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# BRIDGING THE GENDER GAP IN STEM: ASSESSING POLICY INTERVENTIONS AND EDUCATIONAL REFORMS IN DEVELOPING COUNTRIES (2010–2025)

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**ABSTRACT:** There have been global strides in science and technology but the gap in STEM, especially prevalent in developing countries, still prevails—a fact every-next post structural inequalities, cultural barriers and policy inefficiencies prevent more women from entering the field. The global frameworks and national processes have sought to address these disparities, the trajectory of change has been disjunctive, generally fragile and with significant regional variation. This paper seeks to evaluate the efficacy of policy interventions and educational reforms in reducing STEM gender gap within a set of developing countries. A mixed-methods study that combines global gender-STEM indicators (2010–2025) of students with quantitative analysis is linked to and informed by a qualitative research component that includes document reviews, case studies in Nigeria, India, Kenya, Bangladesh, and Colombia as well as interviews with stakeholders of the education sector. The evidence indicates that while enrolment and retention of women in STEM has increased in some contexts as a result of specific policy targeting , there remain systemic issues to be tackled. Such factors include socio-cultural stereotypes, poor monitoring systems and visibility of women. Enabling environments were stronger when reforms sat at the intersection of local normative expectations and global benchmarks. The paper makes useful inputs to educational planning and gender equity dialogue, underscoring the urgency of measures that are multi-component and contextually relevant. It also presents a model for future reform and stakeholder collaboration in STEM equity.

**Keywords:** STEM education, gender equality, policy reform, developing countries, educational equity, women in science, inclusion.

## I. INTRODUCTION

Despite having made vast contributions to global economies and societies, women are four times more likely to drop out of STEM fields than men. However an increasing number of women remember past generations and to increase awareness on the importance of gender equality at school level, where there are still active believes that Science is a man thing. Available data from UNESCO (2021) show that this share is only 35% globally with lower percentages observed in those studied regions sub-Saharan Africa, South Asia and Latin America. Cultural Stereotyping, poor educational access, inadequate role models and poor policy implementation continue to be a challenge for improved female inclusion in STEM, particularly in Engineering, Information Technology and Physical Sciences in the developing world (Akinola & Olayanju 2022; Okeke 2021).

While governments and international bodies have introduced numerous reforms to tackle this gender imbalance, the path-breaking policies are neither consistent nor sustainable. While educational reforms have brought about gender-sensitive curricula, scholarship schemes, and mentorship programs, the filings enrollment of girls in STEM are still low in many regions (Mlambo & Mabokela, 2020). Structural inequalities, such as gendered labor markets and the continued pervasiveness of patriarchal norms, are also still managing to cancel out many of these policy successes. Some well-intentioned reforms achieve little in poor outcomes, based on socio-cultural expectations such as the idea that girls can not have a "non-traditional" career regardless of how they are developed (Abubakar & Lawal, 2023). Therefore, the real challenge is not to design intervention but to make them contextually applicable at scale in the long run.

The study is conceived as a necessity to critically evaluate policies and educational reforms that are pursued between 2010 and 2025 in order to counteract the gender deficit in STEM fields in developing countries. The primary goal is to evaluate the effectiveness of major policies and reforms designed to promote gender equity in STEM education and employment. This is especially in relation to what interventions have proven more/less effective, and the sustained barriers and enablers of female participation in STEM. In this analysis, Miklavz will consider macro-level policy frameworks and micro-level educational practices to produce a more complex understanding of what incentivizes or discourages change.

To help answer these questions, the report focuses on two broad research questions: What policies have been most effective in increasing STEM participation among girls in developing countries? But what is it like for women studying STEM subjects in these areas? Integrating quantitative trends in STEM enrollment and attainment with qualitative insights from stakeholders—especially students, educators, and policy makers—the study will produce a comprehensive evaluation of how policies influence socio-cultural dynamics as well as their impact in practice.

This study is limited in time to the period between 2010 and 2025 and region-specific studies within developing countries across Africa, Asia, and Latin America. The focus will be on STEM subjects with low levels of female enrolment in the past (e.g. engineering, computer science and physics). The study will also examine age cohorts of students within secondary and tertiary institutions before transitioning back first to avoiding paternalistic interventions, and finally not intimating we intervene at all early leads to longer-term aged-storylines.

This research holds significant implications for multiple stakeholders.It gives policymakers a rigorous set of recommendations based on evidence to better target, or reframe, national policies for increasing representation of women in STEM. These findings point out reforms in pedagogy and institutional support that educators and curriculum designers are called on to institute in order to compliment the learning of all students. Lastly, the study provides information to development institutions and international donors about scalable and context-specific interventions that can be integrated into wider gender and education frameworks. This way, it builds towards the collective global efforts of advancing Sustainable Development Goals (SDG), specifically SDG 4 on quality education and SDG 5 centered around gender equality, changing the STEM engagement scenario within developing areas (United Nations, 2022; Kanyongo & Osei, 2021).

## II. LITERATURE REVIEW

### 2.1 Conceptual Framework

#### 2.1.1 The Gender Gap in STEM: Global vs. Local Patterns

The gender gap in STEM fields indicates a cultural issue both developed and developing nations share, although its magnitude as well origin is peculiar to each. High-income countries have made little progress in narrowing the gender gaps in STEM employment rates, while low- and middle-income countries remain close to parity. Globally, women make up only 28% of the workforce in science and engineering, with significantly lower proportions in engineering (16%) and information technology (10%) (UNESCO, 2021). In many cases, women are underrepresented in STEM disciplines by virtue of the fact that historically their involvement has been limited (Kabeer et al., 2021; Okafor & Akinwale, 2022) and thus this predicament primarily affects developing countries such as sub-Saharan Africa and some parts of South Asia where structural disparities often exist and where socio-cultural expectations can dictate gender role stereotyping.

Local trends are often manifestations of deep-seated inequalities at an early age which dissuade girls from becoming interested in science-oriented subjects. Data show that in Nigeria, India and Ethiopia curve out from STEM pathways during secondary education with many having the disadvantage of societal norms and dysfunctional institutional arrangements(Ukwuoma, 2022). Regional disparities in terms of quality education, access to female role models in STEM, and institutional readiness for gender-inclusive policies magnify the stressor.

#### 2.1.2 Policy Landscape: Global Benchmarks and Local Interventions

Global agencies like UNESCO and UN Women have been leading the way by providing frameworks, policy guidelines, and capacity-building to tackle this gender disparity in STEM. The project UNESCO STEM and Gender Advancement (SAGA), on the other hand, offers a full analysis methodology for gender gaps in science, technology and innovation between countries (UNESCO, 2021). UN Women (2022) further reiterates synergies for gender-responsive budgeting, affirmative actions policies and mechanisms of accountability to enhance women's inclusion in STEM.

