Overcoming Policy and Practice Fragility and Enhancing Security of Science, Technology and Innovation Educational Achievement for Females in Uganda

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Abstract

The Sustainable Development Goals 2030 (SDG 4 and 5) provide for the attainment of quality education for all, including women. Africa Agenda 2063, Uganda Vision 2040, the Third National Development Plan (NDP III) similarly all provide unequivocal reiterations on the need for the provision of quality inclusive education that will drive national socio-economic transformation. This is particularly envisioned through a robust science, technology, engineering and mathematics (STEM) education that fosters relevant science, technology and innovation (STI) knowledge, skills, values, attitudes and competences to constitute the epicentre of the transformation. Promoting the achievement of women in equal measure to men in STEM and STI is critical to the socio-economic transformation agenda. However, there exist gaps in the policy framework and the implementation of STEM education that undermine STI educational achievement, especially for women. This conceptual paper is aimed at examining the fragility of legal and policy frameworks for STEM/STI education and the strategies for enhancing STI educational achievement for females in the Ugandan context. We argue that strengthening the policy implementation of gender-responsive STEM/STI education is a precursor of socio-economic transformation of nations and the entire world. The paper adopts a semi-systematic literature review methodology to examine legal and policy documents for strengths, flaws and implementation gaps with the aim of recommending strategies for enhancing STEM/STI educational achievement for females in Uganda.

Keywords: *Education; Gender Policy; Science; Technology; Innovation*

Introduction

Science, technology, engineering, mathematics and innovation (STEMI) are vital to achieving internationally agreed development goals (Tizikara et al., 2019) and regarded as not only a precursor to industrial development but also to socio-economic development (Bichi et al., 2019; Gonzalez et al., 2020). STEMI help to develop skills and competences and promote innovation, which are necessary for national growth and development (Gonzalez et al., 2020). Tizikara et al. (2019), however, caution that unless the objectives, worries, circumstances and capacities of women and men are taken into account while creating STEMI policies and carrying out STEMI activities, STEMI cannot successfully assist fair and sustainable development. There are many barriers to success in the STEMI professions, particularly for girls and women, which require consideration. According to Tizikara (2019) and UNESCO (2020), women's and girls' capacity for STEMI participation is egregiously underdeveloped and underutilised. Girls and women are underrepresented in educational, entrepreneurial and employment possibilities, in addition to having less access to information and technology (Bichi et al., 2019; Gonzalez et al., 2020; Namatende-Sakwa & Longman, 2013).

According to rankings of gender equality around the world, Uganda's gender gap decreased from 70% in 1996 to 48% in 2017 (Tizikara, 2019). There was 90 % equality in educational attainment. Women's presence in professional and technical fields climbed from 22% in 2006 to an average of 35% in 2014. According to a 2012 UNDP report, women hold 22% of top management positions in the public sector and make up 33% of the entire workforce. The Uganda National Academy of Sciences honour roll lists 65 Fellows, only nine of whom are women.

There are not many disparities between girls' and boys' views about science in the first years of secondary school, according to studies. However, it is important to remember that there are significant leakages along the education pipeline, particularly for girls. According to Tizikara (2019), just 17% of women were represented in the natural sciences, 23% in engineering and technology, 31% in the medical sciences, 20% in agricultural sciences, and 27% in the social sciences, according to the 2015 UNESCO Science Report. According to the 2016 Women in Global Science and Technology (WISAT) assessment of gender and STI in Uganda, there were 39% females overall, with significant heterogeneity within institutions. These statistics follow several initiatives, among which are gender mainstreaming and affirmative action in higher education access, that aim at increasing the participation of girls/women in STEMI (Ampaire et al., 2021; Nabbuye, 2018).

A research study to track and map the career paths of a cohort of engineers who received their degrees between 2008 and 2012 found that just 15% of female engineers were nationally mobile, considerably fewer women were registered, and 34% of female engineers worked in fields unrelated to engineering. According to the Uganda Bureau of Statistics (UBOS, 2017), the majority of women-owned businesses were concentrated in the trade sector (44%), education, health and social work (49%), as well as lodging and food services (65%), highlighting the strong influence of the patriarchal culture that predominates in Ugandan society and the traditional " male" dominance of industries requiring technical skills.

