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Mathematics Education and the Southern African Development Community Woman: Cross-Country Insights into Participation and Policy

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Abstract

The participation of women in mathematics education is a significant concern, with ongoing gender disparities evident across various educational contexts. Despite increased awareness of the need for gender equity, women are underrepresented in mathematics from primary to higher education and professional fields. This study reviews factors influencing women's participation in mathematics education in Zimbabwe, Namibia, Botswana, and South Africa, using qualitative research methods. It identifies barriers and opportunities affecting women's involvement in math-related fields. Key factors include occupational interests, work-family balance, and the impact of gender stereotypes. Findings reveal that negative stereotypes and self-efficacy beliefs adversely affect women's participation and motivation. The study emphasizes the importance of a supportive educational environment, mentorship, and positive role models in boosting women's confidence in mathematics. Recommendations for policies and practices to enhance women's participation in STEM and mathematics education are also provided.

Keywords: Gender Equity, Mathematics Education, STEM Education, Stereotypes, Women's Participation

Introduction

The underrepresentation of women in STEM fields constitutes a significant global concern (UNESCO, 2017). In the Brazilian context, Couy and Gazire (2024) have identified that mathematics education continues to face significant challenges regarding gender inclusion. For instance, teacher training curricula often lack a critical approach that addresses gender inequalities, leading to educational practices that can perpetuate stereotypes and discrimination (Couy and Gazire, 2024). Additionally, Batista et al. (2024) affirm that historical analyses reveal that until the latter half of the 20th century, the majority of teaching materials were developed without consideration of gender issues. Although subsequent curricular revisions have occurred, many existing materials remain contaminated by stereotypes (Batista et al., 2024). In the 21st century, the global economy increasingly relies on science, technology, engineering, and mathematics (STEM). Despite notable advancements in gender equality, women continue to be underrepresented in numerous STEM fields (Vuraya, 2021). A pivotal instrument for bridging this disparity is mathematics education.

Mathematics serves not only as the foundation for all STEM disciplines but also as a crucial facilitator of analytical thinking and problem-solving abilities (Fitzallen, 2015). Achieving mastery in mathematics demands logical reasoning, critical thinking, and persistence, competencies that are essential not only for success in STEM but also valuable in numerous aspects of daily life. As articulated by Fitzallen (2015), mathematics functions as the language of STEM, with every STEM domain, from data science to architecture, engineering, and health sciences, heavily relying on mathematical principles. Furthermore, mathematics education plays a significant role in fostering self-confidence and intellectual autonomy (Sheena Jade et al., 2023). Therefore, by actively promoting mathematics education among women, societies can empower them to pursue, excel in, and take leadership roles within STEM careers (George, 2024). The remarks alluded to above imply that without this foundation in mathematics, many young women may find themselves unprepared or discouraged from pursuing further education or careers in these disciplines. In this study, the term STEM will be used to emphasize mathematics as the foundational discipline underlying the other fields mentioned.

In the context of this study, empowerment is defined as the capacity of vulnerable groups to exert control and influence over various aspects that impact their lives by enhancing their skills and augmenting their resources (Duckett, 2024). Von Maltis and Bahta (2024) categorize women's empowerment into three distinct dimensions: agency, resources, and enhanced social capital. Within the framework of agency, von Maltis and Bahta (2024) refer to the ability to make decisions; resources pertain to assets, health, and education; and social capital encompasses economic opportunities. Research conducted by Maltis and Bahta (2024) indicates a strong correlation between knowledge acquisition and formal education in the realm of women's empowerment.

According to UNESCO (2017), women account for only 35% of STEM students in higher education, with representation being even lower among rural and Indigenous communities. This gender disparity is exacerbated by a disconnect between Western-centric STEM curricula and the lived experiences of many learners. Harding (1998) posits that Western science frequently marginalizes alternative knowledge systems, thereby reinforcing epistemic hierarchies that exclude women, particularly from non-dominant cultures. Consequently, reimagining STEM education through a pluralistic framework that incorporates Indigenous Knowledge Systems (IKS) may facilitate new avenues for women's participation and leadership within the scientific domain.

For numerous women and girls, achieving excellence in mathematics enhances self-esteem and effectively counters the pervasive societal stereotypes that portray STEM fields as predominantly male domains (Master, 2020). By investing in equitable and high-quality mathematics education for females, societies can unlock the full potential of half the population, thereby driving progress not only in STEM but also across all areas of human advancement (George, 2024). Research studies (Tereshchenko et al., 2023; Kuchumova et al., 2024) indicate that when women receive encouragement and demonstrate strong performance in mathematics from an early age, they are more inclined to pursue advanced studies and careers in STEM during and after their university education. Consequently, it is essential to establish robust and inclusive mathematics education systems to guarantee equal access to these fields.

Various studies (Stoet et al., 2016; Gevrek et al., 2020), have indicated that different countries exhibit distinct cultural attitudes toward women's participation in mathematics. Recognizing these differences can illuminate how societal norms and values impact the involvement of females in this academic discipline. Furthermore, research conducted by Schreiber and & Ashkenazi (2024) indicates that diverse student populations respond variably to different educational strategies. This finding suggests that educational systems may adopt varying methodologies for teaching mathematics, which could influence female participation. A comprehensive understanding of these methodologies may reveal effective strategies for engaging women in mathematics. The objective of this study is therefore to conduct a comparative analysis of the involvement of women in Mathematics education and the associated policies promoting female participation in Zimbabwe, Namibia, Botswana, and South Africa. Comprehensive data pertaining to the participation of women in Mathematics from the aforementioned countries was collected from documented sources and analysed through the lens of relevant theoretical frameworks.

