UNIVERSITY OF LAGOS, NIGERIA
Inaugural Lecture Series 2019

TOPIC:

BEYOND BIAS AND BARRIERS: FULFILLING THE POTENTIALS OF WOMEN AND GIRLS IN SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM)

By

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An Inaugural Lecture Delivered at the University of Lagos, J. F. Ade-Ajayi Auditorium on 9th October, 2019

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ISSN: 119-4456

Published and Printed

By

University of Lagos Press and Bookshop Ltd.
Works and Physical Planning Complex
University of Lagos
Akoka – Yaba, Lagos
Unilag P. O. Box 132

Email: info@unilagpress.com

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My dear Students (Past and Present)
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Gentlemen of the Press
Distinguished Guests, Ladies and Gentlemen

1. PREAMBLE AND FELICITATION

My journey to this podium was slow but eventful. I thank the Almighty God for preserving my life to this day. I also thank the Vice Chancellor for giving me this wonderful opportunity to deliver my inaugural lecture. It gives me pleasure and satisfaction to stand here this afternoon as the inaugural lecturer.

Mr. Vice Chancellor Sir, distinguished Ladies and Gentlemen, this is the 4th inaugural lecture from the Department of Science and Technology Education of this great university. The first was given in 2006 by Prof. T.D. Baiyelo of blessed memory.

Mr Vice Chancellor Sir, I am a product of one of the best Universities in Nigeria, the University of Nigeria, Nsukka where I obtained my Bachelor of Science and my Doctorate degrees. Through my academic journey, I taught variously at the University of Nigeria, Nsukka, Rivers State University of Science and Technology, Port Harcourt and finally berthing at

the University of Lagos. In this lecture, Mr. Vice Chancellor, Sir, I stand as a Professor of Science Education to tell you a bit of what I have been professing throughout my career.

Let me start by asserting that since 1992 when I obtained my Ph.D., I have been led by my conviction that everyone needs science education no matter how rudimentary to be able to function in our modern digitized world. Indeed, it is the responsibility of science educators to ensure that science education is delivered effectively to all learners irrespective of sex or other circumstances. Throughout my career as a teacher, I have followed with keen interest the difficulties faced by all stakeholders in making science accessible to all. One area of longstanding concern is the low rate of female participation in STEM subjects and consequently STEM careers. The gender gap in STEM education participation and achievement has been the subject of extensive research over many decades. While gender differences in science and mathematics achievement appear to have decreased in recent years in many countries, as shown in large-scale cross-sectional studies, they have not been eliminated. Moreover, while more women are entering the STEM workforce than ever before, women are still significantly underrepresented in STEM occupations in many countries.

Earlier on in my career, I had conducted a lot of researches that investigated sex difference not as a primary objective. It is, however, axiomatic in any study to breakdown the sample into reasonable subsamples and scrutinize the differences between these subsamples on all variables being measured. Thus it was entirely logical to record differences between the sexes. Some of these differences turned out to be quite marked and these subsequently changed my research focus.

The factors that led to this difference by females vary. Research has shown that females' under-achievement and representation is a complex phenomenon, with many of the characteristics of a vicious cycle linking socialization, schooling, the labour market and family responsibilities. But this cycle can be broken. We need to understand the drivers

behind this situation in order to reverse the trends. This conviction has propelled my research interest and activities and today I present my scorecard on my academic journey so far.

Mr. Vice Chancellor Sir, distinguished ladies and gentlemen, my inaugural lecture titled **"Beyond Bias and Barriers: Fulfilling the Potentials of Women and Girls in Science, Technology, Engineering and Mathematics (STEM)"** is organized as follows:

- Introduction
- Current Status of Girls and Women in STEM
- Factors Influencing Girls and Women's Participation, Progression and Achievement in STEM
- Interventions that help fulfil the potentials of Women & Girls in STEM Education
- My Research Contributions towards fulfilling the Potentials of Women & Girls in STEM
- Conclusion and Recommendations
- Acknowledgement

2. 1. INTRODUCTION

1.1 STEM EDUCATION AND THE 2030 SUSTAINABLE DEVELOPMENT AGENDA

- ***Only 18 women have won a Nobel Prize in Physics, Chemistry or Medicine since Marie Curie in 1903, compared to 572 men.***
- ***Today only 28% of the world's researchers are women.***
- ***Too many girls are held back by discrimination, biases, social norms and expectations that influence the quality of education they receive and the subjects they study.***

Irina Bokova

UNESCO Director-General (2017)

Such huge disparities, such deep inequality, do not happen by chance. Both education and gender equality are an integral part of the 2030 Agenda for Sustainable Development,

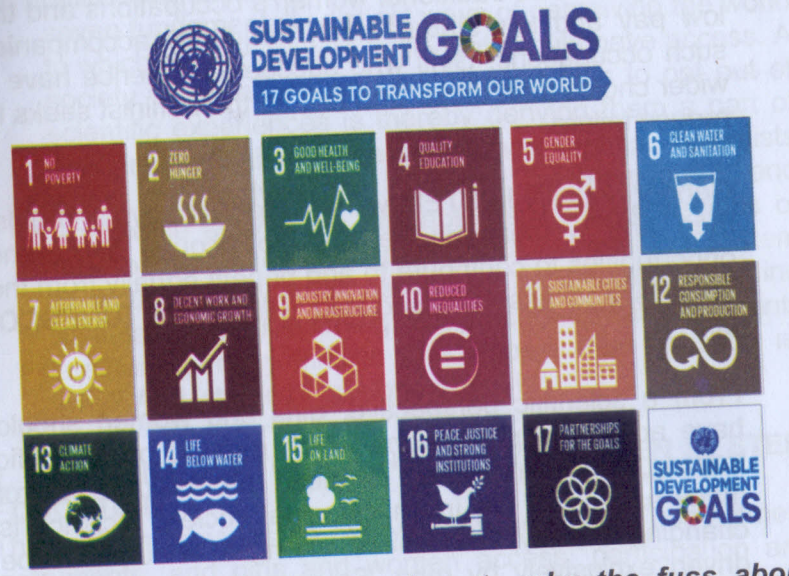
adopted by the United Nations General Assembly on September 25th, 2015 as distinct Sustainable Development Goals (SDGs) but also as catalysts for the achievement of all other SDGs.

The 2030 Agenda for Sustainable Development calls for a new set of goals to end poverty, protect the planet and ensure prosperity for all. The agenda includes 17 Sustainable Development Goals (SDGs) including SDG4 on Quality Education and SDG5 on Gender Equality.

UNESCO recognizes that achieving the 2030 agenda requires the cultivation of transformative, innovative and creative thinking and skills, competent and empowered citizens **(UNESCO, 2016).** For education to achieve its potential, urgent changes are needed. This includes steps to eliminate persistent disparities in education access, participation and achievement to improve educational quality and provide learners with the knowledge, skills attitudes and behaviour to ensure inclusive and sustainable societies **(UNESCO, 2017).** Science, Technology, Engineering and Mathematics (STEM) education underpins the 2030 agenda for sustainable development. STEM education has already brought about improvements in many aspects of life such as health, agriculture, preserving the environment, reducing poverty, infrastructure and renewable energy. It is also key for preparing students for the world of employment, enabling them entry into in-demand STEM careers of tomorrow. Leaving out girls and women in STEM education is a loss for all. For the SDGs to be achieved, everyone needs to be involved including women and girls.

The Incheon Declaration and Framework for Action for the implementation of SDG4 notes that the focus on quality and innovation will require strengthening STEM and particular attention should be given to providing girls and women with scholarships to study in the STEM fields **(UNESCO, 2016). The Addis Ababa Action Agenda**, which provides a global framework for financing sustainable development, calls on countries to scale up investment in science, technology,

engineering and mathematics education ensuring equal access for women and girls. **(UN, 2015).**



The question may be posed as to why the fuss about females having equal access with males to STEM?

1.2 WHY FOCUS ON GIRLS AND WOMENS' EDUCATION IN STEM

Ensuring girls and women have equal access to STEM education and ultimately STEM careers are imperatives from the human rights, development, scientific and education perspectives.

- From a human right perspective, equity as contained in the human rights declaration, means giving everyone, female or male, equal opportunities to societal and personal pursuits and accomplishment including Science and Technology.

- From a development perspective, is the society's need for scientists and technologists, and regrets the loss of capable girls from the supply of scientific manpower. But there is also a more radical, feminist approach, concerned with social inequity. Girls who cannot or will not learn science are cut off at an early age from a wide

range of careers and interests. By conforming to a feminine stereotype which excludes science they are moving towards traditional women's occupations and the low pay and low status which frequently accompanies such occupations. Girls who succeed in science have a wider choice than those who fail, so the feminist seeks to reduce failure.

Gender equality in STEM will ensure that boys and girls, men and women will be able to acquire skills and opportunities to contribute to and benefit equally from the benefits and assets associated with STEM **(UNESCO, 2017).**

- From a scientific perspective, girls and women should have access to professions which depend on scientific training, since members of these professions control many aspects of life in an industrial society. Science is changing society, and these changes should not be driven exclusively by men. So, substantial numbers of women should become professional scientists and technologists. All women should have sufficient scientific understanding to enable them to take full and informed part in current debates on issues such as environmental pollution, energy resources and genetic engineering. At a practical level, science is important for a feeling of competence and environmental mastery. A woman in an industrial society is surrounded by machinery and labour-saving devices; often she does not understand or control this equipment sufficiently to even carry out simple repairs. She is encouraged to rely on 'experts' almost invariably men. This encourages a feeling of incompetence and inadequacy. Women become passive consumers of an incomprehensible male-structured environment. More and adequate scientific education for girls could help combat this situation.

For educators too, girls' underachievement in science is a practical problem. Science is widely considered an

essential part of general education, without which a person's experience is incomplete. In Hirst's (1969) philosophy of education, science comprises one of the seven fundamentally distinct ways of perceiving the world to which every complete individual should have access. A society which allows and encourages girls to opt out of scientific experiences is thereby denying them a part of their intellectual heritage as human beings. Scientists whom themselves find science a meaningful and worthwhile activity are probably especially conscious of this, they are often keen to introduce learners to a system of thought and way of viewing the world which they find stimulating and rewarding. But present-day arrangements are failing many girls in this respect. The question is, why? And what can be done about it?

2. CURRENT STATUS OF GIRLS AND WOMEN IN STEM EDUCATION

This section provides an overview of the gender commitment instruments, and girls and women access, participation and learning achievement in STEM education at primary, secondary and higher education levels.

2.1 THE POLICY ENVIRONMENT

The topic, "improving girls and women's access to and participation in science," has been addressed in a number of international agreements affecting education and gender issues. Some of the major ones are discussed below:

- World Conference on Education for All (EFA) in Jomtien Thailand in 1990 prioritized the need for improving access to education for all.

- The World Education Forum (26-28 April 2000 Dakar) adopted the Dakar Framework for Action, Education for All: Meeting our Collective Commitments. In so doing, its participants reaffirmed the vision of the World Declaration on Education for All adopted ten years earlier in Jomtien, Thailand, 1990. The EFA Dakar goals have its 5th goal "Eliminating gender disparities in primary and secondary

education by 2005, and achieving gender equality in education by 2015, with a focus on ensuring girls full and equal access to and achievement in basic quality education."

- The Beijing Platform for Action, adopted at the **Fourth World Conference on Women (1995)** calls on Governments and all stakeholders to increase women's access to and retention in science and technology, including adapting curricula and teaching materials and by increasing the share of women teachers in scientific and technological disciplines at all levels of education.

- The outcome document of the 23rd special session of the **UN General Assembly (2000)** highlights the need to encourage and support the education of girls in science, mathematics and new technologies, and technical subjects, and to encourage women through career counselling, to seek employment in high-growth and high-wage sectors and jobs.

- The Science Agenda-Framework for Action of the UNESCO **World Conference on Science (WCS) (1999)** calls for special efforts by governments, educational institutions, scientific communities, non-governmental organizations and civil society, with support from bilateral and international agencies, to ensure the full participation of women and girls in all aspects of Science and Technology.

The World Summit on the Information Society **(WSIS)** recognizes, in the **Geneva Plan of Action (2003)** and the **Tunis Agenda for Information Society (2005)** the importance of promoting women's participation in Information and Communications Technology **(ICT),** including at decision making level.

The Commission on Science and Technology for Development **(CSTD)** is the sole functional commission

of the United Nations Economic and Social Council **(ECOSOC)** to have a Gender Advisory Board **(GAB)** established in **1995**. The **GAB,** previously the Gender Working Group, developed a set of 'Seven Transformative Action Areas to progress toward gender equality, which were endorsed by **ECOSOC** in **1995.** In **2006** the **GAB** added an eight transformative action area. The **CSTD** has addressed gender equality issues in its resolution.

- The Eight Millennium Development Goal adopted in **2000** by the international community includes the third goal with a target to eliminate gender disparity in primary and secondary education, preferably by **2005** and to all levels of education not later than **2015**.

- The Seventeen Sustainable Development Goals adopted post **2015** by the United Nations has the 5th goal as Gender Equality.

These international treaties and agreements have raised the profile of gender disparities in education and in science and technology and some countries have forced these issues on to the national policy agenda. For instance, under the auspices of UNESCO, a World Conference on Women, Science and Technology was held in **Ouagadougou, Burkina Faso in 1999.** The box below summarizes its resolutions. The **Ouagadougou Declaration** urged the governments of member states to "pursue and intensify their efforts in order":

- To eradicate certain sociocultural factors that force girls and women into imposed, fixed roles.
- To promote informal education suited to the interests and aspirations of women and underlining the advantages that scientific and technological knowledge would procure for their future.
- To make use of the scientific and technological potential of African women; the knowledge, know-how, life skills, handed down over the generations in numerous fields (pediatrics, pharmacology, culinary practices).
- To renovate the scientific and technical teaching programmes and materials in order to make them more attractive to girls.
- To create technical training programmes for girls and women that integrate the advances made in science and technology.
- To adapt training of trainers policies as regards gender, i.e. social equality between the sexes.
- To promote women to decision-making positions in the field of science and technology.
- To create a new regional, national and international partnership aimed at promoting African girls and women in the realm of science and technology.

***Box 2.1:** The Ouagadougou Declaration*

In Nigeria national policies and standards are centrally developed, articulated and monitored, while implementation is done at state level. Nigeria has signed, ratified or acceded to some United Nations protocols, enacted some regional and domestic laws/conventions and is therefore committed to their implementation.

These include:-

- UN Convention on the Rights of the Child (CRC)

- Convention on the Elimination of all forms of Discrimination against Women (CEDAW) (1981)
- The African Charter on the Right and Welfare of the African Child (ACRWAC)
- The Constitution of the Federal Republic of Nigeria 1999
- Universal Basic Education Act (UBE) 2004
- In addition to all these are some that are specifically addressing gender:
- National Gender Policy (2006)
- National Policy on Gender in Basic Education (2007). This policy is meant to address the cultural attitudes and practices hindering girls participation in education. The policy also advocates for the need for women/girls education as a roadmap to gender equality and social justice.

Furthermore, Nigeria is also a signatory to EFA, MDGs, SDGs, Commonwealth Plan of Action and all the goals on gender equality. Nigeria can therefore not afford to be seen to lag behind other Nations in giving effect to these very important instruments. The country was unable to meet MDG Goal 3 on gender equality by the end of 2015 but efforts are being made to improve on the achievement recorded so far towards SDGs 5.

2.2 GLOBAL OVERALL EDUCATION TRENDS: ACCESS, PARTICIPATION AND PROGRESSION

Girls' and women participation in STEM education needs to be considered in the context of their overall access to, and participation in education. While access to education for girls and young women has globally improved, there exist persistent disparities in participation and progression both among and within regions and countries.

Trends show a small but consistent increase in female students' enrolment rates at all levels of education since 2000 as could be seen in Fig. I

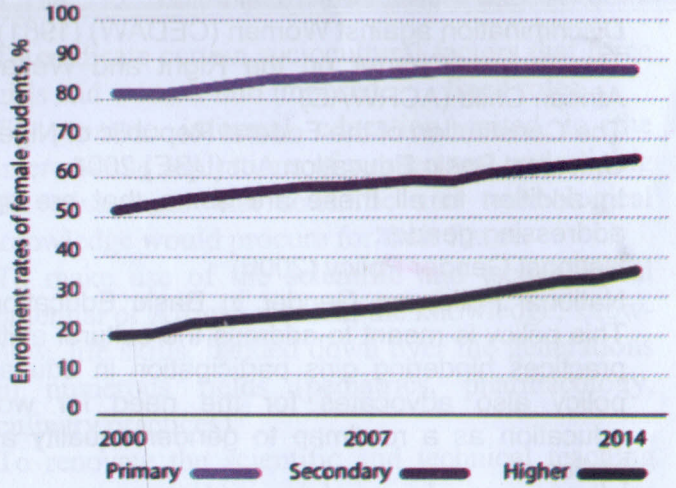


Figure 1: Enrolment Rate of Female Students, by Level of Education, the World Average

Girls' enrolment in education is increasing globally, especially in higher education.