Gender parity is a factor in the admissions procedures at educational institutions in Uganda. Despite having lower average cut-off scores for admission, female students are still underrepresented in most courses. The universities have set aside quota allocations for female students of at least 27 to 30%. At Busitema University, female enrolment grew by 21% between 2014 and 2018, faster than male enrolment, which rose by 13% (Busitema University, 2018). Although it met the quota requirement, the total male-to-female student ratio remained at 68 to 70% for men and 30 to 32% for women. There were gender inequalities in the enrolment in the various courses, with a significantly lower percentage of women enrolling in engineering and science and education. There were observable differences between courses in the percentage of female students enrolling in postgraduate study, which were also similarly lower. Similarly, women made up only 23.8% of the academic faculty in 2018. Engineering (18%), health sciences (21%) and agriculture (24%) faculties had lower female staff ratios than natural resources and environment (36%) and science and education (9%). The senior echelons were dominated by men. The larger percentage (58%) of female teaching assistants suggests that there is a conscious effort to recruit and guide young ladies into academic careers. The proportion of women in the administrative and support cadres was 35% and 27%, respectively.

In order to assist gender mainstreaming and university development, the Busitema University gender policy places a strong emphasis on gender research, budgeting, quality control and university outreach activities that pool information, skills, experiences and resources from the broader population. Three of the university's initiatives are gender-focused and represent best practices: (i) a minimum quota allocation of 27 to 30 % has been established for female students admitted in all undergraduate courses, and this has been maintained over time across all faculties; (ii) admission to the university is merit-based but with a gender lens, offering females lower cut-off points than males; and (iii) the university allocates funds for conducting gender-sensitive research. This is true for nearly all Ugandan universities.

Women continue to be underrepresented and devalued in STEM education (Nabbuye, 2018; Nakayiwa et al., 2020) and in paid employment, particularly in high potential areas and high-status occupations (Tizikara et al., 2019). This is true despite increased levels of education. Even though there are more girls in education than ever before in many fields, they are notably underrepresented in STEM fields. In all facets of the education value chain and job "pipeline", from interest in majoring in STEM disciplines in post-secondary education to STI professional careers, the representation of women gradually falls behind that of men (World Bank, 2018). To promote the desired gender equity in access to and achievement in STEMI fields at higher education levels and in the labour market in Uganda, this study was carried out to examine and close policy and practice gaps on STEMI education in the Ugandan higher education sector.

Purpose of the Review

The aim of this review was to locate and analyse the literature on the legal and policy frameworks for STEMI in Uganda, identify gaps between policy and practice and make recommendations for bridging policy and practice.

Review Questions

The study attempted to provide answers to three main questions:

(i) What legal and policy frameworks are in place to promote the participation of girls/women in STEMI in Uganda?

(ii) What are the gaps between policy and practice that lead to continuous underrepresentation of women in STEMI?
(iii) How do the legal and policy frameworks for STEM and STI translate into strategies for enhancing participation at national and institutional levels?

Methodology

This paper is based on a semi-systematic review of literature. The literature comprised peer-reviewed journal articles, institutional reports, books and book chapters, and conference proceedings on the topic of gender in STEM and STI. The search strategy used to locate and select the documents for analysis was based on different dimensions of the topic. The search followed a strategy based on keywords related to STEM, STI, gender, gender parity, gender policy, education and higher education. The bulk of documents were located from institutional databases and Google Scholar. The search field comprised titles, abstracts and full documents. Duplicate and inaccessible documents were eliminated. The search moved from screening of titles and abstracts to complete reading of full texts. The decision on selection, inclusion and exclusion of texts identified in the search was guided by the research purpose and questions. A narrative analysis and integration of data were done. Texts were analysed for similarities and differences in relation to the research purpose and questions.

Findings

Legal and policy frameworks of STEM and STI education in Uganda

Uganda is pro-women since it has signed international gender protocols. All levels of central and municipal government encourage gender-responsive legislation, policy and administration. In the 1960s, the Uganda Women's Union and the Uganda Council of Women were established in order for women to exert their political authority in Uganda. Upon entering power in 1986, the NRM government immediately committed to removing discrimination against women in official policy and practice and to encouraging women's participation in all facets of national development. The institution and promulgation of "quota" laws and policies contributed to an increase in female participation in political institutions, a rise in the enrolment of girl children in school and a gradual transformation of the legislative agenda as a large number of laws pertaining directly or indirectly to gender equality were introduced and promulgated. Intense deliberations and debates involving female politicians and activists resulted in the establishment of, among others, a ministry responsible for gender issues (1987), the National Women's Council (1993) and the Equal Opportunities Commission (2007).

