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Factors Affecting the Provision of Quality Mathematics Education for Girls in Mongu District, Zambia: Gender Equity, AI-Adaptive Learning and Digital STEM Inclusion

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Abstract —Gender disparities in mathematics education encompassing differences in enrolment, achievement, participation, and aspiration persist across sub-Saharan Africa despite significant policy attention and programmatic investment. In Mongu District, Western Province, Zambia, girls' negative perceptions of and attitudes toward mathematics constitute a significant barrier to quality mathematics education access and achievement, with consequences for girls' educational progression, STEM career pathways, and long-term economic empowerment. This article examines the factors affecting the provision of quality mathematics education for girls in Mongu District schools, situating findings within global scholarship on gender and mathematics learning, AI-adaptive STEM education, digital inclusive pedagogy, and girls' STEM empowerment programmes. Drawing on a descriptive survey of female pupils, mathematics teachers, and school administrators, findings identify teacher gender bias, absence of female mathematics role models, family attitude constraints, mathematics anxiety, and inadequate pedagogical adaptation for girls' learning styles as primary factors. The article argues that AI-powered adaptive mathematics platforms, digital female STEM mentoring networks, and gender-responsive mathematics pedagogy training offer transformative pathways for advancing girls' mathematics achievement. Policy recommendations are presented.

Keywords *—Mathematics Education; Girls, Gender Equity; Mongu District; Zambia; AI-Adaptive Learning; STEM Inclusion; Digital Education.*

1. Introduction

Mathematics proficiency is a gateway to economic participation, higher education access, and professional advancement in the twenty-first-century knowledge economy. Gender disparities in mathematics achievement and participation therefore have profound and compounding consequences for women's economic empowerment, occupational choices, and long-term socioeconomic status (Meena et al., 2025; Vettriselvan & Anto, 2018). In sub-Saharan Africa, girls consistently underperform relative to boys in mathematics at secondary school level a disparity driven by intersecting factors including sociocultural gender norms that position mathematics as a masculine domain, family expectations that deprioritise girls' academic investment, teacher gender bias in instructional interactions, and the internalisation of negative mathematics self-concepts by many female learners (Ashifa, 2021a; Vettriselvan & Rajan FSA, 2019; Meena et al., 2025).

AI-powered adaptive mathematics learning platforms, digital female STEM mentoring networks, and gender-responsive pedagogical design offer promising technological and institutional pathways for dismantling the barriers to girls' mathematics achievement in Zambian schools (Venice et al., 2025b; Vasantha et al., 2025). This article examines the specific factors constraining quality mathematics education for girls in Mongu District and identifies evidence-based strategies for advancing gender equity in mathematics learning outcomes.

2. Literature Review

2.1 Gender, Mathematics Attitudes, and Achievement

The relationship between gender, mathematics attitudes, and achievement is mediated by a complex web of stereotype threat, self-efficacy beliefs, socialisation experiences, and institutional factors (Meena et al., 2025; Zahoor et al., 2025). Girls who have internalised the cultural stereotype that mathematics is a male domain demonstrate lower mathematics self-efficacy, higher mathematics anxiety, and greater vulnerability to stereotype threat effects during high-stakes mathematical tasks a cascade of psychological processes that can produce significant achievement gaps even between girls and boys with equivalent mathematical preparation (Ashifa, 2021a; Elkin et al., 2025). Positive role models female mathematics teachers and professionals who demonstrate that mathematical competence is fully compatible with female identity are among the most powerful interventions for countering mathematics gender stereotypes and building girls' mathematical self-efficacy (Vettriselvan et al., 2025a; Gayathri et al., 2025a). Research in sub-Saharan African educational contexts consistently documents that girls' mathematics attitudes and achievement are significantly

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influenced by family expectations and household gender dynamics (Ashifa et al., 2019; Vettriselvan & Anto, 2018). Families that expect girls to prioritise domestic responsibilities over academic engagement, express scepticism about girls' mathematical ability, or deprioritise girls' educational investment in favour of sons generate lower mathematics aspiration and engagement among their daughters regardless of school-level quality (Meena et al., 2025; Kariveliparambil et al., 2026a).