Methodology

This paper reviews journal articles, books, book chapters, and published research, using the inclusion and exclusion criteria for participant selection. This method is essential in research, as it helps researchers identify suitable respondents (Hornberger and Rangu, 2020). In this study, the specified method was utilised to select and organise literature on the role of mathematics education in empowering women, in alignment with the study's goals (Patino and Ferreira, 2018). Creswell (2016) outlines a five-step process for analysing data from reviewed articles: i) becoming familiar with the data; ii) coding; iii) developing themes; iv) evaluating; and v) naming these themes. Popenoe et al. (2021) further condensed this process into three steps: i) identifying data that address the research questions; ii) thematically organizing the data; and iii) synthesising, analysing, and presenting the data. In this study, relevant literature on STEM education was identified to address the research objectives. The data were systematically organised according to the countries being investigated. Subsequently, the results of the data analysis were compiled and synthesized in alignment with the study's objectives.

Theoretical Framework: Gender Equity in Mathematics Education

Bishop and Forgasz (2007) assert that equity encompasses the principles of fairness and justice. However, they emphasize that equity should not be conflated with equality. Rather, equity is characterized as "relational" and context-dependent. Similarly, Antony and Walshow (2007) define Gender equity in mathematics as a comprehensive approach that recognises and responds to the unique needs stemming from a variety of home environments, diverse mathematical identities, and a breadth of perspectives. This concept emphasizes the importance of tailoring educational experiences to accommodate differences in students' backgrounds, which may include socioeconomic status, cultural influences, and prior experiences with mathematics (Isaacs et al., 2023; UNESCO, 2024). By understanding these distinct mathematical identities, educators and state authorities can create more inclusive learning environments that better support all students, ensuring that each individual receives the attention necessary for their academic and future professional success in mathematics.

Mathematics has historically been perceived as a discipline dominated by males (Essop et al., 2024). Promoting gender equity in mathematics has the potential to empower young women, fostering in them the belief that they are equally capable in mathematics as their male counterparts. When women are mathematically educated and confident, they are more likely to participate in innovation, policy formulation, and community leadership (Schiebinger et al., 2020). Similarly, Terán-Bustamante et al. (2024) assert that increasing the participation of women in the STEM sector will not only benefit the individuals involved but also enhance the competitiveness of industries, sectors, and nations by integrating a broader diversity of perspectives, which is essential for fostering innovation and development. These assertions may have positive ripple effects, including improved family wellbeing, more inclusive workplaces, and stronger national development outcomes. Gender equity policies in mathematics, hence, could support not only individual empowerment but also societal progress (Terán-Bustamante et al., 2024). This study thus aims to conduct a comprehensive analysis of existing literature to establish the role of mathematics education in empowering women, particularly in their entry into STEM careers. The study also examines how mathematics education can promote women-informed decision-making and enhance their capacity to contribute to their communities.

Inclusion of Women in STEM/Mathematics Education in Zimbabwe

Zimbabwean women are significantly underrepresented in STEM professions, with only 28.79% of women holding STEM degrees, in contrast to 71.21% of men (Maisiri, 2024). Research studies conducted by Vuraya (2021) and Gudyanga (2017) indicate that negative biases and stereotypes within Zimbabwe's STEM landscape may adversely affect the perceived competence and participation of women in scientific disciplines. Furthermore, the majority of STEM educators are male, with female representation at only 21% (Mawere, 2013). These statistics highlight the urgent and pressing need to promote and educate more women in STEM fields. Maisiri's study also demonstrates that many women in Zimbabwe, particularly those with low to middle skill levels, derive their livelihoods primarily from the agricultural sector rather than from science and mathematics.

The primary challenge regarding the underrepresentation of women in STEM fields within universities originates from high schools, where a significantly lower number of girls pursue STEM subjects (Sevilla et al., 2023). Exposure to STEM courses during high school is recognized as the most effective strategy to enhance the likelihood of enrolment in STEM university programs. In response to this issue, the Zimbabwean government has implemented measures aimed at fostering STEM skills among its population as a means to rejuvenate the economy. According to Vuraya (2021), the curriculum in Zimbabwe's primary and secondary schools mandates that students dedicate 30% of their overall study time to STEM subjects, with Mathematics being a compulsory component (Maisiri, 2024). However, it is noteworthy that Mathematics may not be compulsory at the advanced level, which is the university entry level in Zimbabwe, resulting in a decreased number of females choosing Mathematics as their major (Vuraya, 2021). This situation raises concerns regarding the "future of work," which requires a substantial labour force to harness the skills instilled in mathematics. The marginalisation of women in this regard will impede Zimbabwe's capacity to capitalise on the advantages presented by emerging technologies (Maisiri, 2024).

In response to the observation that a limited number of students were pursuing STEM subjects in Zimbabwe, particularly with a notable decline in the number of female students advancing in sciences at the A level, a program was initiated in 2016 to promote more intake in these fields of study (Ngwenya et al., 2017). The 2016 STEM initiative provided financial support for the education of A-level students who enrolled in STEM subjects, with a particular emphasis on encouraging female participation. This pioneering effort, spearheaded by the Ministry of Higher and Tertiary Education, aimed to substantially increase the enrolment of students in STEM programs at universities nationwide. The initiative sought to nurture a new generation of graduates prepared to excel in a competitive global environment. As highlighted by Gadzirayi et al. (2016), the Zimbabwean government acknowledged that equipping individuals with STEM skills cultivates a dynamic, problem-solving mindset within society, fostering a culture of exploratory learning and innovative thinking essential for sustainable development.