Numerous laws, policies and initiatives have been enacted and implemented to enhance women's social, educational and health circumstances, economic autonomy, civic engagement and empowerment, either directly or indirectly. Local frameworks such as the 1995 Constitution, Vision 2040, NDP II, the National Women's Council Act (1993), the Equal Opportunities Commission Act (2007), the National Youth Policy (2001) and the 2016 NRM Manifesto uphold gender equality. The National Gender Policy (2007) supports gender mainstreaming in all government ministries, departments and agencies (MDAs) and local governments and mandates quotas for women in executive posts. The Gender in Education Sector Policy (2009), the National Strategy for Girls' Education (2000), the Social Development Sector Strategic Investment Plan and institutional gender policies aim to eradicate all types of gender inequality in education, social services and the workplace.

The United National Council on Science and Technology (UNCST) is responsible for national coordination of activities, while the Ministry of Science and Technology (MoSTI) provides political and policy leadership on all issues pertaining to the implementation of STI (MoSTI, 2017; United Nations [UN], 2020). Besides, the ministries of Agriculture, Animal Industry and Fisheries (MAAIF), Education and Sports (MoES), Finance, Planning and Economic Development (MoFPED), Gender, Labour and Social Development (MoGLSD), Tourism, Trade and Industry (MoTTI) and Health (MoH) have a direct impact on the management and operation of the STI ecosystem.

The National Development Programmes (NDP) II and III, and Vision 2040 granted STI sector status. In order to promote the implementation of the National Science, Technology and Innovation Policy enacted in 2009, a five-year National STI Plan was subsequently formulated in 2012. The primary purpose of the National STI Policy was to develop and strengthen national capabilities for the generation, transmission and utilisation of scientific knowledge, skills and technologies necessary for achieving Uganda's development goals. The STI strategy prioritises research and development as key factors of Uganda's technical and social development. In addition to increasing the number, qualifications and productivity of research personnel, the strategy aims to increase Uganda's Gross Expenditure on Research and Development (GERD) from 0.5% of GDP to the African Union-recommended 1%.

Uganda also subscribes to the Science, Technology and Innovation Strategy for Africa (STISA), which the African Heads of State adopted in 2014 to accelerate Africa's transition to an innovation-led, knowledge-based economy by enhancing STI preparedness in terms of infrastructure, professional and technical competence, and entrepreneurial capacity. By virtue of its membership in the East African Community (EAC), Uganda's STI system became a constituent member of the East African Science and Technology Commission (EASTECO) established in 2007 (and became operational in 2015) to enhance cooperation in the development of regional science and technology policies; to encourage joint mobilisation, use, management and development of resources, both material and human, for the development of science and technology in the EAC remit; and to provide a forum for the exchange of information and experiences among member states. The East African Regional Science, Technology and Innovation Policy will ensure that universities become centres of excellence for investments in education, technical competencies, and training, especially in science technology and education.

Gaps between Policy and Practice

Global trends in gender disparity in STI and STEM

Knowledge gaps exist even in advanced knowledge civilisations. Women's participation in the knowledge society is unequal or negligible everywhere, including the US. The number of women in STI is declining in the world's major economies. In most nations, women make up less than 30% of engineers, physicists and computer scientists. Women have less access to land, capital, technology and education, which are needed for the knowledge society and linked professions (Namatende-Sakwa & Longman, 2013). Economic position, government and political roles, access to economic, productive and technological resources, and a supportive policy environment affect female parity in STI. Health care, childcare, fair pay and gender mainstreaming benefit women.

Sub-Saharan Africa has 30% of the world's ICT professionals who are women. These facts indicate STI gender disparity. Global surveys compare male and female mathematicians, computer

scientists and natural sciences. Initiative of Women in Science and Engineering (IWISE), a global four-year project on women in STEM, found underrepresentation of women and that science policy and women's promotion, recruitment and retention lacked balance. Over 50% of undergraduate, graduate and post-graduate students were men, although female faculty presence increased with seniority (averaging 42% of assistant professors, 34.2% of associate professors and 23.4% of full professors). One-third of tenured faculty recruits were women. Retaining and advancing women into roles with more authority, resources and high-impact research seems to be the biggest challenge.