At national level, many developing countries have reacted with a series of measures. For instance, the Ministry of Education in Kenya issued a “STEM for Girls” policy targetting its Vision 2030 approach and has been following up by implementing the National Education Policy 2019 focussing on gender equality in science education specifically mathematics (Hasan & Kabir, 2023). However, these responses are typically local in nature and as such are often hindered by issues related to sustaining the response, political will, financing, and institutional coherence (Nnaji & Umezinwa, 2021). In addition, the degree to which these interventions are situated within the larger educational ecosystem and social context affects policy success.

#### 2.1.3 Educational Reforms and Curriculum Changes

While governments and institutions may aim to close the gender gap in STEM, educational reform has been one of the main methods by which they make this happen. These initiatives include the adaptation of gender sensitive curricula, editing textbooks to identify women representation in science, provision of laboratories for girls' schools and offshoot programs such as mentor ship, schemes scholarships aiming to support female students- Akinola & Olayanju (2022).

In Ghana, for example, the Girls Education Unit of the Ministry of Education sponsors female secondary school students to join science camp and coding bootcamps. Moreover, India's "Kishori Shakti Yojana" encourages STEM capacity-building for adolescent girls with the help of non-formal way of education (Sharma & Bhatia, 2020). Notwithstanding this concerted effort, research suggests that curtailing an educational program to an easier one without contextualization of appropriate content knowledge, teaching pedagogy and classroom involvement may have only a temporary impact (Mlambo & Mabokela, 2020).

#### 2.1.4 Barriers to Female Participation in STEM

Even as an increasing number of policy interventions and educational reforms have been made, multiple constraints have been observed vis-à-vis female participation in STEM in developing countries. These include the social, cultural and societal standards that often shape society into believing that certain subjects or careers are more suitable for boys than girls. Meanwhile, in many settings STEM is still seen as masculine,and girls are socialized away from technical or mathematical subjects (Abubakar & Lawal, 2023).

And it does nothing help that the women role models in STEM education and industry are sorely lacking. Many young girls cannot see themselves succeeding in the STEM field due to visibility of success stories are few likely leading to self-dought, and hence a limitation (Chikwere& Arowolo, 2021). Institutional biases also survive, such as a school environment indifferent to gender issues, lower levels of teacher expectation directed toward female students, and biased hiring in STEM industries (Makinde & Kanyongo, 2022).

Research also shows the compounding effects of gender inequality across intersectional identities such as poverty, rural residence, disability and ethnicity — with an increased gender gap for even more marginalised girls that face further exclusion (Tadesse & Wondimu, 2022). While these facts may appear to demand a more intersectional, context-specific and justice-oriented approach to policy as well as educational reform.

### 2.2 Theoretical Review

The persistent gender disparity in STEM education and careers can be more comprehensively understood through a multi-theoretical lens that captures both structural and agency-related dynamics.As we try to understand this issue in all the intricate details, a few frameworks are emerging as relevant for microsocial development interventions — Social Role Theory, Feminist Institutionalism, and Capability Approach — that interrelate gender roles and institutional norms with individual agency.

For example, in social role theory, advanced by Eagly and Wood (2012), it is believed that socially derived expectations about appropriate behavior for men and women primarily account for gender differences in occupational roles such as the low representation of women in STEM fields. Traditional gender socialization processes that hesitant to send all of the lady with the communal roles, for instance caregiving and teaching, as opposed towards the agentic roles of leadership and science engines reinforce these expectations. Gender roles, as social construct, are persisting in many developing countries and are usually propagated by family, religion and media that consequently affects the educational decisions and career aspirations of girls at an early age (Udegbe & Owolabi, 2020). The ongoing stereotype of STEM as the realm of males perpetuates stereotype threats, self-departure from science careers and relative paucity in parental or institutional backing for when girls show preference to these disciplines (Okeke & Aina, 2021).

Feminist Institutionalism contributes to this understanding by investigating how institutional structures (whether formal — laws, policies, educational systems; or informal — norms, practices, organizational cultures) embed gendered power relations that privilege men and disadvantage women. The theory posits that institutions are not gender-neutral, but rather informed by masculinist norms and logics which materialise in male-dominated STEM facumatlties, curricula that is steeped in men-and-masculinity bias and the consistently weak evaluation of women's contributions fuelling systems of reproduction Munir & Jones (2010) as cited by Mackay et al., 2010 as well as ambivalent recruitment processes Chappell & Waylen, 2013). These institutional barriers are combined in developing countries with ineffective implementation of gender equity laws or an underfunded educational reforms and policy incoherence, thus weakening the impact of gender mainstreaming on STEM education. Feminist Institutionalism also underlines the importance of actors, e.g., female scientists, policymakers and advocacy groups to interrupt institutional inertia by navigating trough agency and strategical interaction (e.g. Tadros, 2019) thus promoting some hope for transformation when power relations within institutions are critically reflected upon and contested.

Favoring a human development perspective, the Capability Approach developed by Amartya Sen and further advanced by Martha Nussbaum hones in on the real freedoms and opportunities for men to live life according to what they value or have reason to value (Sen 1999; Nussbaum 2011). This framework therefore provides a way to move beyond access or participation of girls and women in STEM, towards a focus on empowerment; looking at whether girls and women have the substantive freedoms to choose and benefit from participating in STEM education and careers. It also seeks to bring more attention to the need to address unfreedoms such as child marriage, gender-based violence and lack of access to resources that limit girls' development potential in the world's poorest countries. It also makes the case for interventions that move beyond parity in numbers to agency, dignity and meaningful choice when moving across educational and career pathways (Unterhalter, 2020). In practice, the Capability Approach advocates policymakers to consider multiple causes of well-being and customize reforms in accordance with how women experience their lives, particularly those who are vulnerable or marginalized.

Put together, these theoretical underpinnings constitute a comprehensive and cohesive basis to study the gender gap in STEM in less industrialized countries. Social Role Theory reveals cultural expectations that lead to gendered decisions; Feminist Institutionalism shows how systemic biases and derive of institutional inertia perpetuate exclusion; the Capability Approach focuses real freedoms and agency for girls and women. The analysis is theoretically grounded in a synthesis of Feminist Institutionalism and the Capability Approach, which combined positions an institutional approach to gender analyzing as well as retain elements that identify individual agency and development outcomes. It is also capturing an approach that focuses on evaluating the impacts of policy interventions and education reforms in diverse sociopolitical but shared-in-theory contexts.

### 2.3 Empirical Framework

Over the interval 2019–2025, a considerably broader literature on gender disparities in STEM education and professional engagement in developing countries was generated as part of new empirical studies, uniquely contributing both micro- and macro-level research focusing on patterns, drivers, and outcomes of women´s underrepresentation. A gender environment framework synthesized through studies from Africa, Asia and Latin America pointed to recurring barriers that reinforce one another in the form of socio-cultural attitudes, institutional obstructionism, absence of women role models, biased teaching practises and ineffective policies which continue to sustain a gender gap in access to STEM.

