

Enhancing Gender Balance in Engineering Education and Practice

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Abstract— Despite the rapid development brought about by the exponential expansion of engineering in technological scope and societal impact that are quite noticeable, the level of representation of women in this unique profession is still very low. Research has shown that few women study engineering at the tertiary institution or university-level with less than 25% of total enrollment, pursuing an engineering career after graduation. Thus, the underutilised pool of talent that women represent may actually limit access to a larger pool of future engineers, entrepreneurs, innovators, etc., and hence a limiting access to a more diverse talent pool. This situation has resulted in impaired creativity and innovation, which is the essence of engineering. This paper therefore reviews the issue of gender balance in engineering education and practice, with the main objective of highlighting the likely causes of the disparity and how it can be alleviated, in order to facilitate and enhance gender balance in engineering education, practice and the profession at large. Closing the gender gap in engineering enrollment and practice will require a lot of re-appraisal of existing strategies on the part of stakeholders. Delimiting policies, primordial cultures, curricula, etc., may have to be changed and career paths made more welcoming in order to enhance women enrollment and participation in engineering.

Keywords Gender, Engineering, Enrollment, Job, Participation

I. INTRODUCTION

Over the years, the engineering profession has been perceived to be a man's domain and has had a poor representation of women across all levels and disciplines worldwide [1-6]. Percentage representation of women in engineering varies across the world. Historically, in the United States, lower representation of women in engineering college programs and careers have been recorded [7-11]. The report of tertiary education-level indicators has demonstrated that in all countries excluding Argentina, Estonia, Iceland, Italy, Poland and Slovenia, one-third or fewer of all graduates in the fields of engineering, manufacturing and construction are women [12]. According to [12], initiatives to promote gender equality in the Organisation for Economic Co-operation and Development (OECD) countries have only yielded poor results. Similarly, in a study of the distribution of tertiary institutional enrollments in Ireland, 11% female entrants into engineering, manufacturing and construction have been recorded [13]. This was indeed behind both the OECD and the European Union - with averages of 15% but ahead of the United Kingdom (UK) figure

TABLE I. UNDERGRADUATE ENROLLMENT BY SEX AND REGION IN NIGERIA IN ENGINEERING BASED FACULTIES: [15].

Undergraduate Enrollment (%) in engineering based faculties by Zone/Region												
Year	NE		SW		NW		SE		NC		Total	
	F	M	F	M	F	M	F	M	F	M	F	M
1997	27	73	23	77	0	100	23	77	12	88	17	83
1998	33	67	23	77	2	98	19	81	15	85	18	82
1999	49	51	26	74	1	99	18	82	14	86	22	78
2000	43	57	15	85	1	99	18	82	11	89	18	82
2001	34	66	34	66	1	99	19	81	12	88	20	80
2002	40	60	50	50	2	98	18	82	17	83	25	75
2003	27	73	42	58	4	96	22	78	16	84	22	78
2004	21	79	48	52	2	98	23	77	-	-	24	77
2005	25	75	53	27	4	96	-	-	80	20	41	60
2006	23	77	55	45	5	95	-	-	17	83	25	75

^a (Where NE – North East; NW – North West; NC – North Central; SW – South West; SE – South East)

of 8% [14]. Reference [15] established that although enrollment in engineering courses was found to increase over a period of ten years in tertiary institutions in Nigeria, the percentage of women enrollment was significantly lower than that of men. It was also reported that the Northwest zone of Nigeria had the least percentage of female enrollments (1-5%) while the percentage female enrollment in Southeast, Southwest and Northeast zones were significantly higher than that of the North Central zone. Southwest zone was however found to have the highest female enrollment figure with an average of 38.9% (see Table 1). The rather low women enrollment recorded, over time, has led to a significantly higher concentration of male professional engineers compared to women [2, 11]. It is therefore crucial to address the issue of decreasing female enrollment in engineering Faculties in tertiary institutions globally, in order to close the gap between male and female training and participation in engineering.