*Note: Net enrolment rates for primary and secondary, gross enrolment ratio for higher education.
Data source: UIS 2016

In primary education, there was considerable disparity in 1999 at the global level, with 92 girls enrolled for every 100 boys. By 2012, the global average had increased to 97 just below the threshold of parity. South and West Asia made the strongest progress, achieving parity from the lowest starting point: 83 girls enrolled for every 100 boys. Sub-Saharan Africa and the Arab States halved the parity gap but remained the regions furthest from the target at 92 and 93 girls respectively for every 100 boys (EFA Monitoring Report, 2015).

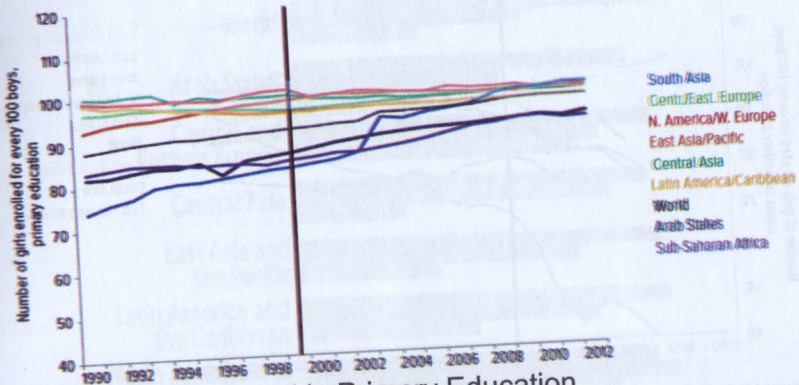


Figure 2: Global Trend in Primary Education
Source: UIS database (2015)

Secondary education was very similar to primary education. At the global level, the disparity in 1999 was 91 girls enrolled for every 100 boys. By 2012, the global average had increased to almost 97 girls, just below the threshold of parity. South and West Asia again made the strongest progress, from 75 girls enrolled for every 100 boys, the lowest starting point, to 93, with rapid progress at both the lower and upper secondary levels.

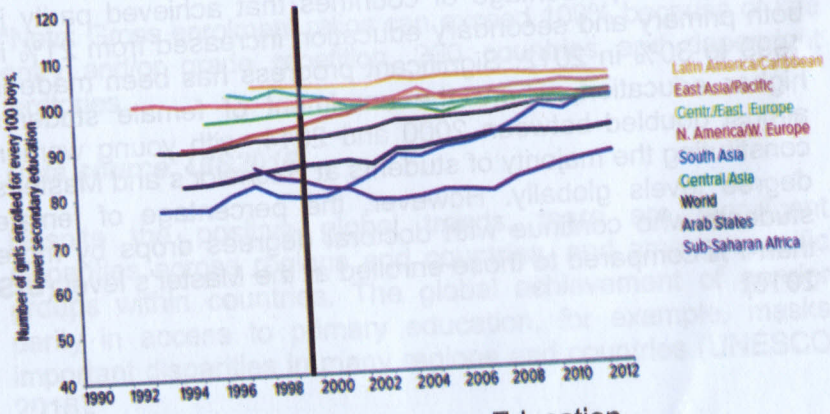
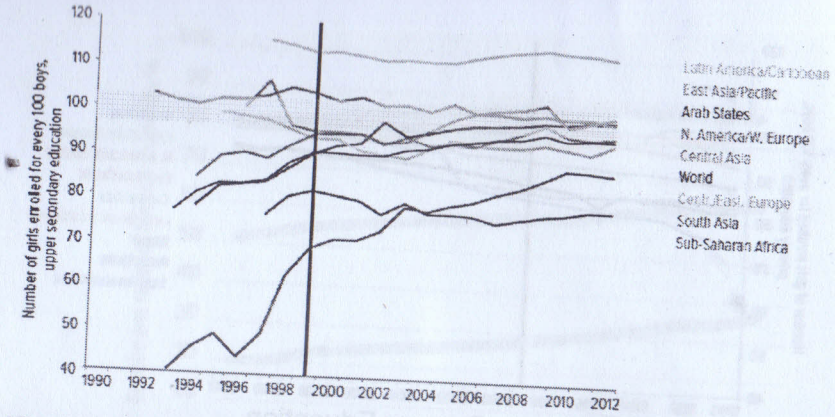


Figure 3: Global Trend in Secondary Education
Source: UIS database (2015)



Source: UIS database

Figure 4: Global Trend in Upper Secondary Education
Source: UIS database (2015)

The Arab States made progress, too, as the number of girls enrolled for every 100 boys increased from 87 in 1999 to 95 in 2012. Sub-Saharan Africa was the region left furthest behind with the slowest progress toward parity, increasing from 82 to 84 girls for every 100 boys. East Asia and the Pacific reached parity, while Latin America and the Caribbean was the only region with disparity at the expense of boys: 93 boys enrolled for every 100 girls.

Globally, the percentage of countries that achieved parity in both primary and secondary education increased from 21% in 1999 to 30% in 2012. Significant progress has been made in higher education, where the enrolment of female students almost doubled between 2000 and 2014, with young women constituting the majority of students at Bachelor's and Master's degree levels globally. However, the percentage of female students who continue with doctoral degrees drops by more than 7% compared to those enrolled at the Master's level **(UIS 2016)**

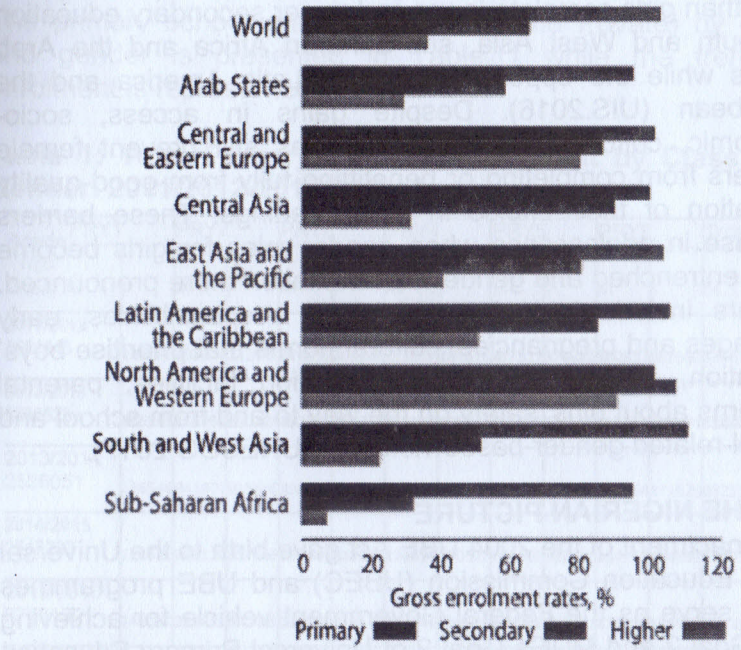


Figure 5: Girls' Gross Enrolment Ratio from Primary to Higher Education in 2014, World and Regional Averages
Regional variations in girls' enrolments, especially in higher education.

*Note: Gross enrolment ratios can exceed 100% because of late entry and/or grade repetition. 200 countries and dependent territories.

Data source: UIS2016

Despite the positive global trends, there are significant disparities across regions and countries, and among specific groups within countries. The global achievement of gender parity in access to primary education, for example, masks important disparities in many regions and countries (UNESCO 2016).

In secondary education, gender disparities are more diverse, with considerable regional differences. For example, more

boys than girls complete lower and upper secondary education in South and West Asia, sub-Saharan Africa and the Arab States while the opposite is true in Latin America and the Caribbean (UIS.2016). Despite gains in access, socio-economic, cultural and other obstacles still prevent female learners from completing or benefitting fully from good quality education of their choice in many settings. These barriers increase in adolescence when gender roles for girls become more entrenched and gender discrimination more pronounced. Barriers include household and care responsibilities, early marriages and pregnancies, cultural norms that prioritise boys' education, inadequate school sanitation facilities, parental concerns about girls' safety on the way to and from school and school-related gender-based violence. (UNESCO 2017).

2.3 THE NIGERIAN PICTURE

The enactment of the 2004 UBE Act gave birth to the Universal Basic Education Commission (UBEC) and UBE programmes which serve as the Federal Government vehicle for achieving EFA Goal 2 and MDGs Goal 2 of Universal Primary Education (UPE). The UBE Act has put in place regulations to ensure the orderly development of basic education in Nigeria as well as ensure that all children of school age are enrolled, attend and complete basic education.

In 2000 most countries of the world, including Nigeria, pledged to achieve EFA, by the year 2015, the six Education for All (EFA) goals by implementing the twelve strategies presented in the Dakar Framework for Action. The sections below present the current trends in access, participation and progress at both primary and secondary levels of education.

- **PRIMARY SCHOOL ENROLMENT**

The nine-year basic education programme comprises 6 years of primary and 3 years of junior secondary education.

Table 1 presents the primary school enrolment figures by class and by gender for a period of five years (2011/2012 – 2015/2016)

The primary school enrolment (Public and Private) by class and gender is presented in Table 1 while the trend in enrolment is represented in figure 4.

Table 1: Total Primary Schools Enrolment by Class and Gender: 2011/2012-2015/2016

Academic Year	PRY1		PRY2		PRY3		PRY4		PRY5		PRY6		Total	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
2011/2012	2581145	2280982	2383172	2128497	2288322	2032452	2130882	2895760	2975173	3752852	3808375	3635824	43167067	11726375
2012/2013	2636528	2469692	2467992	2302244	2327902	2203292	2191632	2050442	2017076	2895212	3853640	3742712	43494766	12663609
2013/2014	2536051	2265462	2410072	2315880	2301392	2165641	2163232	2963847	2988428	3784578	3856642	3716292	43255789	12545408
2014/2015	2547233	2285302	2411202	2317665	2353432	2112052	2182522	2005262	2016039	3822962	3847152	3646995	43393310	12049225
2015/2016	2743132	2460502	2434502	2320498	2338892	2135702	2177452	2990382	2003382	3813712	3738562	3549952	43435940	12155241

Source: FME Nigeria Digest of Education Statistics 2014-2016

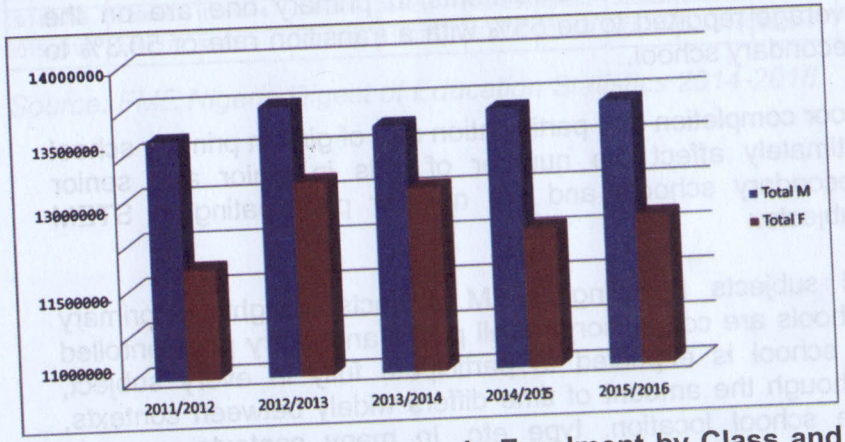


Figure 6: Total Primary Schools Enrolment by Class and Gender: 2011/2012-2015/2016

From the Table, it is evident that female enrolment in primary school is lower than that of males. Girls enrolment dropped as

they progressed from primary 1 (age 6) to primary 6 (age 11). Primary six completion rate was also lower for females. 48.5% was the highest percentage recorded for the females (Statistics in Education 2017).

Table 2: Number of Pupils Completing Primary Six by Gender

	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016
Boys	1808375 (52.5)	1853640 (51.5)	1847151 (52.8)	1847151 (52.8)	1738565 (52.8)
Girls	1635824 (47.5)	1742719 (48.5)	1716298 (48.1)	1646995 (47.2)	1549953 (47.2)
B+G	3,444,199	3,596,359	3,572,941	3,494,146	3,288,518

Source: FME Nigeria Digest of Education Statistics 2014-2016

The completion rates are generally very low. The recorded average completion rates are 52% for boys and 48% for girls. The average completion rate at the end of primary education as a percentage of enrolments in primary one are on the average reported to be 55% with a transition rate of 50.3% to secondary school.

Poor completion and participation rate of girls in primary school ultimately affect the number of girls in junior and senior secondary schools and the number participating in STEM subjects.

All subjects including STEM subjects, taught in primary schools are compulsory for all pupils and every pupil enrolled in school is expected to participate fully in every subject, although the amount of time differs widely between contexts, like school location, type etc. In many contexts, sex-role stereotyping is reinforced at this age range. Few primary school teachers are especially concerned with science and few are aware that they may be influencing their children's latter achievement in science (Udeani 2005) Also teachers have

been found to evaluate girls' ability in STEM subjects at a lower rate than boys ability even when they are performing at similar levels (Lohbeck et al. 2017). Early educational experiences have been found to have a positive effect on students' choice of mathematics and science courses later as well as their career aspirations (Kemani et al. 2015).

- **JUNIOR SECONDARY SCHOOL ENROLMENT**

Summary of JSS Enrolment: 2011/2012-2015/2016

The total school enrolment in JSS (2011/2012 to 2015/2016) in Table 3 is presented by Class and Gender while Fig. 5 shows the graphical presentation.

Table 3: Total Junior Secondary Schools Enrolment by Class and Gender: 2011/2012-2015/2016

Academic Year	JSS I		JSS II		JSS III		Total		
	M	F	M	F	M	F	M	F	M+F
2011/2012	1066345	1119450	1299781	1071S83	1053563	1299908	3419689	3490941	6910630
2012/2013	1106980	1002141	1083366	997137	1031613	947527	3221959	2946805	6168764
2013/2014	1146044	1000501	1112942	975287	1052484	915836	3311470	2891624	6203094
2014/2015	1139849	1021844	1096002	984251	1024258	914087	3260109	2920182	6180291
2015/2016	1105711	986744	1034979	919675	952856	839022	3093546	2745441	5838987

Source: FME Nigeria Digest of Education Statistics 2014-2016

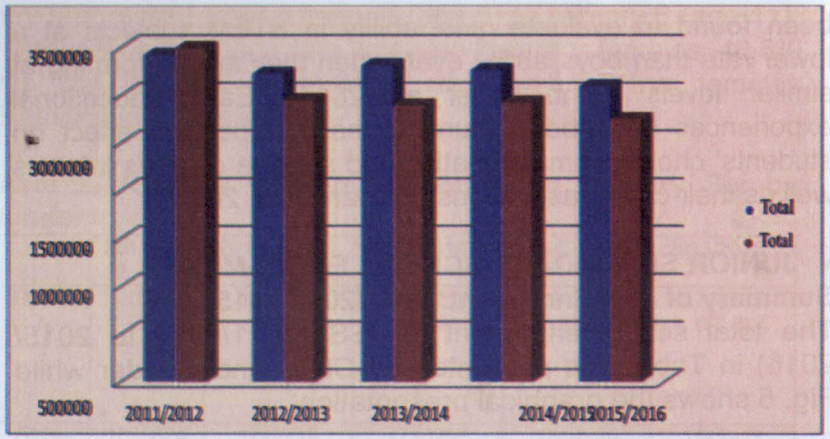


Figure 7: Total Junior Secondary Schools Enrolment by Gender: 2011/2012-2015/2016

Source: FME Nigeria Digest of Education Statistics 2014 - 2016

Table 3 Presents the Junior Secondary School enrolment by gender from 2011/2012 to 2015/2016. As in the case of primary school enrolment, all junior secondary students are expected to participate in every subject including STEM. Completion rate at this level of education is important especially for girls' participation in STEM. However, the provision of a basic science course for all in primary and junior secondary schooling is not a sufficient remedy if the experiences of girls, and expectations of them, result to the majority of them 'choosing' away from science when the compulsory study is lifted in senior secondary school.

- **SENIOR SECONDARY SCHOOLS ENROLMENT**

The Senior Secondary School, also known as Post-Basic Education, is of a three year duration. This education level occupies a critical position in Nigeria's education system, because of its dual role in preparing students for tertiary education and the labour market.

The enrolment in Senior Secondary schools by Gender from 2011/2012 to 2015/2016 is shown in Table 4 and graphically illustrated in Figure 6.