Using case of Nigeria, Akinola and Olayanju (2022) found that inconsistencies across localised interventions for STEM policy implementation are inherent because despite existing national strategies, they fail to act in concert with each other at the expense of a more streamlined impact. This dovetails with findings of Mlambo & Mabokela (2020) in South Africa where despite a marked rise in women's enrolment at the tertiary level into STEM disciplines, institutional environments were still toxic places as reported high levels of academic marginalization and limited mentorship opportunities by women. Furthermore, another study by Makinde and Kanyongo (2022) investigated the differences in cultural setting among West African countries observed that negative attitude of girls to studying science are due by their country of origin and not that the girls are poor academically.

Indeed research in East Africa, like Tadesse and Wondimu (2022), highlight that barriers to STEM pathways can also be intersectional -- for example, girls in rural areas or of a particular ethnic group in Ethiopia are even more excluded due to the double marginalization of place-based and socio-cultural discrimination. Mutua and Kipruto (2020) evaluated science camps and mobile STEM labs introduced through government-sanctioned programs in Kenya and reported modest increases in awareness but minimal retention of girls into long-lasting STEM disciplines.

Sharma and Bhatia (2020), for example, conducted an evaluation of India's STEM-for-Girls initiative in South Asia and found that while outreach campaigns raised awareness, immediate engagement was counteracted by infrastructure conditions at schools and teacher attitudes as well as insufficient career counselling services at the time (p. 695). A closer look at Bangladesh's long awaited National Education Policy by Hasan and Kabir (2023) revealed that the gender equity statements are more symbolic than substantive, with minimal accountability mechanisms to enforce its provisions. Likewise, a study of pedagogical practices in public schools in Pakistan (Kaur & Kaur 2021) revealed gendered teacher expectations, which led to boys being more actively engaged in mathematics and science subjects — thus reinforcing the pattern of classroom hierarchies.

Nguyen and Tran´s (2021) case study on Vietnam refers to the neoliberal character of education development in Southeast Asia. They point out that there has been an increase in girls majoring in STEM subjects at the upper secondary level, but that they are grossly underrepresented at HEIs because of financial barriers and ideas to do with gendered employment: Similarly, in Indonesia, Surya and Hakim (2022) analyzed government-sponsored STEM scholarships for girls which expanded access, while completion rates differed due to family duties and the absence of academic support mechanisms.

Latin America is a patchwork. Torres and Ramírez 2021 in Mexico analyzed public university enrolment data to determine that there are large male-female disparities in engineering and ICT-related programs compared to other academic disciplines, even though the presence of females is relatively high. Mendes and Oliveira (2020) found longitudinal data from Brazil, showing that exposure at an early age to extracurricular science-related activities increased girls with interest in STEM fields persistence but institutional gender bias meant that they were replaced by men once they graduated from university. Díaz and Gómez (2023) likewise investigated how STEM education policy reforms in Colombia affected on the one hand equity in enrolment, which increased, but on the other learning outcomes and transition to STEM careers, which continued to lack equity, with particularly detrimental effects for Afro-Colombian and Indigenous girls.

Cross-national studies Country comparisons also provide valuable new insights. Kabeer et al. Theoretical and empirical work by Nikaw Tye (2021), drawing from multiple country level data, shows that even though educational access for the girl child has improved markedly in recent years, a structural exclusion continues unabated due to lack of policy-cultural convergence. This research reinforced the idea of targeting local stakeholders—including parents, teachers and community leaders—for efforts to reform STEM schooling. Similarly, Unterhalter (2020) made a case for integrating gender equity with education sector plans through the lens of Capability Approach and recommended focusing policies not only on enrolment but also in enhancing meaningful participation and achievement.

However, qualitative literature contributes additional depth to the experience of living with COPD. In a study using interviews with Nigerian girls in technical colleges, conducted by Okeke and Aina (2021), students expressed strong dedication to their studies but often received verbal or psychological violence from their male counterparts, as well as their teachers. Abubakar and Lawal (2023) again on the narratives of female graduates in STEM from northern Nigeria them emphasised the role of mentorship and females as key school leader in Australia. Tadesse and colleagues (2014) found in Ethiopia that girls who was successful on the STEM pathway were likely to attribute it to encouragement from younger male teachers, hinting that enlightened actors within education could exert a transformative influence.

Describing STEM intervention for most school subjects and technological innovations worthy of mention. Owusu and Ampofo (2021) in Ghana also found that girls benefitted when the learning tools were ICT-based and content gender-sensitive/interactive for the teaching and learning of MasterTrainer Council secondary schools. The UNESCO (2021) cross-country research also reiterated that gender-responsive pedagogy and digital tooling for extended delivery and impact can be highly significant.

Moreover, while advances are notable in the empirical research literature, gaps and implementation lags remain; there is an ongoing need for culturally sensitive and intersectional evidence-informed intervention as well as monitoring systems. The results depict the need to situate educational development within all embracing social and economic policy frameworks that are in tune with the actualities of the lives of girls and young women. The recommendations of that analysis hint at the kinds of policies likely to be effective, policies which tackle access together with institutional culture and transitions from education in combination with strong accountability mechanisms .

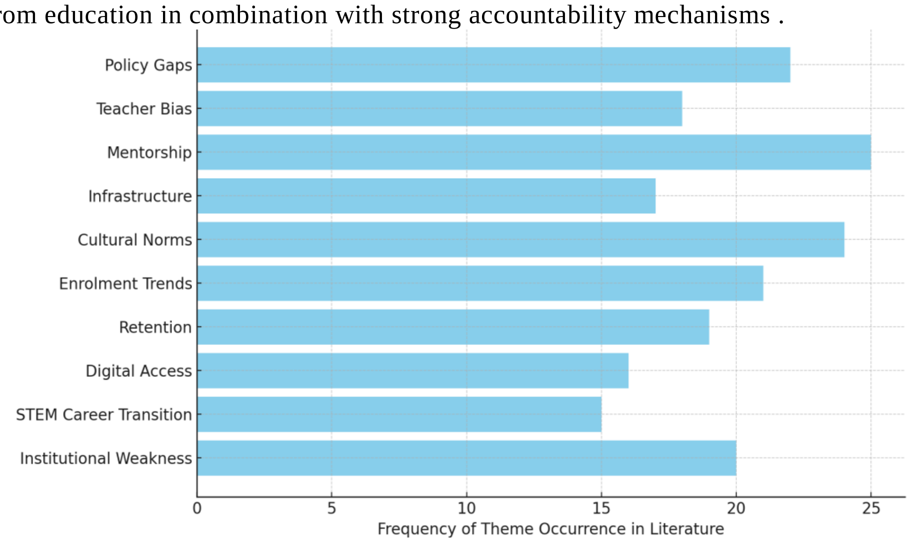


**Figure 1: Thematic Map of Reviewed Literature (2010–2025)**

Mentorship, cultural norms, and policy gaps emerge as the most frequently cited themes in peer-reviewed literature between 2010 and 2025. Other prevalent topics include enrolment and retention challenges, digital access, and institutional limitations. The thematic distribution highlights the need for multifaceted strategies that address both systemic and behavioral dimensions of the gender gap in STEM education.

