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Reimagining Educational Leadership for Gender Equity: A Gender-Transformative Framework to Advance Girls in STEM Education in Nyagatare District, Rwanda

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Abstract
Persistent gender disparities in Science, Technology, Engineering, and Mathematics (STEM) education reflect deeply rooted structural, cultural, and psychological barriers. This study investigates these dynamics in Nyagatare District, Rwanda, using a sequential explanatory mixed-methods design. Guided by Critical Feminist Theory, Social Cognitive Theory, Stereotype Threat, Role Congruity, Expectancy–Value, and Social Constructivist perspectives, data were collected from 322 students and 109 teachers through surveys, complemented by focus groups and interviews with parents, school leaders, and education officers. Quantitative analyses revealed significant associations between gender perceptions, career guidance, parental support, and exposure to inclusive role models ($p < 0.05$). Thematic analysis highlighted persistent socio-cultural norms, institutional inertia, and internalised stereotypes limiting girls' STEM participation. Findings informed the development of the Gender-Transformative Educational Leadership for STEM (GTELS) framework, integrating leadership, pedagogy, and community engagement to guide culturally responsive, systemic interventions. Complemented by the Hills of Equity model, GTELS operationalises pathways from structural reforms and social norm shifts to sustained STEM engagement, emphasising mentorship, visible female role models, and evidence-based leadership strategies. This study contributes theoretically by synthesising multiple frameworks into a coherent model and practically by providing actionable strategies for policymakers, school leaders, and educators. While contextually grounded in Rwanda, GTELS offers a transferable, scalable approach for advancing gender equity in STEM education across Sub-Saharan Africa, positioning girls as emerging innovators and leaders in the 21st century.

Introduction

Gender disparities in Science, Technology, Engineering, and Mathematics (STEM) remain among the most persistent inequities in global education. Women account for only one-third of researchers worldwide, and their underrepresentation in leadership and advanced technical roles limits inclusive participation in the knowledge economy (UNESCO, 2023). These disparities are reinforced by socio-cultural norms, stereotypes, limited mentorship, and structural barriers that constrain girls' persistence in STEM education and careers (Dasgupta & Stout, 2021; Steele & Aronson, 1995). Across Sub-Saharan Africa, a paradox of progress is evident. While gender parity has been largely achieved at primary levels, gaps widen in higher education and advanced STEM disciplines. Rural regions face compounded disadvantages due to infrastructural deficits, digital exclusion, and entrenched ideologies framing STEM as male-dominated (African Union, 2021; Wang, Degol, & Ye, 2022).

Rwanda exemplifies this paradox. Anchored in frameworks such as the Girls' Education Policy (2008), the Education Sector Strategic Plan (2018–2024), and Vision 2050, the country has achieved measurable gender equity reforms (Government of Rwanda, 2020; MINEDUC, 2018–2024). Nevertheless, persistent challenges remain. Female lower-secondary enrolment increased marginally from 54.1% in 2020/21 to 54.6% in 2022/23, while women's participation in Technical and Vocational Education and Training (TVET) declined from 46.7% to 43.4%. Digital literacy remains markedly lower among women (9.6%) than men (14.7%) (NISR, 2024).

Nyagatare District, Rwanda's largest agrarian hub, provides a revealing case. Despite hosting 234 secondary and vocational schools and emerging TVET colleges, the net secondary attendance rate remains low at 18.6%, with girls slightly advantaged at 20.8% versus boys at 16.4% (RPHC5, 2022; Official Gazette, 2024). Girls encounter intersecting constraints, including entrenched stereotypes, scarce career guidance, and a lack of visible role models, all of which shape STEM enrolment and long-term aspirations (Nzabonimpa & Jackson, 2022; Uzabakiriho et al., 2025).

This study interrogates how gender biases and stereotypes manifest within Nyagatare's school communities and their impact on girls' participation and aspirations in STEM. It examines how parents, teachers, headteachers, and educational leaders either reinforce or disrupt these patterns and seeks to advance leadership-driven, community-anchored interventions capable of dismantling structural and psychosocial barriers.