Despite these efforts, Zimbabwe's capacity to retain students in STEM disciplines remains exceedingly low (Maisiri, 2024). The Ministry of Higher Education estimates that a mere 17% of total enrollment in Zimbabwean tertiary institutions is situated within STEM fields (Chitate, 2016), with an even lower representation of women in these areas. Moreover, Gadzirayi et al. (2016) indicate that, among several contributing factors, limited resources have significantly impeded the learning of STEM subjects, with boys and men ostensibly having greater access to these scarce facilities compared to their female counterparts. Consequently, the Zimbabwean government must take a page from other nations to promote female STEM role models as a means of encouraging increased participation of women in STEM fields (Maisiri, 2024). The importance of female STEM role models is further supported by Herrmann et al. (2016), who demonstrate that written communication, such as letters from accomplished female STEM leaders, has positively influenced schoolgirls to persist in their STEM studies.

Shin, Levy, and London (2016) assert that exposure to biographies of successful female role models in STEM increases women's interest in pursuing careers within these fields (Blackburn, 2017). In Zimbabwe, significant efforts have been made to promote female role models in STEM through initiatives such as a 2018 multimedia outreach program at universities, which showcased the achievements of successful women in these disciplines (Dube, 2018). Furthermore, increased media representation of women in STEM can help mitigate the prevalence of negative stereotypes encountered within domestic environments. Notably, Zimbabwean female STEM role models, such as Charmaine Kahiya, have actively engaged in mentoring young girls (Maisiri, 2024). Charmaine initiated the Ai-Vaka Capacity Building initiative to enhance the accessibility of STEM education for girls residing in underprivileged communities. Nevertheless, there remains a considerable amount of work to be done to further this cause.

In an effort to empower women in STEM within Zimbabwe, the Women University of Africa (WUA) in Zimbabwe has effectively integrated gender considerations into its framework, resulting in an impressive female participation rate of 86.2% in the programs provided by the institution. This initiative serves as a valuable case study, illustrating successful strategies for enhancing and sustaining female representation in the fields of mathematics and science. The findings of Garwe and Chikwiri (2021) underscore the potential for leveraging such approaches to increase the engagement of women in STEM disciplines.

According to the Herald (March 18, 2025), Zimbabwe hosts the annual Women in Science, Technology, and Innovation (WiSTI) conference. This inaugural Women in STEM conference represented a significant milestone in the country, showcasing a remarkable level of attendance and engagement. As a result, it has the potential to serve as a successful platform for promoting women's participation in STEM programs and professions. Consequently, this event was established as an annual event, facilitating opportunities for women to convene and collaborate on their scientific inquiries. This initiative reinforces the government's commitment to promoting gender equity and equality within the fields of STEM. The conference is anticipated to serve as a pivotal moment in advancing female leadership in scientific and mathematical disciplines, thereby ensuring that women are not merely participants but essential contributors to the nation's developmental agenda.

The Zimbabwean government has also established a presidential scholarship program aimed at supporting female students in the STEM fields. This initiative, backed by a fund of US$10 million, seeks to enhance opportunities for young women, particularly those from marginalized backgrounds, to pursue education in STEM disciplines. Since its inception in 1995, the program has facilitated the placement of undergraduate, Master’s, and PhD students at various international and regional universities (Zvavahera, 2014, Chronicles, 13 March 2025). The objective of the program is to ensure that 80% of the scholarship beneficiaries are women, with the remaining 20% allocated to male students (Chronicles, 13 March 2025).

Government initiatives aimed at promoting women's participation in STEM fields have far-reaching implications for achieving gender equity, driving economic growth, fostering innovation, and facilitating social transformation. When these programs are thoughtfully crafted and executed, they serve as powerful tools for empowering women, enabling them to access educational and professional opportunities that have historically been limited (Isaacs, et al., 2023). Women inclusion in STEM also contributes to more comprehensive solutions to societal challenges, ultimately benefiting communities and economies at large. This is because, if the programs are successfully implemented, they can lead to a more equitable society where women contribute fully to the socio-economic landscape, driving progress in multiple dimensions.

Inclusion of Women in STEM/Mathematics Education in Botswana

Introduction

In Botswana, women and girls comprise 52% of the total population, which is approximately 2.3 million individuals. Despite their significant demographic presence, women and girls encounter considerable challenges in accessing their human rights due to various laws, policies, sociocultural practices, and customs that hinder their opportunities for political leadership, academic advancement, and economic success (Ojo, 2024). In addition, gender inequalities in Botswana are also linked to legal frameworks and cultural norms that obstruct women's and girls' access to essential opportunities, resources, and positions of power. The structural drivers of gender inequality, characterized by unequal gender roles and power dynamics between men and women, persist across all social institutions, resulting in diverse forms of discrimination against girls and women (Lardies et al., 2019).

The current organisation of the STEM landscape in Botswana is primarily influenced by the nation's development visions for 2016 and 2036, as well as the 2011 National Policy on Research, Science, Technology, and Innovation (RSTI), (Government of Botswana, 2016). The 2011 RSTI Policy is designed to deliver a comprehensive framework that encompasses clear visions, programs, incentives, measures, designated roles, targets, and monitoring indicators (Jackson et al., 2022). This policy spells out the necessity of promoting gender inclusivity and preventing discrimination against individuals based on factors such as race, ethnicity, gender, social status, age, and disability to enhance participation in STEM fields (Lemarchand & Schneegans, 2013). The RSTI Policy is dedicated to addressing the structural drivers of gender inequality to elevate the participation of women in Science and Technology from an early age, thereby maximizing the nation's human potential. Furthermore, targeted initiatives are established to ensure equal opportunities for both men and women in pursuing careers in the sciences and engineering (Jackson et al., 2022).