IWISE data showed no substantial or systematic changes in STEM techniques. There were emerging but limited gender-equity programs. Women's presence on strategic, decision-making committees was crucial because it is critical to have varied viewpoints and because participation builds leadership abilities and visibility. Women's underrepresentation hurts the entire field. While the gender gap in STEM studies and STI professions is well-documented globally, fresh data shows a substantial disadvantage in new and developing industries. Women lack career-advancing chances and resources.

Gaps in policy and practice in Uganda

According to Ssali's (2019) research on gender equality in local and international laws and policies and their implementation, as well as an earlier assessment of gender equality and STI (WISAT/WOUGNET, 2015), Uganda had strong gender-sensitive policies and legislative measures, but implementation issues prevented the country from reaching its intended goals. Women dominate nursing, secretarial and clerical positions in Uganda's public, health and education sectors, according to UNCST (2016) and UNDP (2012). In Uganda's government, men control certain positions and sectors, while women focus on caregiving. Uganda's public administration has not reached the critical mass of 30% women in decision-making positions, and the situation is far worse at the sub-national level. According to the 2011 Ministry of Public Service Gender Mainstreaming Guidelines, the top gender issues in public administration are recruitment, selection and promotions, with gender-insensitive instruction, progress, assignments, gender-inclusive vocabulary, work atmosphere and workplace harassment as leading concerns.

In both the public and private spheres, Ugandan women are viewed as weaker than men (Tizikira, 2019). Personal decisions are more important to women than family decisions. Significant partner impact exists on women's economic decisions, such as whether to work or study. Despite their numbers, girls and women have fewer opportunities to access resources (Namatende-Sakwa & Longman, 2013). Rural women observe and transmit their culture's customs. Lack of social security thwarts the ambitions of many women; many drop out of school and are unable to complete their degrees, diminishing their professional chances. As a result of stereotypes, caring for children, managing the family's finances and maintaining the home are regarded as "women's duties", limiting the identity and social role of women. Women must balance career and domestic duties.

Regional spatial inequality is on the rise. This imbalance is caused by poverty, infrastructure, societal pressures and early childbearing. Over 50% of Ugandan girls are married before the age of eighteen, and young women have a 5% lower literacy rate than young men. Women confront lifelong obstacles to adult literacy education, such as husbands discouraging their wives from enrolling in adult literacy and higher education programmes.

Universal primary education (UPE) ensures equal access to education, particularly for rural and impoverished populations. Enrolment in UPE has increased despite contested implications,

particularly for young women. Girls' enrolment is determined by their age and their mother's education, not by gender bias. Parental education has no effect on males. With UPE in place, the classrooms became overcrowded and the majority of students were average performers. The increased student-teacher ratio means it is more difficult to facilitate and direct learning in large classes. Owing to the poor quality of education, numerous classes contained students of incorrect age due to late enrolment or grade repeat.

The Ministry of Education acknowledged education leakage, particularly for girls, in 2017 (World Bank, 2018). In 2004, one out of every ten elementary school students attended secondary education. Between 2011 and 2015, survival and transition rates for boys and girls declined. Survival rates for boys and girls fell from 32% in 2011 to 30% in 2015, while transition rates dropped from 67% in 2011 to 53% in 2015. From 2000 to 2016, 66.8 million boys and 66.1 million girls attended primary school, while 16% of male elementary school graduates and 14% of female graduates attended high school.

According to the National Strategy for Girls' Education, hurdles to gender equality in secondary education include location, menstruation, family obligations and school attitudes. In 2007, the introduction of universal secondary education (USE) increased the number of girls enrolled in public secondary schools by 49%. Owing to tuition and the idea that secondary education is more advantageous for boys, the plan encouraged girls from low-income homes to attend secondary school. Since the implementation of the USE started, teachers' working conditions have deteriorated and students' motivation has decreased. Girls' parents view education as the government's primary responsibility, despite the policy's intention to involve multiple parties.

As with measures aiding women in STI occupations, there is an imbalance in the recruitment, advancement and retention of women in high positions. Despite affirmative action, men have an advantage due to the absence of participation targets or quotas. Administration structures and service delivery have not been prioritised despite the emphasis on gender equality. Without flexible employment options and equivalent procedures, women are disadvantaged by their caregiving responsibilities and "double load" (Tizikara, 2019).

Women are disadvantaged relative to males due to a lack of awareness of policy effects on women and men and the perception that men are breadwinners. According to studies, gender roles at home are more stable than in public settings. Changing the gender division of labour and sharing domestic responsibilities are important to gender equality in the workplace (World Bank, 2018). For working women to successfully navigate the home and the job, they need an education in life skills. Despite laws and dismissals, young female workers and students are frequently subjected to sexual harassment, including during recruitment and in return for grades/tests.

