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OVERCOMING GENDER INEQUITY IN SCIENCE AND TECHNOLOGY GRADUATE EDUCATION IN GHANA

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ABSTRACT

Women remain underrepresented in science and technology (S&T) education in Ghana. Unfortunately, very little is known about policies designed to enhance women's participation, or about the experiences of those women who have successfully pursued S&T in Ghanaian universities. To gain a better understanding of how some women have overcome longstanding obstacles to gender equity in S&T graduate education in Ghana, a qualitative inquiry was undertaken to examine key policies aimed at enhancing women's participation in S&T, assess the efficacy of those policies, and explore the personal experiences of a cohort of women who have been successful in three S&T graduate level education centres in Ghana.

A conceptual framework, guided by feminist theory, presents a sequence of three approaches—(a) consciousness-raising; (b) affirmative-action; and (c) gender mainstreaming—complemented by structuration theory. This framework has helped elucidate how the development and effective implementation of gender policies can lead to the transformation of institutional, social, and global structures. Structures in turn can impact women's agency and help overcome gender disparity in S&T higher education (HE). The analysis of the women's stories provided insights into how gendered challenges impacted the professional aspirations of women academics in the S&T centres studied.

KEYWORDS

Science and technology; higher education; gender; policy; structuration theory; qualitative inquiry; Ghana.

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INTRODUCTION

Gender inequity in science and technology (S&T) disciplines, is currently one of the greatest development challenges facing countries globally. Although this problem is well-known, its complexity is broadly underrated, and causes are not well understood. In 2009, women represented 24% of those pursuing S&T careers in the USA (Langdon et.al., 2011). In Canada, in 2011, women aged 25 to 34 accounted for 39% of university graduates with an S&T degree compared with 66% of university graduates in non-S&T programs (Hango, 2013). The female postsecondary enrolments in engineering in Canada were 21% in 2017 (Statistics Canada, 2021). Similarly in developing countries, the gender distribution is significantly higher for men than women in S&T programs. In Chinese universities in 2005, women represented 22.7% of engineering majors with enrolment disparity between urban and rural graduates (Guo, Tsang & Ding, 2010). In Latin America, women are under-studied in S&T fields. Women represented only 11 % of graduates of higher education institutions (HEI) in 2007 (Castillo, Grazzi & Tacsir, 2014). The paucity of data has precluded scholars from getting a better understanding of the contributing factors and thus making it difficult for policymakers to initiate effective evidence-based interventions.

In many African countries, HE is regarded as a critical force for modernization and development. However, the highest level of gender disparity in S&T HE in the world has been found in sub-Saharan Africa (SSA). In 2011, the proportions of female instructors in S&T faculties in Mozambique and Zimbabwe were 23% and 24% respectively (Morna & Jambaya-Nyakujara, 2011). African countries continue to face a shortage of S&T specialists.

Women's enrolment in S&T HE in Ghana followed the same trends as that of other sub-Saharan African countries. Gender distribution of students at the Kwame Nkrumah University of Science and Technology (KNUST) in Ghana was on average 27.2% from the academic years 2011-2012 to 2015-2016 (KNUST, 2017). The gender-disaggregated statistics reveal enrolment of women as being only 16% of total admissions at the University of Mines and Technology of Ghana for the academic year 2011–2012 and the gender distribution of employees in mining companies in Ghana in 2014 was 14% for women (Rufai & Mohammed-Aminu, 2016). The overall pattern of exclusion and marginalization is perceivable at both administrative and academic tracks, but it is most acute for senior academic and research positions (Mama, 2003). Knowledge gaps are a key constraint to innovation, productivity growth, and economic development.

Equally intriguing, in view of the relative scarcity of women in the S&T fields, there is surprisingly little knowledge concerning the attributes and the experiences of those Ghanaian women who do enrol and teach in S&T fields. This in turn limits the efficacy of policies that purport to augment female student enrolment in S&T programs. The creation of equal opportunities related to gender means the elimination of obstacles, biases, prejudices, and gender stereotypes that impede

women's participation in the formal economic sector. The United Nations (UN) 2030 Sustainable Development Goals (SDGs) assert that inclusive and equitable quality education is not only an essential human right, but is required for a peaceful, prosperous and sustainable world (United Nations, 2015). Consequently, the United Nations Educational, Scientific and Cultural Organization (UNESCO), in 2018, increased its focus on women in science, building on existing programmes and introducing new initiatives towards Sustainable Development Goal 5: Gender Equality and full participation of women at all levels of decision-making (UNESCO, 2019). The inclusion of women in research and development enhances research responsiveness to social needs and potentially contributes to new ideas, patents, and technology (Schiebinger, 2014). It is necessary to examine the relative efficacy of policies that have been put in place that are ostensibly designed to overcome these obstacles and thence increase female enrolment in S&T HE programs. Equally important is the need to understand the characteristics and the experiences of Ghanaian women who do study and teach in S&T fields.

The purpose of this study, therefore, is to assess the policies instituted to address gender inequity in HE in Ghana and to examine the experiences and perceptions of African women who have achieved entry into graduate level S&T programs in three regional Africa Centres of Excellence (ACEs) as students, instructors, and administrators. To address the purpose of the study, my specific research questions are:

Main Questions:
What are the experiences of women in S&T graduate programs in Ghana?
To what extent have these women been affected by policies and strategies?

Sub-questions:

- To what extent are these policies and strategies conceived as: a) forms of consciousness-raising? b) affirmative action? and/or c) gender mainstreaming?
- What obstacles have women in S&T graduate programs had to overcome to pursue their studies and careers in S&T fields?
- What factors have enabled these women to overcome these obstacles?
- In what ways have the aforementioned policies and strategies facilitated women's pursuit of S&T studies and careers?

For this study, three typologies of gender-related policies are examined. They include: a) those that can be defined as fostering consciousness-raising on gender issues; b) those that are designed as affirmative action measures that aim specifically to foster gender equity by increasing the participation of women as students, instructors, and administrators in graduate S&T education and research; and c) those that can be regarded as gender mainstreaming that aim to normalize gender equity as a feature of everyday practice. The focus is to examine the personal, cultural, and socio-economic factors that have enabled women to gain access to and participate in S&T HE in Ghana.