II. GENDER ISSUES IN ENGINEERING IN A DEVELOPING COUNTRY - NIGERIA AS A CASE STUDY

A. Female Enrollment in Engineering in Nigeria: Obafemi Awolowo University, Ile-Ife as a Case Study

Table II and Figs. 1-2 show the male-female enrollment situation between 2011 and 2016 in the Faculty of Technology, Obafemi Awolowo University, Ile-Ife, Nigeria. It is clear from data on these table and figures, that apart from the modest case

of the Computer Science and Engineering program (and to a lesser extent, that of Chemical Engineering), female enrollment

TABLE II. TOTAL NUMBER OF ENGINEERING STUDENTS BY DEPARTMENT – (FACULTY OF TECHNOLOGY, OAU, ILE-IFE)

Department	2011		2012		2013		2014		2015		2016	
	M	F	M	F	M	F	M	F	M	F	M	F
Agricultural and Environmental Engineering	171	22	192	24	141	24	141	24	161	27	204	28
Chemical Engineering	455	80	450	99	434	95	413	104	384	100	402	97
Civil Engineering	257	24	260	18	250	21	264	23	271	24	328	23
Computer Science and Engineering	484	167	517	175	522	179	500	172	559	157	543	252
Electronic and Electrical Engineering	625	59	610	64	663	62	628	62	660	65	621	66
Food Science and Technology	49	14	44	19	45	14	63	17	68	18	54	14
Materials Science and Engineering	114	10	107	11	99	14	105	13	116	16	124	17
Mechanical Engineering	384	18	380	18	379	14	369	15	398	20	451	26

level in all the other engineering courses in the Faculty of Technology, in the last five (5) years is nothing to write home about. The situation is the same in the Faculties of Science and Environmental Design and Management in the University. Whereas, in the sister Faculties of Arts and Humanities, Social Sciences, Pharmacy and Law, average enrollment ratio of male to female is in the range 3:2 - 5:3; respectively. This situation is essentially the same in the Southwestern part of Nigeria, but gets worse in the North-West and North-East. The Institute for Gender Studies in the University (OAU, Ile-Ife) is carrying out a systematic evaluation of the situation, with a view to alleviating and balancing it out over time.

III. POSSIBLE CAUSES OF LOW ENROLLMENT OF FEMALE CANDIDATES IN ENGINEERING COURSES

Recent research efforts have been focused on the reasons for poor representation of women in engineering profession, globally [2, 4, 12, 16-21]. Various explanations have been offered to explain women's low enrollment and participation in engineering [11, 22-25], and a number of factors such as the wider sociocultural and labour market preconceptions, psychosocial influences, traditional stereotyping roles, low motivation, etc., have also been found to influence the low enrollment and participation of women in engineering [3, 5, 26-30].

A. Sociocultural and Labour Market Gender Preconceptions

One of the challenges women face in attempting to penetrate successfully and persevere in historically male-dominated work environments, such as in engineering, has been reported to emanate from traditional, primordial, gender hierarchies and norms that prevail in the family, clan and society [5]. Most household units have a traditional structure in which the male is the dominant gender [5, 31, 32]. This

stereotype-role, which usually spills over to organisational policies and practices that maintain women's marginalised work-roles, has been reported to have become entrenched in the gender-biased organisational cultures in traditional communities, particularly in sub-saharan Africa and the Middle-east [1, 33-35]. These wider sociocultural and labour market biases have been found to greatly affect female recruitment, training and advancement in engineering and consequently career choices and perspectives among young females [1, 27, 36-38].

B. Low Exposure to Career Paths and Opportunities in Engineering

The Harvard Implicit Association Test, which was carried out using more than a half million people globally, reported that more than 70 percent of those tested, associated the male with science and engineering and female with the arts [9]. Similar results were recorded by other researchers [39]. Such implicit beliefs were observed to directly influence the decision of parents, and other family members and friends, to discourage young girls from pursuing science subjects and engineering careers [11, 23-27, 37, 40]. This situation has resulted in the stereotyped upbringing of girls, resulting in their lack of exposure to career paths in engineering from an early age.