Despite equal the existence of opportunity regulations and legislation, certain difficulties remain unsolved, such as the societal construction of gender in conventionally masculine positions assumed by women, isolation and sexual harassment, and generational variations in the perception of women in STEM/STI. Some are neglected or irrelevant (such as recruitment and promotion practices for part-time, hourly paid, pregnant women and older staff). The nation invests in STEMI education for youth, but does not develop mid-career practitioners or value, employ and retain veterans. Others, especially those that recruit from a small, elite pool of professionals, lack clear protocols for recruitment, staff development and advancement.

The Employment Act mandates equal compensation for equal work (2006). Anecdotal research suggests that working women do not always want to exert extra effort to create the performance skills necessary for promotion because "they are married to men who earn more; and since the

husbands provide for everything, they do not need to stress for promotion." This kind of thinking is problematic. First, this does not apply to single women or widows. The gender wage gap should also be investigated. If they assume that all households have a male wage earner, travel and housing allowances can lead to unequal financial gains.

Entry, retention and completion by gender in STEM education in Uganda

Facilitating factors

Since the Beijing World Conference on Women in 1995 and the Johannesburg World Summit on Sustainable Development in 2002, the global community has attempted to involve women and girls in research (Tizikara, 2019). In 1975, March 8 became International Women's Day. It has become a rallying cry for the rights and involvement of women, particularly in the political and economic spheres. At its 81st plenary session in December 2015, the United Nations proclaimed February 11 as International Day of Women and Girls in Science to encourage women and girls' equitable access to and participation in science, gender equality and empowerment.

According to Tizikara (2019), affirmative action in education policy has decreased gender gaps in education but not in employment. In general, women benefit from the national STI research system. These research methodologies involve women in the selection, creation and application of technology through consultation and collaboration. Diverse assistance programmes encourage girls to enrol in STEM courses and women to pursue and remain in STI fields. Numerous networks and organisations help girls and women who pursue professions in STEM and STI. The integration of gender problems and comprehension of gender usage and access patterns are crucial for STI prevention among women.

National gender-sensitive investments and interventions in STI have centred on establishing the institutional structures required for effective and sustainable STI policy implementation, and approaches that facilitate the application of a gender lens, ensuring that both women and men benefit; establishing and maintaining effective partnerships and consultations with stakeholders in the study and application of science; and utilising tools.

Hindering factors

There are gender disparities in health, social standing, the economy, and access to resources. This restricts the access of women and girls to technology, knowledge, education, scientific research, employment, decision-making and the private sector (Namatende-Sakwa & Longman, 2013). From 2002 to 2014, Uganda's GERD averaged 0.31% of GDP, rising from 0.17% in 2010 to 0.48% in 2010. According to the ministries of Education and Finance, the proportion of the national budget allocated to education increased from 12% in 1991 to 21% between 1997 and 2000. In FY 2019/20, it was 10%, down from 18% in 2001–2006. Investments in tertiary/university education decreased from 11% in 1997 to 8% in 2002, averaged 11% from 2003 to 2012, increased to 20% in 2016, and then again to 13% in 2019.

Tizikara asserts that Ugandan women are innovators, entrepreneurs, guardians of STI sub-systems, researchers and practitioners (2019). Owing to "gender leakages", women are underrepresented in education, work and creativity. Multiple studies demonstrate girls' difficulties in STEM fields. Inappropriate education for girls, security issues, a pedagogy that favours boys and unequal access to technical and vocational education are culprits. The absence of female STEM role models, popular culture depictions, and cultural attitudes, female discomfort in male-dominated

classes, lack of encouragement and support for females in STEM topics, and harsh and inhospitable academic systems are highlighted.

Self-perception and confidence are reasons why women are underrepresented in STEM fields. Some women (and their parents/guardians) believe that girls cannot flourish in maths and science at the same level as boys. Long-standing gender stereotypes and cultural biases contribute to the underrepresentation of women in STEM fields (Frosina & Mwaura, 2016). Some locations dictate women's occupational choices (and Study fields).