Conceptual and Theoretical Framework

The study is anchored in a robust, interlocking theoretical architecture. Critical Feminist Theory illuminates how structural inequities and power relations shape outcomes (Hooks, 2021). Social Cognitive Theory explains the influence of self-efficacy, role models, and observational learning on STEM persistence (Bandura, 1997; Master et al., 2022). Social Constructivist Theory emphasises how gendered learning identities are socially produced through interaction (Vygotsky, 1978; Kumpulainen & Wray, 2021). Complementary frameworks, including Stereotype Threat and Role Congruity theories, highlight how environmental cues and leadership norms affect participation (Steele & Aronson, 1995; Eagly & Diekman, 2005), while Expectancy–Value Theory foregrounds motivation and perceived utility as central to persistence (Eccles & Wigfield, 2020; Wang et al., 2022).

Building on these theoretical foundations, this study introduces three synergistic models that collectively offer a groundbreaking framework for advancing gender equity in STEM. The Gender-Responsive STEM Equity Model (GRSEM) (Uzabakiriho, Gaparayi, Ndayambaje, & Tukahabwa, 2025) positions school–community perceptions as critical mediators, elucidating how stereotypes are translated into barriers that shape girls' participation in STEM. The Gender-Transformative Educational Leadership in STEM (GTELS) framework conceptualises leadership as a strategic catalyst, capable of dismantling structural and cultural constraints, reshaping perceptions, and fostering inclusive, high-performing educational ecosystems. Complementing these, the Hills of Equity model visualises the complex structural, relational, and behavioural obstacles as "hills" that girls must navigate, offering a dynamic blueprint for targeted, evidence-based interventions that flatten these barriers and sustain equitable engagement. Together, these models advance an unprecedented, integrated approach that bridges theory, leadership practice, and actionable strategies, positioning this study as a globally relevant and transformative contribution to gender-responsive STEM education.

Collectively, these frameworks provide a comprehensive explanatory and practical blueprint for transforming STEM education in rural African contexts, offering both theoretical innovation and actionable strategies to advance gender equity in science and technology.

Method

Research Design and Paradigm

This study used a sequential explanatory mixed-methods design to explore gender biases and stereotypes affecting STEM participation in Rwandan secondary and TVET schools. Guided by a Social Constructivist paradigm and interpretivist epistemology, it combined large-scale quantitative surveys with in-depth qualitative inquiry, allowing statistical rigour to inform contextual understanding. The methodology was theoretically anchored in Critical Feminist Theory, Social Cognitive Theory, Social Constructivism, Stereotype Threat, Role Congruity, and Expectancy–Value Theory, collectively shaping the development of the **GTELS** and **Hills of Equity** frameworks. This approach enabled a nuanced, evidence-based understanding of systemic and cultural barriers in STEM education.

Study Area

The research was conducted in Nyagatare District, Rwanda's largest agrarian hub. The site was purposively chosen for its socio-cultural diversity, geographic variation, and the coexistence of General Education and TVET schools. Its urban, peri-urban, and rural settings provided a microcosm of national gender dynamics in STEM and aligned with Rwanda's Education Sector Strategic Plan (2020/21–2024/25), which prioritises gender-inclusive STEM leadership (MINEDUC, 2021).

Study Population

The population included Senior 4–6 students, Levels 3–5 TVET trainees, STEM subject teachers (Mathematics, Physics, Chemistry, Biology, ICT, and TVET fields), headteachers, SGAC parents, Sector Education Inspectors (SEIs), and the District Education Officer (DEO/STVET). Eligibility required a minimum of one year of active STEM engagement; individuals with limited exposure were excluded to ensure informed perspectives.

Sample Size and Sampling

Purposive sampling (Patton, 2002) targeted participants directly engaged in STEM teaching, learning, or leadership. The quantitative strand involved 322 students and 109 teachers. Sample sizes were determined using Cochran's formula (1977), achieving a 95% confidence level and 5% margin of error, ensuring sufficient power for chi-square and correlation analyses (Cohen, 1988). The qualitative strand engaged 34 information-rich participants (12 headteachers, 10 SEIs, 11 SGAC parents, and one DEO/STVET) across 33 schools (15 General Education and 18 TVET). This ensured gender balance, institutional diversity, and representativeness of leadership roles.

Data Collection

Quantitative data were collected through structured Likert-scale surveys. Items were measured on a five-point scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree), covering gender biases, leadership responsiveness, school–community perceptions, participation rates, and barriers to STEM achievement. Pilot testing in Gatsibo District yielded a Cronbach's α of 0.935, indicating high reliability. Content validity was ensured through expert review, construct validity via factor alignment with theoretical models, and methodological validity through triangulation.

