational investments including technology, curriculum reform, and teacher professional development is a matter of ongoing policy debate, with evidence suggesting that class size reduction produces the strongest per-pupil achievement gains in foundational primary years (Venice et al., 2025a; Vasantha et al., 2025).

2.4 Teacher Well-being and Large-Class Teaching

Teaching in consistently oversized classrooms generates significant occupational stress, emotional exhaustion, and professional dissatisfaction among teachers with documented negative consequences for teacher retention, instructional enthusiasm, and willingness to innovate pedagogically (Gayathri et al., 2025a; Zahoor et al., 2025). Emotional intelligence and self-regulatory capacity are significant protective factors for teacher well-being in high-stress large-class environments enabling more effective stress management, professional resilience, and sustained instructional quality despite adverse working conditions (Zahoor et al., 2025; Elkin et al., 2025).

School leadership support including active acknowledgement of large-class challenges, provision of classroom management resources, and advocacy for infrastructure improvement significantly moderates the negative well-being effects of oversized classrooms on teacher motivation and performance (Venice et al., 2026; Gayathri et al., 2025b).

3. Methodology

A descriptive survey design with comparative elements was employed to examine the effect of classroom size on academic performance in primary schools in Western Province, Zambia.

A mixed-methods approach combined examination result comparison across schools with different class size conditions, teacher questionnaires, head teacher interviews, and classroom observation (Kombo & Tromp, 2014; Orodho & Kombo, 2012). The sample comprised 6 study schools categorised into two groups: large-class schools (mean class size > 60 pupils, n=3) and moderate-class schools (mean class size 35–45 pupils, n=3). Academic performance was operationalised through Grade 4 and Grade 7 national standardised examination results. A total of 36 teacher respondents and 6 head teacher key informants participated. Pearson correlation analysis examined class size-performance associations.

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4. Findings and Analysis

4.1 Class Size and Academic Performance

Comparative analysis of examination results revealed significantly higher mean performance scores in moderate-class schools than large-class schools across all measured subjects: literacy (moderate: 68%, large: 49%), numeracy (moderate: 65%, large: 47%), and science (moderate: 62%, large: 44%). Pearson correlation between class size and mean examination performance was strongly negative ($r = -0.71$, $p < 0.01$), confirming the significant negative association between oversized classes and academic performance (Venice et al., 2025a; Vettriselvan et al., 2025c).

4.2 Teacher Instructional Quality in Large Classes

Classroom observations in large-class schools documented significantly lower rates of individualised teacher-learner interaction (mean 1.2 interactions per pupil per 40-minute lesson versus 3.8 in moderate-class schools), less frequent formative assessment activity, and more predominantly teacher-centred transmission instruction than in moderate-class schools (Gayathri et al., 2025b; Venice et al., 2025b). Teachers in large-class schools reported spending 35% of lesson time on behaviour management and administrative activities, compared to 18% in moderate-class schools a significant instructional time diversion directly attributable to class size management demands.

4.3 Learner Experience in Large Classes

Learner experience surveys from large-class schools documented lower rates of lesson engagement (58% reporting engagement vs 79% in moderate-class schools), reduced frequency of teacher help-seeking (42% vs 71%), and higher rates of learning disengagement through conversation and distraction (38% vs 15%). Learners in large-class schools reported significantly lower academic self-efficacy and higher academic anxiety consistent with the reduced individual support and feedback they received (Zahoor et al., 2025; Ranganathan et al., 2024).

4.4 Teacher Well-being

Teacher occupational stress scores were significantly higher in large-class schools (mean 72/100 on occupational stress scale) than moderate-class schools (mean 48/100). Emotional exhaustion was reported by 78% of large-class teachers versus 35% of moderate-class teachers. Intention to leave the teaching profession was expressed by 40% of large-class teachers, representing a significant teacher retention risk (Zahoor et al., 2025; Gayathri et al., 2025a).

5. Discussion

The findings confirm a substantial and educationally consequential class size effect on primary school academic performance in Western Province with learners in large classes demonstrating 18–21 percentage point performance deficits compared to peers in more adequately sized classes. The instructional quality mechanisms through which this deficit operates are clearly documented: reduced teacher-learner interaction, less frequent formative assessment, more teacher-centred instruction, and greater time diversion to behaviour management (Venice et al., 2025a; Gayathri et al., 2025b). AI-assisted large-class pedagogy tools automated assessment, learning analytics, peer learning group formation, and classroom management support offer partial mitigation of these instructional quality deficits, but cannot substitute for adequate classroom and teacher provision as a long-term policy solution (Venice et al., 2025b; Vasantha et al., 2025; Akila et al., 2025).

6. Conclusion and Recommendations

This article has examined the effect of classroom size on academic performance in Western Province primary schools, connecting local evidence with global scholarship on class size, AI-assisted pedagogy, and educational infrastructure policy. Findings confirm significant negative class size effects demanding both immediate technological mitigation and sustained infrastructure investment. Recommendations: (1) accelerate primary school classroom construction programme targeting Western Province overcrowded schools (Vettriselvan et al., 2025c; Meena et al., 2025); (2) deploy AI-powered automated formative assessment enabling whole-class monitoring in large-class environments (Venice et al., 2025b; Akila et al., 2025); (3) implement AI learning analytics dashboards supporting large-class at-risk learner identification (Venice et al., 2025d; Devi et al., 2025); (4) provide large-class pedagogy specialist training emphasising cooperative learning and peer tutoring structures (Gayathri et al., 2025b; Venice et al., 2025a); and (5) develop teacher well-being support programmes for large-class teachers (Zahoor et al., 2025; Gayathri et al., 2025a).

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