In addition, the National Policy on Gender and Development, along with the National Gender Commission established in 2016, addresses a comprehensive range of issues, systems, and institutions to ensure that men and women have equal opportunities to enhance their potential as individuals and valuable citizens of Botswana (Essop et al., 2024). The overarching objective of this policy is to reduce inequalities in the opportunities and outcomes of social, economic, political, cultural, and legal development for both genders (Government of Botswana, 2016).

In line with Isaacs et al. (2023), the Botswana Vision 2036 also emphasises the importance of a robust science, technology, and innovation sector as a cornerstone for economic development and the establishment of a knowledge-based economy. This vision advocates for an enabling policy environment that promotes research and development, fosters innovation and commercialization, and safeguards indigenous knowledge alongside intellectual property rights (Government of Botswana, 2016). Furthermore, the vision articulates an aspiration for gender equality, envisioning a society in which all individuals, regardless of gender, have equal opportunities to engage actively in the economic, social, cultural, and political advancement of the nation (Government of Botswana, 2016, p. 22). The importance of Mathematics education in these issues cannot be overlooked, as it plays a pivotal role in empowering women. By enhancing women's proficiency in Mathematics, we cultivate critical thinking and problem-solving skills that are essential for effective participation in economic and political spheres. These competencies enable individual women to engage actively in discussions and contribute to decisions that influence their communities and broader society.

Because of the existence of educational policies that promote women's inclusion, Botswana stands out among African nations for having achieved the goal of equal participation in education, with the number of girls not only matching that of boys but, in fact, surpassing it at both primary and junior secondary levels (Mungoo, 2017). Nevertheless, several studies indicate that female students at the primary school level consistently outperform their male counterparts in mathematics and science disciplines (Ayuso et al., 2020; Blažev et al., 2017; Dunne et al., 2005; Kabote, 2014). Furthermore, at the junior secondary level, girls demonstrate superior performance in mathematics, while boys tend to outperform girls in integrated science (World Economic Forum, 2022). However, despite the good performance of girls over boys in the STEM disciplines, the socialisation processes in Botswana have been found to lead young girls to associate subjects such as science and technology with masculinity (Essop et al., 2024). This perception is likely to impact the aspirations and self-image of young women, resulting in their pursuit of disciplines outside of the STEM fields in higher education.

Further to this, while girls still outperform boys in high school, the absence of effective mentorship and the provision of misguided advice by educators and parents contribute to negative perceptions related to careers in STEM (Craig et al., 2018). This observation suggests that gender stereotypes adversely affect the advancement of female students in STEM disciplines as they progress through their educational journeys.

The Human Resource Development Council of Botswana (HRDCB, 2022) has revealed that enrolment in tertiary education exhibits a higher participation rate among female students compared to their male counterparts. Nevertheless, women remain significantly underrepresented at the doctoral level, where the number of male graduates exceeds that of female graduates. The information from the HRDCB is based on the overall participation of women in all the university disciplines and not STEM in particular. Data specific to STEM fields, particularly gender-disaggregated statistics in engineering, manufacturing, and construction, reveal notable gender disparities, with female students constituting only 29% of the enrolment, compared to 71% of male students (HRDCB, 2022). Mathematics is recognised as the foundational discipline upon which numerous fields such as engineering, manufacturing, and construction are established. This underrepresentation implies that the male demographic continues to maintain a substantial advantage in mathematical abilities relative to their female counterparts. Consequently, such a disparity may significantly influence the selection and participation of women within these traditionally male-dominated professions, underscoring the persistent challenge of achieving gender equity in mathematics-intensive careers.

The under-representation of women in STEM fields in Botswana universities and professions is primarily attributed to discriminatory practices that hinder their participation. For instance, the STEM landscape is significantly influenced by gender science stereotypes, which associate scientific achievements more closely with men than with women (Elu & Price, 2017; Huyer, 2019). Research conducted by Sato et al. (2021) indicates that gender bias during grant review processes adversely affects women's success in obtaining research funding. Furthermore, a continent-wide study in Africa has demonstrated that men receive a greater amount of funding compared to women in engineering and applied sciences (Fisher et al., 2020). Additionally, another study addressing the career experiences of African scientists by Prozesky and Mouton (2019) reveals that the challenge of balancing work and family life is notably significant for 80% of women researchers. According to Prozesky and Mouton's (2019) study, there is a significant disparity in the contributions of partners to household labor between male and female scientists. The study reveals that partners of male scientists take on a considerably greater share of domestic responsibilities, contributing a striking 47% of the household labor. In contrast, partners of female scientists are responsible for only 23%. This indicates a pronounced imbalance in support systems within these households, suggesting that male scientists benefit from a more substantial domestic contribution from their partners compared to their female counterparts. The findings raise important questions about gender roles in domestic labour and the implications for career advancement in the scientific community. Predominantly, the most frequently cited structural barrier to women's full participation in STEM is rooted in unequal gendered beliefs and expectations regarding their roles as caregivers (Beaudry et al., 2023; Fisher et al., 2020). Such discrepancies as alluded to above can significantly impede women's progression to higher academic or research positions within STEM disciplines. In addition to the factors alluded to above, women's participation in STEM in Botswana is hindered by factors that primarily include workplace sexual harassment, gender pay disparities, low job security particularly for young women scientists holding contract positions, and a deficiency of mentors and role models (Mukhawana et al., 2020; Prieto-Rodriguez et al., 2022; Prozesky & Mouton, 2019).