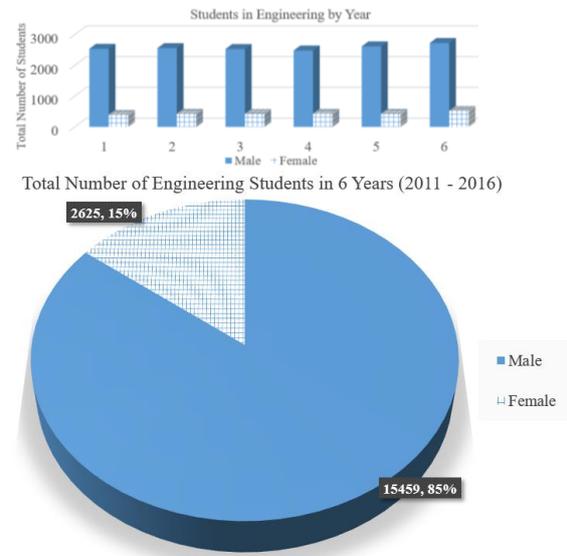


Fig. 1. Total Number of Male-Female Engineering Students Enrollment by Year (OAU, Ile-Ife; 2011-2016)

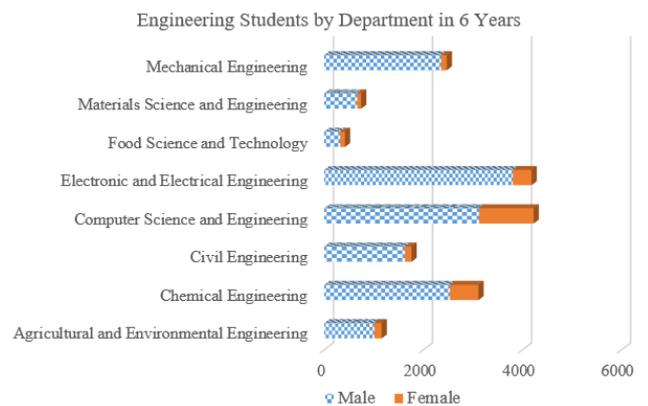


Fig. 2. Male-Female Engineering Students Enrollments by Department in the Faculty of Technology, Obafemi Awolowo University (2011-2016)

Over the years, girls were brought up to know that their role in life is to be a home maker, or an early-child Arts or Home-economics teacher, hence typically girls are surrounded with toys such as baby dolls, miniature diner sets and doll houses while boys were given building blocks, toy cars and tool boxes. Consequently, boys have been exposed to the world of engineering right from their infancy while girls were made to believe that their main duty is with their family, and any career that will interfere with this is inappropriate for them. Given this role-stereotyping, wide gender segregation in science-based education subjects have been recorded [8, 31, 37]. Thus, girls have been known to consider careers in arts, education, humanities, or social sciences rather than engineering or any of the technical fields [29, 36-37, 40].

C. Psychosocial Influences

Psychosocial influences have been established to be responsible for female students' attitude towards STEM-related (i.e. Science, Technology, Engineering and Mathematics) subjects, which constitute the conventional pathways into engineering study [30, 41]. This has been found to greatly influence future career choices as well as levels of achievement and perspectives. Moreover, gender differences in STEM-related subjects such as mathematics, science and engineering have been found to begin with the performance of students as young as 15 years old [12, 13, 40, 42].

In particular, the poor performance in mathematics has been attributed to psychological issues, which is dependent on the societal influence, rather than the general belief that it is due to differences in the physiological makeup of girls, when compared to boys. Girls' lower participation rates at school and beyond have also been attributed to their lower levels of confidence in these subjects. Consequently, it has been suggested that myths, which exist around gender issues in STEM-related subjects, such as girls don't like STEM, girls don't have innate ability to study STEM-related subjects, girls lack preparation to pursue and succeed in engineering, must therefore be busted in order to improve girls' enrollment in engineering [11, 13, 23, 37, 41].

D. Formulation and Implementation of Gender Insensitive Policies

It had been noted that men have dominated policy development globally [43]. These policies are known to have been used in the establishment and operation of most of the existing organisations, hence they are structured and function in ways that do not always support women's career patterns and their need to integrate work with family responsibilities [1, 2, 26, 34, 41, 45, 46]. These challenges have been reported to affect the retention of women in engineering, while scaring away younger ones from attempting to pursue careers in engineering. Gender-sensitive policies and frameworks are therefore considered to be vital, in order to increase the participation of women in engineering [15, 26, 40].

