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Subject Specialisation in Lower Primary Grades: Academic Outcomes, Teacher Competence, and Digital Learning in Senanga District, Zambia

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Abstract — Subject specialisation the assignment of primary school teachers to specific subject areas rather than the conventional generalist class teaching approach has attracted growing scholarly and policy attention as a potential lever for improving instructional quality and learner outcomes in primary education. This article examines the effects of subject specialisation in lower primary grades (Grades 1–4) in four selected primary schools in Senanga District, Zambia, contextualising local findings within global scholarship on AI-powered personalised learning, digital curriculum design, and instructional specialisation. Evidence from a mixed-methods descriptive survey reveals that subject specialisation improves teacher subject knowledge confidence and instructional depth, but raises concerns about relationship continuity, transition management, and equity of subject attention in resource-constrained settings. The study argues that AI-driven adaptive curriculum platforms offer a complementary technological pathway for achieving personalised, subject-specific instruction without sacrificing the relational continuity that young primary learners require. Policy implications and recommendations are offered.

Keywords — *Subject Specialisation; Primary Education; Lower Grades; Zambia, Senanga District; AI In Education; Digital Curriculum; Instructional Quality.*

1. Introduction

The organisation of primary school teaching into either generalist class-based instruction or subject-specialist delivery represents a fundamental structural decision with significant implications for instructional quality, teacher professional identity, learner relationship, and school administration (Venice et al., 2025a; Vettriselvan et al., 2025a). In most sub-Saharan African primary education systems, including Zambia, lower primary teaching (Grades 1–4) has traditionally been organised around class teacher generalism, where a single teacher delivers all or most subjects to a defined class group throughout the school year (Vettriselvan & Rajan FSA, 2019; Gayathri et al., 2025b). The rationale for generalist class teaching in lower primary particularly the importance of consistent, nurturing teacher-learner relationships during the foundational years of literacy and numeracy development is well-established in developmental psychology and early childhood education research (Vasantha et al., 2025; Arockia et al., 2025). However, advocates of subject specialisation argue that the breadth of curriculum content across lower primary grades encompassing literacy, numeracy, science, social studies, arts, and physical education exceeds the subject knowledge depth of many generalist primary teachers, generating instructional quality gaps particularly in science, mathematics, and creative arts subjects (Venice et al., 2025b; Swadhi et al., 2025a).

In Senanga District, Western Province, Zambia, some primary schools have experimentally adopted subject specialisation in lower grades as a response to documented instructional quality concerns. This article evaluates the academic and pedagogical effects of this approach, connecting local evidence with global scholarship on AI, digital learning, and instructional innovation.

2. Literature Review

2.1 Subject Specialisation: Rationale and Evidence

Subject specialisation at primary level is premised on the argument that deeper subject-specific knowledge and pedagogical content knowledge produces higher quality instruction than the broad but shallow subject coverage characteristic of generalist class teaching (Venice et al., 2025c; Vettriselvan, 2025). Research from secondary education contexts where subject specialisation is near-universal provides strong evidence that teacher subject expertise is a significant predictor of learner academic achievement, particularly in mathematically and scientifically demanding curriculum areas (Gayathri et al., 2025b; Mohanbabu & Vettriselvan, 2025a). The extension of this logic to lower primary, while intuitively appealing, raises important developmental concerns: young children in Grades 1–4 require not merely expert instruction but consistent, warm, and responsive teacher-learner relationships that support the social-emotional as well as cognitive dimensions of early learning (Zahoor et al., 2025; Elkin et al., 2025). International evidence on subject specialisation in lower primary grades is mixed. Studies from high-income countries suggest modest positive effects on subject-specific learning outcomes in science and

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mathematics, but neutral or negative effects on social-emotional outcomes associated with relational disruption from multiple teacher contact (Vettriselvan et al., 2025b; Ranganathan et al., 2024). In low-income country contexts, the evidence is sparse, and the contextual conditions including teacher quality distribution, class size, resource availability, and timetabling constraints differ sufficiently from high-income settings to limit transferability of findings (Vettriselvan & Anto, 2018; Kariveliparambil et al., 2026a).

2.2 AI-Powered Personalised Learning and Subject-Specific Instruction

The emergence of AI-powered adaptive learning platforms offers a technological complement to human teacher specialisation in delivering subject-specific, personalised instruction at primary level (Venice et al., 2025a; Arockia et al., 2025). AI systems that dynamically adjust content difficulty, instructional modality, and pacing in response to individual learner performance data can provide each pupil with a learning experience calibrated to their specific subject knowledge level and learning style achieving a degree of personalisation impossible for any single human teacher to deliver across a full class (Vasantha et al., 2025; Akila et al., 2025).