### 2.4 Conceptual Framework

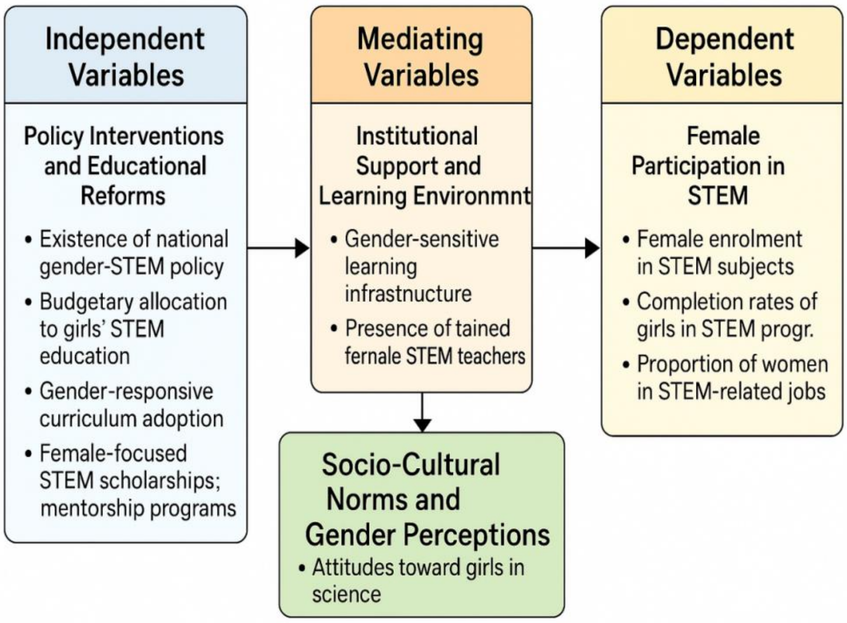


**Figure 2: Conceptual framework on Bridging the Gender Gap in STEM**

#### 2.4.1 Explanatory Note on the Conceptual Framework

A conceptual framework for this study (Fig. 2) suggests a model of policy intervention and education reform impact of women participation in STEM among developing countries along with its methodological problem. It delineates cause-and-effect pathways in which reforms are expected to lead to change, taking into account enabling and constraining institutional and socio-cultural environments. That aligns well with what both theoritical insigths and empirical evidence shown in the study.

The framework centres on the Dependent Variable: Female Participation in STEM and is measured through direct indicators to infer changes in the people's perceptions and behaviours, such as joining of girls in STEM subjects (at secondary/tertiary level), or girls completing STEM programs, followed by women participation by occupation within the domain of employment. Such results nevertheless are part of a larger impetus to achieve gender equity in science and technology.

The main Independent Variable of the study is,Policy Interventions and Educational Reforms These include: national policies that support gender equity in STEM, budget allocations for girls' STEM education, gender-responsive curricula and pedagogies, scholarships and mentorship programs geared toward female students, and teacher capacity development. Consequently, these policy actions are likely to support female participation directly by taking on pervasive structural barriers in the education and workforce pipelines.

The image provides the most accurate overview of how different types of quality reforms impact outcomes, and it is unique in introducing a Mediating Variable—Istitutional Support & Learning Environment—that bridges the relationship between reforms and outcomes. And it identifies factors related to the school level and the system of gender-responsive infrastructure, availability of qualified female STEM teachers, an effective mentorship system in schools and gender equality mechanisms in universities and ministries. These institutional features are critical for converting policy intentions into practical support for female students.

In addition, the model includes a Moderating Variable of Socio-Cultural Norms and Gender Perceptions, which could moderate the direction and strength of reforms affecting STEM participation. This includes general societal norms surrounding girls and science, family-support levels, cultural or religious limitations on autonomy inherent in the case of many girls and sharing domestic responsibilities which leave little time for learning. If these cultural constructs do not get effectively tempered then even soundly constructed policies are bound to be grossly ineffective in many developing country settings.

Alam (2018) The two arrows Denote Direction Flow of the Framework: From above It Comes from Policies and Reforms then Through Institutional Mediators and Socio-Cultural Moderators among Which It Is

Being Embedded. The design of this systems-minded model acknowledges the intricate nature of education reform, emphasizing that shifting policy requires multi-level integration and buy-in.

The study utilizes a mixed-methods design in its operationalization of this framework, thereby enabling quantitative analysis of policy effectiveness as well as qualitative examination of the experience dimension. This helps in providing an understanding of not only what works, but also how and why certain interventions work or do not work depending upon different contexts.

At the end of the day, it is both an analytical road map and a practical policy tool. It guides further exploration of the gender equity pathways in STEM and underscores the necessity to align deep structural reforms with institutional readiness and cultural realities to support sustainable, inclusive program build-up.

## III. METHODOLOGY

This study employs a qualitative research design utilizing systematic literature review and multiple case study analysis with the purpose of ascertaining the extent to which policy interventions and educational reforms implemented in developing countries address gender disparities in STEM. Underlining the integrated approach In order to analytically embrace both general trends and in-depth insights into the effectiveness, limitations, and impacts of STEM-related gender policies between 2010 and 2025.

We then use the review component to systematically synthesize peer-reviewed academic studies, reports by international organizations (e.g UNESCO, UN Women, World Bank), and policy documents relevant to gender and STEM. The literature was sampled with purposive sampling approach of the years 2019–2025 indexed on Scopus, Web of Science and Google Scholar. Search terms were generated in combination: “gender gap in STEM,” “STEM education reforms,” “women participation in STEM,” developing countries, and gender policy in education. Criteria was for relevance to STEM education and gender in developing contexts, national or regional reforms or policies, and employed empirical methods or policy evaluation. This allowed us to build a strong conceptual and empirical base from which we could evaluate trends, lessons learned, and continued challenges.

In addition to the review, the case study analysis investigates five low- and middle-income countries in Africa, Asia, and Latin America— Nigeria, India, Kenya, Bangladesh, and Colombia (Bangladesh technically maintains global eligibility for GAC competition in 2020)—selected for geographic representation, documented policy activity on STEM gender equity, and data availability. With a range of socio-political contexts, policy environments and education system conglomerate the countries offers an interesting basis for comparison. The case studies that are included in this article trace the pathway of national interventions for women and STEM over the 15 years, with a particular focus on:

Policies development and implementation (STEM scholarships, curriculum reforms, teacher training)

One could image further variables which had to do with how the institutions where these teachers are trained work (the school level support, mentorship structure, teacher gender balance…);

Socio-cultural contextual barriers (e.g. parental attitudes, gender norms and early marriage);

Tangibles (e.g. changes in female enrollment & completion rates in STEM)

Evidence of specific cases is drawn from national reports, ministry publications, ongoing academic reviews of ECD programs conducted at UPEACE (including interviews where possible), and additional program evaluations carried-out by various international development agencies such as UNICEF, DFID and USAID. Where possible, potential policy narratives were triangulated with statistical evidence based on available secondary datasets on STEM enrollment and completion rates by gender.