LITERATURE REVIEW

Gender Inequity in the Formal Sector

The organizational cultures of formal education systems are very much influenced by social structures that have shaped mainstream educational discourse and the professional identity of educators. Entrenched gender roles and intercultural relations have created structural barriers to women's professional aspirations. This is especially evident in HE where gender is a crucial element in the organization and division of labour that has effectively limited women's upward mobility. Gender inequities persist in the higher ranks of academia, which in turn affects retention. This is apparent in the customary congregation of women academics in lecturer positions with limited opportunities for promotion.

While the access rate to HE reaches 76% in Western countries, African countries barely exceed 18 % (UNESCO, 2018). Women made up just 10.5% of the academic staff and 5.3% of the assistant professor and higher positions in Ethiopia (Semela, Bekeleb, & Abraham, 2020). At the University of Ghana (UG), women represented 21% of associate professors, 19% of senior lecturers, 24% of lecturers, and 42% of assistant lecturers in 2012-2013 (National Council for Tertiary Education (NCTE), 2014). There is substantial evidence that urban-rural and social-class disparities exist within the education system. Inequitable participation of women has limited economic progress because a large part of society's human resources is neglected (Ako-Nai & Obamawoye, 2018; Okorafor, Obidile, Okorafor, & Uduanochie, 2015).

Women in S&T in Higher Education

There is little doubt that more and more professional jobs will be in the S&T fields. This raises concerns about current disparities in S&T disciplines where almost everywhere in the world male enrolments outweigh that of females. Despite the global expansion of HE systems, participation rates among women in S&T HE and in the academic workforce have lagged behind those of their male counterparts. The situation is worse in graduate S&T education level. Vast numbers of women represent untapped human capital that could enhance the S&T workforce. Early-career female researchers experience career choice constraints preventing some of them from successfully reaching career advancement (Nielsen, 2017).

S&T disciplinary cultures are gendered because social and cultural practices, images, and identities are related to specific aspects of masculinity and tend to contribute to the proliferation of gender segregation in the fields of scientific inquiry. Numerous studies have revealed that women are regularly exposed to stereotypes and discrimination (Bosak, Eagly, Diekman, & Sczesny, 2018; Liani, Nyamongo & Tolhurst, 2020). More broadly, however, the norms, standards, organizational structures and practices in S&T HEIs are frequently mirror images of patriarchal structure and practices. Studies have demonstrated that women perform better in a cooperative learning environment. Competitive teaching methods used in S&T programs are not particularly favourable to women and tend to exacerbate the ethical and social problems that challenge students in S&T education and suggest inefficiency in tackling the issue of gender disparity in S&T classes (Witherspoon & Schunn, 2019). The scarcity of female role models is also a

contributing factor to the gender gap from an early stage of the S&T education journey (Siani, Marley, Smith, & Donnelly, 2020).

Gender Inequity in S&T Higher Education in Ghana

Despite the exceptional surge in enrolment in Ghana's system of HE over the past 10 years, full gender parity has not been reached, especially at the graduate level (Atuahene & Owusu-Ansah, 2013). Many women who would be eligible for graduate education do not have access and are thus excluded from the formal socio-economic sector. Those women who are able to gain access to HE, often opt for humanities and social sciences rather than S&T disciplines. The government of Ghana's (GoG) HE policy goal on enrolment has been 60:40 for S&T and Arts and Humanities respectively since the eighties (Ministry of Education (MoE), 2010). However, enrolment trends over the past few decades suggest that this policy goal is far from being achieved. The Ghana 2010 women undergraduate enrolment rate in arts and humanities was 78% compared to 22% in S&T (Atuahene & Owusu-Ansah, 2013). One of the most significant interventions initiated by the MoE to promote girls S&T education was the introduction of the Science, Technology and Mathematics Education (STME) initiative launched in 1987. The main goal of the STME clinics was to achieve a target of 30% of female students in HE pursuing a career in S&T fields. The program managed to increase girls' participation from 12% to 25% within 25 years but did not reach the ultimate goal of 30% female representation before it was discontinued and replaced with a boys and girls S&T programme (MoE, 2010).

Women originating from poor backgrounds and those living in rural areas have the most difficulty accessing HE in Ghana, partly due to high perceived opportunity costs and traditional views concerning the appropriate role of women as wives and mothers. In rural areas in Ghana, only 29% of women are literate compared to 52% of men (Mabokela & Mlambo, 2015), and low socio-economic status is correlated with low school attendance rates. This relates to power relations between Ghanaian males and females and traditional norms and values that strongly encourage women to fully embrace the gendered role assigned to them. Generally, in Ghanaian society, women's primary role was to give birth, raise children, and care for household needs (Alhassan & Odame, 2015). Customary practices entrenched in masculine organizational cultures continue to hamper the effectiveness of existing legislation and gender policies. Women continue to struggle for access to formal education, particularly in S&T fields. The average female participation in engineering programs between 2010 and 2015 was 13.6% at KNUST (see Table 1).

Table 1 Gender distribution of students from 2010-2011 to 2014-2015: Faculty of Engineering, KNUST

Academic Year	Students	Number		Percentage	
		Male	Female	Male	Female
2010–2011	1116	980	136	87.8	12.2
2011–2012	1153	966	187	83.8	16.2
2012–2013	1402	1211	191	86.4	13.6
2013–2014	1325	1111	214	83.8	16.2
2014–2015	1061	986	75	92.9	7.1

Note: Adapted from "The state of gender parity, underprivileged and minority enrolments in public universities in Ghana". Baraka Policy Institute (BPI) (2016).

The lowest female representations of academic and non-academic positions were 19% and 20% respectively in 2012-2013 (see Figures 1 and 2 below).