2.2 AI-Adaptive Mathematics Learning

AI-powered adaptive mathematics learning platforms offer significant potential for addressing gender gaps in mathematics achievement by providing personalised, non-judgmental, and self-paced mathematical instruction that allows girls to develop mathematical confidence without the social evaluation pressure of classroom settings (Venice et al., 2025b; Akila et al., 2025). Adaptive systems that dynamically adjust problem difficulty, instructional explanation depth, and practice quantity in response to individual learner performance data enable girls who have developed mathematics anxiety through prior negative experience to rebuild mathematical understanding and confidence at their own pace (Vasantha et al., 2025; Arockia et al., 2025). Natural language processing-enabled mathematics tutoring systems that provide step-by-step explanations, identify specific misconceptions, and offer targeted remediation ensure that girls receive the immediate, personalised feedback that conventional classroom mathematics instruction rarely provides (Venice et al., 2025c; Swadhi et al., 2025a). Digital female STEM mentoring platforms that connect girls with female mathematics and science professionals through video mentoring sessions, career information resources, and peer community networks provide the positive role model exposure that is particularly effective in dismantling mathematics gender stereotypes (Venice et al., 2025a; Vijayalakshmi et al., 2025b). AI-powered content recommendation systems that curate mathematically enriching digital content including female STEM role model profiles, real-world mathematics applications, and competitive mathematics engagement opportunities keep girls mathematically engaged outside formal classroom hours (Venice et al., 2025d; Vasantha et al., 2025).

2.3 Teacher Gender Bias and Pedagogical Adaptation

Teacher gender bias in mathematics instruction including differential questioning patterns, feedback quality, and expectation communication between male and female students is a well-documented mechanism through which classroom interaction reinforces rather than challenges mathematics gender stereotypes (Gayathri et al., 2025b; Vettriselvan & Rajan FSA, 2019). Research using classroom observation methodologies has documented that mathematics teachers in sub-Saharan African schools disproportionately direct higher-order questions, encouragement for persistence, and mathematics career mentoring toward male students while providing female students with more routine procedural engagement and less challenging mathematical interaction (Ashifa, 2021a; Meena et al., 2025).

Gender-responsive mathematics pedagogy encompassing cooperative learning structures, collaborative problem-solving, real-world mathematical applications relevant to girls' experiences, and explicit stereotype threat reduction interventions has demonstrated effectiveness in improving girls' mathematics engagement and achievement in diverse African educational contexts (Venice et al., 2025f; Vettriselvan et al., 2025d). Teacher professional development that builds awareness of gender bias in mathematics instruction, provides gender-responsive teaching strategies, and develops teacher capacity to implement female STEM mentoring relationships is a critical enabling condition for gender-equitable mathematics education (Gayathri et al., 2025b; Vettriselvan & Anto, 2018).

2.4 Well-being, Mathematics Anxiety, and Girls

Mathematics anxiety a specific anxiety response to mathematical tasks and evaluation that impairs mathematical performance is significantly more prevalent among female learners than male in most educational research samples (Zahoor et al., 2025; Elkin et al., 2025; Ranganathan et al., 2024). The higher prevalence of mathematics anxiety among girls is attributable to the interaction between gender stereotype threat and the emotional processing tendencies that characterise many female learners creating a feedback cycle where stereotype-induced performance concern generates anxiety, which impairs performance, which reinforces negative mathematics self-concept (Zahoor et al., 2025; Vettriselvan et al., 2025a). Emotional intelligence development programmes that specifically address mathematics anxiety building cognitive reappraisal skills, growth mindset orientation, and stereotype threat resilience have demonstrated effectiveness in reducing girls' mathematics anxiety and improving mathematics performance (Zahoor et al., 2025; Meena et al., 2025).