The study uses thematic content analysis in order to guide data interpretation and will code the literature and case data for recurring themes around policy effectiveness, barriers, enablers, and outcomes using NVivo. Topics were pre-organized based on a factor analytic model of the study, specifically the interaction among policy reforms (independent variable), institutional support (mediator), socio-cultural norms (moderator) and female participation outcomes(dependent variable). Cross-validating against sources iteratively for enhanced coding reliability

The ethical issue in this study was eliminated by using only the public available or institutionally accepted materials regarding case study. All primary data used in this research (e.g interview material, direct quotations) received the ethical guidelines set by their original publications.

This methodological design also includes a broad character, balance between depth and breadth of the content being analyzed [16]. One of the key strengths of the paper is that it combines this macro-level perspective on trends and scholarly debates with more micro-level, context-specific understanding — through case studies of impact — on what works, what does not work, and why, which enhances its explanatory power as well as policy and development relevance.

## IV. CASE STUDIES: NATIONAL EXPERIENCES IN GENDER-STEM REFORM

### 4.1 Nigeria: Policy Potential vs. Structural Constraints

Nigeria has initiated a series of gender focussed educational reforms that have sought to promote girls participation in STEM not limited to but still significant being the National Policy on Gender in Basic Education (2014) and partnerships such as the Girls' Education Project (GEP3) with UNICEF. The policies have promoted girl-child enrolment, made scholarships preferential for them, and ensured a wider coverage of the awareness campaigns in communities (Akinola & Olayanju, 2022). But it is still being piecemealed, especially in rural and northern territories where some norms of early marriage prevails, poverty and religious conservatism.

Research evidence shows that while there has been an increase in enrollment of girls at the secondary level in STEM, retention rates among female students in tertiary-level STEM disciplines are still low (Makinde & Kanyongo, 2022). There has also been labor market discrimination as well as poor institutional support for STEM career transition. In addition, cultural teachings still portray science and technology as male centric in spite of role models and pressure groups such as (Abubakar & Lawal, 2023). In addition, the partial aid available to these students, their difficult access to infrastructure in different parts of rural Colombia and gender insensitive pedagogy contribute to deeper systemic exclusions.

### 4.2 India: Integrating Mentorship and Systemic Reform

India represents a contextualised example of how genderSTEM agendas can be operationalised in a coherent manner, with the introduction of national initiatives such as (1) STEM for Girls Initiative jointly initiated by IBM and state education departments (2) Vigyan Jyoti programme where brilliant girls are nurtured for pursuing science (Sharma & Bhatia, 2020). These are, in turn, nested within broader reforms ushered under the National Education Policy (NEP) 2020 - that articulates aspirations for gender equity and interdisciplinary STEM pathways.

Preliminary evidence evidences that these programs have not only increased STEM enrolment but also improved retention by creating a sense of motivation, mentorship and institutional continuity (Hasan & Kabir, 2023). A key factor that helped improve girls' self-confidence and career aspirations was the involvement of female scientists/engineers as mentors & role models (Kaur & Kaur, 2021). Still, a rural-urban divide remains and digital divides act as barriers to technology-based initiatives in underserved areas.

### 4.3 Kenya: Expanding Access through Outreach and Innovation

Kenya has made significant progress in expanding girls' access to STEM through strategic policy and outreach programs embedded within its Vision 2030 Education Sector Plan. Key initiatives include science camps for girls, mobile STEM laboratories, and affirmative action in technical and vocational education (Mutua & Kipruto, 2020). These programs are supported by the Ministry of Education and private partners such as UNESCO and Microsoft.

However, although there is an apparent upward trend of girls in enrolment towards ICT and technical courses, issues persist on retention as well as the dynamics within the classroom where it concerns gender. The literature reviewed reveal that teachers hold implicit biases which seem to influence girls engagement and performance in science subjects e.g., Makori & Lutomia (2022). Moreover, rural schools are often poorly equipped with basic amenities like labs and Internet access which in turn restricts the benefit of STEM reforms. Despite the challenges, Kenya provides an example of the necessary and viable path forward to adaptation in sub-Saharan Africa.

**Table 1 Cross-Country Comparison of STEM Gender Policies and Reforms (2010–2025)**

| **Country** | **Key Policies** | **Implementation Strength** | **Outcomes** | **Challenges** |
|---|---|---|---|---|
| **Nigeria** | National Gender in Education Policy (2014); Girls' Education Project (UNICEF partnership) | Moderate – Good policy design, weak school-level delivery, limited rural coverage | Increased enrolment in STEM at secondary level; high dropout in tertiary education | Sociocultural norms, funding gaps, institutional gender bias |

| | | | | | |
|---|---|---|---|---|---|
| | India | STEM for Girls Initiative; Vigyan Jyoti mentorship program | Strong – Well-funded, coordinated nationally with sustained mentorship support | Improved enrolment and retention in STEM; positive mentorship impact | Teacher bias, rural-urban digital divide |
| 4 | | | | | |
| | Kenya | STEM Outreach Programs; Science Camps for Girls; Vision 2030 Education Framework | Moderate – Active outreach, but gaps in teacher training and rural penetration | Growth in female enrolment in ICT and technical subjects; retention still low | Lack of trained STEM educators, weak infrastructure in rural schools |
| | Bangladesh | National Education Policy (2019); Gender Equity Action Plans | Weak – Policies exist but lack implementation and monitoring frameworks | Rising awareness, but marginal enrolment increase; poor completion rates | Early marriage, limited community support, underfunded reforms |
| | Colombia | Plan Nacional Decenal de Educación (2016–2026); Digital Innovation Strategy | Moderate – Urban success, but uneven rural engagement and limited institutional reform | Improved digital STEM participation in cities; low transition to careers | Fragmented governance, low private sector involvement |

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**4. Bangladesh: Awareness Gains vs. Systemic Limitations**

Bangladesh has been taking a number of initiatives, such as school-level reforms in curriculum and promoting digital literacy through National Education Policy (2019) and Gender Equity Actions Plans for early introduction of STEM (Hasan & Kabir, 2023). Durantes los Advertencia Públicos y las Sobrecogedoras con de ONG se ha conseguido más concienciación en la sociedad respecto a la indigencia de hembras en ciertas disciplinas del ciencia y tecnología.

These attempts, however, have fallen short with most schools only serving to increase an extra few percent of STEM enrollment among females and even less so in more specific subjects such as physics, engineering and mathematics. Based on research from Tadesse and Wondimu (2022), a combination of early marriage, parental suspicion and the conservatism of communities have continued to swallow female aspirations. This is complicated further by systemic faults such as the non-existence of gender-sensitive teacher training and monitoring frameworks. However, more recent assessments showed that the findings are not as encouraging and suggest that stronger accountability mechanisms combined with greater community involvement from-the-grassroots-up will be necessary to have enduring outcomes (Chowdhury & Rahman, 2021).