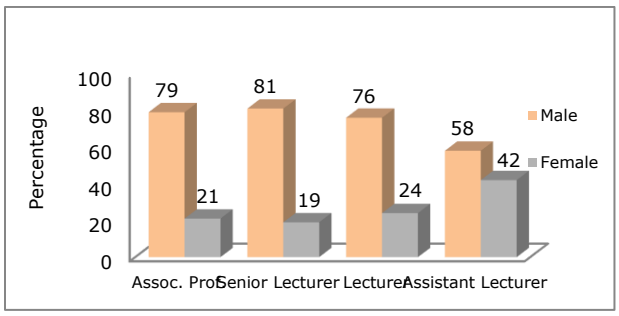

Figure 1. Distribution of Academic Staff UG: 2012-2013 (NCTE, 2014)

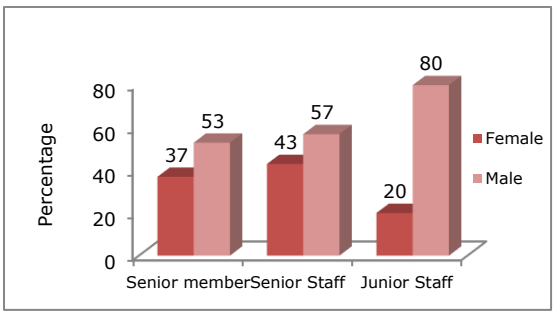

Figure 2. Distribution of Non-academic Staff, UG: 2012-2013 (NCTE, 2014)

Overall, as reflected in the statistics discussed above, women are underrepresented in Ghanaian HE, particularly in S&T programs and unlikely to be represented in policy decision-making regarding gender equity in S&T (Tsikata, 2009). It is thus imperative to gain a better understanding of the obstacles women have faced in the pursuit of HE to develop and implement effective policies to address gender inequity.

Obstacles to Access and Retention of Women in S&T in Ghana

In Ghana, gender inequity is revealed in all aspects of human life: the economy, security, education, health, politics, etc. Those who advance through the formal education system into HE tend to be in the most financially secure sectors of the population. Universities in Ghana are themselves inequitably distributed, with most situated in the most economically advantaged regions (Ashanti, Central, Eastern, Volta, and Greater Accra regions) to the detriment of other historically disadvantaged regions (Atuahene & Owusu-Ansah, 2013). In Ghana, 70% of students in public universities reside in only three regions: the Greater Accra, Ashanti, and Eastern regions (Arthur & Arthur, 2016). Indeed, there is a consensus in recent studies that HE in Ghana remains elitist (Mabokela & Mlambo, 2015).

In rural areas, family resources are often limited, requiring that parents be selective in financial support for their children's education. Early marriage, common under

customary law, was often arranged or agreed upon by the fathers and other senior kinsmen of the prospective bride and bridegroom. This type of arrangement is still prevalent in the northern and rural parts of the country. In addition, throughout much of Ghanaian society, marriage and motherhood are regarded as the primary goals in life for women (Kilu & Sanda, 2016). This prevailing norm is organized around an unwritten social contract, that Kuenyehia (1995) calls the *gender contract*. It is a social contract that conflicts with the realities of the modern world where women are progressively expected to work not only to provide for the family but also to improve their social status. Nevertheless, "despite the reallocation of employment responsibilities, the gender contract remains relatively static, thus entailing women having to adjust their own lives to cope with conflicting employment and family roles" (Kuenyehia, 1995, p. 18–19).

Concerns about gender disparity in HE have led scholars globally to examine common differentiated obstacles that women face in HE, especially in S&T fields. These can be characterized as psychological; attitudinal; socio-cultural; and institutional. Psychological obstacles are themselves wide ranging, but in explaining gender discrimination in HE, states of anxiety and poor motivation are commonly regarded as the most psychological underpinnings for reduced numbers of women in S&T studies (Moeller, Salmela-Aro, Lavonen, & Schneider, 2014). Women are often raised to develop nurturing and caring attitudes while men are encouraged to use machines and computers. There is a correlation between exposure to information technology (IT) and women's positive attitudes toward IT. The more exposure women have to IT, the more positive the attitudes they develop (Ertl & Zauchner-Studnicka, 2020). Throughout their schooling, women are frequently socialized to accept S&T fields as primarily suited to men, a notion that is reinforced in S&T textbooks that very rarely refer to the work of female scientists. Invariably, therefore, female students often view S&T education as a hostile culture that begins early in their schooling and continues throughout HE.

For women who desire to pursue studies and eventual careers in S&T fields in Ghana, the obstacles they face in gaining access are therefore numerous, based largely on structural inequities rooted in deep-seated socio-cultural factors, socio-economic circumstances, and gendered social practices within the Ghanaian society. Power relations have contributed to lower participation of females in S&T education. Traditional socio-cultural beliefs and instructional practices perpetuate male hegemony not only in S&T institutions but in Ghanaian society as a whole. The scarcity of qualified S&T instructors, especially female faculty who can serve as role models for women, has likewise discouraged female interest in S&T fields. Although specific reasons for the underrepresentation of women in S&T disciplines are varied, there is compelling evidence that these gendered differences in enrolment rates reflect broader social inequities and differentiated opportunity structures that are embedded in a deep-seated patriarchal culture (Boateng, 2015).

Patriarchy exists in most human societies and has been reinforced by cultural values based on the institutionalisation of male domination over females while reiterating and preserving the gender roles, attitudes, and social stereotypes between the sexes (Dlamini & Adams, 2014). Patriarchal ideologies connect women

to motherhood and caregiving, while men are portrayed as assertive, aggressive, and protective of their families and thus responsible for their financial well-being. Gender equity requires that multiple oppressions and concerns about access be addressed. Integrating gender into S&T research design promotes excellence in research, creativity in innovation, and social equity (Tannenbaum, Ellis, Eyssel, Zou & Schiebinger, 2019). However, there is no clear evidence as to whether Ghanaian policies put in place such as the Africa Centres of Excellence (ACEs) have been effective in facilitating women's access to S&T in HE, in particular, access to graduate education. A key aim of this article, therefore, has been to shed light on the extent to which such measures have had an impact in enhancing women's access to S&T graduate studies and subsequent careers in S&T fields.

CONCEPTUAL AND THEORETICAL FRAMEWORKS

While many factors contribute to gender inequity in S&T, the perspectives discussed earlier suggest a lack of awareness of the role of gender, institutional culture, and societal beliefs in shaping women's conception of themselves and of S&T fields. The inability of HEIs and governments to effectively implement gender policies has contributed to gender inequity in HE in Ghana. To investigate how the development and efficient implementation of gender policies can help overcome gender inequity in S&T graduate education programs in Ghana, a conceptual framework was created to explain policy issues (see Figure 3 below). The framework is based on three main approaches: (a) advocacy to raise consciousness about underlying gender-disparity issues in graduate S&T programs; (b) a gender affirmative-action approach to recruit and train a critical mass of female scientists; and (c) the promotion of gender mainstreaming as a way of normalizing gender in university culture.