Nevertheless, despite not being fully developed, there are already established networks of dedicated stakeholders in Botswana focused on promoting gender equity and inclusivity in STEM fields. These collaborative efforts involve government agencies, educational institutions, non-profit organizations, and industry partners who work together to foster a supportive and empowering environment for women pursuing careers in science and technology. Through mentorship programs, workshops, and community outreach initiatives, they are actively addressing the barriers that women face in these fields, ensuring that aspiring female scientists and engineers have access to resources, opportunities, and a network of support that encourages their growth and success (Essop et al., 2024). Notable examples of these stakeholders include the Forum for Women Engineers and Girl Scientists in Africa (WEGSA), the African Academy of Sciences (AAS), and Debswana, a collaborative initiative between the De Beers Group and the Government of Botswana that promotes the participation of girls and women in STEM.

Additionally, the Organization for Women in Science in Developing Countries (OWSD), Botswana Chapter, plays a significant role. These institutions and networks actively address inequalities between genders and inspire girls and women to pursue education and careers in STEM fields.

In 2021, North Carolina State University established a partnership with Botswana to assist the nation in achieving the objectives outlined in its Vision 2036 initiative (Denson & Babyati, 2024). This collaboration is consistent with the aspirations articulated by the Ministry of Tertiary Education, Research, Science, and Technology, which aims to transition Botswana's economy from a resource-based framework to a knowledge-based one (Government of Botswana, 2016). Experts in economics identify two critical issues requiring attention in Botswana: the enhancement of STEM education within secondary institutions and the underrepresentation of women in STEM careers (Kennedy & Odell, 2014; Koketso, 2015). To address these challenges, North Carolina State University and the Botswana International University of Science and Technology (BIUST) initiated the eSTEM Botswana program. This distance mentoring initiative, referred to as an eMentoring program, is designed to support female high school students who have expressed interest in pursuing careers in STEM fields. As an intervention, eMentoring has demonstrated effectiveness in assisting women in STEM by providing exposure to industry professionals and workplace training, thus serving as a vital mechanism for engaging female secondary students enthusiastic about STEM disciplines (Denson & Bayati, 2024).

Women in STEM (WiS) is another organization established by a diverse group of students and young professionals in Botswana who are pursuing various careers in STEM fields across different institutions. Founded in 2018 with the support of the Development in Africa with Radio Astronomy (DARA) and the Newton Fund, WiS emerged following the completion of DARA and African Very Long Baseline Interferometry (AVN) student training programs. The organization aims to disseminate knowledge and resources related to Space Science, Technology, and other relevant STEM disciplines, with a particular focus on engaging the youth, who represent a significant portion of Botswana's population and a notable percentage of the unemployed demographic. WiS prioritises the empowerment of women within STEM fields while also actively involving men to promote resource sharing and collaborative projects. These objectives are achieved through a range of initiatives, including training programs, events, project development, and partnerships. WiS operates under the auspices of the Botswana International University of Science and Technology (BIUST) in affiliation with AVN-DARA and its Department of Physics and Astronomy within the College of Science.

Organisations such as those alluded to above have the potential to provide mentorship and serve as role models for women, thereby inspiring and motivating them to pursue careers in STEM. Initiatives that link female students with women professionals can also significantly enhance their confidence and career aspirations. By promoting the achievements of women in STEM, these organisations can work to challenge existing stereotypes and societal perceptions that may discourage women from entering STEM fields.

Inclusion of Women in STEM/Mathematics Education in Namibia

Mathematics is widely recognized as a fundamental science discipline, integral to various fields of study. Throughout the following discussions, any reference to science will encompass mathematics, highlighting its critical role in advancing scientific inquiry and understanding. Thus, when exploring scientific concepts, it is essential to acknowledge and include mathematics as a pivotal contributor to the broader scientific landscape.

Namibia experiences a perennial significant gender gap, particularly in the fields of science, technology, engineering, and mathematics (STEM), despite constitutional guarantees for gender equity. A 2018 report by UNESCO identified inadequate exposure to STEM education at the primary level, as a significant area in need of improvement in Namibia. In a subsequent report published in 2024, UNESCO observed that prevailing social norms and institutional cultures hinder many girls from pursuing careers in STEM fields, thereby contributing to a notably low representation of women in these sectors. Nevertheless, there is an increasing acknowledgment of this issue and concerted efforts to address it, as evidenced by recent STEM fairs, and programs such as the Organisation for Women in Science for the Developing World (OWSD) chapter at the University of Namibia. According to the OWSD website, owsd.net, the OWSD Namibia Chapter was established in June 2019 at the University of Namibia. Its objectives were centred on the empowerment of women in the field of sciences and the promotion of female participation in STEM disciplines. Recent conferences organised by OWSD have addressed the structural challenges that women encounter, including access to resources, training opportunities, and professional networks. These conferences aimed not only to empower women but also to highlight their significant contributions to the scientific community. However, challenges persist. According to Hubbard (2000), Namibia's 1990 Constitution guarantees equal protection under the law and prohibits gender discrimination, yet practical implementation remains a challenge. Despite these obstacles, progress is being achieved in certain areas (Human Sciences Research Council, HSRC, 2021).