Qualitative data were collected through semi-structured interviews and focus groups that probed socio-cultural norms, leadership practices, and institutional barriers. Sessions were audio-recorded, transcribed verbatim, and translated where necessary to preserve contextual meaning.

Data Analysis

Quantitative data were analysed using SPSS v21. Descriptive statistics summarised demographic characteristics and survey distributions. Chi-square tests assessed associations between categorical variables such as gender and STEM subject choice, with Phi and Cramér's V quantifying effect sizes. Spearman's rank-order correlation tested ordinal relationships among Likert-scale responses (Field, 2018). Qualitative data underwent inductive thematic analysis (Braun & Clarke, 2006), with coding guided by GTELS and Hills of Equity frameworks. Themes and sub-themes were refined through cross-case comparisons, and triangulation of sources enhanced validity. Integration of quantitative and qualitative results clarified how gender biases, school–community dynamics, and leadership practices intersect to shape STEM participation.

Ethical Considerations

Ethical clearance was granted by the University of Rwanda's Institutional Review Board on 8 March 2024). Participation was voluntary. Informed consent was obtained from adult participants, while parental consent and student assent were secured for minors. Participants were briefed on study objectives, confidentiality, and withdrawal rights. All data were anonymised, securely stored, and reported using pseudonyms. The study adhered strictly to the Belmont principles of respect, beneficence, and justice (Riddle, 2025).

Results

This study presents an integrated analysis of gender biases in STEM education within Nyagatare District's secondary schools, based on 431 students and teachers (n = 431). Gender biases were observed across institutional discouragement, classroom dynamics, leadership opportunities, and social interactions. Findings are interpreted through five interlocking theoretical lenses—Critical Feminist Theory, Social Cognitive Theory, Social Constructivist Theory, Stereotype Threat & Role Congruity, and Expectancy–Value Theory—providing a robust conceptual and empirical foundation for understanding systemic inequities (Hooks, 2021; Bandura, 1986; Vygotsky, 1978; Steele & Aronson, 1995; Eccles & Wigfield, 2020).

The conceptual scaffolding integrates the Gender-Transformative Educational Leadership for STEM (GTELS) model with the Hills of Equity framework. GTELS (Figure 1) articulates how leadership-driven, gender-responsive interventions interact across structural, relational, and behavioural layers to foster girls' STEM participation. The Hills of Equity (Figure 2) provides a sequential roadmap: foundational systemic reforms precede social norm shifts and leadership identity development, enabling sustainable equity.

Table 1: Key Chi-Square Results for Gender Bias Variables (N = 431)

Survey Item	χ^2 (df = 8)	p-value
Awareness of discouragement of girls in STEM	8.793	0.36
Support for girls' extracurricular STEM	12.287	0.139
Boys receiving preferential attention	8.711	0.367
Girls underestimated in STEM classes	6.164	0.629
Girls underrepresented in STEM leadership	21.108	0.007
Girls mocked or criticised by peers	6.237	0.621
Teacher favouritism toward male students	10.952	0.204
Discouragement from STEM competitions	16.72	0.033
Discouragement from STEM careers	12.57	0.128
Exclusion from STEM projects	12.315	0.138

Table 1 highlights systemic gender bias in STEM pathways. Significant disparities emerged in girls' underrepresentation in leadership (p = 0.007) and discouragement from competitions (p = 0.033), while other indicators, though not statistically significant, reveal widespread awareness of inequities across the learning ecosystem.

Perceptions of Gendered Barriers and Supports in STEM

Table 2: Perceptions of Gendered Barriers and Supports in STEM by Awareness Level (N = 431)

Factor	Not at all / Strongly Discouraged	Slightly Aware	Moderately Aware	Very Aware	Extremely Aware / Strongly Encouraged
Discouragement in STEM	22	23.4	25.5	20.2	8.8
Support for Extracurriculars	22.5	18.1	28.1	23.4	7.9
Boys Favoured	24.1	20.2	30.6	17.6	7.4
Girls Underestimated	19.3	20.6	27.6	23.4	9
Leadership Gaps	32	14.4	8.8	27.6	17.2
Competition Discouragement	11.6	11.4	23.4	29	24.6
Career Discouragement	13.9	9.7	26.2	29	21.1
Gender Encouragement	7	16.7	29.9	30.4	16
Equal Teacher Treatment	3	6.3	21.6	31.3	37.8
Resource Provision	2.6	8.8	25.3	26.5	36.9
Positive STEM Atmosphere	2.1	9.5	21.1	29.2	38.1

Table 2 consolidates Likert-scale patterns across all domains—awareness, classroom dynamics, leadership, competition, careers, and school climate—into a single comparative matrix. Results reveal systemic inequities: over 60% report moderate-to-high awareness of discouragement, underestimation, and competition/career barriers. Conversely, teacher fairness, resource provision, and positive school climate are strongly recognised (≥ 65%). This juxtaposition highlights the paradox of structural support coexisting with entrenched cultural and psychosocial barriers, demanding integrated reforms at policy, pedagogical, and community levels.