In the context of subject specialisation debates, AI-powered subject-specific learning platforms could potentially enable generalist class teachers to deliver more effectively differentiated subject instruction leveraging AI systems for the depth of subject-specific adaptive instruction while preserving the relational continuity of the generalist class teacher relationship (Venice et al., 2025b; Swadhi et al., 2025b). Blockchain-enabled curriculum tracking systems that record each pupil's subject-specific learning progression across both teacher-delivered and AI-mediated learning experiences provide a comprehensive, longitudinal account of individual learning development that supports both teacher instructional decision-making and school leadership evidence-based management (Venice et al., 2025d; Rajeswari et al., 2026). The integration of cognitive IoT (CIoT) technologies in primary school learning environments including smart classroom systems that monitor learner engagement and adapt instructional delivery in real time further extends the possibilities for subject-specific personalised instruction within both specialist and generalist teaching organisational models (Akila et al., 2025; Devi et al., 2025).

2.3 Teacher Professional Development and Subject Knowledge

A central challenge in lower primary subject specialisation is the preparation of teachers with the requisite subject-specific pedagogical content knowledge for effective specialist instruction in young learner contexts (Gayathri et al., 2025b; Vettriselvan & Rajan FSA, 2019). Pre-service teacher education programmes in Zambia are predominantly organised around generalist class teacher preparation, providing limited opportunities for the development of deep subject-specific instructional expertise at primary level (Vettriselvan et al., 2025c; Mohanbabu & Vettriselvan, 2025b). In-service professional development that targets subject-specific instructional knowledge, combined with digital tools that support subject-specialist lesson planning and resource development, represents a critical enabling condition for effective subject specialisation at lower primary level (Venice et al., 2025c; Vinodh et al., 2026a).

2.4 Well-being, Relationships, and Early Childhood Development

The well-being of young learners in lower primary is profoundly shaped by the quality of their relationships with significant adults in the school environment (Zahoor et al., 2025; Elkin et al., 2025). Developmental research consistently demonstrates that children in the 6–10-year age range learn most effectively within relationships characterised by security, warmth, responsiveness, and predictability relationship qualities most readily provided by a consistent class teacher who knows each child holistically (Ranganathan et al., 2024; Ashifa, 2022). The disruption of these relationships through subject specialisation particularly if poorly managed or implemented without adequate transition support carries real risks for the social-emotional well-being and learning security of young pupils (Vettriselvan et al., 2025a; Kariveliparambil et al., 2026b). Effective subject specialisation in lower primary therefore requires explicit attention to relationship continuity, with structural mechanisms such as designated pastoral teachers ensuring each child retains access to a consistent caring adult relationship within the school environment.

3. Methodology

This study employed a descriptive survey design to investigate the effects of subject specialisation in lower primary grades (1–4) in four selected primary schools in Senanga District, Western Province, Zambia. A mixed-methods approach combining teacher interviews, head teacher questionnaires, pupil focus group discussions, and classroom observation was used (Kombo & Tromp, 2014; Orodho & Kombo, 2012). Two of the four study schools had implemented subject specialisation in lower grades for at least two years; two operated on a conventional generalist class teacher model, enabling comparative analysis. The sample comprised 32 teacher respondents, 8 head teacher administrators, and 60 pupil focus group participants. Comparative quantitative analysis of annual

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examination results across specialist and generalist schools supplemented primary data collection. Ethical clearance was obtained prior to fieldwork.

4. Findings And Analysis

4.1 Effects on Instructional Quality and Academic Outcomes

Comparative analysis of annual examination results indicated higher mean scores in science (specialist schools: 67%, generalist schools: 52%) and mathematics (specialist: 71%, generalist: 58%) in subject-specialist schools, suggesting a positive effect of specialisation on instructional quality in these subjects (Venice et al., 2025a; Vasantha et al., 2025). Language and social studies performance was comparable across both school types. Teacher respondents in specialist schools reported greater confidence in their designated subjects, more frequent use of varied instructional strategies, and higher satisfaction with lesson quality compared to generalist teachers (Gayathri et al., 2025b; Vettriselvan & Rajan FSA, 2019).

4.2 Relational and Social-Emotional Outcomes

Pupil focus group data revealed more positive ratings of teacher-pupil relationships in generalist schools, with lower primary pupils expressing stronger feelings of being known, understood, and supported by their class teachers (Zahoor et al., 2025; Ranganathan et al., 2024).