**4.5 Colombia: Digital Inclusion with Institutional Gaps**

Colombia Colombia is a unique case of gender-STEM advancement through its Plan Nacional Decenal de Educación 2016–2026 and Digital Inclusion Strategy, aligning both in STEM education specifically calling the urban underserved. Chicas STEAM offers mentoring programs, digital training and entrepreneurship for girls (Díaz & Gómez 2023).

While the above interventions have led to higher digital participation and awareness among female students, particularly in cities like Bogotá and Medellín. There are still challenges in the rural areas, where school infrastructure is poor and connectivity issues persist. In addition, despite a relatively enabling policy environment concerns still persist in inter-agency coordination and long term financing (Torres & Ramírez, 2021). Without a national surveillance system in place, assessing program outcomes on an ongoing basis is not possible.


**Figure 3: SWOT Analysis of Gender-STEM Reform in Nigeria**

The SWOT analysis shows Nigeria's reform strengths include national policy frameworks and NGO partnerships. However, implementation weaknesses such as rural exclusion and dropout rates hinder progress. Opportunities lie in digital innovation and demographic potential, while threats include entrenched gender norms and weak accountability systems. These insights highlight the need for multisectoral alignment to sustain gender inclusion in STEM.

**4.6 Synthesis of Case Insights**

Together, these case studies illustrate that while national policy commitment is a necessary starting point, implementation strength, institutional continuity, and cultural engagement are critical determinants of success. India and Colombia demonstrate how structured mentorship and digital innovation can yield measurable improvements. Nigeria and Bangladesh highlight the adverse effects of weak institutional delivery and cultural resistance. Kenya, though mid-performing, shows promise through innovative delivery and multi-stakeholder collaboration.

The key takeaway is that gender-STEM reforms must be multi-dimensional, context-sensitive, and integrated into broader educational and labor systems to generate lasting impact.

## V. DISCUSSION OF FINDINGS

**5.1 Findings**

The results of the review and case study analysis provide a note on progress accompanied by continued structural bottlenecks in addressing this challenge of gender gap in STEM from developing world perspective.

Some of the improvement is real, but uneven and fragile, even when the reform efforts have been pronounced; change remains highly dependent on institutional capacity, on local conditions and socio-cultural factors, and to some degree also on how far or deep ‘gender’ has entered educational policy frameworks in relation to overall system governance.

Policymakers in all five national cases did successfully raise the profile of gender inclusion in STEM, especially at the secondary to post-secondary education policy levels. Although in countries like India and Bangladesh, STEM-for-girls national campaigns, scholarship schemes and awareness drives did witness significant upticks of female students enrolling to science-based courses between 2015 and 2022. Through affirmative action policies and outreach programs by the Ministry of Education in Kenya, there have been some success stories with respect to an increase in female enrolment in technical and vocational institutions, especially relating to ICT technology and engineering courses. Colombia also noted that reforms in education with a STEM focus, introduced through Plan Nacional Decenal de Educación 2016-2026 had helped to increase the participation of girls in digital technology and innovation programmes.

Nonetheless, enrolment gains are not always paralleled by completion rates or professional entry into STEM fields. Indeed, in Nigeria, where a number of reforms and interventions, including the National Gender in Education Policy (2014) and the Girls Education Project have been enacted at the basic level to address girls dropout rates in STEM with limited success; rearing her head at the tertiary level resulting largely from financial challenges of predominantly poor guardians; gender-insensitive learning environments; and scarce opportunities for quality post-graduation employment. In Bangladesh, which has seen trends similar to those in Nigeria, early marriage and family responsibilities are impacting retention and graduation rates for female STEM students.

One commonplace over cases is the gap between design and delivery of policy within institutions. The majority of countries have at least endorsed some gender-STEM policies that are considered to be progressive, but the institutional and school-level translation is less uniform. It is even more pronounced in the scant integration of gender-responsive pedagogy. Teachers in all five countries still exhibit biases, with many holding negative expectations for girls in mathematics and science subjects, and their use of instructional materials that depict women participating in scientific occupations remains limited. In response to the conclusions, it is found that teacher professional development programs designed to mainstream gender equity have mostly been short-term measures applied over limited geographic ranges, and as such have not always had national impacts on STEM education outcomes both in Kenya and Colombia.

One supporting factor that influences persistent change in countries is the involvement of difference-maker mentors and women role models. In India, government-supported mentorship programs like Vigyan Jyoti also led to increased participation and self-confidence among girls studying sciences. Lack of visible female role models at school or in STEM institutions and unconscious biases in Nigeria and Bangladesh on the other hand, were noted as critical psychological and aspirational- based barriers prevalent.

The study found that access to institutional support — such as attending a safe school and facilities, Science Labs, Counseling Services, Financial aid etc. — is an important mediating factor. In Kenya, schools using a “whole-school gender support approach” (such as implementing gender clubs, science fairs for girls, separate sanitation facilities) showed significantly better STEM performance on the part of female pupils. Governments also attempted to address mental health challenges experienced by mothers and infants in the perinatal period through community-based interventions although these were largely pilot initiatives .

In addition, changes have been successfully adopted and implemented The role of socio-cultural norms and gender ways in which reforms are understood and acted upon has proved to be a strong moderator. Patriarchal norms, early marriage practices and community attitudes deemed the sciences to be an inappropriate career choice for women in all case countries, which in turn influenced both parental support and girls' own aspirations. For instance, the LAT analysis identified gender roles and cultural beliefs regarding family duties and female self-sufficiency as culturally relevant factors in Bangladesh and Nigeria where females are less likely to participate in engineering or computer science sectors. In countries with relatively less stringent formal gender norms, such as in Colombia, implicit biases among families and institutions can still erode girls' confidence in their grades.

In essence, they suggest that although national policy and reform have laid a foundation for change, the implementation of gender equality in STEM has been stalled by contested spheres between national and local context coupled with entrenched socio-cultural norms. However, isolated and pilot project success stories suggest that reform can work if it is accompanied by comprehensive support systems, community involvement in intervention planning and implementation (Ware and McKenna, 2017) as well as cultural change efforts. But scalable frameworks are missing along with sturdy monitoring and evaluation leading to waning impact over long periods.