Table 3: Gendered Pathways in STEM: Mapping Exclusion Across Leadership, Competitions, Careers, and Classrooms (N = 431)

Awareness Level	Leadership Exclusion (%)	Mocked for STEM Ability (%)	Discouraged from Competitions (%)	Discouraged from STEM Careers (%)	Excluded from Projects (%)
Not at all aware	18.1	22.7	23.9	24.6	25.5
Slightly aware	20.4	18.6	18.8	16.7	18.1
Moderately aware	26	24.1	23	23	26.5
Very aware	23.9	21.3	19.5	23.9	17.4
Extremely aware	11.6	13.2	14.8	11.8	12.5
Total	100	100	100	100	100

This table synthesises respondents' awareness of five critical dimensions of gender bias in STEM education—leadership exclusion, ridicule for STEM ability, discouragement from competitions and careers, and exclusion from projects. The data reveal intersecting patterns of structural and psychosocial marginalisation, underscoring the urgent need for transformative leadership, inclusive pedagogy, and equity-driven reform.

Toward Deeper Insight: Bridging Quantitative Patterns with Lived Experiences in STEM Gender Equity

The quantitative findings reveal persistent gender biases affecting students' STEM choices, classroom dynamics, leadership opportunities, and extracurricular involvement in Nyagatare District (n=431), with female respondents particularly aware of leadership and competition barriers. These patterns align with Social Cognitive Theory (Bandura, 1986), Critical Feminist Theory (hooks, 2000), and Social Constructivist Theory (Vygotsky, 1978), highlighting the complexity of systemic inequities. The mixed awareness and uneven support emphasise the need for multi-stakeholder, evidence-based strategies including teacher training, gender-responsive leadership, parental engagement, and policy reforms (UNESCO, 2021; Wang et al., 2022). The following qualitative data will complement these findings by providing deeper insights into lived experiences and community perspectives, enriching the overall understanding of gender equity in STEM education.

Qualitative Results

The qualitative findings deepen the understanding of gender equity in STEM education across Nyagatare District, complementing the quantitative analyses by giving voice to lived experiences, daily practices, and the subtle ways biases shape opportunities. While quantitative trends highlighted persistent gender gaps in subject selection, leadership roles, and extracurricular participation, the narratives here illuminate how these patterns unfold within schools, families, and communities.

Baseline Terrain: Structural Barriers and Policy Alignment

Across multiple schools, girls described a pervasive sense of fear and self-doubt in approaching STEM subjects. One participant simply said,

"*Girls are most afraid to join STEM.*" (KII-DEDU001)

This anxiety reflects how deeply internalised beliefs intersect with structural constraints, echoing GTELS's premise that personal and systemic factors jointly limit girls' participation. Many students admitted to avoiding science or mathematics despite genuine interest, citing societal pressures to conform to gendered norms favouring humanities and languages.

Teachers and educational leaders reported that policies promoting gender equity were unevenly implemented. Outdated laboratories, scarce teaching materials, and limited monitoring of gender-sensitive initiatives created a challenging learning environment. In GTELS's "Hills of Equity" metaphor, these structural weaknesses form the foundational layer: without solid base-level support, interventions aimed at higher-level cultural or leadership change struggle to gain traction.

Where leadership actively embraced gender-responsive approaches, schools reported positive shifts. Leaders secured resources, enforced equity standards, and modelled inclusive behaviours. Yet these schools were the exception rather than the rule, highlighting how critical institutional commitment is to alter the landscape for girls in STEM.

Social Modelling and Climate: Teacher Practice and Curriculum

Teachers' attitudes and curriculum design emerged as decisive factors shaping girls' engagement in STEM. Several participants emphasised the need for professional development that addresses unconscious bias and fosters gender-sensitive pedagogy:

"*Professional development is necessary to understand how bias affects teaching STEM subjects.*" (KII-ST015)
"*Teachers need training to ensure girls are equally encouraged to participate in science and technology.*" (KII-ST016)

Observations revealed that teachers who deliberately countered stereotypes—by highlighting female scientists, rotating leadership roles in group work, and ensuring equitable classroom participation—saw higher engagement from girls.