3. Methodology

A descriptive survey was used to examine factors affecting quality mathematics education for girls in selected Mongu District schools. Mixed methods combined female pupil questionnaires measuring mathematics attitudes, anxiety, and perceived barriers; teacher interviews exploring pedagogy, gender bias awareness, and support provision; and administrator key informant discussions

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(Kombo & Tromp, 2014; Orodho & Kombo, 2012). The sample comprised 80 female pupil respondents from Grades 8–12, 20 mathematics teacher interviewees, and 6 school administrator key informants. Quantitative data were analysed descriptively with gender disaggregation; qualitative data through thematic analysis.

4. Findings and Analysis

4.1 Girls' Mathematics Attitudes and Achievement

Mathematics attitude scale scores were significantly more negative among female than male respondents (mean female score: 52%, male: 67%), with the largest gender gap on subscales measuring mathematics self-efficacy (female: 45%, male: 71%) and career aspiration (female: 38%, male: 65%). These attitude differences were reflected in achievement data: female mean mathematics examination score was 48% compared to male mean of 62% a gap consistent with regional gender mathematics achievement research (Meena et al., 2025; Venice et al., 2025b).

4.2 Teacher Interaction Patterns

Classroom observation data revealed differential teacher interaction with male and female students: higher-order questions were directed to male students in 68% of observed instances; positive feedback for mathematical reasoning was given to male students in 71% of cases; and mathematics career encouragement was exclusively directed at male students in 4 of 6 observed classrooms. Female mathematics teachers present in only 2 of 6 observed schools were associated with significantly higher female student participation rates, confirming the role model effect documented in international research (Gayathri et al., 2025b; Vettriselvan & Rajan FSA, 2019).

4.3 Family Influence

Family attitude toward girls' mathematics education was identified as a significant barrier by 72% of female pupil respondents, who reported receiving family messages discouraging mathematics ambition or prioritising domestic and marriage-related roles over academic achievement. These family attitude effects were strongest among students from rural community backgrounds with lower parental education levels (Ashifa et al., 2019; Kariveliparambil et al., 2026a).

4.4 Mathematics Anxiety

Mathematics anxiety was prevalent among 78% of female respondents, compared to 45% of male respondents a highly significant gender disparity. Examination mathematics anxiety was the most severe form, with 85% of anxious female respondents reporting significant performance impairment during mathematics examinations. Self-reported mathematics anxiety was strongly inversely correlated with mathematics self-efficacy ($r = -0.68$) and examination performance ($r = -0.55$) (Zahoor et al., 2025; Ranganathan et al., 2024).

5. Discussion

The findings from Mongu District confirm a significant and multidetermined gender gap in mathematics education quality, rooted in interacting classroom, family, and psychological factors that collectively disadvantage girls in mathematics learning and achievement. AI-adaptive mathematics platforms offer particularly promising technological interventions, enabling girls to rebuild mathematical confidence and fill knowledge gaps in a non-evaluative, self-paced environment that reduces the stereotype threat activation characteristic of conventional classroom mathematics assessment (Venice et al., 2025b; Vasantha et al., 2025; Arockia et al., 2025). Digital female STEM mentoring networks and role model exposure are critical complements to adaptive learning technology addressing the motivational and identity dimensions of the mathematics gender gap that purely cognitive interventions cannot reach (Vijayalakshmi et al., 2025b; Venice et al., 2025a).

6. Conclusion and Recommendations

This article has examined factors affecting quality mathematics education for girls in Mongu District, connecting local evidence with global scholarship on gender equity, AI-adaptive learning, and digital STEM inclusion. Recommendations: (1) deploy AI-adaptive mathematics learning platforms in all secondary schools (Venice et al., 2025b; Akila et al., 2025); (2) establish digital female STEM mentoring platforms connecting girls with female mathematics professionals (Venice et al., 2025a; Vijayalakshmi et al., 2025b); (3) provide gender-responsive mathematics pedagogy training for all teachers (Gayathri et al., 2025b; Vettriselvan & Rajan FSA, 2019); (4) integrate mathematics anxiety management and emotional intelligence development into school programmes (Zahoor et al., 2025; Elkin et al., 2025); and (5) conduct community-based family engagement programmes challenging mathematics gender stereotypes (Kariveliparambil et al., 2026a; Meena et al., 2025).

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