E. Negative Perception of the Engineering Field

The engineering field has been perceived to have a masculine culture that is non-inclusive, has a bias against women in relation to recruitment, development and career advancement and has a higher tolerance of behaviours that could be viewed as sexual harassment, bullying and discriminatory [2, 47]. Consequently, there exists the general perception that jobs within such engineering service

organisations would be challenging at every stage of the career for women. Parents therefore do not encourage their daughters to pursue a career in engineering and most of the time do everything to dissuade any that chose to demonstrate a flair for engineering. Following this set of negative perceptions of engineering and the anecdotal feedback from others about negative experiences, low enrollments etc., are expected to be recorded in engineering faculties, globally [2, 16, 17, 26, 41, 43, 47]. It has been observed that the stereotypes and myths about women's lack of ability and aspirations, as well as their role in procreation are often used to justify the activities of organisations that exclude women from recruitment and development activities [3, 8, 48-50]. This situation may further exacerbate the fear of girls and parents on the choice of engineering as a career. Parents and girls would therefore rather invest in careers with 'good' future prospects that guarantee easy access to the workforce and future career advancement. By recognising, challenging and sanctioning any form of stereotyping or gender-bias that many organisations have about female candidates, their work and potential for success in the male-dominated industry have therefore been cited as possible ways to increase female participation and retention in engineering fields. This will enhance female enrollment as more female role models will be available to inspire more girls to choose engineering as a career.

F. Lack of Awareness of the Opportunities that Abound in Engineering

Low participation of women in engineering and low enrollment in engineering have also been ascribed to lack of awareness of the opportunities and the career paths that are available in engineering [16]. Most girls lack practical knowledge about engineering and often had to seek out information on their own in order to make the choice of a career. Oftentimes, it is known that some who ventured into engineering courses may have their families as their main motivational factor because they have had relatives working, or who had worked, in engineering fields. It is therefore necessary to publicise what an engineer does and what engineering career prospects can be, so that children - both boys and girls - can develop an awareness of engineering as a career choice, at an early stage [16].

IV. ACTIVITIES AND INITIATIVES THAT WILL CREATE GENDER BALANCE IN ENGINEERING EDUCATION

In order to increase female enrollment and participation in engineering training and practice, a range of activities and initiatives that will promote gender balance in the profession have been suggested to create more opportunities for females to study and pursue careers in engineering. Such activities should enhance dissemination of the right information about engineering to prospective students, parents and teachers; motivate girls to study sciences in their secondary school and technical colleges; inspire female engineering students to excel in their course of study and graduate to become a role model to the next generation of female university aspirants, and in creating a more transparent organisational culture in general, which would be effective in recruiting and retaining women in engineering, thereby making the choice of a career in engineering a viable choice for women [15, 28, 38, 51, 52].

A. Dissemination of the Right Information About Engineering

It has been rightly pointed out that to increase women enrollment and participation in engineering they will have to be aware of what engineering entails in order to see it as a potential career choice [16]. Educational awareness therefore has a significant role to play in creating gender balance in engineering education. Organising career talks that will provide information on the full range of career opportunities available to girls have been cited as a way to enlighten them on the prospects that abound in engineering and which in consequence, may enhance female enrollment in engineering [53-61]. Interactive career events, which will showcase engineering as an exciting career path for women and is aimed at inspiring young women to consider engineering as a career have therefore been recommended to educate girls on the prospect of studying engineering [62-64]. It has also been suggested that the career events be specifically tailored to secondary school students, parents, teachers and guidance counsellors, with the main objective of leaving the audience with the message that a world of fantastic opportunities awaits women in engineering. Presentations, which would emphasize on the broad range of disciplines of engineering, technology and the intrinsic value of the profession to society in everyday life have been cited as a way to enhance female enrollment in engineering [[64]. Students in the junior secondary schools, who are at the stage where decisions on subject choices relating to their future careers are usually made, should be particularly targeted. The teachers and guidance counsellors in secondary schools should be given accurate information on engineering courses and the engineering profession to ensure that they continue with the message for it to reach as many prospective students as possible. Specific high-profile women engineers may also be invited to attend and act as ‘ambassadors for engineering’ in such events. They should also be invited to speak at the event and play active roles in the campaign to help motivate the younger ones [41, 54-61]. In addition to this, showcasing of profiles and case studies of women that have excelled in engineering (which could act as role models to potential applicants), with whom they can identify with, relate to and be inspired by, have been suggested to be present at such events to enhance female enrollment and participation in engineering [22-23, 65].