Curriculum representation also mattered. Respondents highlighted the importance of integrating gender equity into the content, rather than treating it as a peripheral issue. Textbooks, examples, and assessments that balanced male and female representation were seen as critical, but barriers included insufficient training, limited resources, and resistance from peers. Without strong leadership support and aligned budgets, teachers noted, reforms often remained symbolic.

Institutional Efforts and Ongoing Challenges

The presence or absence of active leadership directly shaped girls' experiences in STEM. Headteachers and education officers who championed equity reported measurable increases in female participation. In contrast, in schools with passive leadership, traditional gendered patterns persisted: boys dominated physics, computing, and math tracks, while girls were steered toward literature and languages.

Several participants described these expectations as "just the way things are," underscoring the cultural embeddedness of inequities. These narratives illustrate how structural and normative barriers intertwine, shaping what students see as possible or acceptable.

Community and Extracurricular Engagement

Families and local communities played a profound role in reinforcing—or challenging—gendered pathways. Many parents, even with good intentions, discouraged girls from pursuing "hard" STEM subjects, citing concerns over workload, marriage prospects, or employment outcomes. Religious norms, peer influence, and community expectations further shaped these choices.

Yet, where schools actively partnered with parents, faith leaders, and local organisations, participants described encouraging results. STEM clubs, mentorship programmes with female professionals, and parental workshops provided girls with practical guidance and aspirational role models. One participant explained,

"*The community is the first to shift its mindset regarding gender stereotypes; it directly affects how children perceive STEM.*" (KII-TC018)

Mentorship and counselling initiatives also played a key role:

"*Counselling and mentorship initiatives in schools can help students navigate gender biases.*" (KII-TC020) "*Engaging religious and community leaders in advocating for gender equity will drive societal change.*" (KII-TC021)

These narratives highlight how social environments—beyond the classroom—actively shape STEM trajectories for girls.

Early Outcomes from GTELS-Informed Interventions
Pilot programmes guided by GTELS principles revealed early signs of progress. Teachers reported improved classroom participation among girls, more equitable group work, and reduced stereotyping in subject selection. Leadership training fostered accountability, while curricula began reflecting gender balance in examples and assignments. Community engagement further reinforced these shifts by aligning home and school expectations.

Impact of Biases on Academic and Career Pathways
Persistent biases extended beyond classroom participation, influencing retention and long-term career trajectories. Several headteachers noted:

"*STEM retention rates are lower for girls due to societal and self-imposed limitations.*" (KII-HT001) "*Female students tend to withdraw from STEM subjects when faced with academic challenges.*" (KII-HT001)

Similarly, biases shaped career aspirations:

"*Gender biases discourage girls from pursuing STEM careers, reducing female participation in scientific fields.*" (KII-HT002). "*A student raised to believe they cannot succeed in STEM will lack confidence and choose other subjects.*" (KII-HT006). These accounts underscore how social expectations, internalised beliefs, and institutional constraints collectively limit opportunities for girls beyond schooling.

Role of School Leadership and Institutional Support
Education leaders emerged as central actors in shaping equitable learning environments. Their influence was visible in both formal initiatives and daily interactions:

"*School leadership plays a crucial role in changing gender perceptions by engaging students in STEM discussions.*" (KII-HT002). "*As a school leader, I emphasise the importance of STEM and encourage both boys and girls to engage in these subjects.*" (KII-HT006)

Inclusive practices, such as gender clubs and policies promoting equal participation, helped normalise equitable treatment: "*The school treats all children equally, allowing both boys and girls to express themselves without issue.*" (KII-HT009). "*We have gender clubs that facilitate discussions around equality and encourage diverse participation in all subjects.*" (KII-HT010)

Strategies for Gender-Inclusive STEM Education
Informants repeatedly emphasised mentorship, role models, and targeted support for girls:

"*Schools should implement mentorship programmes where successful female STEM professionals inspire and guide students.*" (KII-HT001). "*Increasing the visibility of successful women in STEM careers can inspire young girls and challenge existing stereotypes.*" (KII-HT008)

Leadership's role remained critical: "*The HT's guidance and support contribute much to giving courage to join STEM.*" (KII-DEDU001)