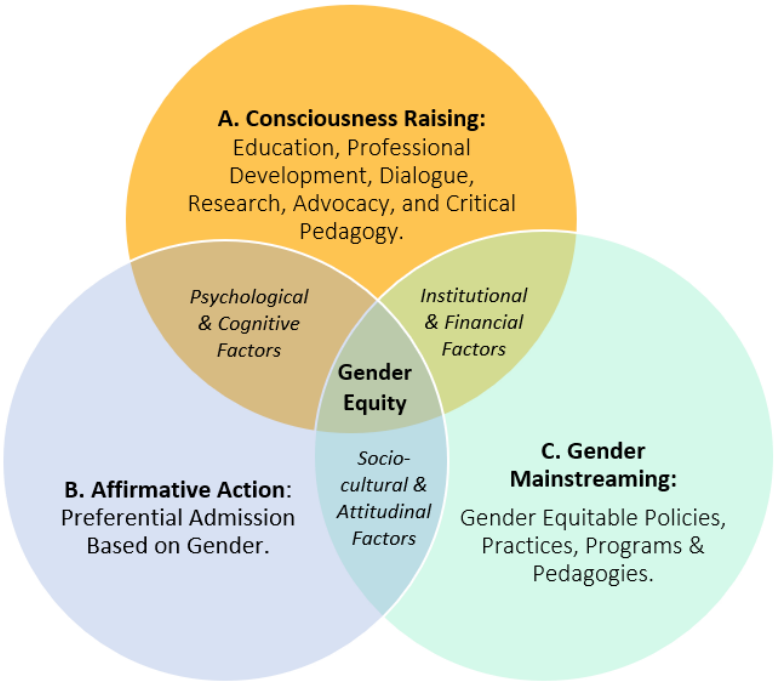

Figure 3: Conceptual Framework

This conceptual framework has been designed based on the assumption that the selected Ghanaian institutions are aware of the effect of gender on the HE system and have formulated policies to address gender inequity, particularly in graduate S&T programs. The main goal is ending the inequitable positions of men and women in HEIs in Ghana, specifically in the ACEs. The Venn diagram graphic has been chosen to show how all three approaches can be used concurrently: each circle intersects with the other. The three circles represent the policies. The intersections of the circles represent the obstacles and/or factors—discussed earlier—that contribute to gender inequity in HE. The intersection of all three circles, represents the expected impact of the effective implementation of the policies on gender equity in S&T HE.

Consciousness-Raising

Gender consciousness-raising efforts, including education, advocacy, media campaigns, and a public process, are all essential to induce change in S&T fields and raise awareness of existing inequities. Awareness campaigns targeting prevailing gender inequities in S&T in the HE context can affect the collective consciousness of stakeholders. The best way to negotiate the various stages of the consciousness-raising process is through dialogue to help change opinions and positions. Achieving critical consciousness requires the involvement of participants at multiple levels. Although such sensitization on gender-disparity issues is essential, concrete actions such as gender affirmative action in recruitment and retention and the promotion of gender mainstreaming are required to level the playing field, particularly in S&T HE in Ghana.

Affirmative-Action Approaches

Awareness leads to new and distinct ways of seeing and understanding gender issues. While being aware of an issue is an important step towards change, it does not necessarily mean that all stakeholders will take actions to change their views, ways of life, and behaviours. Often "males publicly support equity, but behind closed doors work to promote the interests of the boys' club, while women are put in their place, in the kitchen where they belong" (Dlamini & Adams, 2014, p. 128). In efforts to foster inclusive education, many countries have introduced affirmative-action programs by giving preferential admission to education for groups that have consistently faced discrimination. Contrary to the arguments of some critics that the affirmative-action program would displace some groups of students to the benefit others, a study done by Bertrand, Hannah and Mulhainathan (2010) showed that affirmative-action policies were actually successful measures for simultaneously increasing diversity and allocating resources to relatively disadvantaged families.

In sub-Saharan Africa (SSA), affirmative action approaches in HEIs have been formally adopted as a part of a revitalization process focusing on inclusion and increased quality, access, and equity. One weakness of using only affirmative action as a means of reducing gender discrimination is that disadvantaged groups who are admitted into programs as a result of affirmative-action policies are often expected to assimilate without any attempt being made to address the institutional and social factors that may have been the root causes of the gender disadvantage in the first

place. This was the case of affirmative action policies aimed at improving women's access to HE in Kenya, Uganda, and Tanzania. Various interpretations of the policy led to different outcomes far from the expected results (Onsongo, 2009).

Gender Mainstreaming

While gender affirmative action measures can temporarily increase educational and employment opportunities for women, they rarely resolve deep-rooted gender stereotypes. Increasing the number of women in power positions will not automatically effect the transformation of entrenched structural and cultural barriers. For sustainable change, a focus must be on gender mainstreaming that denotes the realization of gender equity across all social, economic, and political sectors. Gender mainstreaming is a public policy strategy to promote gender equity in all aspects of life. It incorporates normative gendered assumptions, processes, and intended outcomes in policy development and implementation. This requires access and participation of women in all educational, economic, social, and political structures.

Gender mainstreaming is a complex undertaking. Major obstacles and limitations include: "ineffective institutional and policy implementation agencies, cultural, traditional practices and patriarchal dominance, low conscious participation of women in decision-making, lack of adequate resources…weak monitoring" (Assefa, Nigussie, & Zeleke, 2013, p. 67). Moreover, well-articulated objectives often do not necessarily lead to successful gender mainstreaming at the organizational and institutional levels. A study conducted by Morley (2010) in two HEIs in Ghana and Tanzania demonstrates that the implementation of policies designed to foster gender mainstreaming often fail to "address the micro-level relays of gendered power that continue to subordinate women" (p. 547). Such outcomes bring about contradictions and tensions as women continue to experience discrimination in their daily interactions. As a result, gender mainstreaming interventions are reduced to tokenistic representations of women in HE environments, while female students and staff continue to face inequitable practices.