Furthermore, social media campaigns that would enlighten both the students and their parents on the prospects abounding in engineering, and which may feature the profiles of female role models, will go a long way to increase awareness of the fact that engineering is a viable career choice for girls. This may likely make a career choice in engineering top on the list of young women for potential career choices and consequently boost the enrollment of females in engineering faculties in our universities. Social media outlets are some of the most effective ways of information dissemination in the world today, hence this will be a most effective way of communication to the desired target audience. Portals and service providers such as YouTube, Instagram, Facebook and Twitter may be exploited to facilitate the required steps in this rather positive direction.

Similarly, linking of schools’ webpages to that of the female engineers’ professional webpage, such as Association of Professional Women Engineers in Nigeria (APWEN) [66], and Society of Women Engineers, (SWE), can be used to facilitate access to information on the engineering profession. Also, activities of women in engineering along with the biographies of ‘role models’ and other relevant information

about women in engineering can be assessed from such webpages. Such procedure can be used to demonstrate that engineering can provide a rewarding and fulfilling career for females, and hence motivate more girls to enroll for engineering [54-61].

B. Recruiting and Supporting Female Students

In order to increase the current low female student enrollment rate, tremendous efforts will have to be made by the government, the university, faculties of engineering and technology, in our various universities and the stakeholder-industries. Provision of scholarships for girls with the best results in the STEM-related subjects to study for the required entry-requirement subjects for engineering may motivate more girls to study and excel in these subjects, right from their secondary schools and this may expectedly place them on the path of a career in engineering. Similarly, scholarships and awards for female students in engineering, at the different levels of their studies in the university, will encourage female enrollment in engineering. These scholarships and bursaries which may be facilitated by the stakeholders, should include financial support, mentoring, industrial attachment placement and invaluable experience in engineering firms and industries. Recipients of these scholarships/bursary awards may be published and well-advertised to facilitate information dissemination to potential students as this may influence their choice of a career in engineering [41, 67].

C. Industrial Training (IT) Placements

It is imperative that female students in engineering are provided with networking opportunities with current engineering executives in order to get a realistic preview of engineering tasks and workplace cultures [64]. This could be accomplished by designing internships, externships and co-op programs that would expose them to engineering workplaces [67]. According to [67], the importance of getting practical experience both as a motivation to get into engineering and as an essential part of starting a career in engineering is vital to encouraging enrollment and participation of females in engineering. Such experience could be instrumental in not only helping female engineering students get a close-up and personal view of what to expect after they graduate, but could also set the foundation for important mentoring and role modelling relationships [64, 67-68]. In OAU, Ile-Ife, Nigeria, in the past couple of years, most female students return from their industrial training placements with glowing reports of their experience in the industry. Such reports give the courses practical relevance, give the students added confidence in their ability and convince them that they had not made a mistake in pursuing a career in engineering. This also usually enhance their focus when they returned to the university to complete their degree programs, improve communication skills through working alongside colleagues, suppliers and customer representatives and facilitate contacts for future employment opportunities. This definitely will motivate them to finish the degree and return to the industry to become role models to other female students.

D. Gender-Responsive Actions from Governments and Stakeholders

Development and implementation of policies that are inclusive, transparent and are available to both male and female students and employees are vital in encouraging the participation of females in engineering. Formulation of

education and labour market policies, enforcement of gender-related laws, affirmative actions, as well as specific initiatives for advocacy and awareness raising, are needed to attract more women and girls into engineering. Furthermore, the integration of women in policy making will result in the formulation of gender sensitive policies that will encourage the participation and retention of women in engineering. Gender-responsive actions from governments are therefore vital to increase female enrollment and participation in engineering [15, 34, 41, 69].