The underrepresentation of women in STI careers has multiple causes. These include domestic and career responsibilities (conflicts between career and family, inflexible hours); (ii) the length of preparation necessary; (iii) gender bias (perception of women in these fields as unfeminine and/or lack of confidence in their ability to perform the work); and (iv) a lack of social encouragement to pursue careers in these fields. Many jobs dominated by women are being lost to automation. Other causes include underrepresentation of women in STEM disciplines, undeveloped infrastructure to enable women to enter or re-enter the workforce, such as child- and elder-care services, and the fact that unpaid labour is predominantly the duty of women are potential causes.

Strategies for enhancing female participation in STI education in Uganda

Increasing the number of women in science is not simple. Involving women requires access to resources, gender empowerment and a robust educational system. Increasing formal (postgraduate) and informal (workplace) education, as well as training programmes for women and girls, can support lifelong education. It is crucial to include mentorship tools, prominent role models, toolkits and funding for "Girls in STEM" programmes that encourage STI careers for women, apprenticeships, workplace training and retraining when they return to the field. In training and programmes for women, balancing job and household responsibilities, discrimination and harassment should be addressed.

A number of government and institutional programmes attempt to increase female involvement in STI and STEM. There are numerous gender-specific regulations that support STI and STEM. Tizikara (2019) examines government-adopted research and development (R&D) programmes. The 2007–2013 Millennium Science Initiative (MSI), the current Research and Innovation Fund (RIF) and a number of presidential initiatives all seek to fund senior and graduate researchers engaged in highly tailored and influential research and innovation projects that drive the nation's development agenda. The establishment of centres of excellence was intended to improve institutional training, research and innovation. These include innovation centres and cluster efforts that promote young inventors and entrepreneurs. The Ministry of Finance, Planning and Economic Development's (MOFPED) budget framework document for 2018/2019–2022/2023 reviews 2016/2017 policy achievements and forecasts increased STI output (MoFPED, 2018). The projects and activities are updated in the second-half budget monitoring report for 2019/2020 prepared by MoFPED (2020).

Girls in Science and the National Plan for Girls' Education (2000) address gender disparities in education and STEM. In 1991, the government awarded 1.5 additional points to girls entering college in an effort to increase the proportion of women in higher education (NCHE, 2013). In 2013, the Higher Education Students' Loan Scheme was established to aid science students. The scheme encourages gender equality.

At the institutional level, policies and affirmative actions have been implemented to address gender disparities in education, particularly in STEM fields. Tizikara (2019) details the initiatives of

Bustema University, Makerere University and Mbarara University of Science and Technology (MUST) to eliminate gender disparity in STEM. According to reports, Busitema University has developed a gender policy to promote gender mainstreaming. The admissions policy of the university promotes more women to enrol in STEM courses, and 27–30% of entrance positions are reserved for women. Women have lower admission requirements than men. These initiatives eliminate gender disparities in STEM. In high schools, outreach programmes promote gender-sensitive career counselling. The higher education access certificate (HEAC) programme at Busitema University is designed to connect students to science courses. In 2019, Makerere University established a STEM affirmative action policy, according to the study by which 40% of STEM occupations were reserved for women. MUST joined the "STEM for Girls" initiative of Google. The project was intended to increase female engagement in STEM fields in secondary schools. This would be accomplished through workshops for science teachers and visits to schools.

UN Women and UNESCO collaborate with international partners to address the gender gap in STEM and digital technologies. Interventions include strengthening women in the workplace, marketplace and society, as well as targeting injustices early in the education system by increasing girls' interest in STEM subjects, combatting stereotypes in the curriculum, and enhancing access to female mentors. In addition, they collect data disaggregated by gender to promote gender equality in national STI policies, strategies, plans and regulations, and they provide fellowships, networking opportunities and mentoring for female academics. L'Oréal-UNESCO for Women in Science has recognised female scientists since 1998. The initiative has recognised, promoted and supported over 3,000 women in science. The foundation has promoted girls' interest in science to encourage the pursuit of vocations.

The world can benefit from the Fourth Industrial Revolution by using the creativity and ingenuity of all women and girls in science and by investing in inclusive STEM education, R&D and STI ecosystems. Applying a gender perspective to STI for development, supporting gender-appropriate teaching approaches and materials, and providing grants and other non-monetary incentives can overcome many of these problems. Technology may not eliminate gender inequality, but it certainly helps. To enable the private sector, IT industry and government to innovate wisely and responsibly, the national STI system should institute prudent measures. Rarely do STI policies and decisions include women's needs and concerns. Due to their economic and cultural significance, women are potent change agents. Using a gendered approach to science and technology for development must account for their interests and concerns. Women in science can contribute to society through shaping science and technology, research and innovation (R&D). In three of the four countries reporting science and technology education intake ratios, males benefit more than females. To promote women's innovation, access to education, capital and markets technology must be improved. Entrepreneurial women need aid.