Table 4: Senior Secondary Schools Enrolment by Class and Gender: 2011/2012-2015/2016

Year	SSS 1		SSS 2		SSS 3		Total		
	M	F	M	F	M	F	M	F	M+F
2011 /2012	1,005,533	838,379	896,194	758,614	795,141	640,861	2,696,868	2,237,854	4,934,722
2012/2013	1,038,285	855,483	952,753	804,620	851,549	708,251	2,842,587	2,368,354	5,210,941
2013/2014	817,348	707,709	788,177	663,797	715,658	599,800	2,321,183	1,971,306	4,292,489
2014/2015	937,172	830,591	882,098	768,910	821,065	695,903	2,640,335	2,295,404	4,935,739
2015/2016	853,435	754,119	853,285	709,294	710,472	594,704	2,417,192	2,058,117	4,475,309

Source: FME Nigeria Digest of Education Statistics 2014-2016

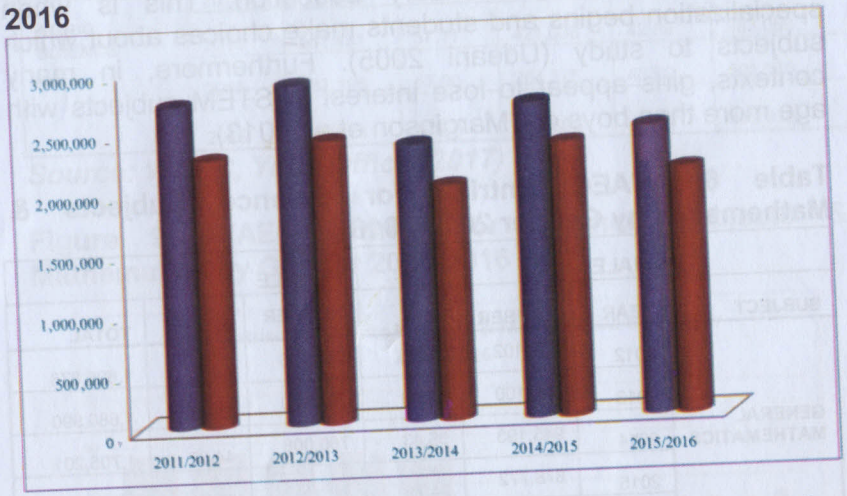


Figure 8: Total Senior Secondary Schools Enrolment by Class and Gender: 2011/2012-2015/2016

Source: FME Nigeria Digest of Education Statistics 2014-2016

Senior secondary school shows a wider gap in favour of boys. In general, there are fewer girls than boys in senior secondary school. This gender disparity in enrolment would further widen the gap between boys and girls studying STEM. From the enrolment statistics available female education drops as they

move from primary through junior secondary school to senior secondary as shown in the Gender Parity Index (GPI) table 5.

Table 5: Gender Parity Index

Level	GPI
Primary	0.92
Junior Secondary	0.90
Senior Secondary	0.88

Source: FME Nigeria Digest of Education Statistics 2014-2016

The gender gap in STEM participation becomes more apparent in senior secondary education. This is when specialization begins and students make choices about which subjects to study (Udeani 2005). Furthermore, in many contexts, girls appear to lose interest in STEM subjects with age more than boys do (Marginson et al. 2013).

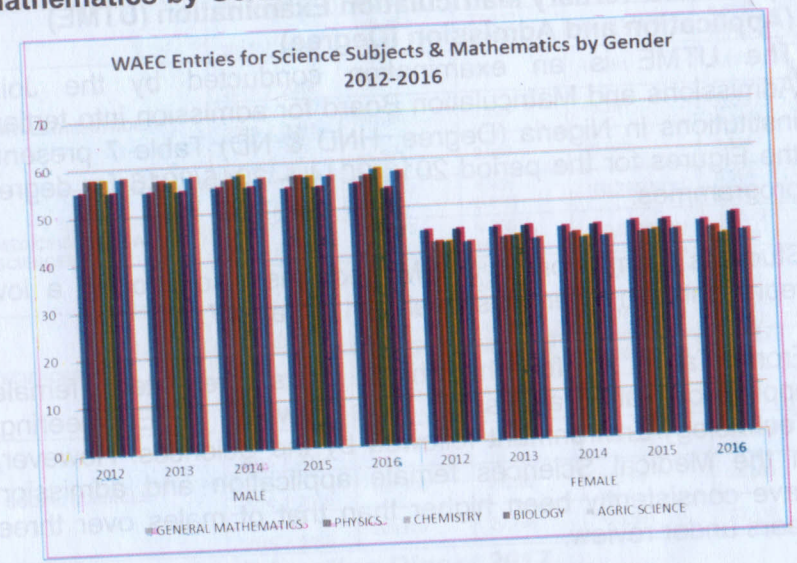
Table 6: WAEC Entries for Science Subjects & Mathematics by Gender 2012-2016

	MALE			FEMALE		
SUBJECT	YEAR	NUMBER	%	NUMBER	%	TOTAL
GENERAL MATHEMATICS	2012	937,102	55.26	758,776	44.74	1,695,878
	2013	929,100	55.00	757,890	45.00	1,686,990
	2014	945,193	55.43	760,008	44.57	1,705,201
	2015	878,772	54.79	725,118	45.21	1,603,890
	2016	822,007	55.39	662,027	44.61	1,484,034
PHYSICS	2012	368,808	57.73	270,026	42.27	638,834
	2013	370,164	57.20	277,009	42.80	647,173
	2014	383,382	56.90	290,399	43.10	673,781
	2015	380,503	57.21	284,595	42.79	665,098
	2016	366,535	56.80	278,773	43.20	645,308
CHEMISTRY	2012	369,972	57.66	271,650	42.34	641,622
	2013	371,125	57.00	278,399	43.00	649,524

	2014	390,790	57.90	284,149	42.10	674,939
	2015	379,685	57.00	286,428	43.00	666,113
	2016	375,821	58.20	269,919	41.80	645,740
BIOLOGY	2012	931,771	55.21	756,017	44.79	1,687,788
	2013	923,301	55.00	754,853	45.00	1,678,154
	2014	797,901	55.39	642,613	44.61	1,440,514
	2015	658,552	54.79	543,185	45.21	1,201,737
	2016	574,171	54.00	489,107	46.01	1,063,278
AGRIC SCIENCE	2012	792,757	57.96	574,956	42.04	1,367,713
	2013	778,622	57.80	568,722	42.20	1,347,344
	2014	561,431	57.11	421,638	42.89	983,069
	2015	337,195	57.00	254,375	43.00	591,570
	2016	276,271	57.56	203,699	42.44	479,970

Source: WAEC, Yaba Office (2017)

Figure 9: WAEC Entries for Science Subjects & Mathematics by Gender 2012-2016



Source: WAEC, Yaba Office (2017)

From the data presented in Table 6 and Figure 7, it could be seen that female enrolment for 0-level examinations in all science subjects and mathematics were consistently lower than for the males. Gender parity was never achieved in any of the science subjects. Enrolment for females was highest in Biology and lowest in Agricultural Science. This underrepresentation at the senior secondary school certificate examinations will impact on girls enrolment in science courses at the tertiary level and further widen the gap between boys and girls studying STEM.

- **TERTIARY LEVEL EDUCATION (DEGREE)**

A clear gendered pattern emerges in higher education in Nigeria. From this perspective female participation in STEM education was reviewed at three levels.

a) Unified Tertiary Matriculation Examination (UTME)
b) Undergraduate Enrolment in STEM Faculties (University of Lagos 2017/2018)
c) Postgraduate Enrolment in STEM Faculties (University of Lagos 2017/2018)

a) Unified Tertiary Matriculation Examination (UTME) (Application and Admission (Degree)

The UTME is an examination conducted by the Joint Admissions and Matriculation Board for admission into tertiary institutions in Nigeria (Degree, HND & ND) Table 7 presents the Figures for the period 2013-2014 – 2015/2016 for degree programmes.

Students' admission in STEM Faculties also showed a low representation of females as shown in Table 7.

From Table 7, for the three years presented, female application and admission was lowest in Engineering/ Technology/Environment followed by the Sciences. However, in the Medical Sciences female application and admission have consistently been higher than that of males over three years under review.

TABLE 7: UTME APPLICATION AND ADMISSION BY YEAR AND FACULTY 2013/2014 – 2015/2016 (DEGREE)

	Male			Female	
PROGRAMME	YEAR	Application	Admission	Application	Admission
ADMIN/MGT SCIENCES	2013 / 2014	76,383	10,646	85,781	9,210
	2014 / 2015	67,419	11,472	68,369	10,226
	2015 / 2016	71,684	10,704	74,239	10,630
AGRICULTURE	2013 / 2014	17,650	9,792	17,736	10,277
	2014 / 2015	14,871	11,562	15,116	11,167
	2015 / 2016	14,641	15,504	12,640	42,040
ARTS/HUMANITIES	2013 / 2014	60,225	14,824	58,925	15,343
	2014 / 2015	33,303	15,354	36,449	16,883
	2015 / 2016	42,040	13,754	48,921	15,016
EDUCATION	2013 / 2014	35,124	28,575	47,160	27,538
	2014 / 2015	28,064	31,354	39,202	34,384
	2015 / 2016	32,624	34,457	42,719	36,982
ENG/TECH/ENVIRONMENT	2013 / 2014	186,505 (90%)	31,738 (86%)	21,150 (10%)	5,008 (16%)
	2014 / 2015	183,693 (84%)	30,603 (84%)	35,716 (16%)	5,620 (16%)
	2015 / 2016	185,250 (90%)	37,813 (85%)	20,781 (10%)	6,894 (15%)
LAW/LEGAL STUDIES	2013 / 2014	42,855	3,901	45,291	3,491
	2014 / 2015	40,758	3,229	45,291	3,333
	2015 / 2016	41,391	2,998	45,620	3,414
MEDICINE/ MEDICAL SCIENCES	2013 / 2014	109,263 (40%)	8,986 (48%)	160,795(60%)	9,554 (52%)
	2014 / 2015	107,175 (40%)	9,355 (47%)	159,070(60%)	10,526 (53%)
	2015 / 2016	126,060 (40%)	9,541 (41%)	189,789(60%)	13,832 (59%)
SCIENCES	2013 / 2014	146,735 (62%)	36,380 (62%)	88,371 (38%)	22,353 (38%)
	2014 / 2015	133,748 (61%)	40,193 (60%)	86,302 (39%)	27,347 (40%)
	2015 / 2016	143,871 (61%)	51,167 (59%)	90,049 (39%)	35,757 (41%)
SOCIAL SCIENCES	2013 / 2014	215,851	28,278	160,272	19,849
	2014 / 2015	187,105	31,292	31,298	23,368
	2015 / 2016	209,837	29,798	153,591	23,419

Source: Nigerian Education Digest 2017

(b) Undergraduate Enrolment in STEM Faculties (UNIVERSITY OF LAGOS)

The same pattern of low female enrolment in the Faculties of Engineering and Environmental Sciences persists. However, the gender gap in the Sciences is narrowing. Females are still recording higher percentages in the Medical Sciences (Clinical & Basic).

Table 8: Distribution of Full-time Undergraduate Students in the Faculties 2017/2018 at the University of Lagos

Faculty	Female (%)	Male (%)	Total
Arts	1925 (62)	1182 (38)	3107
Basic Medical sciences	318 (58.8)	222 (41.2)	540
Clinical Sciences	664 (62.7)	394 (37.3)	1058
Dental Sciences	197 (48)	212 (52)	409
Education	3154 (60)	2106 (40)	5260
Engineering	580 (17.2)	2795 (82.8)	3375
Environmental Sciences	414 (24.8)	1256 (75.2)	1670
Law	1233 (66)	635 (34)	1868
Management Sciences	2176 (48.7)	2289 (51.3)	4465
Pharmacy	448 (62.4)	270 (37.6)	718
Science	2352 (45.5)	2811 (54.5)	5163
Social Sciences	1992 (52.7)	1783 (47.3)	3775
Total	**15,453**	**15,955**	**31,408**

Source: Pocket Statistics, Academic Planning Unit, University of Lagos

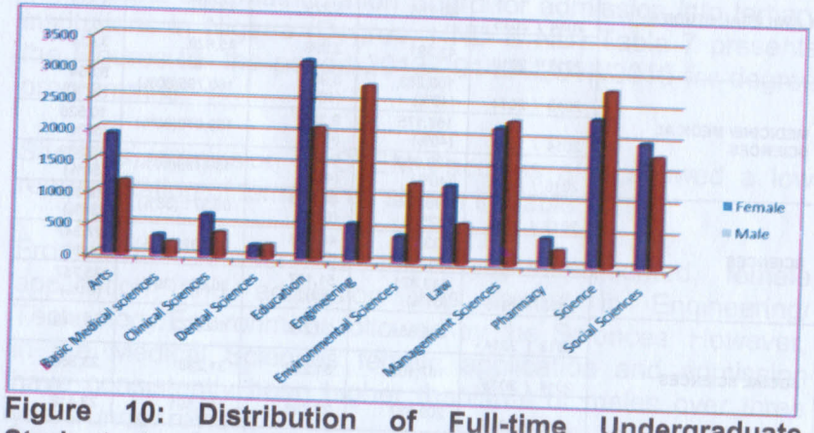


Figure 10: Distribution of Full-time Undergraduate Students in the Faculties 2017/2018 at the University of Lagos

c) Distribution of Full-time Postgraduate Students in the Faculties 2017/2018 at the University of Lagos

Data from the University of Lagos School of Postgraduate Studies as seen in Table 9 shows the same pattern of low female enrolment in STEM Faculties. Female enrolment is lowest in Engineering with below 16.5% enrolment, followed by Environmental 21.4% and below. Female enrolment in the Sciences at the postgraduate level was up to 42.7%. However, as in the undergraduate level females recorded higher percentages in the Medical Sciences (Pharmacy 66%; Clinical Sciences 59%).

TABLE 9: ENROLMENT OF NEW ENTRANTS IN ALL FACULTIES AT THE POSTGRADUATE LEVEL 2017/2018 UNIVERSITY OF LAGOS

Faculty/Institute	Total Female %	Total Male %	Grand Total	Percentage
Arts	338 (58.5)	239 (41.5)	577	6.36163175
Basic Medical Sciences	89 (49)	92 (51)	181	1.99558986
Clinical Sciences	145 (59)	100 (41)	245	2.70121279
Education	667 (68.7)	303 (31.3)	970	10.6945976
Engineering	93 (16.5)	468 (83.5)	561	6.18522602
Environmental Sciences	126 (21.4)	461 (78.6)	587	6.47188534
Law	347 (56.5)	267 (43.5)	614	6.76957001
Management Sciences	1195 (46.6)	1371 (53.4)	2566	28.2910695
Maritime Studies	13 (38.2)	21 (61.8)	34	0.37486218
Pharmacy	64 (66.0)	33 (34.0)	97	1.06945976
Science	418 (42.7)	561 (57.3)	979	10.7938258
Social Sciences	852 (51.3)	807 (48.7)	1659	18.2910695
Grand Total	**4347**	**4723**	**9070**	**100**

Source: Pocket Statistics, Academic Planning Unit, University of Lagos

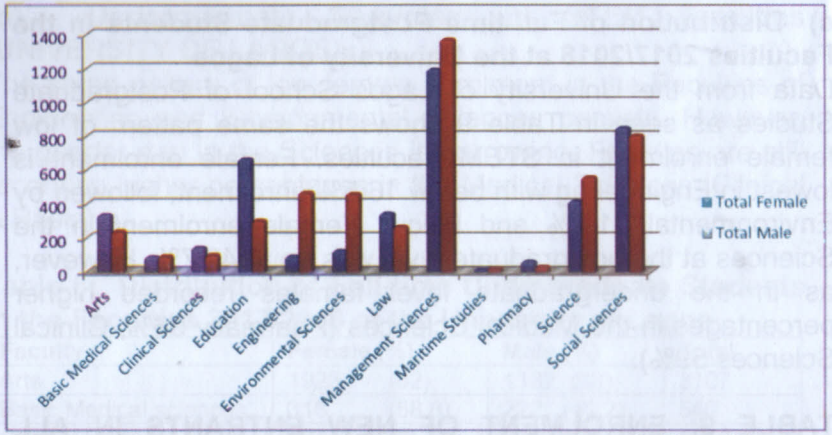


Figure 11: Enrolment of New Entrants in all Faculties at the Postgraduate Level 2017/2018 University of Lagos

- **Females in Academic STEM**

In a study by Udeani & Ejikeme (2011) on the underrepresentation of females in academic STEM field, they found that women were under-represented in Engineering, Science and Technology and more likely than men to be found studying Health Sciences or the Humanities. The picture is still the same as could be seen in Table 9 where data was available for the University of Lagos.

Table 10: Academic Staff in STEM Faculties at the University of Lagos

Faculty	2014/2015		2015/2016		2016/2017	
	Female	Male	Female	Male	Female	Male
Engineering	23 (14%)	139 (86%)	23 13.5%	148 (86.5%)	26	161
Environmental Sciences	24 (24%)	74 (76%)	26 24.5%	80 (75.5%)	21	84
Medical Sciences	–	–	–	–	–	–
Science	77 (34%)	145 (66%)	80 33%	162 (67%)	88	172

Source: Pocket Statistics, Academic Planning unit, University of Lagos, 2018

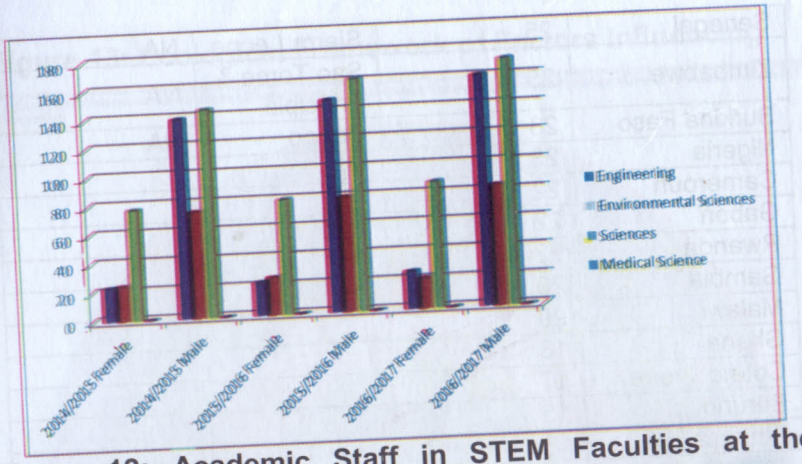


Figure 12: Academic Staff in STEM Faculties at the University of Lagos

- **Female Researchers in STEM**

In sub-Saharan Africa where data is available, no country has achieved a Gender Parity whereby 45% to 55% of researchers are women. Worldwide Average is 29%. Women remain underrepresented in R & D in every region of the world (Udeani 2017).