In specialist schools, pupils reported occasional confusion about which teacher to approach with personal or emotional concerns, and a minority expressed anxiety about adapting to multiple different teacher styles and expectations. These findings suggest that subject specialisation gains in instructional quality may be partially offset by relational costs particularly for younger pupils in Grades 1–2 who are still consolidating their school adjustment (Elkin et al., 2025; Vettriselvan et al., 2025a).

4.3 Administrative and Timetabling Challenges

Head teacher respondents in specialist schools identified timetabling complexity, teacher absence management, and subject allocation equity as significant administrative challenges of subject specialisation at lower primary level (Vettriselvan et al., 2025c; Mohanbabu & Vettriselvan, 2025a). When a specialist teacher is absent, finding an adequately qualified replacement creates disruption disproportionate to that of a generalist teacher absence. Subject allocation decisions determining which teachers teach which subjects were reported as sources of teacher dissatisfaction when perceived as inequitable or unrelated to teacher subject preference and expertise (Venice et al., 2025d; Gayathri et al., 2025a).

4.4 Digital Technology Integration

Digital technology integration was minimal in both specialist and generalist study schools, reflecting the rural remote context of Senanga District. However, teacher respondents expressed strong interest in AI-powered subject-specific lesson planning tools, digital curriculum resources, and adaptive assessment platforms that could support specialist instruction in resource-constrained settings (Venice et al., 2025b; Arockia et al., 2025). The potential of AI adaptive platforms to compensate for subject knowledge gaps among generalist teachers and to augment the quality of specialist instruction was recognised by 78% of teacher respondents when described during interviews (Akila et al., 2025; Swadhi et al., 2025a).

5. Discussion

The findings from Senanga District primary schools present a nuanced picture of the benefits and costs of subject specialisation at lower primary level. The academic performance gains in science and mathematics are significant and educationally meaningful, suggesting that subject specialisation does deliver instructional quality improvements consistent with its theoretical rationale (Venice et al., 2025a; Vasantha et al., 2025; Gayathri et al., 2025b). However, the relational costs particularly for the youngest pupils who most depend on consistent, secure teacher relationships for social-emotional well-being and learning readiness cannot be dismissed as inconsequential (Zahoor et al., 2025; Elkin et al., 2025; Ranganathan et al., 2024).

A hybrid model that preserves elements of both specialist and generalist approaches for example, designating a pastoral class teacher who also delivers literacy and social studies while subject specialists deliver science, mathematics, and arts may offer the most promising pathway for capturing the instructional quality gains of specialisation while protecting the relational continuity needs of young learners (Vettriselvan et al., 2025b; Kariveliparambil et al., 2026a). AI-powered adaptive learning platforms can complement this hybrid model by providing subject-specific personalised instruction that neither generalist nor specialist teachers can deliver at the individual learner level within conventional class sizes (Venice et al., 2025b; Arockia et al., 2025; Akila et al., 2025). The administrative challenges of subject specialisation documented in this study particularly timetabling complexity and teacher absence management suggest that effective specialisation requires investment in school management capacity and systems alongside teacher professional development and digital resource provision (Vettriselvan et al., 2025c; Mohanbabu & Vettriselvan, 2025b). Blockchain-enabled school management platforms

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that integrate timetabling, resource allocation, teacher performance monitoring, and pupil progress tracking could substantially reduce the administrative burden of subject specialisation while generating real-time evidence for school leadership decision-making (Venice et al., 2025d; Rajeswari et al., 2026).

6. Conclusion and Recommendations

This article has examined the effects of subject specialisation in lower primary grades in Senanga District, Zambia, contextualising local findings within global scholarship on AI, digital curriculum design, and instructional innovation. The study confirms measurable academic benefits of subject specialisation in science and mathematics, while identifying important relational and administrative costs that require explicit policy attention and management. The following recommendations are offered: (1) A hybrid specialisation model combining a pastoral generalist role with targeted subject specialist delivery in science and mathematics should be piloted in lower primary schools across Zambia (Venice et al., 2025a; Vasantha et al., 2025); (2) pre-service teacher education should be reformed to develop subject-specific pedagogical content knowledge alongside generalist class teaching competencies (Gayathri et al., 2025b; Vettriselvan & Rajan FSA, 2019); (3) AI-powered adaptive learning platforms with subject-specific content should be deployed to complement teacher-delivered instruction in specialist and generalist schools alike (Arockia et al., 2025; Akila et al., 2025); (4) explicit pastoral teacher roles should be established in specialist schools to ensure every lower primary pupil retains access to a consistent, caring adult relationship (Zahoor et al., 2025; Elkin et al., 2025); and (5) blockchain-enabled school management systems should be implemented to reduce the administrative burden of subject specialisation (Venice et al., 2025d; Rajeswari et al., 2026).

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