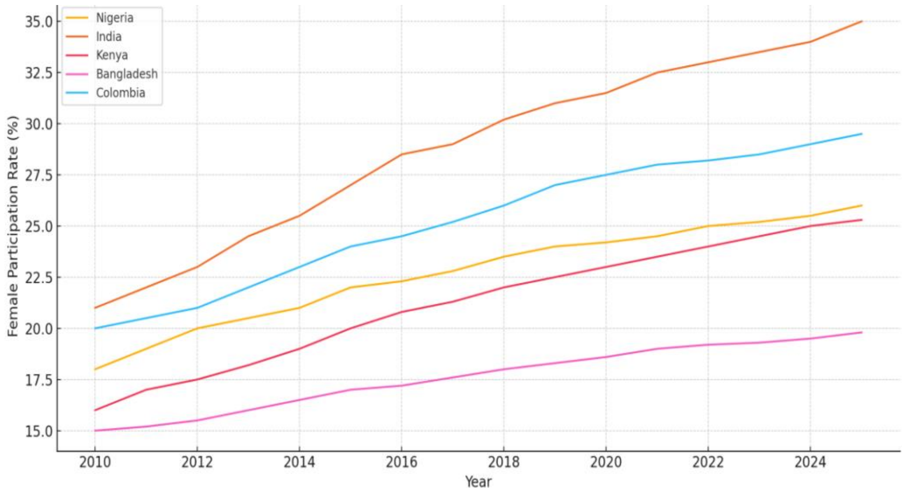


**Figure 4: Trends in Female Participation in STEM Education in Selected Developing Countries (2010–2025)**

The chart reveals a gradual but uneven increase in female STEM participation across all five countries. India and Colombia show the most consistent upward trends, reflecting strong policy implementation and mentorship programs. Nigeria and Kenya demonstrate moderate growth, while Bangladesh lags due to persistent socio-cultural barriers. These trends underscore the need for context-specific, sustained educational reforms.

### 5.2 Discussion and Policy Implications

#### 5.2.1 Discussion

The results of this study lend support to the theoretical view that inequalities in STEM participation have their origin in a web of policy regimes, institutional dispositions and cultural institutions. These insights from Social Role Theory, Feminist Institutionalism, and the capability Approach demonstrate the importance of policy interventions but also why they are only a small component of what is needed. This ineffectiveness is, at least in part, due to the institutional environment in which programs are implemented and to deeply rooted social norms that imply otherwise here women's status within other areas (gender norms), beliefs about women education (education norms) and expectation about women workforce participation.

From a Social Role Theory viewpoint, the enduring association of STEM with masculine traits is prevalent in each case country with low societal expectations for girls being competent in science and engineering. As a form of sexism, these beliefs are learned at an early age and solidified through class interaction, media portrayals, and family reinforcement. At these transition points, attrition is still high—at a time when we have never seen more students enrolling in STEM and the demand for STEM workers has never been greater!

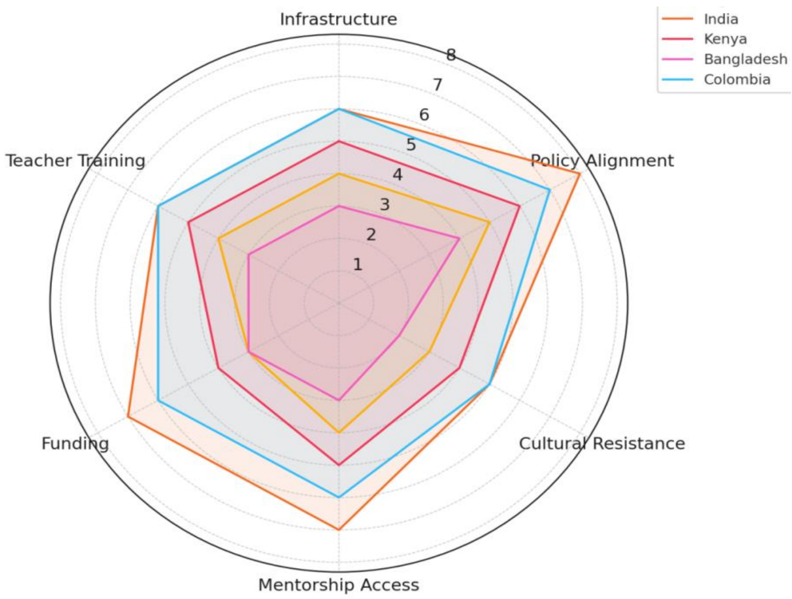


**Figure 5: Barriers and Enablers to Female STEM Participation by Country**

The radar chart reveals that India and Colombia show stronger enabling environments for girls in STEM, particularly in mentorship, policy alignment, and infrastructure. Nigeria and Kenya show moderate support, while Bangladesh scores lowest across most categories due to limited funding, institutional readiness, and cultural constraints. These disparities highlight the need for targeted, country-specific strategies in gender-STEM policy design

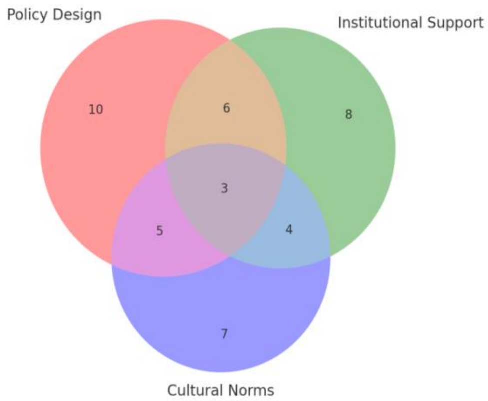


**Figure 6: Intersection of Policy, Institutional, and Cultural Factors in STEM Gender Gaps**

The diagram reveals that effective policy interventions alone are insufficient unless supported by strong institutions and conducive cultural environments. Areas where all three domains intersect represent the most enabling conditions for gender equity in STEM. However, most country-level efforts fall into dual or isolated domains, underscoring the need for integrated strategies that bridge institutional, policy, and cultural divides.

However, as with that of the Capability Approach, it tells us girls' substantive freedom to choose and achieve success in STEM subjects will not be achieved by de jure desegregation on its own, where formal barriers are stripped away; instead it is absolutely necessary that we create conditions. These include gender-inequalities related to time poverty from household responsibilities through to the new frontiers of violence against girls in schools and improved access to financial and social capital. Countries where interventions focused on socio-emotional factors, like mentorship or safe learning spaces, were more likely to report impact in terms of increased confidence, retention and career orientation among girls.

Most importantly, the study indicates that progress in gender equity in STEM and related areas is partial and uneven, as policymaking to promote gender equality at the national level is fragmented and symbolic as opposed to significant. In the Third Planning Times, structural transformation necessitates a departure from episodic reform to focused, gradual and context-sensitive policy enactment. Further, a lack of accurate sex-disaggregated data on participation in STEM by gender, geographical location and socio-economic status has hampered effective monitoring and evidence-based policymaking.