Table 11: Female Researchers as a Percentage of Total Researchers in Africa in STEM

Country	Percentage	Country	Percentage
Namibia	44	Chad	NA
Central African Republic	42	Eritrea	NA
Mauritius	42	Liberia	NA
Cape Verde	40	Guinea Bisau	NA
Seychelles	36	Comoros	NA
Madagascar	32	Swaziland	NA
Mozambique	32	South Sudan	NA
Lesotho	31	Congo DR	NA
Tanzania	30	Niger	NA
Angola	27	Benin	NA
Botswana	27	Equatorial Guinea	NA
Kenya	26	Somalia	NA

Senegal	25	Sierra Leone	NA
Zimbabwe	25	Sao Tome & Principle	NA
Burkina Faso	23	Congo	NA
Nigeria	23		
Cameroun	22		
Gabon	22		
Rwanda	22		
Gambia	20		
Malawi	20		
Ghana	18		
Cote d' Ivoire	17		
Burundi	15		
Ethiopia	13		
Guinea	10		
Togo	10		

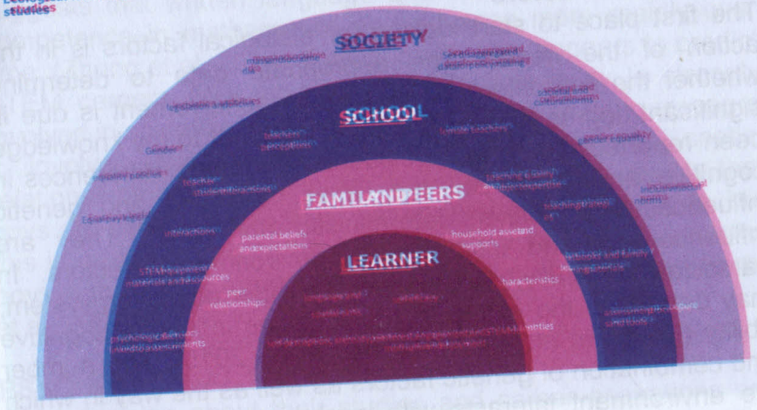
Source: UNESCO Institute of Statistics 2016

In Africa, Guinea and Togo have the lowest percentage of female researchers in STEM (10%). Most women in Science and Technology are in academic and research institutions, where the pay is lower than an industry. (Udeani 2012).

FACTORS INFLUENCING GIRLS AND WOMEN PARTICIPATION, PROGRESSION AND ACHIEVEMENT IN STEM EDUCATION

Identifying the root causes of women and girls poor participation in STEM is hardly straight forward. As with any complex issue, there is no Achilles heel, no single underlying reason that explains it. Rather, these barriers have been likened to an invisible web with intertwined strands representing cultural, societal, personal, institutional, political and economic obstacles (Dickney 2011). To better explain these factors and understand the interrelationships among them, this section adopted an ecological framework developed and used by UNESCO (2017). The framework compiles and presents these factors at the individual, family, institutional and societal levels. These factors are briefly described below:

Figure 13: Ecological Framework of Factors Influencing



Females in STEM

- **Learner Level:** Biological factors that may influence individual abilities, skills and behaviour such as brain structure and function, hormones, genetics and cognitive traits like spatial and linguistic skills. It also considers psychological factors, including self-efficacy, interest and motivation.
- **Family and Peer Level:** Parental beliefs and expectations, parental education and socio-economic status and other household factors, as well as peer influences.
- **School Level:** Factors within the learning environment, including teachers' profile, experience, beliefs and expectations, curricula, learning materials and resources, teaching strategies and student-teacher interactions, assessment practices and the overall school environment.
- **Societal Level:** Social and cultural norms related to gender equality and gender stereotypes in the media.

3.1 LEARNER LEVEL FACTORS

BIOLOGICAL FACTORS

- **Genetic Factors**

The first place to start looking for biological factors is in the action of the genes. The appropriate data to determine whether the sex difference in science achievement is due in significant degree to genetic effects have not to my knowledge been reported. There is no evidence of genetic differences in cognitive ability between the sexes, however, and genetic influences are neither deterministic nor static. They are influenced by and interact with environmental factors. In particular, the family, classroom or the wider education system, may determine the extent to which genes influence cognitive ability (Kovas et al. 2007; Thomas et al. 2015). The number and combination of genetic factors as well as the way in which the environment interacts with each individual genetic type may cause different patterns in motivation, learning ability and achievement (Kovas, et al. 2012).

- **Brain Structure and Function**

Neuroscience research has demonstrated some differences in brain structure and function between men and women, however few reliable differences have been found between boys' and girls' brains relevant to learning or education (Elliot 2013) Studies on the neural basis of learning have not found that boys and girls master calculation or other academic skills differently and that no difference in brain composition can explain gender differences in mathematics achievement (Spearman, et al. 2013) other research evidence suggests that there are no differences in boys' and girls' cognitive abilities, communication and personality variables (Riegle- Crumb et al. 2012; Wang 2013).

Girls and boys appear to develop equally well in early cognitive skills that relate to quantitative reasoning and knowledge of objects in the environment (Hyde 2005). These findings suggested that there are more differences in basic cognitive, emotional and self-regulatory abilities among individuals within each sex than between men and women.

- **Language and Spatial Skills**

Research on cognitive predictions of STEM learning in children suggests that written language and spatial skills can predict competence in mathematics and advance more rapidly over time. (Zhang et al. 2014). Spatial ability also appears to predict STEM careers (Wai et al. 2009). Spatial ability is strongly involved in scientific thinking. The kind of task used to measure it involves the perception and manipulation of spatial relationships, especially in the visual mode. Data exists that boys are considered to have better spatial skills than girls, but this is probably due to the family environment which provides boys with greater opportunities to practice these skills (Kovas et al. 2007).

PSYCHOLOGICAL FACTORS

Girls' decision about their studies and career aspirations are influenced to a great extent by psychological factors, which ultimately affect their engagement, interest, learning motivation, persistence and commitment in STEM.

This section presents some key findings on psychological factors that impact on girls STEM studies and career aspirations. These are discussed under the following subheadings:

- **Self Efficacy**

Self efficacy affects STEM education outcomes and aspirations for STEM careers, as well as performance. (Udeani 2012; Adedokun et al. 2013; Uitto 2014). The Programme for International Student Assessment (PISA) 2015 found that girls have lower self-efficacy in science and mathematics than boys, a difference that has remained largely unchanged since 2006. Udeani (2012) found out that girls with higher self-efficacy performed as well as boys and much better than girls with lower self efficacy. Studies Rabenberg (2013) noted that girls who assimilate gender stereotypes have lower levels of self-efficacy and confidence in their ability than boys.

- **Interest**

Interest plays an important role in girls engagement in STEM at school, their subject choices in higher education and their career plans. Girls interest in STEM is closely linked with their perception of self-efficacy and performance and is heavily influenced by their social context, including parents' expectation (Udeani 2003), their female peers (Rabenberg 2013); Dasgupta & Stout 2014); stereotype threat (Hill et al., 2010; Lippa, 2005; Guo et al. 2015) and the media (Cheryan et al., 2012). Interest is also influenced by girls overall learning experiences in school (Udeani 1995, 2013) especially at earlier grades including the influence of STEM teachers (Udeani 2003; Robert 2015; Baker 2013; Hughes et al. 2013) and their teaching strategies (OECD 2015, Baker 2013) and exposure to role models (Udeani 2017).

In general, most studies have found a strong positive relationship between interest in science and achievement, participation and choice of STEM career. However, studies (Udeani 1995, Udeani & Odogwu 2011, Udeani 2012, Nzewi 2007) have shown that girls appear to lose interest in STEM subjects with age, suggesting that earlier intervention is needed to sustain girls interest in these fields.

- **Attitudes**

Closely related to interest is attitude towards STEM studies. The investigation of students' attitudes towards studying science has been a substantive feature of the work of the science education research community for the past 40-50 years. Some studies reported more negative science attitudes and lower perceived competence than male students (Shumow & Schmidt, 2013) and that their career aspirations in science could be predicted by their knowledge and attitudes towards mathematics, science and engineering (Satler et al. 2012).

Other studies (Udeani 1995, Udeani 2003, Udeani 2012) found that in upper secondary education boys showed greater interest in engineering and girls showed greater interest in biology, health and medicine and that boys had greater technology-related career goals than girls. Studies that

investigated attitudes of students to science may be said to be inconclusive. However, most found that boys are more likely on the average to exhibit a more positive attitude to mathematics, physical sciences, computers and technology than girls.

Enjoying learning science and performance in science are also positively related (Udeani et al. 2016). Also, PISA 2015 found that boys enjoy science more than girls in the majority of the participating countries. Socio-economic status also matters as more advantaged students are more likely to expect a career in science, even among students with the same enjoyment of learning science.

These psychological factors need to be taken into consideration in interventions targeting girls since improving girls' confidence and self-belief can boost their achievements and increase their preference for study and career choices in STEM.

FAMILY AND PEER LEVEL FACTORS

- **Parental Belief and Expectations**

Parents, the wider family and peer groups play an important role in shaping girls attitudes towards STEM. In the developing world, poverty is the foremost cause of unequal access to secondary education and science learning in particular. In turn, this restricts young girls access to a university degree in any field. Access to consistent long-term education especially in science remains elusive for many girls (UNCTAD 2011) Parental and family beliefs and expectations about STEM are themselves, influenced by education-level, socio-economic status, ethnicity and wider social reforms.

Parents with traditional expectations of gender roles reinforce gendered behaviour and attitudes in children (Bandura & Bussey 2004) Differential treatment of girls and boys can reinforce negative stereotypes about gender and ability in STEM, deterring girls from these fields (Wang & Degal 2013) for example, in some contexts, parents have lower expectations of girls ability in mathematics and place less

value in girls participation in science and mathematics (Stoet et al. 2016; Tenenbaum & Leaper 2003; Andre et al., 1999; Udeani 2001, 2003, 2012, 2017, 2018, Udeani et al. 2017,2018).

It is also well documented that parents have a strong influence on the career choices of their children through the home environment experiences and support they provide (Tenenbaum & Leaper 2003; Hill and Tyson 2009; Hyde et al., 2006; Udeani 2001, 2003, Udeani et al. 2017, 2018).

Some research suggests that girls' career choices are more influenced by their parents expectations whereas boys' career choices are more influenced by their own interest (OECD 2016; PISA 2015) Mothers have been found to have a significantly stronger influence on their daughters' decisions to study STEM than on their sons' decisions in a number of settings (OECD 2016; PISA 2015; Buschor et al. 2014).

- **Parents' Education and Profession**

Parents education is an important factor for girls studying STEM. Many studies in industrialized countries have shown that children of more highly educated parents take more mathematics and science courses in upper secondary education and perform better (Jodl et al. 2001; Sumpkins et al. 2006) Udeani 2003, 2004, Udeani et al. (2017, 2018) found that in a study comparing multiple influences on children's science achievement found that mothers' education had the largest effect.

Also, the presence of family members with STEM careers has been shown to influence girls pursuit of STEM studies (Tan et al. 2013).

Parents in STEM fields are likely to familiarize girls with STEM careers in ways that other role models cannot and debunk the perception that STEM occupations are difficult to combine with family life. (OECD 2016). Studies have shown that women scientists more frequently have parents who are scientists than their male colleagues (UNESCO 2010, Udeani, 2004).

- **Household Assets and Home Support**

Students from middle to higher socio-economic status have been shown to perform better in science and mathematics (Udeani 1994; 2003; Udeani et al. 2017, 2018).

This may be related to parents providing additional learning support at school and homelike provision of access to instructional support including engaging private tutors. Udeani (2003) reported that parents in multiple studies consistently scored low on provision of school materials (23.4%) and attendance at PTA meetings (34.0%). These two are very important areas in which home support is required for success in school. Learning materials are not always available in schools and where necessary, parents are usually called upon to provide these materials.

Access to other learning materials and instructional support can also spark and maintain interest in STEM studies and affect achievement. For example, students who regularly use a computer or tablet at home have been found to perform better in science at the secondary level, regardless of their sex (PISA 2015). Parents/families with limited resources may not have the funds, time or connections to promote mathematics and science learning for their children. This has been documented as a factor affecting girls participation in engineering programmes in the Republic of Korea and the United States among other settings (OECD 2016).

- **Peer Influence**

Girls' confidence, motivation and feeling of belonging are affected by the peer climate in STEM education. (Leaper et al. 2012). Peer relationship influences children's beliefs, behaviour, academic achievement and motivation, especially during adolescence (Barker & Aspray 2006). Students with friends who value academic achievement are more likely to value mathematics and science (Jones et al. 2013). Similarly, girls might be discouraged from taking STEM subjects if their peers and immediate environment view these subjects as inappropriate for women (Robnett & Leaper 2013). Female peers, in particular, can significantly predict girls' interest and

confidence in both mathematics and science (Robnett, 2013; OECD, 2005).

SCHOOL-LEVEL FACTORS

This section looks at school-related factors that affect girls' participation, achievement and progression in STEM subjects. This includes the environment within which STEM education takes place, teachers, teaching strategies, the curriculum and learning materials and assessment.

TEACHER FACTOR

- **Teacher Quality**

The quality of teachers is considered the single most important in-school factor, at primary and secondary levels, in determining students' overall academic achievement. (OECD 2005) Udeani (1992) found out that the single most important factor affecting students' achievement in science is subject specialization and experience of the teacher. Subject expertise is a key element of teaching quality (OECD 2005). There are shortages of STEM specialized teachers in many contexts, particularly in rural and remote communities. This affects the quality of STEM instruction for all learners irrespective of sex (Udeani 2012, 2017).

- **Teachers Attitude**

While most of the research on teacher quality does not examine gender differences, some studies have found that teachers may have a particular influence on girls' participation and engagement in STEM education. Many teachers including female teachers, despite paying much lip service to equality of girls and boys, do not believe that girls have the ability to study mathematics and science. They believe that these disciplines call for struggle and determination and that girls are not capable of coping with difficult subjects. Teachers generally have low expectations of girls' ability to perform well in STEM subjects. Udeani (2003; 2012) also stated that science teachers are known to set higher expectations of achievement in science for boys than for girls and that this has the effect of increasing the achievement of boys. She explained this effect by using Brophy and Good's (1970) explanation. Brophy and

Good had summarized this expectancy model in this way: a teacher expects specific behaviour and achievement level from particular students and as a result, unintentionally behaves differently towards them.

This treatment communicates verbally or non-verbally to the students what behaviour and achievement the teacher expects from them. The feedback received such as praise, in turn influences their achievement level, interest, motivation and self concept. Where this treatment persists over time, it will shape the students' achievement and behaviour to conform to the teachers' expectation. It follows that teachers having overtly or covertly conveyed to females a lower level of expectation, force them to fit into such expectation which are lower achievements. Because of this negative expectation, STEM teachers do not encourage the females in their classes to work hard and improve on their performance. In another study, Udeani (2011, 2012) found that students like or dislike of a subject depended on the teacher. When a teacher is not gender-sensitive, his/her attitude favours the more aggressive boys to the detriment of girls. When girls are not able to cope with the attitude of a teacher, they recoil into their shells, pay less attention in class, hardly participate and start skipping classes. The teachers who participated in the study indicated their observations for girls poor performance in STEM subjects. Their reasons are as listed below:

- Girls are not as clever as boys
- Girls are shy
- Girls exhibit low interest in science
- Girls have poor language and communication skills
- The science curriculum is not suitable for girls
- Science equipment are not female-friendly
- Science textbooks are not gender sensitive
- Girls are weak
- Girls do not require mathematics and science in their future roles as wives and mothers.

The teachers also mentioned the major problems they encounter teaching science to girls. These include:

- Low interest on the part of the girls

- Poor language and communication skills
- Poor achievement
- Lack of cooperation from parents
- Lateness to school

- **Female Sex Teachers**

The employment of female teachers has been associated with improved educational experiences and enhanced learning outcomes for girls in different contexts, across different subjects (Unterhalter et al. 2014). Female teachers have been found to positively influence girls perception, interest and confidence in STEM subjects. (Rabenberg 2013) as well as their STEM carrier aspirations (Stearms et al. 2016). The UNESCO 2016 GEM report found that girls do better in introductory mathematics and science courses and more likely to follow STEM careers when taught by female teachers. Female teachers can positively influence girls' education in STEM by dispelling myths about sex-based, innate abilities among boys and by acting as role models for girls (Baker 2013; Stearns et al. 2016). They may also be more sensitized and have more positive attitudes towards gender equality in the classroom than their male colleagues as found by Nzewi (1994).