According to the Human Sciences Research Council (HSRC,2021), women and girls in Namibia account for 51.57% of the country's population, which totals approximately 2.54 million individuals. According to Afrobarometer's 2018 survey, 15% of women and 14% of men reported experiencing gender-based discrimination within the year preceding the survey. Among the 13 African countries participating in the **Science Granting Council Initiative**, Namibian women reported the third highest incidence of discrimination, following Malawi and Zambia, and sharing the same level with Uganda. The reported instances of discrimination highlight broader societal and cultural norms that may undermine the recognition of women's contributions within STEM disciplines. This situation of discrimination has the potential to perpetuate stereotypes and discourage young women from pursuing educational and career opportunities in STEM fields (Issacs, et al., 2023). The high prevalence of discrimination reported by women in Namibia participating in the Science Granting Council Initiative shows substantial obstacles to achieving gender equality in sciences. It also portrays the necessity for comprehensive strategies to confront these challenges effectively. By prioritising policy reforms, cultural transformations, and the implementation of supportive initiatives, it could be feasible to create a more inclusive and equitable environment that not only empowers women but may also foster scientific innovation (Phiri & Mwaanga, 2020).

Moreover, the initial **National Policy on Research, Science and Technology**, adopted in 1999, led to the establishment of the **Research, Science and Technology Act 23 in 2004**. This legislation facilitated the establishment of the **National Commission for Research, Science, and Technology (NCRST)**, which has played a crucial role in the development of a **Research and Development (R&D)** fund and the implementation of a national program for research, science, and technology (Namibia Science & Technology Policy, 1999). The primary objective of Act 23 of 2004 was to enhance the promotion of scientific and innovative activities. While the act primarily focuses on the regulatory framework for establishing scientific institutions, it lacks articulations of guiding principles. Furthermore, despite addressing regulations pertinent to Namibian research personnel, there is no reference to inclusivity and gender equality within the recruitment provisions and very little is being done to promote women in STEM fields (Mare et al., 2024). If recruitment policies fail to actively promote gender equity, it is likely to dissuade women from pursuing careers in STEM fields, and as a result, cultural biases may continue to exert influence over hiring decisions.

Progress in advancing **Science, Technology, and Innovation (STI)**, as well as in promoting gender equity and inclusivity, is acknowledged in the revised **National Science, Technology, and Innovation Policy (2020-2030)** of Namibia. This policy has been developed and adopted in response to obligations arising from Vision 2030. It explicitly identifies the enhancement of gender equality as a key objective, accompanied by specific gender-based strategies. Moreover, the policy articulates a guiding principle that emphasizes the importance of a gender and equity-sensitive approach, which has the potential to inform appropriate interventions for men, women, youth, children, the elderly, and other historically disadvantaged, marginalized, and vulnerable communities, including individuals with disabilities (Pg. 6). Nevertheless, the terms "disadvantaged," "marginalised," and "vulnerable communities" are not clearly defined within the policy framework (Mare et al., 2024). This lack of specificity suggests that the interests and needs of women may not be comprehensively addressed by the policy.

A 2014 study revealed that the distribution of researchers in Namibia, categorised by scientific field and gender, consists of 28% women and 72% men. This data indicates a significant disparity in gender representation within the research community, highlighting ongoing discrimination against women. Nevertheless, Namibia has numerous stakeholders dedicated to promoting gender equity in Science, Technology, and Innovation (STI), who strive to empower women in the fields of Science, Technology, Engineering, and Mathematics (STEM). Among these organisations are:

(i) The Namibia University of Science and Technology (NUST)

The Namibia University of Science and Technology (NUST) hosts the Women in Science (WiSci) Girls STEAM Camp. The objective of the WiSci Camp is to bridge the gender gap in the fields of STEM by providing access to education, mentorship opportunities, and leadership training.

(ii) Forum for African Women Educationalists Namibia (FAWENA)

The **Forum for African Women Educationalists Namibia (FAWENA)** implements a variety of initiatives focused on women empowerment. The Science, Mathematics, and Technology (SMT) program, which is one of the initiatives, aims to enhance interest and participation among girls, thereby facilitating their academic excellence in SMT subjects at all educational levels. FAWENA conducts supplementary classes during school holidays, organises science clubs, and engages role models from scientific fields. Additionally, FAWENA awards female top achievers in SMT subjects to further encourage their academic pursuits. By presenting awards to top achievers, FAWENA not only recognises their hard work and dedication but also highlights the importance of female representation and success in traditionally male-dominated disciplines. This is likely to inspire young women to pursue excellence in these fields, which are crucial for innovation and progress in the 21st century.

(iii) Namibia Women in Engineering (NAMWIE)

Namibia Women in Engineering (NAMWIE) aims to enhance awareness of engineering as a viable career option for young girls while providing a supportive platform for women engineers in Namibia. Given that mathematics is integral to the field of engineering, it is through the study of mathematics that young girls are empowered to pursue careers in this discipline.

(iv) SADC Women in Science, Engineering and Technology Organisation (WISETO) Namibia Chapter

The mission of the SADC WISETO Namibia Chapter is to encourage increased participation of women in the fields of STEM by cultivating a supportive academic and social environment that facilitates their career pursuits in these areas. This initiative is designed to address the significant under-representation of women within STEM professions.

Inclusion of Women in STEM/Mathematics Education in South Africa

The resolution of South Africa's critical skills shortages, as well as the country's preparedness for a digital future, hinges on the enhancement of female participation and education in STEM fields (Sedibo et al., 2024). Historically, these disciplines have been predominantly occupied by white males, a phenomenon attributed by researchers (Braselmann, 2003; Borum & Walker, 2012; Herzig, 2004) to the prevailing Western ideology that posits intellectual inferiority of women compared to their male counterparts. This perception suggests that women are not considered intellectually equipped to engage in STEM careers. Additionally, Mills (1997) and Wilkins-Yel et al. (2019) indicate that the scientific community has established racial barriers within societies, thereby legitimising perceived racial disparities, particularly regarding the intellectual and social inferiority of African populations. This has resulted in the perpetuation of institutionalized racism and sexism, and fostered the reproduction of such biases within the scientific discipline.