"*School leadership is key. Creating female-friendly spaces has proven effective in encouraging girls to stay engaged in STEM subjects.*" (KII-SEI008)

Engaging parents and communities was also essential: "*Parents must be actively involved in changing narratives around girls and STEM.*" (KII-SEI002)

"*When parents understand that girls can excel in STEM, they start encouraging them more.*" (KII-SECM2005)

These narratives collectively reveal the interplay of structural, instructional, community, and leadership factors in shaping girls' STEM experiences. They illustrate that while challenges remain, targeted interventions guided by GTELS principles show promise in transforming opportunities and perceptions.

Discussion

Structural and Cultural Influences on Gender Equity

This study confirms that gender biases in STEM are deeply embedded within structural and cultural contexts in Nyagatare District, with broader resonance across Rwanda and Sub-Saharan Africa. Variations in leadership representation, access to competitions, and resource distribution reflect the interaction between systemic inequities and school–community perceptions (SCP), as conceptualised in the Gender-Responsive STEM Equity Model (GRSEM). Leadership visibility, allocation of resources, and prevailing social norms shaped both the manifestation and perception of biases, emphasising that interventions must be context-sensitive rather than uniform (Spencer et al., 2016; Sommer et al., 2018). These findings align with regional evidence highlighting the catalytic role of female role models and community endorsement in fostering rural STEM engagement (DeJaeghere & Wiger, 2013; Morrell et al., 2020).

Awareness versus Action: Bridging the Knowledge Gap

High awareness of gendered barriers did not consistently translate into equitable practices or leadership opportunities, highlighting a knowledge-to-action gap (Fullan, 2016). Social Cognitive Theory posits that observational learning and self-efficacy development require visible female leaders, mentorship, and reinforced expectancy beliefs (Bandura, 1997). Qualitative narratives illustrated that without structured interventions—such as teacher training, leadership engagement, and community involvement—awareness alone is insufficient to drive meaningful change (KII-DEDU001; KII-ST015; KII-ST016; Biraimah, 2016; Mukamana & Habimana, 2020).

Mentorship, Role Models, and Leadership as Catalysts

Evidence from quantitative and qualitative analyses underscores the transformative potential of mentorship, visible female role models, and leadership engagement. Within the GRSEM and GTELS frameworks, these factors function as evidence-based interventions (EBIs), whose effectiveness increases when mediated by SCP. GTELS-informed initiatives in Nyagatare enhanced female participation, equitable classroom interactions, and reduced stereotyping, illustrating how leadership-driven interventions can "flatten the Hills of Equity" (Figure 8) and link systemic reforms to lived experiences. These findings correspond with regional studies demonstrating that structured mentorship and female visibility sustain girls' STEM pathways (Johnson et al., 2022; Mlambo & Adetunji, 2021).

Interplay of Structural Support and Psychosocial Barriers

Even in settings with strong leadership and adequate resources, cultural expectations, peer norms, and internalised beliefs constrained girls' STEM choices and career trajectories. These patterns align with the Social Constructivist perspective, which emphasises that learning is shaped by social interactions and internalised societal norms (Vygotsky, 1978). Effective interventions, therefore, must operate across multiple levels—policy, school leadership, classroom practices, peer culture, and community norms—to ensure sustainable equity (UNESCO, 2021; Wang et al., 2022). This study illustrates how independent variables (school–community networks), mediators (perception-shaping mechanisms), catalytic leadership interventions, and dependent outcomes (systemic reforms) interact dynamically. The integration of GRSEM, GTELS, and the Hills of Equity operationalises culturally responsive, evidence-based strategies for dismantling stereotypes, promoting sustained gender equity, and creating adaptable entry points for policy, practice, and research.

GTSEM cycle: Implications for policy, practice, and scalability

Grounded in empirical evidence from Nyagatare, the GTSEM Cycle (Figure 1) synthesises GRSEM, GTELS, and the Hills of Equity into a multidimensional, leadership-driven framework for systemic transformation in STEM education. It illustrates how school–community networks interact with perception-shaping mechanisms and catalytic leadership interventions to dismantle gendered stereotypes and sustain equity. For policymakers, the model aligns local realities with continental and global gender equity agendas. For practitioners, it identifies actionable strategies—community mobilisation, leadership development, and institutional reform. For researchers, the GTSEM Cycle offers a replicable conceptual framework bridging theory and practice, contributing to the advancement of gender-responsive educational leadership in Rwanda and across Sub-Saharan Africa.