Structuration Theory

Structuration theory conceptualizes human agency, or the power or capability to act, as situated within larger social structures and practices. The structuration theory explains the mutuality of individual agency and structuring of social roles and practices in the shaping of both family and professional life of individuals (Wheeler-Brooks, 2009). In the context of education, this process is doubly structured since structuration occurs between both individuals and educational institutions and between individuals and society at large. Structuration theory, therefore, offers a framework that allows for the discussion of both agency and social structure that influence the freedom of women. Structuration in this context provides a lens for the analysis and discussion of the constitution of the women participants in Africa Centres of Excellence. Often, gender parity hides many of the structural relations of power and inequities perceptible in formal education. It is, therefore, necessary to move beyond parity and advocate for structural change.

Feminist Theory

The question of power arises in regard to privileges associated with such factors as gender, race/ethnicity, tribal identity, economic status, and location, on which power differentials have been historically evidenced (Collins, 2000). To produce a body of knowledge that reveals "concealed structures" of inequality and possibly offers insight into how to change repressive interactions, it is crucial to adopt a "critical gaze" on social structures and oppressive practices. Feminist scholarship focuses on the ways gender affects the conception of knowledge while scrutinizing the way research is conducted and justified. It is mainly based on the assumption that marginalized and oppressed people are in privileged positions to gaining knowledge of social realities related to their social positions. Feminist researchers tend to confront the issues of power, authority, and ethics while advocating for the emancipation and empowerment of the oppressed and marginalized in order to challenge the status quo and effectuate social transformation (Hayes & Bigler, 2013).

METHODOLOGY - MULTIPLE QUALITATIVE CASE STUDY APPROACH

To examine the manifestations and interconnection of women agency and structural changes happening in Ghanaian society, this study uses a qualitative methodology (Creswell, 2013). It allows researchers to probe into the real-life experiences of the participants. It can also be a way of giving voice to the voiceless or the marginalized by allowing them to tell their stories in the way they perceive them. A collaborative and reflexive research encourages non-hierarchical relationships between researchers and participants, who co-create knowledge (Creswell, 2013) bringing about transformation, which can lead to gender equity. This study specifically adopts a multiple case study approach, targeting three ACEs in two universities in Ghana, to examine the relationships between gender and power and the women's experiences in S&T programs. In this study, each of the ACEs represents a case.

The objective of this study has been to generate empirically grounded insights into a host of educational factors and societal forces that influence the evolving status of African women in S&T programs at three ACEs in Ghana. In light of the numerous problems faced by women in participating in S&T programs, relevant policies put in place by the GoG, the UG, and KNUST as well as by the three ACEs are reviewed and analysed. The policy analysis is followed by one-on-one in-depth interviews to elicit the experiences of a cohort of these women, asking them to provide information about (a) the obstacles they had to overcome to enter graduate S&T programs as students, instructors, and administrators; (b) how their lived gendered experiences have been negatively or positively impacted by global, institutional, social and family structures, and (c) their perceptions of their current status and of S&T education overall.

Data Collection

Study Sites

A current World Bank (WB) ACE initiative supported by the GoG is one of the government's efforts to increase student participation in S&T programs, especially of women. The dual goals of the ACE project, launched in 2014, are to develop and

strengthen the capabilities of S&T graduate-level programs while simultaneously augmenting female enrolment in S&T fields and reinforcing the contribution and status of female researchers and graduate students in these programs (World Bank, 2014). Ghana has three S&T centres—with students from West and Central Africa—which are the sites of the study.

The West Africa Centre for Crop Improvement *(*WACCI*)* admits and trains doctoral students in plant breeding and master's students in seed science and technology. During the implementation of the ACE project, female student enrolment at WACCI increased from 35% in 2014-2015 to 40% the following two years. However, the distribution of female staff at WACCI was only 20% in the academic year 2016-2017 (WACCI, 2017).

The West African Centre for Cell Biology of Infectious Pathogens *(*WACCBIP*)*, also at the UG, offers training and research (master's degrees and PhDs) on the cell and molecular biology of infectious pathogens. At WACCBIP the student population increased from 30% in 2014-2015 to 40% the following two years while female staff representation remained unchanged at 33% (WACCBIP, 2017).

The Regional Water and Environmental Sanitation Centre in Kumasi (RWESCK) at KNUST is a centre of excellence for graduate studies and research in water and environmental sanitation. The Centre trains master's and doctoral students in science, technology, engineering, and mathematics (STEM). Again, the female student distribution at RWESCK increased from 25% in the academic year 2015-2016 to 40% in the following year. Female staff statistics were not available at the time of the data collection (RWESCK, 2017).

Sampling and Profile of Participants

A purposeful sampling, the Creswell (2013) approach, was used. Given the limited number of female instructors and administrators at the ACEs, male instructors and administrators were also interviewed to corroborate the policy documentation analysis. In total, 29 participants were interviewed (females: n=7 Master's students; n=14 PhD students and n=3 administrators and/or instructors) and (males: n=5 administrators/instructors). The participants were from the following programs: plant breeding (PB), Biochemistry, Cell & Molecular Biology (BCMB), Water Resources Engineering & Management (WREM), Environmental Sanitation & Waste Management (ESWM), Water Supply & Environmental Sanitation (WSES), and Quality Assurance Unit (QAU).

Two sets of interviews were conducted in the summer 2017 over a period of four months. The first set of interviews involved the male administrators and instructors to help shed more light on the procedures and practices that explain the surge of female participants in S&T graduate programs at WACCI, WACCBIP and RWESCK during the implementation of the ACE project. The second set of interviews was with female students, female administrators, and instructors to explore the experiences and perspectives of the female participants. Transcripts were shared with participants for validation. To protect participants' rights and anonymity, pseudonyms were used in the transcript report and analysis.