To improve STI for women in agriculture, it is essential to integrate gender considerations and to comprehend gender usage and access trends (Namatende-Sakwa & Longman, 2013). There are gender-biased/focused STI initiatives for validating, protecting and improving local knowledge, innovations and skills in food production, energy, water, nutrition, transport and natural resource management, and numerous technologies have been developed and disseminated, particularly those aimed at reducing women's workload and improving their health, addressing gender-differentiated needs and problems, or providing women with economic opportunities.

Modern, clean, affordable, sustainable (green and renewable) energy (domestic biogas, solar home systems) and clean and efficient household cooking solutions and home designs (cook stoves that use a wider variety of biomass as fuel, chimneys/hoods and adequate ventilation in kitchens) have improved health, food security and time savings. Most family caregiving decisions are made by women. Artificial Intelligence (AI) and routine labour automation can save healthcare expenses by minimising bureaucratic procedures. Online platforms for communicating and obtaining sensitive information enhance the health care autonomy of women. Apps that track the menstrual cycle could reduce absences from class and work.

Discussion

The Government of Uganda recognises the importance of STI and gender equality in the process of national development. The potential for industrialisation and job creation in Uganda is great if the manufacturing, agricultural and agro-processing sectors are revitalised. In this context, having access to highly qualified domestic technical personnel is important for success. Consequently, the government has made significant strides in creating an enabling policy environment for enhancing the participation of girls and women in STEM and STI and to take advantage of the social and economic growth benefits resulting from gender-sensitive STI initiatives. Several sector policies, strategies and pieces of legislation, as well as institutional frameworks, articulate gender equality and STEM education and employment issues. However, as is the case in many nations, national policies and strategies appear to have neglected the need to address some of the most significant obstacles to girls and women's pursuit of higher education. Diaz-Chavez and Mungo (2021) posit that such obstacles manifest in low enrolment of girls in STEM. This finding is in agreement with that by Hafkin (2016), who reasons that sector-specific policies, programmes and projects may not always reflect constitutional and legislative commitments to gender equality and inclusion. Watera (2018) adds that the majority of policies, plans and strategies focus on resource, infrastructure and finance difficulties rather than the key barriers to girls' enrolment in STEM fields.

For instance, policies have not targeted the groups of people who socialise children into different societal and cultural roles. Children's choices, accomplishments and goals are influenced by their parents, families and community members. Girls' attitudes towards fields relating to science and technology are impacted by this socialisation. This is in agreement with UNESCO's (2020) and Watera's (2020) argument that gender bias and stereotypes in families, communities and the education system have prevented girls and women from participating in STI and STEM. The government has also made accommodations for students' financing in the form of a higher education loan programme to among other objectives promote the participation of girls in STEM courses in higher education. However, owing to the high competition, many needy female students are locked out of the scheme. Thus the policies have resulted in a number of improvements, but the representation of girls and women in STI and STEM is still marked by pronounced disparities, as evidenced by the low enrolment of women in STEM courses at universities.

Similarly, the proportion of women and girls working in STI- and STEM-related professions has remained low, a sign that there is a mismatch between policy and practice. Despite the impressive techniques used by the government and colleges, few women select careers in STEM fields. Because there are not enough girls participating in STEM at lower educational levels to create a pool for university entrance, STEM enrolment is still low. According to Watera (2018), this is due to social factors that reinforce preconceptions within the educational system, as well as teacher and curriculum

gender bias that results in gender-insensitive pedagogy. Public gender equality programmes or policies that encourage girls' participation in STEM fields typically do not address these problems. If teacher development programmes included strategies for eradicating gender prejudice from schools and classrooms and retraining instructors in gender-sensitive pedagogy, they might be successful. Women are also underrepresented in research and academic professions in Uganda and globally owing to barriers to networking, juggling work and family obligations, and career planning. Government has established an innovation fund to support scientific and innovative research but, like the loan scheme, this project is very competitive and many female researchers are thus excluded.