STEM disciplines in South Africa have a documented history of exclusion (Mkhize, 2022). During the apartheid era, structural and cultural limitations predominantly affected women, resulting in white men constituting the majority of students enrolled in higher education programs within the fields of science and engineering (Case & Jawitz, 2004; Moshupi, 2013). Conversely, African individuals were often required to obtain special authorization to attend predominantly white universities that offered STEM courses or were compelled to pursue these studies abroad (Mlambo, 2017). Despite the current era's significant demand for skilled and talented young individuals capable of contributing innovative ideas and solutions, the STEM field continues to face challenges related to gender disparity and the underrepresentation of women (Ahmatiy, 2024).

Racist and sexist ideologies continue to persist within the STEM disciplines, with the implementation of meaningful changes progressing at a sluggish pace. As noted by Mkhize and Idahosa (2021), there has been little transformation within STEM fields and settings, despite mounting calls for reform from universities. Notably, the enrolment of numerous African students in STEM programs has catalyzed some reform efforts. Nevertheless, significant gender disparities remain, particularly within engineering disciplines, despite the increasing participation of women in the Science, Technology, Engineering, and Mathematics (STEM) fields (Ntombela, Ramabodu & Moloi, 2025). Women aspiring to pursue careers in these areas frequently encounter challenges such as restricted access to education, insufficient guidance, and prevalent discrimination (Amon, 2017). For example, South African women constitute only 23% of the STEM workforce, with a mere 17% occupying leadership roles (Taylor, 2023). Research indicates that South African women are actively engaged in efforts to transform the STEM disciplines by redesigning policies aimed at attracting African students (Badat & Sayed, 2014; Nyamnjoh, 2016).

According to data from the South African Higher Education Management Information System (HEMIS) covering the period from 2008 to 2018, African women represented 33.9% of registered students in STEM disciplines in 2018, an increase from 27.5% in 2008. Additionally, they accounted for 10% of total enrolments in 2018, up from 7.7% in 2008. However, similar disparities are observed in graduation rates. Despite a robust undergraduate graduation rate where women constituted 62.5% of graduates in STEM fields, only 10% attained master's degrees and a mere 2.1% completed doctoral programs in 2018 (HEMIS, 2018). Al-Haj Ali and Hijazi (2020) identify various barriers contributing to these trends, including societal stereotypes, organizational biases, and a lack of role models and mentors. Such obstacles may discourage women from pursuing or remaining in these professions, leading to elevated turnover rates and a loss of potential talent.

On the other hand, research indicates that White women have significantly benefited from affirmative action policies in the fields of science, technology, engineering, and mathematics (STEM) (Borum & Walker, 2012; Taylor et al., 2023; Mugambwa, Mwebaza & Namubiru, 2017). Furthermore, most of the existing literature addressing issues of exclusion and marginalization within STEM is primarily centred on the experiences of White women (Borum & Walker, 2012; Taylor et al., 2023). As a result, there is a prevailing perception within STEM disciplines that systemic transformation is occurring through the inclusion of White women. However, African women continue to be significantly underrepresented in these fields (Mkhize, 2022). This limited representation may adversely affect the career trajectories of African women in STEM. Consequently, the potential for scientific inquiry and technological innovation may be diminished, as women's unique perspectives and essential contributions are not fully integrated into these domains.

In 2016, the United Nations (UN) introduced the Sustainable Development Goals (SDGs) with a vision to promote social, economic, and environmentally sustainable development (Ntombela, Ramabodu & Moloi, 2025). The fifth goal emphasizes the achievement of gender equality and the empowerment of all women and girls. This emphasis arises from the UN's recognition of the integral role women play in contributing to the economic landscape of societies, highlighting that gender equity is a critical target for realizing this objective. The significance of gender diversity within STEM fields cannot be overstated, as empirical evidence demonstrates that diverse teams enhance innovation and improve problem-solving capabilities (Borrego, Foster & Froyd, 2014).

Research indicates that women encounter numerous challenges in engaging with STEM fields, as well as in other sectors outside of STEM. For instance, studies by Barrientos (2014), Manyungwa et al. (2019), and Canton (2021) explain the difficulties faced by women in South Africa along various value chains. These challenges include: (i) a limited presence and representation in decision-making roles, especially within higher-value and more specialized segments of value chains; and (ii) gender-based discrimination and inequality, wherein women receive lower wages than their male counterparts for equivalent work (Alkadry and Tower, 2006; Ruzungunde et al., 2020; Gould et al., 2016). Furthermore, traditional gender roles and societal norms present additional barriers to entry for women in certain sectors. (iii) Concentration in low-value segments often leads to engagement in informal economic activities, such as small-scale agriculture and craft production, which are typically characterized by a lack of social protection, limited access to credit, and heightened vulnerability to economic shocks. (iv) Additionally, the intersectionality of vulnerable groups, particularly women from marginalized communities such as rural women, women with disabilities, and women from ethnic minorities. This can result in additional barriers and discrimination within value chains (de Silva de Alwis, 2008; Canton, 2021). This phenomenon may be linked to the exclusion of women from STEM fields, which serve as a foundation for creativity, critical thinking, and innovation.