Table 1 List and profile of participants: students/instructors/administrators

No	(Pseudo) Name	ACE	Student/Position	Program	Gender	Nationality
1	Marietta	WACCI	Master's	PB	Female	Ghana
2	Gloria	WACCI	PhD	PB	Female	Nigeria
3	Helen	WACCI	PhD	PB	Female	Ghana
4	Iris	WACCI	PhD	PB	Female	Cameroon
5	Jane	WACCI	PhD	PB	Female	Ghana
6	Karl	WACCI	Administrator/Instructor	PB	Male	Ghana
7	Michael	WACCI	Administrator	PB	Male	Ghana
8	Richard	WACCI	Administrator/Instructor	PB	Male	Ghana
9	Olivia	WACCI	PhD	PB	Female	Ghana
10	Lynda	WACCI	PhD	PB	Female	Ghana
11	Janet	WACCI	PhD	PB	Female	Ghana
12	Margaret	WACCI	PhD	PB	Female	Ghana
13	Patience	WACCI	PhD	PB	Female	Cameroon
14	Joana	WACCBIP	Instructor	BCMB	Female	Ghana
15	Georgiana	WACCBIP	Administrator/Instructor	BCMB	Female	Ghana
16	Edith	WACCBIP	PhD	BCMB	Female	Ghana
17	Esther	WACCBIP	Master's	BCMB	Female	Ghana
18	Doris	WACCBIP	Master's	BCMB	Female	Ghana
19	Golda	WACCBIP	Administrator	BCMB	Female	Ghana
20	Joseph	WACCBIP	Administrator	BCMB	Male	Ghana
21	Gladys	RWESCK	Master's	WREM	Female	Ghana
22	Sylvia	RWESCK	PhD	WREM	Female	Ghana
23	Delphi	RWESCK	PhD	ESWM	Female	Ghana
24	Zara	RWESCK	Master's	WSES	Female	Ghana
25	Jill	RWESCK	PhD	WREM	Female	Ghana
26	Gilberta	RWESCK	Master's	WSES	Female	Ghana
27	Deborah	RWESCK	Master's	WREM	Female	Ghana
28	Zoe	RWESCK	PhD	ESWM	Female	Ghana
29	Don	KNUST	Administrator	QAU	Male	Ghana

The preliminary analysis of the policy documents includes the following steps. Firstly, an examination of the key policies aimed at enhancing women's participation in S&T in Ghana focusing on the three typologies of gender related policies. Secondly, one-on-one semi-structured interviews with the male and female participants. Female participants' experiences were analysed in three main areas: (a) their experience of gendered affirmative-action and other supportive gender-equitable policies (b) the participants' experiences of gaining access to and participating in these programs; and (c) the participants' perceptions of the status of young-women vis à vis S&T education in general.

The main limitation of this study involves the small number of female participants for the policy interviews. A further challenge was that data collection was done during the final exams period and the summer breaks. This was likely a reason why the response rate from female instructors was very limited.

Data Analysis
The presence of all three applied science disciplines (health science, agricultural science, and STEM) in the same country helps to triangulate the data collected from the three ACEs. Following preliminary analysis of the policy documentation, the qualitative data coding and analysis drew upon the Maxwell (2013) thematic analysis method, facilitated by the use of Nvivo software. The Maxwell approach to qualitative research asserts that classifying analysis starts with the identification of the different elements of relevant data.

Findings and Results

Phase 1: Analysis of Gender-Policy Implementation at WACCI, WACCBIP and RWESCK
The policy documents analysis revealed that while some policies (formal and informal) have been successful, a few of them have not achieved the outcomes expected, either from lack of appropriate funding, poor physical facilities, the gap between policy development and implementation, or lack of political will. Overall, sensitization programs on gender issues have been successful in raising awareness to a certain extent but must be sustained. Moreover, the formulation of gender-equitable policies and programs does not necessarily lead to the implemention of projects and activities that actually increase women's access to resources or participation in influential public and political decision-making positions. Affirmative-action policies were introduced into university admission procedures in the mid-nineties as a corrective measure for the long-standing gender-based disparities. Universities have adopted various quota systems such as lowering the admission cut-off points by one point for female students in various programs. Often, there are no specific figures for female admission, as the quotas change from year to year. Furthermore, it is difficult to assess how this strategy has been used in other institutions and if it has been applied selectively or across the board. The administrators of the respective ACEs were interviewed to gain insight into the factors that contributed to the increase in admission rates.

<u>Consciousness of Gender Issues</u>
Most participants seemed to have some knowledge of gender issues and noted that gender could sometimes have a negative impact on the success of women in S&T programs. The administrators/instructors from WACCI, WACCBIP and RWESCK (KNUST) noted respectively:

> They [researchers] recently said that gender is an attribute of society. It is society that differentiates between men and women and assigns specific roles based on gender (Michael, WACCI).

> I think, historically, women have not been given the opportunity to study sciences. However, now, there is a deliberate effort to try to involve them and give them a chance (Joseph, WACCBIP).

> I think it has been this individual consciousness. After the Beijing Conference on Women, people became aware of the issue, and so, individually, people began to talk about the issue (Don, KNUST).

Administrators at the three centres confirmed that neither university has a written gender policy. Meanwhile, all participants (administrators and instructors) claimed that they had been using their institution's gender policy. It was apparent that they were referring to informal policies that had not been prepared in any coherent form. When asked about the existence of a gender policy, Michael (WACCI) responded, "you know, this gender balance issue is a new thing basically… In all those established institutions, many people are now becoming aware of the issue. So, policies are being developed." Don (KNUST) claimed, "As a Quality Assurance and Planning Unit, we implement the KNUST policy as reflected in the University strategic plan 2016–2025. However, we are working on the actual gender policy."

Affirmative Action and Gender Mainstreaming

The government seemed to be keenly aware of the negative impact of gender discrimination on the socio-economic development of the country. The social consciousness raising efforts earlier on have seen some progress in tackling gender issues in a limited way. Notwithstanding various campaigns for gender equity through affirmative-action programs, there remains the challenge of bridging the gender gap in education, especially in HEIs. In particular, gender inequity in HE enrolment and instructors/administrators' recruitment remain a problem.

The UG and the KNUST, like many African universities, have been marked by structural inequity with respect to region (rural versus urban), ethnicity and race, social class, and gender. The findings described above reveal that low representation of women in S&T fields is an alarming global phenomenon, for "the leaking pipeline" still exists. The interviews with administrators confirmed what was found in the review and analysis of policy documents and helped corroborate the information in the policy documents examined in the first phase of the study.

Phase 2: Women's Experiences and Perspectives

The women experienced challenges and obstacles due to conflicting family and career demands but benefited from supportive factors.