Inter-ministerial Coordination amongst allied ministries, such as the ministries of education, women's affairs or gender equality, science, technology and innovation, and labour have also been suggested as a way to strengthen and facilitate effective implementation of gender-sensitive policies [15, 34, 41]. Gender-responsive actions across ministries in order to create more opportunities for girls and women to study and pursue careers in engineering, as well as in investment opportunities, review of education policies and frameworks to stimulate interest in STEM-related subjects among girls have also been recommended to enhance the closing of the gap between male and female enrollment and participation in engineering [15, 34].

E. Promoting More Female Role Models in STEM Fields

Recent research has shown that by using stereotype inoculation-based models that are predicated on contact with female experts in STEM related fields, may enhance female students' liking for the fields [53]. On the basis of these factors, female candidates were also found to identify with engineering fields while their confidence and aspirations were also enhanced by their contact with these female experts that served as role models to them. According to [15, 41, 53, 70], matters of teachers' education and policies on recruitment of teachers should be processed and implemented to ensure a fair representation of both male and female teachers in all subjects, especially in STEM related subjects. Recruitment of more female teachers in mathematics and science at the secondary school level has also been cited as a way to promote more female role models in STEM related subjects and encourage more girls to choose these subjects in their secondary schools, while paving a way for them to choose engineering as a career. Similarly, recruitment of more female faculty members in engineering at higher institutional levels will attract more women into engineering [15, 54-56, 60-62, 70].

F. Development of All-Inclusive Engineering Curricula

Engineering curricula are never static but are always under pressure for revision to incorporate newer or more modern and versatile science and technological tools and to meet the demands of employers for graduates with the required skills. Consequently, universities are always required to provide a wide range of accredited engineering degree programs that will not only reflect their philosophy and student demography, but to also enhance and improve on the regional needs. Making the engineering profession more welcoming by focusing attention on constant or regular curriculum development has therefore been cited as a way to increase women's enrollment rates in engineering [67, 71].

A recent study on the low participation of women in engineering exposed a systemic weakness in curriculum, with over-emphasis on fundamental science and technological applications [41, 67]. Although the curricula may need to reflect these and other social contexts of engineering

applications, it was suggested that greater emphasis should be on human-centred designs and sustainable development that will reflect the current needs for engineers and attract more women enrollment and participation [67, 71]. The development of coursework programs and research in academic cultures that would respond to these demands and that use a wider combination of sound educational concepts, assessments, physical spaces and resources, including engagement with industry have also been suggested to enhance the inclusivity of the learning environments.

Furthermore, it has been strongly suggested that the engineering curricula should emphasize more on creativity. Students should be made to appreciate the design elements, i.e. the creative elements of engineering, so they can come up with ideas, proffer solutions to identified problems, and test those ideas, with an ultimate focus on benefitting the community in a positive way and solving real, tangible problems. Series of skills acquisition sessions may be put together where students may be introduced to basic laboratory procedures and be given opportunity to carry out basic projects such as solid-work projects, mechanical design, basic programming and process and reactor design that will bring out their creativity and develop their innovation skills.

Finally, it has been recommended that curricula and learning materials should undergo further rigorous review from a gender perspective to ensure that they do not perpetuate gender stereotyping. The involvement of a representative group of stakeholders comprising of male and female experts in curricula reviews, has therefore been suggested to facilitate this [41].

V. THE BENEFITS OF INCREASING FEMALE PARTICIPATION IN ENGINEERING

For any nation to attain, maintain and sustain, global leadership and competitiveness in engineering and technology, such a nation must invest in research and innovation and grow a talented large workforce in science, technology and engineering [41]. However, research has also established that there is a critical mass of talent that is not being tapped to solve the global science and technology problems [41, 51, 72]. Challenges in areas such as energy, environment and health-care require the input of as many talented minds as possible to help proffer solutions to solving the problems [72]. Promoting a culture of diversity in engineering has therefore been suggested as a way to offer different perspectives on problems and potentially, a wider variety of solutions. Based on the research carried out by [68], increasing enrollment and participation of females in engineering would result in the following benefits:

- a) solution to skills shortages;
- b) access of employers to a broader base of talent;
- c) increased innovation potential;
- d) enhanced market development;
- e) greater return on human resource investment;
- f) stronger financial performance;
- g) improved governance and
- h) increased national economic growth index.

Consequently, it has been suggested that attempts should be made to facilitate increase in women enrollment and participation in engineering by all the stakeholders [15, 41, 45, 51, 68, 73-76].