Discussion and Conclusion

This study found that despite the existence of educational policies that promote women inclusion in STEM education, the lack of discussions on reducing gender disparities indicate a significant gap in pedagogical practices (Freires et al., 2025). This is because societal norms and stereotypes concerning gender roles can impede the effective implementation of policies (Cookson, et al., 2025). Furthermore, when educators and students harbour biases against women in STEM fields, it may adversely impact classroom dynamics and discussions (Lavy V. & Megalokonomou, 2024). According to Teran-Bustamante (2024), there are two critical factors that decision-makers and public policymakers must take into account. The first factor pertains to the representation of women in university and professional settings within the fields of STEM and the skills that are derived from their participation. The second important factor involves the influence of stereotypes. This study compiled research derived from a range of scholarly sources such as (Master, 2020; Vuraya, 2021; Gudyanga, 2017; Sato et al., 2021), indicating that stereotypes and cultural limitations related to gender roles in the countries examined in this study, significantly affect women's engagement in STEM fields. Traditional beliefs often position STEM as a male-dominated domain, thus reinforcing the perception that women are inherently less capable in these disciplines. Such gender stereotypes notably influence career choices from an early age, which in turn affects women's retention rates in STEM careers. These stereotypes serve to diminish women's perceived potential and obstruct their professional advancement (McKinnon et al., 2024). Despite progress made by the four countries in narrowing the gender gap in STEM disciplines through gender equity policies, cultural stereotypes remain prevalent, particularly in rural regions where traditional views on gender roles are more deeply rooted (Denson & Babyati, 2024; Ntombela, Ramabodu & Moloi, 2025; Garwe & Chikwiri, 2021). Empirical data from the literature indicate that while Botswana has achieved gender parity in education, this equality is not fully realised within STEM fields (Mungoo, 2017). Conversely, Namibia has implemented policies and programs aimed at enhancing STEM education in its higher learning institutions. However, existing STEM policies, such as those from NCRST, Fawena, NAMWIE, and WISETO, lack the necessary guiding principles to ensure their effectiveness (Mare et al., 2024).

The legal frameworks governing education and gender equality differ across the specified countries, which influences the disparities in women's access to STEM education. Although each of the four countries features a progressive constitution that advocates for gender equality and equity, and has implemented policies designed to enhance women's representation in STEM fields, the execution of these policies remains inconsistent (Hubbard, 2000). In South Africa and Botswana, there is a notable concern regarding the educational opportunities afforded to black women, who frequently do not have access to the same quality of education and support systems as their white counterparts (Borum & Walker, 2012; Taylor et al., 2023; Mugambwa, Mwebaza & Namubiru, 2017). This inequality significantly limits their prospects in STEM fields. Consequently, addressing these disparities may enable targeted interventions that take into account the intersectionality of race and gender, ensuring that programs are both inclusive and equitable. In addition, the Namibian Constitution explicitly prohibits discrimination based on sex and affirms equal rights for both men and women. However, the implementation of these rights remains inconsistent, resulting in ongoing disparities in STEM participation (Ndeunyema, 2020).

Socialization also significantly influences attitudes toward STEM education among young women. In Botswana, for instance, cultural norms may lead girls to prioritize traditional gender roles over academic aspirations, resulting in diminished interest in pursuing STEM careers (Essop et al., 2024). Similarly, in Namibia, Zimbabwe, and South Africa, despite various initiatives designed to encourage female participation in STEM, entrenched gender norms continue to pose significant challenges (Lardies et al., 2019; UNESCO, 2024; Ruzungunde et al., 2020). The socialization process frequently reinforces stereotypes that imply women are less suited for careers in technical and scientific fields, thereby further obstructing their engagement in STEM education. In Zimbabwe, notable progress has been made in enhancing resources for STEM education, with the bigger portion of the governmental funding directed particularly at incentivising female students to select STEM subjects at the A Level. However, the sustainability of this program remains at risk due to prevailing economic challenges (Gadzirayi et al., 2016). Additionally, research indicates that female scientists tend to publish less than their male counterparts, emphasising the obstacles encountered by women in academia and the STEM workforce (Beaudry, et al., 2023). This disparity contributes to the persistent gender gap within these sectors. Data from Beaudry et al.'s (2023) study highlight that the gender gap is especially pronounced in STEM fields, where male interest significantly surpasses that of females.

In conclusion, the exclusion of women from STEM education represents a significant challenge in various regions worldwide. In countries such as Zimbabwe, Namibia, Botswana, and South Africa, this exclusion is shaped by a complex interplay of factors, including stereotypes, cultural limitations, legal structures, socialization processes, and the availability of resources. Generally, it is often perceived that women are not sufficiently intellectually equipped to pursue studies in STEM disciplines. Although numerous initiatives have been implemented to promote gender inclusivity, the benefits tend to be inequitably distributed, frequently favoring men over women. To cultivate a genuinely inclusive environment within STEM education, it is necessary to address these disparities and implement comprehensive strategies that support all women, irrespective of their background or race. Interventions designed to address gender-related barriers within STEM environments, such as mentoring, supervisory support, and the establishment of broader networks and linkages for women in STEM fields, may significantly contribute to the advancement of gender equality and equity in these domains (Fisher et al., 2020; Prieto-Rodriguez et al., 2022). For instance, the implementation of awareness programs for educators that focus on the deconstruction of gender stereotypes and the creation of more inclusive environments would be effective (Batista et al., 2024). It is only through concerted efforts that we can aspire to achieve gender equality in STEM fields and empower women to excel in these essential areas.

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