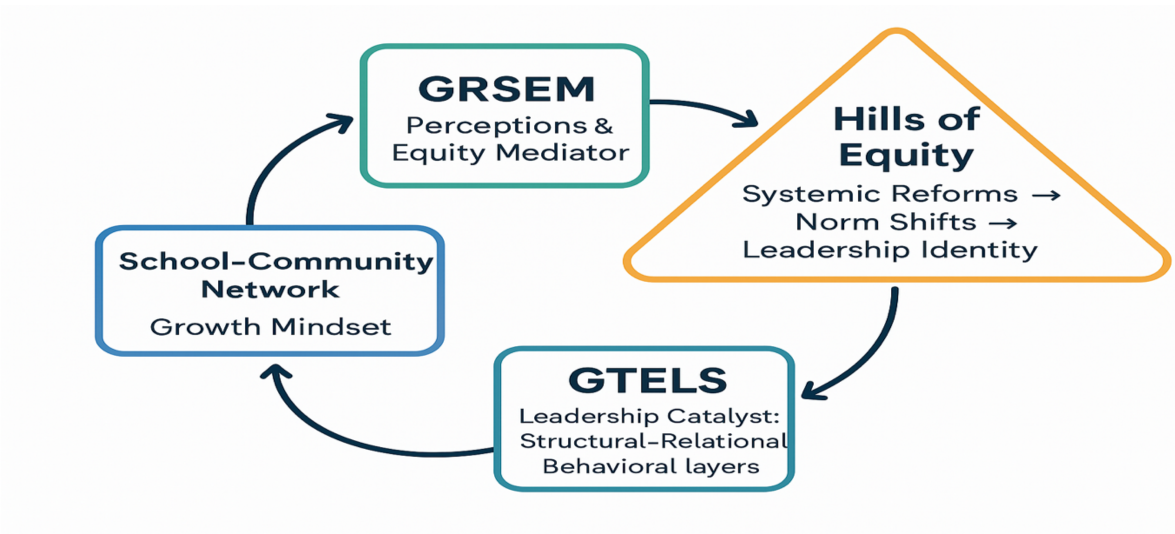

Figure 1. The GTSEM Cycle integrates the school–Community Network, GRSEM, GTELS, and the Hills of Equity into a dynamic pathway of gender-transformative leadership in STEM. This framework empirically illustrates how community perceptions, catalytic leadership, and systemic reforms interact as independent, mediating, and dependent variables to dismantle stereotypes and enable sustainable gender equity in STEM education.

Conclusion

This study highlights persistent structural, cultural, and pedagogical barriers limiting girls' participation in STEM education in Nyagatare District, with relevance across Sub-Saharan Africa. Gendered stereotypes, unequal classroom practices, and limited access to mentorship were identified as key constraints. Leadership-driven, community-anchored interventions guided by the **GTELS** framework demonstrated potential to reshape perceptions, transform classroom dynamics, and create equitable opportunities for all students, showing that systemic change is achievable when leadership, pedagogy, and community engagement are strategically aligned.

Theoretically, this research synthesises Critical Feminist Theory, Social Cognitive Theory, Stereotype Threat, Role Congruity, Expectancy–Value, and Social Constructivist perspectives into a coherent interpretive framework. The **GTELS** and Hills of Equity models provide empirically validated, context-sensitive tools to recalibrate socio-cultural norms and challenge entrenched stereotypes, offering a roadmap for culturally responsive, equity-driven STEM reform.

Practically, sustainable transformation requires embedding gender-responsive pedagogy, strengthening STEM clubs, expanding mentorship pipelines, and mobilising inclusive community engagement. School leaders and education officers play a central role in institutionalising these practices in scalable, contextually relevant ways.

Although limited by its single-district, cross-sectional design, the study provides a foundation for future research exploring scalability, intersectional factors such as disability and socioeconomic disparities, and the use of digital platforms to expand mentorship access.

In conclusion, girls in STEM are emerging innovators and leaders. Policymakers and practitioners should integrate GTELS principles into national frameworks, institutionalise equity audits, expand mentorship and STEM programmes, enhance teacher training, mobilise school–community partnerships, and invest in digital solutions. These strategies position gender equity in STEM as both an educational imperative and a catalyst for social transformation across Rwanda and Sub-Saharan Africa.

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