Despite their overall positive influence on STEM outcomes few countries have significant proportions of female teachers with specialization in science and mathematics. Female teachers are more likely to specialize in science than mathematics at both primary and secondary levels, but there are significant variations between countries (UNESCO 2013). Udeani et al. (2017) in a statewide study in Lagos state, Nigeria found females science teachers were represented as much as their male counterpart in sciences in secondary schools. However, the study did not find any significant difference with respect to the achievement of students if they were taught by either male or female teachers.

- **Teaching Strategies**

Effective instructional strategies can create a constructivist learning environment that motivates and engages girls.

(Spearman et al. 2013). TIMSS (2011) found that the way in which the curriculum is taught in primary and lower secondary education significantly affects students opportunities to learn mathematics and science (Jensen et al. 2016).

Following a series of researches Udeani, (1992, 1994, 2004, 2012, Udeani et al. 2016) It was concluded that the instructional method employed by the teacher in the science classroom help girls to achieve better. In one of the studies, Udeani (2004) 43.6 per cent of the girls in the sample mentioned that the way the teacher teaches the subject was the reason, they liked the science subject. In an experimental study, Udeani et al. (2016) developed and tested a gender friendly instructional strategy and used it in teaching both boys and girls in five secondary schools in Lagos Mainland. The result showed that the girls' achievement, attitude and interest improved incrementally over a period of one school term. The girls also indicated enjoyment of science activities. Eggleston, Galton and Jones (1976) from their study concluded that a greater proportion of female science teachers use teaching methods that encourage pupil participation in designing experimental procedures, making inference and proposing and testing hypothesis. Girls prefer this approach, but the approach is more often encountered in biology than in physics and chemistry classes- a finding which reinforces girls liking for biology as compared with physics and chemistry. The findings of both studies suggest that if the appropriate method is used, females will achieve as much as their male peers.

Pedagogically, it is believed that healthy academic competition among students would enhance achievement, hence teachers tend to sustain competition in STEM classrooms (Burns 1987).

However, it has been found through research that not all learners benefit in a competitive learning environment. Female students lose out in a competitive academic environment. They prefer cooperative academic environment for their optimal performance (Okeke 2000; Nzewi and Osisioma 2000; Okebukola 1985). However, most of our science classrooms are competitive. Njoku (2000) also stated that boys always

dominate science learning activities in co-educational schools when the instructional strategy adopted is competitive Obianyo (2015) reported that teachers overt and covert instructional behaviour influence learners' achievement. The overall effect is that unconsciously, teachers teach science to make boys excel, thereby creating the impression that the girls cannot cope.

To improve girls' performance, the teaching strategies within the classroom need to change to support female learners differently. Specific teaching strategies have been shown to particularly help girls and to reduce the gender gap in STEM achievement while being beneficial to all students. These include, for example, student-centred, inquiry–based and participatory strategies, as well as strategies that improve girls' self-confidence and take account of their specific interests and learning styles. (Udeani 1992; OECD 2015).

- **Teacher-Student Interaction**

Irvine (1986) investigated the initiating behaviour of students interaction and teachers' reaction to such interactions, that is the quantity and quality of teachers verbal feedback statements to the students and the number of public response opportunities available to students. Findings from this study indicated that boys initiated more positive and negative interactions with teachers than girls, male students received significantly more positive and negative feedback than the female students; boys received more non-academic feedback than the girls.

These non-academic feedbacks were mostly geared towards making them realize the societal expectations from them and the need for them to work harder.

Adigwe (1999) investigated the pattern of classroom interaction in two classrooms each of Biology, Physics and Chemistry. He used a modified version of the Brophy and Good's (1970) dyadic interaction system. He found that teachers asked the male students more academic and procedural questions than they asked the female students;

while the females had more social interactions with the teacher than the males. Adigwe then concluded that male and female students have unequal opportunities for learning science in Nigerian classrooms.

Numerous research show that interactions between teachers and students influence girls' engagement, self-confidence, self-efficacy, performance and persistence in STEM studies (Udeani 1995; Elstad, et al. 2009; Johnson, 2007). Teacher interaction with students may create an unequal environment and reinforce gender stereotypes. Classroom observational studies in some contexts (Udeani 1996) have shown that girls have less instructional and discussion time, ask fewer questions and receive less praise than boys (Sadker et al. 2009). Furthermore, the way in which teachers manage social relationships and peer interaction within the classroom may encourage or hinder engagement in classroom activities (Cappella et al. 2013).

Adequate attention must be paid to ensuring equitable and positive interactions among students. Cooperative learning strategies is an effective way to create positive attitudes toward instruction, boost achievement and self-esteem (Baker, 2000). As mentioned earlier, girls appear to prefer collaborative learning environments than competitive or individual work (Okebukola 1985; Nzewi and Osisioma 2000).

Cooperative learning can also create a more comfortable atmosphere for girls to ask questions, participate in activities and interact with teachers (Udeani et al. 2017; Skolnik 2015).

However, on other occasions, group work can disadvantage girls and advantage boys. (Leman et al. 2016) for example, some studies have found boys to take leadership roles, argue and defend their views while girls may take stereotypical, secondary and more passive roles (Baker 2000) have less opportunity to speak in groups and avoid confrontation with peers (Leman et al. 2016). It is therefore important that teachers are aware of, and can manage, gender dynamics in

classroom interactions, between teachers and students and among student themselves.

- **Curriculum Materials**

Science and Technology curriculum materials used in Nigerian and indeed most African countries are grossly gendered biased in favour of males and decisively against the females (Erinoso, 1997).

Textbooks and instructional materials used in science classrooms are known to carry implicit messages about the relationship between gender and science. Research reported by Whyte 1986; Bazkler and Simonis, 1991; Biachini, 1993; Udeani 1993; Nzewi 2000; Owolabi and Onafowokan 2001; all showed that, particularly in the physical sciences, illustrations, examples and applications presented in resource materials are more familiar in general to the experiences and interests of males than those of females. The low representation of females in textual illustrations may produce a negative reinforcement bearing in mind that illustrations in textbooks as pointed out by Powell and Garcia (1995), may be important in providing students with role models that enable them to develop perceptions of themselves in possible societal roles in science. Furthermore, according to the authors' representations in books afford students an opportunity to view themselves as active participants in science related activities and provide them with positive self-concepts of themselves in relation to science.

Furthermore, Udeani (2003, 2004, Udeani & Odogwu 2011) noted that most mathematics and science syllabi used at the primary or secondary school level do not take account of the needs of girls in their lives after school. Most secondary school syllabi seem to assume that all students are going to become full-fledged professional mathematicians and scientists at the end of basic secondary schooling. There is far too much emphasis on definitions, laws, formulae and abstract procedures and little on mathematics and science as a way of thinking and looking at the world around us. Most everyday examples of scientific processes are drawn from the world of

men and boys. It is indeed rare to find examples taken from everyday experiences of girls and women. Improving girls interest and achievement in STEM requires ensuring that the curriculum accommodates girls' perspectives and avoids gender stereotypes.

STEM curricula and textbooks, need to consider girls experience, learning style and interests. However, Sinnes et al. (2014) noted that caution is needed when adapting curricula to try to attract girls to STEM subjects, as some researchers argue that changing curricula to reflect typical girls' and boys' interest may contribute to reinforcing gender stereotypes and reproducing the gender differences that the changes were intended to overcome. It is therefore important to ensure a balanced curriculum in order not to deter students.

- **STEM Equipment, Materials and Resources**

The availability of equipment, materials and resources are essential to stimulate students' interest and enhance learning in STEM subjects. Access to resources for scientific experiments, in particular, has been associated with improved learning outcomes in students (Udeani et al. 2017) and in particular with girls achievement and interest in science subjects (Simpkins et al. 2015) in Cambodia for example, science laboratories were found to have a positive impact on student participation and helped to overcome preconceived beliefs about girls' low abilities in science. TIMSS 2011 found a positive correlation between the availability of science laboratories and girls' and boys' achievement in science.

Ensuring that there are enough materials for every student and avoiding competition over access to resources is also extremely important. For example, in some schools in Nigeria and indeed Africa, a single science textbook can be shared by four students on the average (Udeani et al. 2017; 2018). This not only hinders learning but also increases the risk of boys monopolizing the material and girls being observers.

Virtual laboratories and ICT-based materials can be another source of learning and practice. Virtual experiments have been

found to be equivalent to laboratory experiments in influencing students' attitudes and performance and could be used as an alternative where physical laboratories are lacking. UNESCO micro science kits can also offer a cost effective alternative where laboratories are not available (UNESCO, 2017).

- **Assessment Tools and Procedures**

Gender difference in achievement scores in STEM subjects can be influenced by assessment procedures, including the construction of assessment tools and the way assessments are administered. Some studies have found that boys are more likely to perform better in multiple-choice mathematics assessments or standardized test than girls (Eurydice, 2010; Mattern et al. 2012) Udeani 2005 in a study to find out the assessment methods preferred by students found that 45% of the girls preferred essay-type examination, 28% preferred objective type questions and 27% preferred practical tests.

The content of assessment are also important, as evidenced by the differential findings in TIMSS as compared to PISA. The gender differences to boys' advantage are much larger in PISA where students are assessed on applied knowledge and skills.

PISA 2012 found that girls do better when they work on mathematical or scientific problems that are similar to those typically encountered in school. However, when required to think like scientists' girls underperform considerably compared to boys.

Gender differences have also been observed in the way teachers mark boys and girls (Eurydice 2010). In one study of Israeli primary students, girls outscored boys in mathematics examinations when graded anonymously, but boys outscored girls when graded by teachers who knew their names. Researchers concluded that the teachers overestimated boys' abilities and underestimated girls', impacting girls' enrolment in advanced level math class in upper secondary (Lavy & Sand 2015). Gender assessment procedures, were also confirmed in other settings for example, in the European Union, female students tended to be marked down and male students

marked up. This has led some EU countries to conceal the name and sex of the student during examination marking (Eurydice 2010).

ROLE MODEL AND MENTORING

The lack of role models is another reason that inhibits the enrolment of females in SMT subjects. There is complete absence of positive female role models in academic and research fields in many communities especially in the rural areas. This situation is even worse in STEM careers where female role models are scarcely available. There is lack of female teachers in STEM subjects to encourage girls especially in higher classes. Women teachers, being the first direct contact of girls to formal education, can help to focus the interest of girls in education and STEM subjects and thereby dispel some of these erroneous notions. Parents also feel that there is lack of female role models in the rural areas as successful women scientists do not reside in the villages. The females that the girls in the villages have as role models are into such business as farming, trading, tailoring, cooking etc. The girls observe that these women are financially empowered and socially visible even though they had no formal education and therefore, do not see the need or the importance of a formal education.

Closely related to the role model is mentoring. Mentoring can be defined as the process in which an experienced – and often older – person takes an inexperienced – and usually younger – person under their wing to encourage them, sharpen awareness of their potential and create avenues for them to reach some set goal (Andam 1999). Bryne (1991) considers mentoring an effective means of upward mobility within the employment sector. Mentoring within the higher education establishment helps ensure that the experience of the mentor helps the mentee gain access to:

- Sources of research grant
- Avenues for publishing
- Recommendation for inclusion on committees

These often yield high visibility for the mentee, who benefits from research grants, publishing opportunities and invitations to serve on committees. This can have a positive spiraling effect for upward mobility of the mentee. Andam (1999) observed that as a group, women in higher education establishment do not often benefit from mentoring. This could be attributed to several factors:

- Social expectations that discourage young women from mixing with male colleagues socially.
- Reluctance of older experienced men in the higher education establishment to take on women as mentees.
- Lack of recreational facilities on campuses of higher education institutions to bring colleagues together.
- Old- boy networks- people tend to recommend those they know already for career- building opportunities. This can cut off the lone woman or women in the minority pushing them further into oblivion.

SOCIETAL LEVEL FACTORS

- **Cultural Barriers**

Societies have long imposed unhelpful gender stereotypes differentiating between what is expected of boys and girls. Boys get education and training because they are expected to provide a family's income and future economic stability. Girls, on the other hand, are brought up to become good wives, mothers and housekeepers (Andre, 2011). To this day in some cultures, misconceptions about girls' capabilities in science abound. Girls who are lucky enough to acquire primary and secondary education are often discouraged from pursuing technical or maths-based fields, being steered by well-meaning parents and advisers towards non-science fields instead (Udeani 2011). These traditional definitions of women's roles in society, and false myths of a girl's intrinsic unsuitability for science, have been fostered and passed down through generations. While they may be easy or quick to remove from entrenched cultural attitudes (UNCTAD 2011). Here too, education can make a difference. Educating a girl, even at the primary level, can transform her into an economic contributor. And it is not difficult to imagine the vast socio-economic potential offered by giving more girls access to science

education at still higher levels, so they eventually participate in science research and innovation.

Girls participation and achievement in STEM education have been found to be positively correlated to more gender-equal societies, where women and girls have access to education, decent work and representation in political and economic decision-making processes.

For example, studies have found that girls tend to have more positive attitudes towards, confidence about and achievement in, mathematics in these settings and gender gap in achievement between boys and girls is smaller (Spearman et al. 2013)

- **Sex Role Stereotyping**

Sex role stereotyping is a very critical factor that influences female participation and achievement in STEM since it appears to be the root cause of the other factors. Sex role stereotyping is the socio-cultural classification of human activities by sex in line with what the society considers appropriate for each sex. The socio-cultural assignment of roles to either of the sexes has given rise to the masculine image of STEM. STEM disciplines are seen as male domain. Consequently, females upbringing tends to shape them away from STEM which are socio-culturally considered inappropriate for them. Decisions about what fields of study or employment are considered possible or appropriate for men and women are deeply embedded in the socialization process.

Furthermore, gender stereotypes in mass media can influence girls perception of their abilities in STEM and their career aspirations in STEM fields (Steinke et al. 2017). Cheryan et al. 2013 found that gendered stereotypes in the media of certain academic fields, such as computer science, can negatively influence women's interest in pursuing these fields.

Gender stereotypes portrayed in the media are internalized by children and adults and affect the way they see themselves

and others. Media can perpetuate or challenge gender stereotypes about STEM abilities and careers.

In conclusion, supportive learning environments can increase girls' self-confidence and self-efficacy in STEM. Exposure to real-world learning opportunities, such as through extra-curricular activities, field trips, camps and apprenticeships, can help inspire and retain girls' interest. Mentoring appears to be particularly beneficial for girls, enhancing their confidence and motivation and improving their understanding of STEM careers.

3. INTERVENTIONS THAT HELP FULFILL THE POTENTIALS OF WOMEN AND GIRLS IN SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM)

The variety of barriers to women's and girls' participation in science and technology education highlights the need for responses that not only focus on encouraging women and girls to enter S & T fields, but also on changing institutions to make S & T more attractive to women and girls. The ecological framework presented in the previous section demonstrates that there is no single factor that influence alone girls and women's participation, achievement and progression in STEM education and that positive outcomes are the interactions among the factors at the individual, family, school and societal levels and demand engagement from stakeholders at each of these levels. Again reference is made to the ecological framework as developed by UNESCO. It also provides examples of interventions presented at the four levels of the ecological model some of which are discussed below.

INDIVIDUAL LEVEL

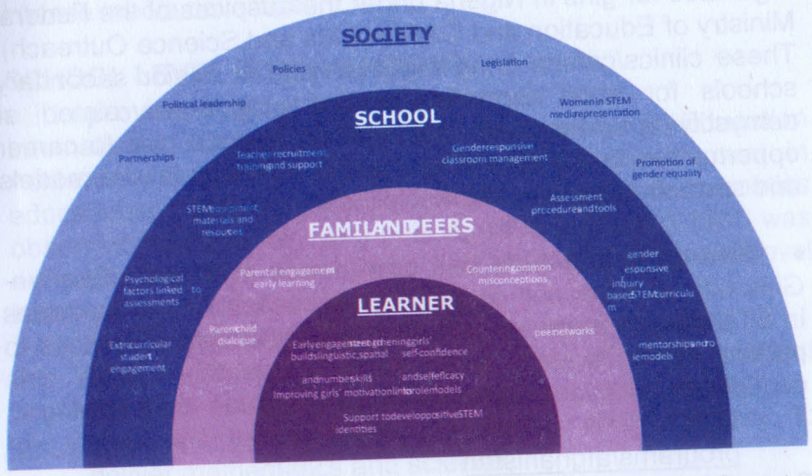


Figure 14: Ecological Framework of Interventions that Increase Girls' and Women's Interest in and Engagement with STEM Education

Source: UNESCO 2017: Cracking the Code: Girls' and Women's Education in Science, Technology, Engineering and Mathematics (STEM)

- **Early engagement to build linguistic, spatial and number skills.** As with most cognitive abilities, these skills are flexible and highly influenced by instruction and practice and can be highly impacted by early exposure and engagement to STEM experiences. Initiating these experiences in early childhood education and care is advocated. Parental engagement and activities to extend school learning into the home and other settings can also be promoted.