Challenges and Obstacles

The findings reveal that participants perceived and/or faced numerous socio-cultural and institutional obstacles that impede women's HE aspirations or careers. Not only did the women face obstacles trying to obtain HE credentials, but they also faced more challenges if their areas of study were not the socially accepted fields for women, i.e., humanities and social sciences. Indeed, graduate education is widely perceived as unnecessary for females because fulfilling traditional gender roles of marriage and child-bearing does not require HE. Esther (WACCBIP) remembered the remarks made by her peers when she told them she was planning to pursue graduate studies: "you have obtained a degree, and you are now aiming for a PhD. Do you not know that if you do not marry before then, you may not find anyone to marry you?" The participants felt constantly under pressure to marry early, forego graduate education, and start a family, perceptions that are consistent with findings in the literature (Abramson, Rippeyoung, & Price, 2015). These socio-

cultural norms, values, and roles deeply implanted in the fabric of African society generally guide HE practices.

The teaching practices adopted by RWESCK seem to have been very challenging, especially for female students trying to adjust to graduate studies. Deborah (RWESCK) noted: "our program is a bit inflexible for women, making it impossible sometimes to catch up. This is particularly true for nursing mothers who have to skip some classes because of their children". Moreover, the daycare services at the ACEs were inadequate and hardly met the participants' needs. Olivia (WACCI) said: "I delivered, and two weeks later, I started my exams. I could not find a daycare for my baby". Women from rural areas face more challenges than their urban peers. Delphi (RWESCK) noted: "gender roles must be adhered to. Rural areas do not have running water in their homes. Women must go fetch water from far away daily, which is not an easy job". Deborah (RWESCK) stated, "from the undergraduate level, I wasn't privileged to have access to those technologies and stuff like that". As discussed above, some participants experienced many challenges in the pursuit of graduate S&T programs and careers, creating a sense of misalignment.

Evidence of Misalignment and Subjective Experience of Tension

The challenges of juggling conflicting family and career demands are evident. Helen (WACCI) recalled her dilemma when she was faced with the decision to pursue PhD studies: "after my master's degree, I got married, and had several miscarriages. I was later offered a scholarship to study for a PhD ... but my brother in-law suggested that I waited and gave birth before I pursued the doctoral degree". The perceived dilemma for many women academics of child-bearing age is to choose between having a family and having a successful career. It is apparent that there is misalignment between social expectations and S&T professional responsibilities, a source of subjective experience of tension in the daily lives of the career women.

Study participants' perceived discrimination in the workplace. Zoe (RWESCK) contended: "some heads of departments prefer men to women. They will tell you that the woman will go on maternity leaves". As argued by Busatto and Marry (2009), "the metaphor of the glass ceiling helps one to focus on the often-invisible barriers qualified women have to deal with in order to gain access to the highest professional positions" (p. 170). Women faculty members are less likely to be elected to high-powered committees that approve or deny tenure and promotion applications (Abramson, Rippeyoung, & Price, 2015). Highly-qualified female engineers encountered the 'glass-ceiling' phenomenon, ushering to lessened career opportunities (Schmitt & Wilkesmann, 2020).

The majority of the participants saw female supervisors as unsupportive and unwelcoming. Olivia (WACCI) remarked: "my current female boss is no different than men. She claimed that pregnancy is not sickness. Therefore, female employees should not come to tell her that they are sick and request time off when they are pregnant". This creates a confusing and difficult question. How then can these female supervisors become role models for women who are aspiring to enter S&T careers? It would seem that women in S&T fields who are acting out their

gender as "women" in a male-dominated environment are inclined to "do gender" in professionally expected ways, and this increasingly requires a rejection of "femaleness" (Mejiuni, 2013). This is a great example where a gender analysis—drawing on masculinities and femininities where men are supposed to be authoritative, strong, while women are expected to be humble and caring—is revealed. Women leaders and mentors often adopt masculine attributes to be taken seriously; then those same attributes make it difficult for female students and supervisees to get the support they need, mostly, from fellow women.

Despite the experienced and/or perceived obstacles, all participants managed to overcome the challenges associated with their graduate S&T programs at the selected ACEs. Certain fundamental factors have helped and encouraged study participants to want to stay in the programs despite the numerous obstacles they have had to negotiate. The following analysis sheds light on the strategies these women have employed to navigate professional environments that are not always supportive.

Supportive Factors

Participants reported that personal agency played a major role in their success in the S&T graduate programs. "In my family, nobody has reached this level of education, and it cannot continue to be like that; at least someone has to break through" (Marietta, WACCI). All women had received some family support, most often from parents, and many as well had gained from the encouragement and advice of teachers and other mentors. Zara (RWESCK) indicated: "my dad is an electrical engineer, so I developed the interest to study engineering at an early age."

In fact, some of them glorified their minority status, claiming it gave them the opportunity to be visible. Zoe (RWESCK) noted: "You see, you are always in the minority. So, a little effort you put in is always noticed". Being a minority can be an advantage in a way but can also play against you. It could be a source of prejudice, bias, and discrimination. Women working in male-dominated positions are not readily accepted and their academic achievements are often overlooked or undervalued.

The women succeeded in overcoming many obstacles they faced in the pursuit of graduate S&T education and careers because of the layers of family and social structures, institutional structure, and the structure of globalization as well as their personal agencies that were supportive of their S&T education and careers. As highlighted by the conceptual framework of this study, participants specifically suggested that the ACE training program be made more female-friendly by being more generous in the admission of women through additional special incentives such as affirmative-action policies. Lynda (WACCI) proposed that socio-cultural and socio-economic backgrounds of female candidates be considered during the admission process.

DISCUSSION: POLICIES, WOMEN'S EXPERIENCES AND PERSPECTIVES

HE policies and initiatives in Ghana have focused on improving and bridging the gender gap in access to education and promoting S&T quality education at all levels. The STME program in secondary schools mentioned above had not reached the 30% enrolment objective before the focus was shifted towards building the capacity of both male and female students. Contrary to the government's claim of success, the gap between gender-policy development and implementation in Ghana is due to the lack of funding, the absence of a clear mandate for inter-ministerial coordination regarding gender capacity, and a shortage of data that presents the challenges to policy implementation processes, thus contributing to the gap between policy and practice (Boateng, 2015). While leaders frequently endorse declarations and conventions espousing the notion of gender mainstreaming, too often they are unwilling or unable to follow up with the necessary mechanism for implementation.