Conclusion

Economists argue that the world of work is changing rapidly, and this change is driven by STEM skills and knowledge. STEM subjects and skills are thus becoming increasingly essential in the competitive world today. Moreover, STEM skills play a key role in fostering development in a country. They are thus essential in accelerating Uganda's development aspirations to a middle income country and the achievement of the SDGs. Gender equality in science and technology is a central ingredient in facilitating these trends. We acknowledge that Uganda has done much in creating an enabling policy environment for the improvement of the participation of Girls and women in STI and STEM. The policy and institutional provisions have brought in some improvements but pronounced disparities can still be found in the representation of girls and women in STI and STEM. This could be attributed to the fact that the underrepresentation of girls and women in science is deeply rooted in unfavourable constructs that legal and policy frameworks have not addressed. Systemic, social and cultural barriers to girls and women's participation in science disciplines and careers still exist. Addressing these barriers would improve entry and retention of girls and women in science, enabling them to favourably compete and excel in their careers.

Therefore, in order to ensure that sustainable development does not overlook the potential talents and contributions of women and girls, STI and STEM policies need to be thoroughly examined. Local, national and regional organisations, as well as innovation networks, must take more initiatives. The socio-economic and environmental transformation envisioned in UN Agenda 2030 and Uganda Vision 2040 is made possible by a more comprehensive, socially inclusive approach to STI and STEM. In order to reduce gender discrepancies in participation in STI and STEM in Uganda, seemingly favourable policies need to change. It is important to revisit the legal and policy frameworks for gaps and effect changes where necessary. Such changes are likely to have significant impacts on young people and women in the workforce. Otherwise, in spite of the robust gender, STEM and STI legal and policy frameworks in place, girls and women may still remain excluded from lucrative and fulfilling job options.

Recommendations

The following recommendations derive from the conclusion. It is critical for Uganda to coordinate policies and initiatives that support STEM education at all levels in order to assist the growth of higher order skills required for modernising or reviving the nation's manufacturing sectors. If women are to benefit from the critically important 21st century abilities, many of which are obtained from education and training in STEM-related disciplines, the government needs to expedite cooperative efforts to promote the participation of girls and women in STEM-related subjects. The STI ecosystem's diverse stakeholders must work together to address girls' and women's underrepresentation in

science disciplines and professions. To effect change, the public and business sectors, academic institutions, communities, teachers, parents and girls and young women themselves must work together. Evidence gathered from local actors must guide policy.

The ministries responsible for education, STI and gender need to establish joint programmes to encourage women's participation in order to increase the number of women who work in STI/STEM. More girls and women are likely to be drawn to STI- and STEM-related fields and careers if there is a combined scholarship fund for awarding bright female students and young female researchers engaged in cutting-edge research and other outstanding scientific achievements.

It is necessary for curriculum developers to address the prejudices and preconceptions produced within the curriculum and learning materials, including textbooks; and this should also be addressed by policy. STEM policy must cover interventions that target parents, too, in order to foster a good attitude towards STEM.

Higher education institutes and universities need to implement strict mentoring programmes for young female researchers in order to assist them in overcoming the challenges of an academic career and other obstacles to their advancement. Girls and young women also require powerful female role models to pique their interest in STEM fields. Role models, encouragement and support for young women to start out and advance in STEM-related occupations would be provided by policy programmes that can bring together women and men from the STI industry. Listening to the success stories of female scientists in academia, business, the corporate world and other STEM-related professions would be more beneficial for girls and women.

A concerted effort to enhance the proportion of female scientific educators at the secondary school level and who are university professors should also be taken into consideration when formulating policy. The advancement of women in science and technology should be documented and shared, suggests Tizikara (2019). For this, a three-pronged approach is suggested: (a) at the national level, the establishment of a journal to publish research and innovation by female scientists, and hosting a symposium to disseminate such works and innovations; (b) universities should include gender equality weeks in their annual curricula so that female scientists can share their experiences and progress; and (c) secondary schools should hold a girls' science day to promote interest in STEM-related subjects. These events are beneficial for increasing the visibility of women in STEM fields, addressing issues of inequity, and advancing gender equality. They provide opportunities to spread knowledge regarding institutional and national gender equality policies and programmes, many of which stakeholders are unaware of.

It is crucial to make conscious efforts to advance gender and women studies, as well as gender equality research and education. In this regard, Makerere, the oldest public university in the nation, has made significant gains, and gender concerns are now included in certain colleges' curricula as themes and courses. If this technique is left to individual institutions, it will not yield much gain. The Ministry of Education and NCHE need to work together in a coordinated effort.

Declaration of Conflict of Interest

We declare no conflict of interest

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Availability of data and material for data transparency

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