- **Developing positive STEM identities-** Girls need support to develop positive math and science identities, to believe in their abilities and have a sense of belonging in STEM studies and careers. This can be achieved by increasing girls exposure to STEM experiences as mentioned earlier. The establishment of STEM clinics and camps like those in Ghana can encourage girls engagement with STEM experiences in an

informal settings. STEM holiday camps for girls have been organized for girls in Nigeria under the auspices of the Federal Ministry of Education and GASO (Girls and Science Outreach). These clinics/camps bring together girls in senior secondary schools for short term intervention programme aimed at demystifying science and mathematics, expose girls to career opportunities in STEM and interaction with female role models and specialists in scientific disciplines.

- **Strengthening girls self-confidence and self-efficacy** – Girls with stronger self-confidence and belief in their capacities in STEM perform better at school and have better chances to pursue stem careers. A lot of initiatives to improve girls confidence, motivation and self-efficacy include the following:-

1. Girls Can Code/Afghanistan (http://womanity.org/programs/afghanistan
2. @IndianGirlsCode/India(http://robotixedu.com/indiangirlscode.aspxAspxAutodetectcookieSupport=1
3. GirlsWhoCode/US (https://girlswhocode.com
4. STEM Camps, Kenya (http://on.unesco.org/2uTmfpF
5. Smarkkidszone.com.ng/Nigeria

FAMILY AND PEER – LEVEL INTERVENTIONS

Engaging parents, as primary caretakers of children, and the wider family is critical to opening doors to STEM studies and careers for girls. Research has found that when parents play an active role in their children's learning, children achieve greater academic success, regardless of socioeconomic status, ethnicity or the parents own level of education (Handerson & Mapp 2002; Cotton & Wikeland 2001).

Furthermore, to counter common misconceptions that STEM studies and careers are not for girls, schools and universities can provide parents with information about STEM educational opportunities and careers and connect them to educational advisors who can counter common misconceptions about careers in STEM. In some African countries like Zimbabwe and Nigeria, awareness – raising campaigns have been organized to address parents perceptions, along with broader quality improvements to STEM education. In a few states in Nigeria,

these campaigns have reached the broad public through intense media coverage.

SCHOOL LEVEL INTERVENTIONS

- **Improving System-Level Challenges**

International Association for the Evaluation of Education Achievement (IEA) found that the overall improvement in educational achievement in science and mathematics observed over a twenty-year period (1995-2015) in TIMSS was accompanied by a number of education system-level improvements. These include:-

- Improved school environments (e.g. safer schools).
- Better educated teachers and more efforts to support teachers' professional development.
- Improved teacher attitude towards their capacity to deliver mathematics and science.
- Higher teachers' satisfaction with their careers.
- More positive student attitude to mathematics and science.
- More engaging instructions by teachers (as reported by students).
- Smaller mathematics and science classes.
- Better curriculum coverage (Mullis et al. 2010).

From the report, education-system level improvement in recent decades have positively impacted on the quality of STEM education delivered in school classrooms, benefitting both boys and girls. The education sector can take other steps at the policy-level and within schools to build girls interest, confidence, engagement and career aspirations in STEM. Some are discussed below:

- **Teacher Recruitment Training and Support**

Ministries of education need to address shortages in qualified teachers for science and mathematics and their deployment to rural and remote areas. There is evidence in some settings that female teachers can have a differential impact on female students pursuit of STEM studies and careers (Kearhey 2015). Teacher education and policies on recruitment must ensure a

fair representation of both male and female teachers in all subjects, especially in STEM and at all levels of education.

- **Building Teacher Capacities**

Teacher education, be they pre and in-service programmes, should ensure that teachers are trained in gender responsive teaching strategies so that female and male students can develop their full potential in STEM-related subjects.

Teachers need to understand the factors impacting on girls interest to participate and continue in STEM education, and to have access to professional development that enhances gender-responsive STEM pedagogy. A range of initiatives are being implemented to strengthen STEM teachers capacity to be more gender-responsive in their teaching practice and classroom management (Udeani 2017, 2018; Sawels Bergh, et al. 2016; OECD 2015).A global initiative that has impacted many African countries is The TeachHer Initiative:-TeachHer is an innovative global public-private partnership, launched in June 2016 by UNESCO, the Costa Rican First Lady, Mercedes Penas Domingo, and the U.S. former Second Lady Dr. Jill Biden. It aims to help close the gender gap in Science, Technology, Engineering, Arts and Design, and Mathematics (STEAM) curricula and careers for young women.

Using UNESCO's network of training institutes, TeachHer is creating a Master corps of Champion educators capable of delivering state-of-the-art curricula in these subjects and building local support networks.

During the 2016 pilot phase, 160 educators from six African and eight Central American and Caribbean Countries participated in the week-long regional training workshop organized by the US Mission to UNESCO with support from UNESCO Field Offices Cluster Offices and the UNESCO International Institute for Capacity-Building in Africa (IICBA). During the workshops, government officials and national partners were exposed to practical methods for creating gender-responsive lesson plans and engaging and inspiring adolescent girls to pursue these subjects and related careers.

Countries were encouraged to create national and local TeachHer action plans. TeachHer also emphasizes the importance of after-school clubs and related activities for girls, and the creation of local networks to support dedicated champions-educators, administrators and their students. (http://unesco.usmission.gov/teacher)

- **Improving Instructional Practices**

Effective teaching practices can help promote girls interest, motivation and engagement in STEM. A meta-analysis identified five strategies that improve students' achievements, attitudes and interest in STEM subjects and careers:

- Context-based
- Inquiry-based
- ICT – enriched
- Collaborative learning
- Use of extra-curricular activities

These strategies can be combined with more targeted ones which have been found to work best for girls including:

- Building a 'science identity' among girls by conveying messages that science is for everyone, using gender-neutral language, projecting examples of women in science and avoiding classroom hierarchies favouring boys.
- Involving girls in hands-on activities that are inquiry-based with adequate time to complete, revise and discuss.
- Providing diverse school experiences that match the different interests of students in science.
- Allowing more time and experience with computers for girls to help increase their technological confidence.
- Providing girls with out of-school academic activities and homework as well as exposure to role models.

- **Strengthening STEM Curricula for Girls**

UNESCO's IBE is partnering with the Malaysian Government on South-South cooperation to promote gender – responsive STEM education in Cambodia, Kenya, Nigeria and Vietnam. The initiative aims to mainstream gender in educational

policies, plans, STEM curricula and teaching, through the development of country-contextualized gender-sensitive guidelines on curricula, pedagogy, assessment and teacher training.

Curriculum designers can create content and resources suited to the learning styles and preferences of girls as well as boys and remove gender bias from textbooks and other learning materials. Teachers also need the knowledge and ability to critically analyse and eliminate possible gender stereotypes present in existing teaching materials and to avoid such stereotyping when interacting with students.

- **Gender Responsive Career Counselling**

Structural and formalized gender responsive career counselling programmes should be considered for both female and male students to have support and objective guidance as they begin to shape their career choices. An Australian study Broadley, (2015) made the following recommendations for career counsellors to help increase girls motivation and engagement in STEM:

- Start STEM career development early, at primary level, before girls lose interest and disengage.
- Collaborate with those who have a strong influence on girls' decisions to pursue or not to pursue STEM, such as parents, siblings, peers and teachers.
- Provide diverse images of STEM professionals, for example, on career posters, in publication and online resources, to challenge the stereotype of the male scientist.
- Use role models and mentors to develop in-school programmes so that girls are in contact with practicing female STEM professionals.
- Promote targeted work experience and out-of-school programmes, such as internships.
- Engage with parents and families, providing them with information about STEM professions.
- Target specific groups, including high-performing and disadvantaged girls.

- Advocate changes in male-dominated workplaces, so that they can attract more women.

In Nigeria career days are periodically set aside in schools to expose students to the career choices available in many fields of human endeavour. However, these career days have not specifically targeted females and science. There is a growing need to expose girls to careers in science, because most girls are not able to relate the science they do in school to the STEM courses available in tertiary institutions. In this area, role models become very important. Successful women scientists in all spheres of life should be encouraged to address students during career days. Additionally promoting positive female role models and images in the classroom, workplace, community and home, in collaboration with volunteers, professional bodies, women's group within S & T networks (both in academia and outside) to address the underrepresentation of women scientists, technologists and educators.

For instance, the Visiola Foundation's afterschool and summer activities in Nigeria facilitate access to role models and create learning environments were girls can work in teams, experiment, take risks, fail, and succeed.

Mentorship programmes have been found to improve girls' and women's participation and confidence in STEM. A US study found that, at lower secondary level, girls who were mentored by female role models during summer activities showed greater interest in science and mathematics when introduced to potential STEM career opportunities.

Mentoring needs to take a broad perspective rather than focusing only on achievement and career choice, mentors can also help girls acquire knowledge to improve their learning and career options including information about materials and strategies, goal-setting and opportunities for learning, networking and meeting others interested in STEM (Stoeger et al. 2013). Mentors can also help girls learn to improve their self-confidence, self-esteem and motivation, to deal with bias, and to overcome anxiety about assessment.

EXPANDING ACCESS TO SCHOLARSHIPS AND FELLOWSHIPS

Scholarships and fellowships reserved for female students and researchers have been established by some countries, organizations and institutions. Some of the notable ones are:

(i) **L'Oréal Foundation**

The L'Oréal Foundation has two programmes supporting girls' and women's engagement in science. **The For Women in Science Programme** is a partnership with UNESCO, which honours and rewards women scientists and showcases their work. **The For Girls in Science Programme** aims to encourage girls to participate in science education and careers.

Since its inception the L'Oréal Foundation and UNESCO have strived to support and recognize accomplished women researchers to encourage more young women to enter the profession and to assist them once their careers are in progress. The L'Oréal commitments include:

(a) Encourage girls to explore scientific career paths.
(b) Break down the barriers that prevent women scientists from pursuing long term careers in research.
(c) Prioritize women's access to senior positions in STEM.
(d) Increasing the visibility of women scientists through publicizing their achievements.
(e) Promote mentoring and networking for young scientists to enable them to plan and develop careers that meet their expectations.

(ii) **Elsevier Foundations Awards** for Early Career Scientists in the Developing World recognizes excellence in research achieved by scientists in developing countries. The award is held in partnership with the Organization for Women in Science for the Developing World (OWSD) and Third World Academy of Science (TWAS).

(iii) UNESCO has been working on various projects that are building momentum around women and girls in STEM including the establishment and observation of the first ever international day of women and girls in science on **11th February 2016. This day dedicated to celebrating women & girls in STEM has had its 4th anniversary.**

(iv) **FEMSA Project (Female Education in Mathematics and Science in Africa).** The FEMSA project aims at promoting participation of girls in mathematics and science education at the primary and secondary school levels and to enhance their performance in these subjects and access to careers in S&T. The FEMSA project began in 1996 and has worked in many African countries including Cameroun, Ghana, Tanzania and Uganda.

(v) **African Women's Forum on Science and Technology (AWFST)** was initiated in 2007. It aims at giving a voice to African Women to Discover, Decipher and Develop Advances in Science and Technology. Some of its projects include:

- The **WE CAN Program** which is an Innovative Network for transformational Change for Women in STI. It is centred around an innovative mentoring programme which joins strategic women leaders to at least 5 women each year working on individual Break Through Innovations (BTIs) across Africa.

(vi) **Next Einstein Forum (NEF)** is committed to advancing and showcasing the role of women in Science, Technology, Engineering and Mathematics.

(vii) **Women in Tech Africa.** The aim of the project is to support women in Tech across Africa. Women in tech Africa mission is 3 fold:

- Creating today's female leaders and role models for tomorrow's women

- Showing the world what a strong African women is capable of achieving.
- Support African growth through Technology.

Women in Tech Africa has membership of women in over 30 countries in Africa and has physical chapters in Ghana, Kenya, London, South Africa and Nigeria. Africa Women in Tech is the brainchild of 4DGH Foundation.

(viii) **Taungana** an African – wide STEM programme run by young women in Science and Technology based in South Africa. Every august (Women's month), Taungana brings together girls in tech-related programs as well as girls from schools, with the aim of exposing them and their teachers to STEM – related activities film it and show their parents and teachers. This exposes students, teachers and parents to the opportunities that arise when girls are involved in this field.

(ix) **Ajesola Solarin Majekodunmi Foundation (ASMAF)** provides scholarships to indigent girls in Universities to complete their studies in STEM and related professional courses.

SOCIETAL LEVEL INTERVENTIONS

- **Policies and Legislation**

Legislation, quotas, financial incentives and other policies can play a significant role in increasing girls' and women's participation in STEM education and careers. These can be made available throughout secondary or tertiary education or to enhance entry into the STEM workforce.

- **Partnerships in Education**

Education is a multi-sectoral, community based enterprise. Individuals, the public and private sector, religious organizations, etc. are all stakeholders in education. What it translates to is that no single entity can achieve success in the educational sector.

Education of girls especially in STEM is one area that requires partnership. For example, the development of intervention

strategies should be participatory and encourage community involvement from the beginning to the end of the process. This will foster a feeling of ownership that will ensure any actions undertaken have the approval, endorsement and support of those involved.

5. MY CONTRIBUTIONS TOWARDS FULFILLING THE POTENTIALS OF WOMEN & GIRLS IN STEM

My contributions centre around theoretical essays, research studies and personal accounts which attempt to answer the questions on the underrepresentation of girls and women in STEM and suggest ways to improve their performance.

My contributions concentrate on the secondary education of girls. This is because as Kelly (1981) noted, it seems likely that improvements to girls' science education will be most readily effected in secondary schools. Most girls encounter formal science education for the first and last time in secondary school. If they drop science at this stage, they are unlikely ever to take it up again. So success at subsequent stages is dependent upon success in secondary science. Although the foundation for girls' attitudes and abilities in science are probably laid before they reach secondary school, it is difficult to intervene in the home or primary school. Few parents or primary school teachers are especially concerned with science and few are aware that they may be influencing their children's later achievement in science.

Similarly it is difficult to intervene at the professional level. Employers will not take the problems of women in science seriously until women constitute a substantial proportion of the scientifically trained labour force and demand to be taken seriously. And this will not happen until large numbers of girls are educated to a high level in science at school.

The prospects for change in secondary schools are more hopeful and that had propelled my research efforts at the secondary school level of education.

As previously mentioned, earlier in my career, I conducted a lot of research that investigated sex differences not as a primary objective. It is however axiomatic in any study to break down the sample into reasonable subsamples and scrutinize the differences between these subsamples on all variables being measured. It was at this initial stages that some of the sex differences turned out to be significant and it changed my research focus.

In the proceeding section, I present a summary of the studies I carried out on the factors influencing girls and women participation, achievement and progression in STEM.

Ecological Factors Influencing Girls & Women Participation, Achievement and Progression

LEARNER	**LEARNER** • Interest • Attitude • Self-efficacy • Motivation • Study Habits 1. Interest (Udeani 1992, 1993, 1995, 2003, 2013, Udeani et al. 2017&2018) 2. Attitude (Udeani 1992, 1995, 2003, 2013, Udeani et al. 2017) 3. Self-Efficacy (Udeani 1992, 2003, 2005, 2015) 4. Motivation (Udeani (2004, 2011, 2012) 5. Study Habits (Udeani (2012) The studies I conducted with these variables provided evidence to show that these variables impact positively on girls participation and achievement in Science. Girls who score high on these measures perform better in STEM than those who do not. A meta-analysis of these studies showed that interest had the greatest effect followed by self-efficacy.
FAMILY & PEERS	**FAMILY & PEERS** • Parental Belief & Expectation • Parents Education • Household assets and Home support Results from these cohorts of studies are somewhat

	inconclusive. However a trend appeared : 4. In developing countries poverty is the foremost cause of unequal access to secondary education and the study of science in particular. 5. Socio-economic status of the parents is another significant factor in female participation in science (Udeani 1992, 2003, 2005, Udeani et al. 2017 & 2018). 6. Parents level of education (especially the mother) impacts positively on girls achievement and progression in STEM (Udeani 2001, 2005, Udeani et al. 2017 & 2018) 7. Differential expectations of parents reinforce gender roles (Udeani 2001, 2003, 2016). 8. Females perform equally well like their male counterpacts when the home environment supports school activities (Udeani 2001, 2003, 2004, Udeani et al. 2018). 9. Supportive Home Environment (Udeani 2005, Udeani et al. 2017&2018)
SCHOOL	**SCHOOL** • Teacher Quality • Teacher Attitude • Female STEM Teachers • Teaching Strategies • Teacher – Student Interaction • Curriculum Materials • Assessment Tools • STEM Equipment, Materials and Resources Most of my work are action research contextualized within the science classrooms. Findings from these cohort of studies showed the following trend: 1. Teacher Quality is the single most important in-school factor at both primary and secondary school determining student overall achievement. ▪ Experience (Udeani 1992, 1993, Udeani et al. 2017, 2018) ▪ Subject Specialization (Udeani 2010, Udeani et al. 2017, 2018) ▪ Personality traits (Udeani 1992, 1993) 2. Teacher Attitude – Teachers have different expectations for their male and female students (Udeani 1992, 1993, 2004, 2006) teachers do not encourage the females in their classes to work hard and improve on their performance.