Given the limited number of women in academic positions across many Ghanaian universities, particularly at academic ranks beyond entry level, or lecturer positions, these findings provide insights into socio-cultural and institutional factors that impact S&T education, the upward mobility of study participants, and the strategies these women have employed to navigate socio-cultural and professional contexts. Structures of gender ideology and the institutional structures have negatively influenced Ghanaian women's successful participation in S&T programs, particularly, at the graduate level. Yet, the supportive factors that helped women overcome the psychological/cognitive, socio-cultural, educational, and institutional obstacles mainly stemmed from the socio-economic background and professional status of the participants' families. These families mostly played the roles of models and mentors. Most often, the educational background of parents is a predictor of their economic and financial status and their ability to financially contribute toward their children's education.

Interestingly, women who do manage to attain positions in academia are sometimes perceived as unsupportive and unwelcoming by many of the female participants. Women who have gained access are more interested in protecting themselves and the positions they occupy than to serve as role models to help women rise to the top. Some participants felt these women are more of a hindrance to the achievement of women empowerment. The syndrome of 'women are their own enemies' persists to some participants in the Ghanaian society and this they believe cannot be addressed in law. The transgression of gender norms for women in positions of leadership or power is an important framework of analysis that helps us understand why sex (being a woman or being a man) is not what is so important but rather the socially constructed attributes of masculine or feminine adopted in positions of power and authority. Adopting gender-sensitive programs and practices require changes necessary at various levels of institutions, particularly, structural changes at the cultural, societal, institutional, and personal levels.

The procedures and plans that the WB ACE project put in place to meet program objectives brought about changes in the systems of operation in the institutions where the program is located. A key goal of the ACE program has been to augment

skills needed at the Master's, PhD, and other postgraduate levels in the West and Central Africa while increasing women's enrolment in S&T fields and reinforcing the contribution and status of female researchers and graduate students in these programs. Accordingly, gender sensitive policies were introduced to promote gender equity at WACCI, WACCBIP, and RWESCK. These requirements have created a real incentive for the ACEs to improve their systems of operation, and these changes led to the positive outlook and success of the female participants in this study.

It is important to note that the ACE program is a donor-driven initiative. One requirement of international donors is that gender equity be a policy imperative, which surely explains why the ACEs seem to be unique in this regard. The WB project provided a monetary incentive to entice the project implementation teams to support and encourage female participation. However, once the project comes to an end and there is no longer an incentive to include women, there is a risk of things returning to the way they were before the ACE initiative, as has been the case in many such donor funded initiatives on the African continent. The ACEs are required to implement resource mobilization activities to raise funds for investment and operation. Hopefully, the ACE program will be sustainable and continue after donor disengagement.

Overall, the interviews provided clear evidence that gender issues need to be revamped in HE in Ghana. The commitment and political will are required for the approval and the effective implementation of gender policies in Ghanaian HEIs studied. Even though affirmative action will help bridge the gender gap in formal education, gender equity cannot be attained until institutional and organizational changes occur. Tackling gender inequities and regional imbalances in access to HE particularly in S&T graduate education requires consistency in the formulation and implementation processes and transformation of institutions at the highest level.

CONCLUSION

The women interviewed seemed to have been a homogeneous group even though some of them came from other regional countries. These findings do shed necessary light on the collective experiences of women scientists at the three S&T graduate centres in Ghana. Documentary analysis corroborated by administrators' interviews revealed that only incoherent, unclear, and informal gender-policy documents existed in the host institutions. Institutional challenges such as poor teaching practices, inconvenient class schedules and inadequate daycare services for students, instructors and administrators with young children were apparent.

There are structures that clearly hindered women's advancement such as family pressure to marry early and forego graduate education, the socio-cultural view of women's place in society, the stereotypical views of women regarding S&T education, unfavorable workplace politics and environment. For most of these women, awareness of broad societal change and the impact of supportive gender-equity practices and/or procedures have helped them overcome the challenges and obstacles they faced and propelled them into S&T HE and careers. Other supportive structures that enabled them to progress in S&T can be identified as affirmative

action, impacts of limited role models, STME and the ACE programs as well as support from family, friends, and informal mentorship.

Structuration theory provided the analytical categories and distinctions necessary to investigate how policies shaped the range of factors influencing the participants' S&T HE processes and careers. Feminist theory is a relevant lens to critically examine gender disparities in the S&T HE in Ghana. By examining the narratives of a cohort of women in the ACE program who overcame socio-cultural, socio-economic, institutional obstacles, the study demonstrated how the exercise of free will and the exertion of personal agency helped the participants succeed in their S&T HE and careers.

Despite decades of efforts aimed at increasing women's representation in S&T fields, throughout the world, women remain persistently underrepresented at the highest levels of many S&T disciplines. Women in academia struggle for identity and power. The gender discrimination issue has been debated globally over the years, and laws have been passed in countries like Kenya and in many others. Yet in Kenya, there has only been limited progress to date. Collective consciousness, only if it is followed up with, or accompanied by, political support, can be an effective impetus for change. However, changing people's beliefs, values, and attitudes, especially in a patriarchal country like Ghana, where men have enjoyed most of society's privileges for many years, is not an easy process. While the issue of gender inequity in S&T has been well established, the impact of this phenomenon on social and economic development of sub-Saharan African countries, in general, and Ghana in particular, has not been substantially investigated.

RECOMMENDATIONS

The HEIs need to mobilize efforts in raising awareness on gender issues. Affirmative action measures will open doors for women and usher in (hopefully) a consensus on the rights of women to succeed in HE.

Scholars and policymakers should aim for a family-friendly environment, which can be done by fostering the perception that S&T studies and careers can be combined with family goals. HEIs should institute policies to address discrimination faced by women in school and the workplace.

Women must be empowered to claim their rights. There is a need for academic women to organize, network, and try to move into decision-making positions to help promote change in the educational system.

Gender-disaggregated data on female intake in S&T HE and female staff recruitment must be collected at national and at institutional levels to monitor the effects of a gender mainstreaming approach. Related to the ACEs, the centres should create a database containing gender-disaggregated statistics.

Follow-up studies should be conducted to determine the extent to which the female study participants who had been successfully influenced by supportive family,

social, institutional, and global structures have in turn contributed to gender equity in S&T disciplines.

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