VI. GENDER GAP IN ENROLLMENT-CAREER SITUATION IN ENGINEERING IN NORTH AMERICA

Historically, in the U.S. and Canada, fields of Science, Technology, Engineering and Mathematics (i.e. STEM-Fields) have been predominantly male occupations; particularly in the inter-related and/or connected engineering fields, both in educational training and professional practice [77]. However, from the time of the so-called “Age of Enlightenment”, and the much earlier “Feminist Revolution of the 1970’s”, there has been an upsurge in female participation in these traditional fields. But there is indeed still a general gender disparity in STEM fields, resulting from discriminating factors, as highlighted earlier. In fact, a report by [78], showed that the gap in the career aspirations of boys and girls in STEM fields exists as early as the eighth grade, with boys more than twice as likely as girls to aspire to be scientists or engineers (i.e. 9 and 3 %, respectively), while girls were more likely than boys to aspire to other professional, business or managerial occupations (i.e. 38 and 20 %, respectively).

It has been suggested by [79] that a few steps needed to be taken to recruit, hire and retain female engineers, including; changing the ratio of tech teams in a proven path to smarter problems-solving, more bright ideas, more success and more money. However, in order to bridge the gender gap and achieve equal pay, [79] has advocated and recommended the following steps;

- a). Bringing in qualified entry level women engineers with mid-level professional skills.
- b). Growing their software (computer-IT) skills on the jobs to match the firm’s needs rather than disrupting the firm’s compensation structure and laid down culture to poach someone who had learned to code elsewhere,
- c). Keeping an-eye out for company culture that drives out accomplished mid-level women.

Furthermore, [80] in a review of the status of the “Top 10” companies for women in 2017, according to female employees’ assessments, reported that controversies over the treatment of women at prominent companies like ‘Uber’ show that when it comes to fair conditions and equal pay for working women, the U.S. still has a long way to go! According to the ‘Fairygodboss’ website; a platform where women can review the companies they work for or have previously worked for, to help speed up better conditions for women, bad reviews are expected to push executives to work harder, and good reviews will encourage businesses to be as good, or better than their competitors [80]. Recently, the site released the best companies for women with IT and/or engineering skills, ranked according to female employees’ assessments, based on three factors, namely;

- a). Overall job satisfaction
- b). Perceived gender equality at work, and
- c). Whether they would recommend other women to work at the company.

Table III shows the latest of such rankings:

It has been suggested that this level of transparency has really pushed companies to improve on their gender balancing. Multi-national firms operating in developing countries may want to adopt these steps, in order to enhance their gender balancing in both the educational training in STEM-based disciplines in general and engineering, in particular, and in labor-market settings.

TABLE III. THE TOP 10 COMPANIES FOR WOMEN IN 2017, ACCORDING TO THEIR FEMALE EMPLOYEES’ ASSESSMENT [80].

Rank	Company	Criteria		
		Overall Job Satisfaction (rating out of 5)	Perceived Gender Equality at Work (%)	Whether they would Recommend Other Women to Work at the Company (%)
10	Thomson Reuters	3.6	67	73
9	Kaiser Permanente	3.7	71	71
8	American Express	3.8	66	76
7	Vanguard Group*	3.8	72	72
7	Apple*	3.9	70	73
6	PwC**	3.8	71	72
6	Deloitte**	3.7	76	72
6	Sales Force**	4.1	62	77
5	GE (General Electric)	3.9	68	82
4	PepsiCo	3.9	76	76
3	Accenture	3.9	75	79
2	Dell	4.2	65	83
1	Boston Consulting Group	4.3	91	82

^b * Vanguard Group and Apple; tied. **PwC, Deloitte and Sales Force; tied.

VII. CONCLUSION

From the foregoing, it is clear that any effort aimed at closing the gap between male and female enrollment in engineering, particularly in the developing nations, will require a lot of re-appraisal of existing strategies on the part of governments, industries, parents, teachers, faculties of engineering and the universities. Prevailing but delimiting policies and dominant primordial cultures may have to be changed; curricula may have to be reviewed and the career path made more welcoming and/or transparent in order to enhance women enrollment and participation in engineering, technology and innovation fields.

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