	3. Female STEM teachers- Udeani et al. (2017 & 2018) did not find any significant differences in achievement of students if they were taught by either male or female teachers, however female students taught by female teachers have more positive STEM/identities. 4. Teaching strategies – When the instructional method employed by the teacher is learner – centred, hands-on and participatory girls achieve better in science subjects. (Udeani 1992, 1994, 1996, 1999, Udeani et al. 2016, 2017 & 2018). 5. Teacher-student interaction – Studies that investigated Teacher-student interaction pattern found that girls have less instructional and discussion time, ask fewer questions and receive less praise than boys (Udeani 1992, 1995, Udeani et al. 2016, 2018). 6. Curriculum Materials STEM Curriculum materials used in Nigeria are grossly gender biased in favour of males and decisively against females Ndukwe (1988), Udeani 2000, 2013, Udeani et al. 2017. 7. Assessment Tools- Girls prefer essay-type test. (Udeani 1995, Udeani et al. 2010) 8. STEM Equipment, Materials and Resources- Access to resources for scientific experiments have been associated with improved learning outcomes in students (Udeani 1994, 2000, Udeani et al. (2017 & 2018).
SOCIETY	**SOCIETY** • Cultural Barriers • Sex Role Stereotyping • Media Cultural Barriers that leads to gender roles and stereotyping have been found to impede girls achievement in STEM. (Udeani 2004, 2012, Udeani & Odogwu 2011).

The Gender Inclusive Instructional Strategy (GIIS)

In collaboration with Prof. Harrison Atagana (UNISA) we developed a Gender-Inclusive Instructional Strategy to make science teaching gender inclusive. Funding for the development, validation and tryout was made possible by a TETFUND research grant in 2012.

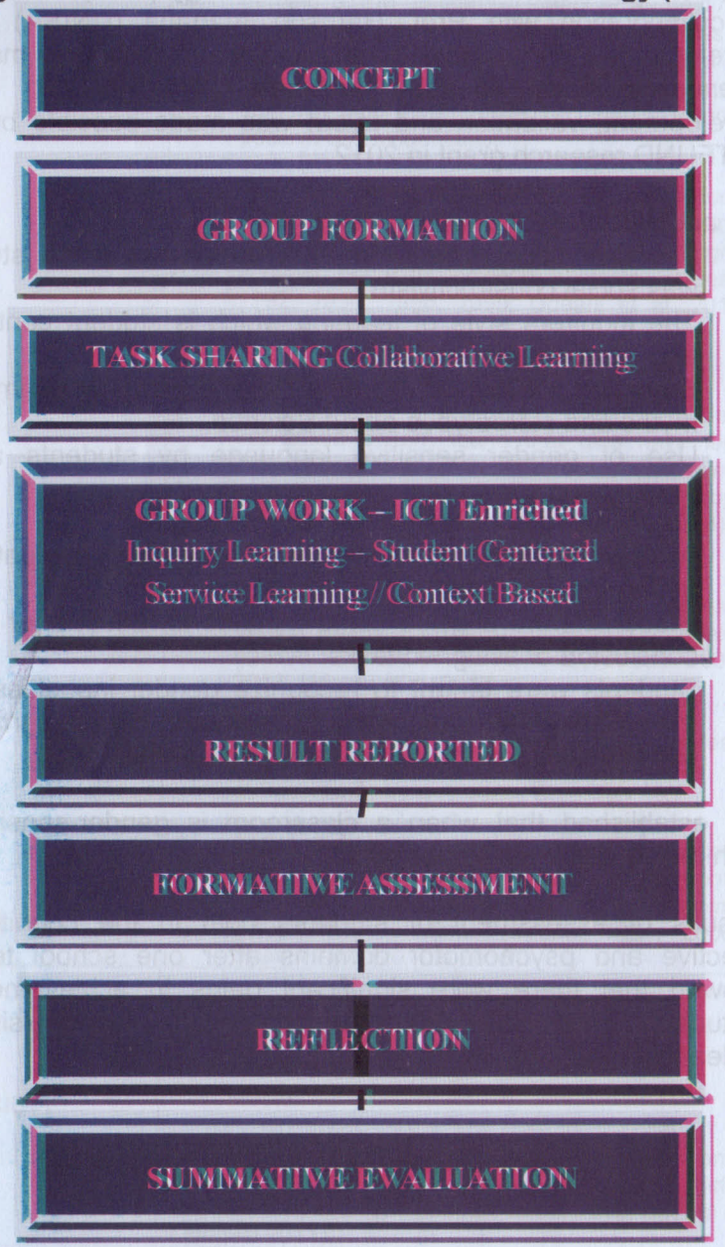
We adopted the following criteria;

1. The theoretical framework that underpinned the study was social constructivism.
2. The inquirers style of learning which is student centred and mostly hands-on in nature.
3. Engaging students in learning experiences that examine myths and stereotypes about Science.
4. Use of gender sensitive language by students and teachers.
5. Emphasized cooperative learning strategies.
6. Allowed for both formative and summative evaluation during the instructional process.
7. Students were allowed some minutes to reflect after the conclusion of assigned tasks.
8. Students were taught to recognize gender inequities in the science classroom and empowered to create learning opportunities that benefit both boys and girls.

We established that when a classroom is gender-sensitive both males and females benefit.

Results of assessment of students both in the cognitive, affective and psychomotor domains after one school term showed that there were significant gains in achievement, attitude, interest, self-efficacy and process skills acquisition (Udeani et al. 2016).

Figure 15: Gender Inclusive Instructional Strategy (GIIS)



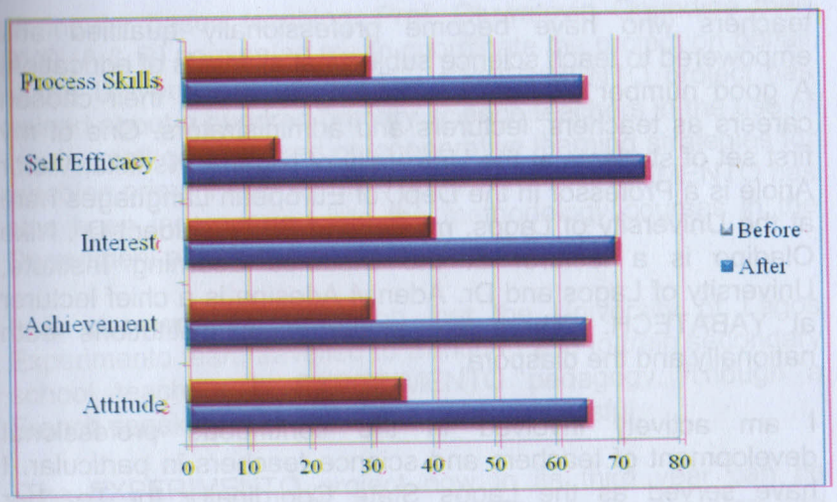


Figure 16: Improvement in Learning Outcomes by Girls after GIIS

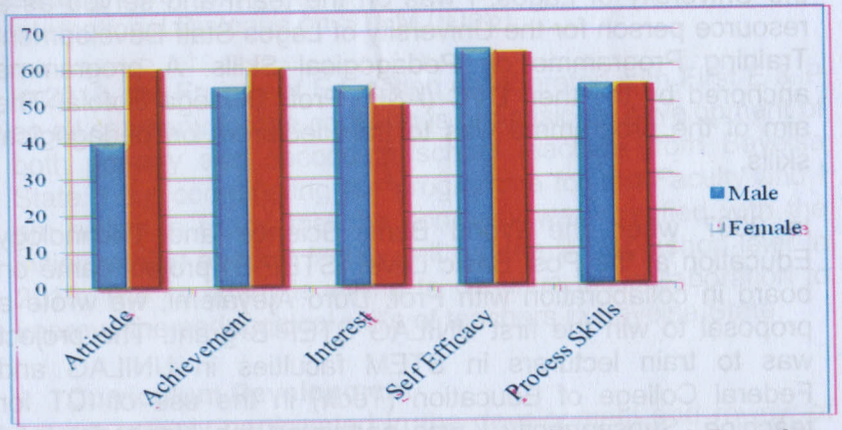


Figure 17: Comparative Outcomes for Males and Females of GIIS

- **Human Resource Development**

I have through formal teaching and supervision of undergraduate and postgraduate students in the Faculties and Institutes of Education in the three universities I have worked for the past thirty-seven years trained hundreds of science

teachers who have become professionally qualified and empowered to teach science subjects at all levels of education. A good number of them are making waves in their chosen careers as teachers, lecturers and administrators. One of my first set of students at the University of Nigeria, Nsukka, Victor Ariole is a Professor in the Dept. of European Languages here at the University of Lagos, my second Ph.D. student Dr. Nike Oladipo is a lecturer at the Distance Learning Institute, University of Lagos and Dr. Adeniyi Adesina is a chief lecturer at YABATECH. Others are scattered in institutions both nationally and the diaspora.

I am actively involved in the continuous professional development of teachers and science teachers in particular. I have served as the Lagos State Coordinator for Teacher Vacation Workshop for Science Teachers for the Federal Ministry of Education and served as resource person for Lagos State SUBEB in various in-service training of teachers. Within the University of Lagos, I was on the team and served as a resource person for the University of Lagos Staff Development Training Programme on Pedagogical Skills. A programme anchored by the then DVC (A&R) Prof. Olusoga Sofola. The aim of the programme was to train lecturers on pedagogical skills.

In 2007 when the World Bank Science and Technology Education at the Post Basic Level (STEP-B) project came on board in collaboration with Prof. Duro Ajeyalemi, we wrote a proposal to win the first UNILAG STEP-B grant. The project was to train lecturers in STEM faculties in UNILAG and Federal College of Education (Tech) in the use of ICT for teaching. Subsequently I was appointed the Monitoring and Evaluation Officer of STEP-B UNILAG and facilitated four cycles of training workshops. Approximately 160 lecturers were trained from both institutions.

Siemens Stiftung's international education project 'EXPERIMENTO' project could not have come at a better time than in 2016, when the Department of Science and Technology Education was in need of resources for the hands-

on inquiry based teaching. Prof. Oluwatoyin Ogundipe then DVC (A & R) nominated me to coordinate the project on behalf of the University of Lagos. The EXPERIMENTO project has trained about a hundred primary science teachers in the use of inquiry method anchored on cooperative learning strategies for teaching primary science. The principle of EXPERIMENTO has also been incorporated into the methodology courses in the Department of Science & Technology Education.

It is also worthy to mention that the University of Lagos Experimento team travelled to Burkina Faso to train secondary school teachers in EXPERIMENTO pedagogy. Though a French speaking country, it was quite successful.

The EXPERIMENTO project now in its third year can be described as quite impactful. In 2018, service learning and 2019 design thinking and coding were added to the training programme. As a fallout from my involvement with Siemens Stiftung I was appointed to the programme committee of the International Dialogue on STEM (IDoS).

In 2018, the Faculty of Education collaborated with First E & P an oil company for the continuous professional development of both primary and secondary school teachers from Bayelsa State. I am coordinating the programme for the Faculty and I am happy to report that the company was satisfied with the initial training and the faculty will run the 2nd workshop later in 2019. The company is willing to continue the collaboration to improve the pedagogical skills of teachers in Bayelsa State.

- **Curriculum Development**

I have actively participated in the development and review of science curricula at all levels of the educational system. Working with NERDC and the Federal Ministry of Education, I was involved in the development and review of the Integrated Science and Biology Curricula in 1996, 2001 and 2015.

As a UNESCO consultant in 2011, I was the team leader in the development of the Harmonized HIV & AIDS Teacher Education Curriculum and the Training Manual. I was also part

of the team that developed the modules for teaching HIV/AIDS concepts at the non-formal education sector. It gives me a sense of satisfaction to say that all these curriculum documents are being implemented effectively in the education sector. Between 2011/2012 working for the National Commission for Non-Formal Education, I was amongst the cohort of science educators that developed e-learning modules in science for the non-formal education sector.

In 2009, I served as a Resource Person, for the Development of National Quality Assurance Model for the Education Sector below the Tertiary Level of Education.

- **Fellowships and Grants**

I served as a Study Consultant to the Federal Ministry of Education for the Education Sector Analysis between 2003 - 2004. I was responsible for the study on the participation of females in Education and in Science, Technology and Mathematics.

The study produced two technical reports – (i) Pre-Diagnostic Bibliography Collation on Studies proposed for the Nigerian Education Sector Analysis and (ii) Situation Analysis of Participation of Females in Education and in Science, Technology, Mathematics and related fields and factors constraining their participation. The findings from the study helped the government to develop a policy framework for girls education especially in Science and Technology Education.

In 2002, I won a study fellowship from the State Department, United States of America, to spend three weeks at the Michigan State University, East Lansing. The fellowship was aimed at developing ICT skills for Women Democratic Organization. I have used the skills acquired to train women and girls in the use of social media and other ICT platforms for women empowerment in the democratic process.

I am an active member of the National Association for Research in Science Teaching the foremost science education association worldwide. Its goals include improving science

teaching and learning through research. In 2009, I won the Linking Science Educators Program (LSEP) Award. This grant enabled me to run an international workshop on building capacity for research. Participants were drawn from UNILAG and NOUN. The outcome of the workshop resulted in research collaboration between the two universities which resulted in some publications.

In 2013, I got a travel fellowship from the Volkswagen Foundation to participate as a gender expert at the First International Workshop on the Global State of Young Scientists (GLOSYS) in Hanover Germany. I was subsequently appointed a Research Partner for West African Sub region for their flagship project – GLOSYS (Africa). This research project covered four countries in West Africa namely Nigeria, Ghana, Senegal and Cameroon and involved the collection of comparative quantitative and qualitative data across the countries. The study due to be completed by the end of 2019 exposed me to academic collaborations with young scientists across the globe.

- **Academic Publications and Affiliations**

In addition to my over sixty research publications in reputable peer-reviewed journals and book chapters. I am the author of three academic books titled (i) Test Development: A Practical Guide for Teachers (ii) Teaching Science in Basic and Secondary Schools: New Concepts for New Challenges and (iii) Research Methods and Statistics in Education. These books are very useful resource materials for both inservice and preservice teachers. I am also the Managing Editor of the Journal of Multicultural Education, a scholarly peer-reviewed journal based in the Faculty of Education, University of Lagos.

At this juncture Mr. Vice Chancellor Sir, I wish to mention two important studies that provided very useful information for our work as science teacher educators. I was the principal researcher for both studies. They are (i) An Evaluation of The Status of Science Education in Secondary Schools in Lagos State funded by CRC Research Grant in 2017 and An Evaluation of the Status of Science Education in Primary

Schools in Lagos State funded by Siemens Stiftung. The findings from both studies have provided useful baseline data for the work we are doing in the Department of Science and Technology Education.

I serve as external examiner to many Colleges of Education and Universities both nationally and internationally. Some of these include the University of South Africa (UNISA), the University of Nigeria, Nsukka, the University of Ilorin, Centre of Environment and Science Education, Lagos State University, Nnamdi Azikwe University, Federal University of Dutsin-ma, Federal College of Education (Tech) Akoka amongst others. These activities enabled me to bring my academic expertise to bear on the improvement of programmes for improved quality assurance.

I belong to numerous professional organizations which have moulded me to be the academic that I am today. I am an ardent member of the African Women in Science and Engineering (AWSE), Organization for Women in Science for Developing World (OWSD), National Association for Research in Science Teaching (NARST). I have contributed substantially in the various programmes of these associations through running workshops, organizing seminars and intellectual discourses.

♦ **Activities as a Gender Consultant/Equal Opportunities Specialist**

In 2006, I diversified into Gender and Energy issues, interrogating specifically the nexus between Gender, Energy and Poverty. This opportunity was made available to me by Engr. (Mrs) Olu Maduka FAEng through her NGO, Friends of the Environment (FOTE), I worked with this NGO as a gender consultant and together with FOTE team developed programmes, workshop and training for individuals working in the area of Gender and Energy. I was subsequently part of the study group that audited the Nigerian Energy Policy.

I have been heavily involved in advocacy matters on gender and girl-child education especially science education. I serve

as a consultant to Federal, State and Local Government Agencies as well as NGOs on Gender Issues in Education, mobilizing and conducting workshops across the country. I also run an NGO, Girls and Science Outreach (GASO) which runs holiday programmes for girls in STEM.

Mr. Vice Chancellor, I have been around the 9University System since 1979, that is, forty years. Naturally, at various times I have served as Cohort Adviser, Head of Department, Member of Senate, served on various committees of University, Senate, Faculty and Department either as Chairman, Member or Secretary. I have also served on Moremi Hall Management Committee and Hall Mistress of Amina Hall, Coordinator or project leader and currently Mr. Vice Chancellor you moved me to the next level and appointed me Director DLI.

In all these duty posts Mr. Vice Chancellor Sir, the one that gave me the greatest satisfaction was cohort advising. I saw my students as my own children and helped them develop to their full potentials. Secondly during the course of preparing their broadsheets I met and worked with some amazing lecturers in the Faculty of Science like Profs Toyin Ogundipe, A. Adekunle, O. Aboaba, Bola Oboh, Carol Umebese and late Dr. Shola Shonubi.

Mr. Vice Chancellor Sir, in all these assignments I had put in my best to make sure that group goals were accomplished in a timely, effective and efficient manner.