**5.2.2 Policy Implications**

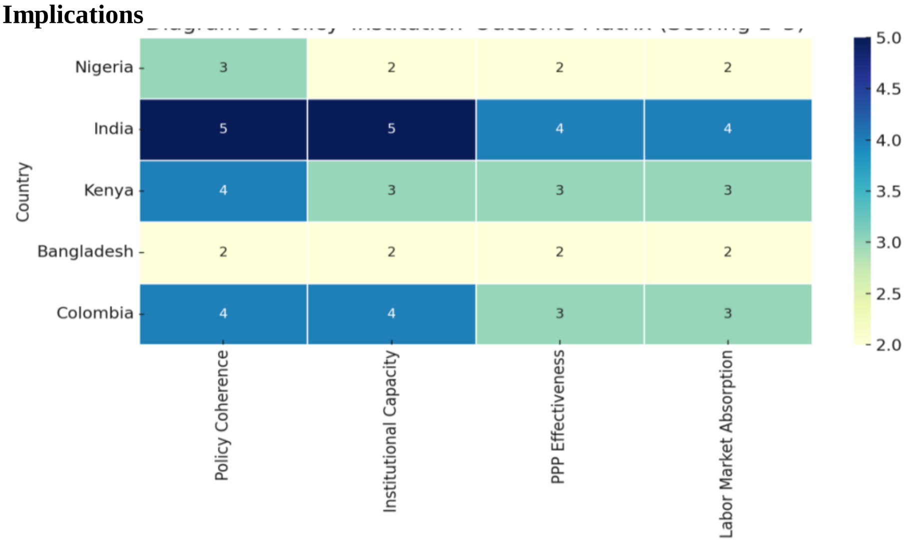


**Figure 7: Policy–Institution–Outcome Matrix (Scoring 1–5)**

The matrix highlights India as having the most coherent and institutionally supported STEM gender policy framework. Nigeria and Bangladesh score lowest across most indicators, reflecting systemic implementation and market integration challenges. Colombia and Kenya display moderate alignment, suggesting partial effectiveness. These findings emphasize the need for stronger institutional and public-private linkages to sustain gender-STEM outcomes.

Strengthen Policy–Practice Linkages: National governments must ensure that gender-STEM policies are not merely declarative but supported by clear implementation plans, funding allocations, institutional capacity-building, and accountability mechanisms. Policies should be integrated into broader national education and labor strategies.

Promote Gender-Responsive Pedagogy and Teacher Training: Educator attitudes significantly influence student performance and aspirations. Pre-service and in-service teacher training programs should be restructured to include gender-sensitivity, inclusive teaching strategies, and the dismantling of unconscious bias.

Expand Mentorship and Role Model Programs: Visibility matters. National programs should invest in networks of female scientists, technologists, and engineers who can mentor, speak, and serve as models in both urban and rural schools. Such programs should be sustained and linked with industry and academia.

Institutionalize School-Level Support Systems: Schools must be equipped with gender-sensitive infrastructure (including sanitation, safety measures, and science labs), guidance counselors, and STEM clubs that actively recruit and support girls. Interventions should target rural and marginalized communities specifically.

Address Socio-Cultural Constraints Through Community Engagement: Policy success depends on shifting societal attitudes. Governments and NGOs should develop culturally sensitive campaigns to engage parents, religious leaders, and communities in promoting STEM education for girls. Interventions must challenge stereotypes while respecting local contexts.

Ensure Data-Driven Monitoring and Evaluation: Ministries of education should invest in gender-disaggregated data systems and longitudinal tracking mechanisms to evaluate policy effectiveness. Collaboration with research institutions and international partners is essential for generating robust evidence and adapting interventions.

Promote Economic Incentives and Career Pathways: Beyond education, attention must be paid to the transition into STEM employment. Public and private sectors should offer internships, scholarships, and employment incentives that prioritize women in emerging STEM fields. Career guidance and industry-school linkages must be strengthened.

In conclusion, bridging the gender gap in STEM requires more than access—it demands transformation at institutional, cultural, and structural levels. Policies must be inclusive in design, equitable in implementation, and sustainable in impact. While progress has been made, a collective shift toward systems-thinking, cross-sectoral collaboration, and inclusive development is essential to ensure that girls and women not only enter STEM fields but also thrive in them.

## VI. CONCLUSION AND RECOMMENDATIONS

### 6.1 Conclusion

The authors aimed to evaluate the effectiveness of policy interventions and educational reforms addressing the gender gap in STEM for developing countries from 2010 to 2025. The study, which draws on an extensive depth of empirical literature and encompasses multiple waves of case studies from Nigeria, India, Kenya, Bangladesh and Colombia shows that despite some gains made in the areas of awareness raising and promoting female participation in STEM disciplines over the years; chronic institutional, cultural and systemic/structural factors still work to destabilize a sustainable gender balance.

Well, the evidence suggests that there is a significant gap between policy ambition and implementation capacity. A lot of reforms are ad hoc and urban-centered not integrated into the system to change whole educational ecosystems. However, in contexts where there is no focus on institutional support structures and socio-cultural norms at the same time as working on reforms then policy impact gets diluted. Moreover, increased enrolment figures do not necessarily translate to improved retention or workforce participation — a situation that reflects the need for policy to go beyond access, and commit to holistic support and long-term empowerment of girls and women in STEM pathways.

The elucidation of the multiple leveOn Monday we asked, Which scientist made a TV appearance performing with his rock band? The three theoretical prisms highlighted both explicit and covert institutional practices in combination with the individual liberties and wider social circumstances which navigate girls' educational trajectories.

While the study is quite comprehensive, they also point to some of its limitations, including the use of secondary data in some cases and no fieldwork conducted within country given difficulties in accessing areas.

Nevertheless, triangulation of findings across contexts in literature and case studies can yield strong insights and actionable policy and practice implications.

**6.2 Recommendations for Future Research**

***Longitudinal Impact Studies***

Future research should conduct longitudinal evaluations of gender-STEM reforms to track not only access but also long-term impacts on career outcomes, income levels, and intergenerational mobility. Understanding the sustainability of outcomes over time is critical to designing effective policies.

***Intersectional Analyses***

There is a need for more intersectional studies that explore how gender interacts with factors such as ethnicity, rural/urban residence, disability, and socio-economic status in shaping STEM participation. Such analyses will help design targeted interventions that leave no one behind.

***Evaluation of Informal and Non-Formal Education Pathways***

Research should examine how community-based initiatives, after-school programs, coding boot camps, and online platforms influence girls' STEM interest and participation, especially in contexts with weak formal education systems.

***School-Level Ethnographies and Institutional Culture Studies***

To better understand the "hidden curriculum" and institutional norms, future studies should employ ethnographic methods to explore how schools and universities shape gendered attitudes toward science and technology from within.

***Cost-Benefit and Scalability Analyses of STEM Programs***

Research is also needed to evaluate the financial sustainability and scalability of pilot programs that have demonstrated success. Policymakers require evidence not only of effectiveness but also of efficiency and replicability in low-resource settings.

***Technology and Digital Inclusion Studies***

With the rise of digital education tools, future work should investigate how technology can be leveraged to promote inclusive STEM education for girls, especially in remote or underserved areas. This includes analyzing barriers such as device access, digital literacy, and gendered online environments.

***Comparative Policy Analyses Across Regions***

Finally, cross-regional comparative research involving countries from different continents can offer insights into how cultural, political, and economic contexts shape the effectiveness of similar policy models. Such comparative work could inform global knowledge-sharing platforms and policy benchmarking efforts.

Bridging the gender gap in STEM in developing countries is both a social justice imperative and a development priority. It requires sustained, evidence-informed, and context-sensitive approaches that combine policy innovation with grassroots engagement. Future research must continue to illuminate not only what works, but how, why, and for whom—ensuring that the global STEM agenda becomes genuinely inclusive, equitable, and transformative.

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