On the political scene Mr. Vice Chancellor Sir, I was appointed the Chairman of the Presidential Visitation Panel to Federal Polytechnic Nassarawa in 1999.

I have also served INEC in various capacities since the inception of the democratic process in Nigeria from 1999.

♦ **On-going Research**

Mr. Vice Chancellor Sir, I am afraid I have to mention, that the two assignments you gave me within the past three years have

led to a paradigm shift in my research focus. I am leaving my comfort zone which is the secondary school level to other levels of education.

1) My involvement with the Siemens Stiftung and Haus der kleinen Forscher Foundation (Little Scientists House Germany) made me to interrogate my earlier belief that it is best to intervene at the secondary school level. My current research efforts is pointing to the fact that it is better to expose children to science as early as they begin to learn the language of communication i.e. science should be a major component of Early Childhood Education, particularly for girls, so that they begin early to form positive STEM identities.

2) Secondly Mr. Vice Chancellor Sir, How do life – long learners learn science? How do they live within their environment to make it sustainable? How can we as ODL practitioners integrate scientific concepts, attitudes and skills into the pedagogical process of Open Distance Education? These two areas Mr. Vice Chancellor Sir, are the areas of my new research focus.

10. CONCLUSION

Achieving parity by getting more girls and women into STEM education and careers requires holistic and integrated responses that reach across sectors that engage girls and women in identifying solutions to persistent challenges. This requires political will, strengthened capacity and investments to ignite girls' interest and cultivate their aspirations to pursue further STEM studies and ultimately STEM careers. Attempts to remedy the gender imbalance in participation in African and indeed most developing countries must target primarily effective and sociocultural practices. It is also important to note that unless these programmes are specifically targeted to assess the status, articulate goals and directly target educational problems of females, they are unlikely to be effective. There is need for systematic support for equity initiatives. Consistent and sustainable support from the government and the educational system is necessary for both

the implementation and continuance of intervention programmes.

I conclude on a somewhat personal note. Throughout my academic training and subsequent experience in the world of science teaching and learning, three convictions have increasingly shaped my own paradigm:

- That women are well able to hold their own in the man's world of science and technology and that they have a unique dimension to lend to the scientific enterprise.
- That great potential is being lost by failure to encourage more women to enter the world of scientific exploration.
- That subsequent generation will judge us, the scientific community, on our ability to use science to benefit the poorest, most disadvantaged sectors of society.

These are crucial issues which we must address. We have to consider afresh the role of women in the scientific enterprise, to think it out again from the beginning. We must secure for women an entirely new value and significance and we cannot do that unless women themselves are allowed to have a say in determining what the value should be.

11. 7. RECOMMENDATIONS

The following recommendations although not exhaustive are advocated. These include:-

(1) Using various fora, media, faith based and community based organizations communities should be educated and sensitized to introduce changes into their sociocultural beliefs and gender role stereotypes that science and mathematics are for boys only and that the place of women is in the home. Women leaders and those doing well in science based professionals should be involved in this kind of campaign.

(2) Gender-responsive action plans across all tiers of education – primary, secondary and tertiary including also Ministry of Women Affairs, Science and Technology in order to create more opportunities for girls and women to study and pursue careers in STEM as well as investment and review of educational policies and

frameworks to stimulate interest in STEM – related subjects among girls

(3) Recruiting more female science teachers to teach science and mathematics at the secondary school level. Intensive targeted gender – responsive in-service and pre-service continuous professional development of science teachers is advocated.

(4) Curricula and learning materials especially at primary and secondary school should undergo further vigorous review from a gender perspective to ensure that they do not perpetuate gender stereotypes.

(5) Promoting more female role models in STEM fields, whether female teachers in mathematics and science at the secondary school level, female students and faculty members in higher education and more broadly more women working in STEM fields is an effective strategy to attract women and girls in STEM fields.

(6) Pastoral programmes and initiatives for female secondary schools science students, female students in tertiary institutions and female STEM professionals would help to address some of the factors which can cause them to discontinue their studies and careers including family responsibilities.

12. 8. ACKNOWLEDGEMENT

Mr. Vice Chancellor, Sir, I cannot end this lecture without acknowledging key individuals and organizations that influenced my academic career.

First and foremost I thank the Almighty God for his benevolence in my life. What I have achieved thus far is by His mercy. I have really enjoyed God's favour in my life and I appreciate Him even more, for today's event.

I want to appreciate the University Management under the able leadership of the Vice Chancellor, Prof. Oluwatoyin Ogundipe *FAS*; the DVCs Prof. Ben Oghojafor, Prof. Folashade Ogunsola, *FAS*, Prof. Oluwole Familoni, *FAS*, the Registrar Mr. Oladejo Azeez Esq, the University Bursar, Mr. Lekan Lawal,

University Librarian, Dr. (Mrs) Yetunde Zaid. Thank you very much for your support whenever the need arises.

My teachers in the secondary school I attended, Anglican Girls Grammar School, Enugu who laid the foundation upon which I have built what I am today.

For my University degrees, I attended the University of Nigeria, Nsukka and the University of Jos. I wish to appreciate with much gratitude my lecturers in the Department of Zoology, University of Nigeria, Nsukka with a special mention of my two model lecturers, Prof. Anya O. Anya *FAS* and Prof. ABC Nwosu. They excelled in instilling self confidence in me. I started my academic journey as an assistant lecturer at the Faculty of Education, University of Nigeria, Nsukka, I appreciate my Ph.D supervisors and lecturers in the Faculty of Education, Prof. Romanus Ohuche, (late) O.C. Nwana, Julie Okpalla and Eunice A.C. Okeke for being patient with me and not being tired of mentoring me even up to this moment.

The nine and half years I spent as a lecturer at UNN were very memorable and I wish to sincerely thank my colleagues and friends Prof. Uche Nzewi, Godswill Obioma, B.G. Nworgu, Grace Offorma, S.A. Ekwelie, Dave and Maria Onyejekwe and Nkechi Offiah. Also included are Mrs Phil Nzewi and Ms. Uju Nwosu. My UNN family is always close by and supportive.

I left UNN for marital pastures and after an uneventful three years at the Rivers State University of Science and Technology Port Harcourt, I berthed at the University of Lagos, the University of First Choice and the Nations Pride in 1994 (Twenty-five years ago).

I want to acknowledge with gratitude Prof. Segun Adesina of blessed memory who employed me into the then Institute of Education and made my transition into UNILAG stress free. Thank you Prof. Adesina. May your great soul continue to rest in peace.

I have enjoyed tremendous friendship and love at the Faculty of Education, I wish to acknowledge all the Deans (Profs Bade Adegoke, Duro Ajeyalemi, M.A. Bidmos, Mopelola Omoegun, Supo Jegede and the current Dean, Prof. Monday Ubangha) and Heads of Departments Profs Helen Odogwu and Uju Esiobu whom I had the privilege of working with. Also under this category I appreciate posthumously the following Profs Obe, Taiwo Odunsi, Temi Busari and T.D. Baiyelo. However, it gives me great pleasure to put on record the immeasurable contributions of Prof. Duro Ajeyalemi to my academic growth in this University. He helped me in no small measure to hone my administrative skills as the Departmental PG Coordinator during his Headship of the Department and Diploma Coordinator during his tenure as Dean of the Faculty of Education. Evidence abound that Prof. Duro Ajeyalemi desired my unhindered progress. I am grateful to him for this.

For every kind word, encouragement, love and support you have given me along my academic journey, I thank the following friends, Profs Funke Lawal, Victor Owhotu, Anthony Oguntoye, Aloy Ejiogu, Mopelola Omoegun, Mopelola Olusakin, Carol Opara, Ajike Osanyin (JIKs Baby) Grace Otinwa, Yemisi Obasoro-John, Cecilia Oladapo, Prof. Pai Obanya, Prof. U.M.O. Ivowi, Drs Ayotunde Adebayo, Bayo Oladipo, Nike Adeosun, Iyabo Abe, Bola Makinde.

For the sisterly love and emotional support when needed, I appreciate Distinguished Prof. Cecilia Igwilo (Ada Mazi), Profs Virgy Onyene, Uju Esiobu, Rosita Igwe, Nnonye Ikonta, Tonia Maduekwe, Adun Adepoju. Also, Sophia Madumere (you taught me how to complete result broadsheet) Ngozi Uzoka, Ngozi Okafor, Pep Ememe, Stella Anyama, Blessing Anyikwa, Maureen Egenti, Mercy Onwuama and Ngozi Chukwu.

The Department of Science and Technology Education holds a lot of nostalgia for me. I love and appreciate all my colleagues both senior and junior. Thank you for allowing me mentor you, thank you for the unity of purpose and most especially thank you for your love Drs S. Adenle, Nike Oke, Sunday Adeyemo, Ngozi Okafor, Tinu Lano – Maduagu, Moses Odoh, Olabiyi

O.S, Jimoh, J.A, Babajide V.F.T, Awofala A.O, Toyin Owoyemi, Fakorede S.O.A, Rachael Okunuga, Shobowale I.O, Oluwaleyimu O.O, Ojo O.T. and Abusomwan. We moved from being a Department to being one big family. God bless you all richly.

Prof. Helen Odogwu my sister, friend and partner in progress, moved with me all along the rough road and propped me up when assistance was needed. I also appreciate posthumously my friend and cheer leader Prof. Ayo Ogunleye.

I appreciate my STEP-B family, a collection of the best minds in STEM faculties at the University of Lagos which I had the rare privilege of teaching how to deploy ICT platforms for their lectures and processes. I say a big thank you for the academic discourses we shared. These high profile students included Prof. Soji Ilori, Dr. Khalid Adekoya, Prof. Ore Oremosu, Prof. Rosemary Egonmwan, Prof. Olayinka Asekun , Dr. Aderonke Lawal-Are, Dr. Ade – Ademilua, Prof. G.O. Esiobu to mention a few.

The family got bigger when the STEP-B Centre of Excellence came on board. As the Monitoring and Evaluation Officer I worked closely with Prof. Ralph Akinfeleye, Prof. Charles Uwadia, Mr. OmoOaiya, Mr Owen Iyorha, Dr. Ify Amobi and of course the Directorate of Academic Planning within the period headed at various times by Profs Cecilia Igwilo and Oluwatoyin Ogundipe. I served under two project managers Prof. Soga Sofola and Prof. A. Adekunle. We became friends, we became family. The STEP-B project spanned through the tenures of four Vice Chancellors, and I wish to acknowledge them for their support at various stations along the journey. Prof. Oyeibidapo –Obe during the initial stages of project development, Profs. Tolu Odugbemi and Tokunbo Sofoluwe for sustaining it and Prof. Rahman A. Bello for moving the project to the next level with the establishment of the Centre of Excellence in Multimedia and Cinematography.

The Siemens Stiftung family is hereby acknowledged and appreciated. A big thank you to Ms Rebecca Ottmann, Dr.

Onyeche Tifase, Ms. Lilo Macfarlane, Mr. Arnold Dieter, members of the Lagos Energy Academy, Mr. Ibe, Tonye Atioegbe and all members of the Dept of Science & Technology Education for their support and dedication towards realizing the goals of the project. The Vice Chancellor, Prof. Oluwatoyin Ogundipe is hereby acknowledged for his support in sustaining the project till date.

I acquired another family in 2013 – the Global Young Academy (GYA) based in Germany. (The Global Young Academy aims to be the voice for Young Scientists and encourages international, intergenerational and interdisciplinary collaboration and dialogue). As research partner for West African Sub region for GLOSyS (Africa) I wish to especially thank Dr. Abidemi Akindele of the Department of Pharmacognosy, University of Lagos, the GYA Champion for West Africa for the partnership to successfully conduct and complete the study.

I appreciate Engr. (Mrs.) Olu Maduka FAEng who in 2006 through her NGO – Friends of the Environment (FOTE) introduced me to Gender and Energy issues. I worked with the organization under her leadership with Late Engr. Chike Chikwendu to develop programmes, workshops and training for individuals working in the area of Gender & Energy. I thank my ENERGIA & FOTE family.

Gratitude and Appreciation go to various organizations which I serve as their Gender Consultant like ALOFOS Science Foundation founded and headed by Prof. Soga & Dr. (Mrs) Yemi Sofola and ASMAF initiated by Prof. Ajesola Majekodunmi. Dr. (Mrs) Nadu Denloye, I have worked with her on various projects but most memorable was in CDNet, a career development initiative she founded and I serve on the board of directors.

For enduring friendships Prof. Anya O. Anya, Prof. Uche Nzewi, Emeritus Prof. Olu Jegede, Emeritus Prof. Soga Sofola, Distinguished Prof. B. Alo and Prof. Oluwatoyin Ogundipe, (our students brought us together in 1998) and post humously Profs

Larry Madubuinyi and Chinyere Aniche. More thanks are due than can be expressed here.

I have benefitted from prayers and consultations of my spiritual fathers. They include Rt. Rev Seyi Oyelade, The Lord Bishop, Diocese of Ife East, Venerable Kingsley Agu, of the Church of Advent, Igbo-Efun, Ven. Seyi Prisola, Vicar, All Souls Church, Lekki. Also, Rev. Prof. F. Fajimirokun & Rev. Dr. Azuka Ogbolumani of the Chapel of Christ Our Light. Special mention of Rev. Fr Dr. Francis M. Isichei, my friend and prayer warrior.

I have enjoyed my interactions and working relationship with academics I met in different areas of service at the University of Lagos and I wish to say a big thank you to all of them for contributing to my growth in academics. Among them are Profs. Duro Oni (Nwannem), S.A. Okunuga, Obinna Chukwu, Bola Oboh, Joy Okpuzor, Frank Okafor, Mike Chendo, Ray Okafor, Dike Nwankwo, Olukayode Amund, Willy Iyiegbuniwe, Joe Mojekwu and more recently my sweet brothers Profs Gbenga Nubi and Mike Adebamawo.

By Divine Favour I was appointed the Director, Distance Learning Institute in August 2018 by the Vice Chancellor Prof. Oluwatoyin Ogundipe. I appreciate you Sir, for making me head another big family. I recognize the presence of the DLI management, members of staff and students of DLI and all of their labour in making today the huge success it has turned out to be. I love you all and together we shall achieve the vision of DLI. Special thanks to the DLI Board Chairman, Prof. R. Ojikutu and other board members for making the job easy.

My students are the apple of my eyes. When I took up an assistant lectureship job in 1982 at the University of Nigeria, Nsukka, I was happy that finally I was going to be teaching. How wrong I was. I found that University lectureship was more of learning than teaching. I learnt from my senior colleagues and my greatest teachers were my students.

I have lectured in three Nigerian Universities and have a huge fan base of past and present students. I wish to thank all of

them for their inspiration. The four teachers and the students we used when developing the Gender Sensitive Instructional Strategy are hereby acknowledged Ms. Comfort Akanji, Mr. Awolowo, Mrs. Sholanke, and Mr. Bello – all are my past students. Also my Ph.D. graduands who naturally became family – Drs Adenike Oladipo, A.I. Adesina, Ngozi Anoh & Ngozi Chukwu.

How can I forget my "Maltina Teacher of the Year" (MTOTY) family. Nigerian Breweries through the Felix Ohiewere Foundation had one goal in mind in establishing MTOTY – to reward teachers for their labour. I am serving as consultant on the programme and acquired another family. Thank you for the friendship – Mr. Kufre Ekanem, Mr. Edem Vindah, Ms Sade Morgan, Mr. Patrick Olowokere, Prof. Pat Utomi, Prof. Mopelola Omoegun, Prof. Thomas Ofuya, Prof. Tijani Abubakar, Mrs. Eugenia Abu, Mr. Segun Adeniyi, Prof. Yemisi Obashoro-John, Prof Musa Maisamari and Ms. Emmanuella Otibho Imumonlen and all the teachers, who had participated across the country.

My inaugural team is profoundly acknowledged – my editors, Profs Nonye Ikonta, Rosita Igwe and Dr. Dele Ashiru, my invisible army that worked tirelessly to achieve this event – Drs Bosede Adesalu, Pep Ememe, Stella Anyama, Ngozi Okafor, Lano Tinu-maduagu, Toun Okunuga, Ngozi Chukwu and Mrs. P. Adefarakan. Also my secretaries, Ms Janet Aderonmu and Mrs Bose Oloyede who typed and retyped with great humour. The ICT teams Mr. Sunday Osho and Maduka Onoka are gratefully acknowledged.

Finally my Family

My parents, Sir Ellis and Dame Jane Ndukwe of blessed memory. Though we were not born with silver spoons in our mouths, they created one for us. They spared nothing to see that all my siblings and I including the females attained our educational dreams. May their souls rest in peace.

My siblings, their spouses, children and grandchildren have been a great source of support in all my endeavours both in

private and my professional life. There are always present and always near to hold my hand and whisper to me "we are here and it is well" by extension the larger NDUKWE family of Oraifite. We are indeed a united family in word and deed. Thank you all for your presence in my life.

My husband of blessed memory Chief Sir Alex Udeani, the Onwanetiloha I of Nsude, I thank you for your unparalleled home support, academic support and every form of encouragement to have me blossom as a fulfilled woman, wife and mother. Even in death I appreciate you. May your soul continue to rest in peace. I wish to also appreciate with great gratitude the UDEANI family who accepted me into their family with much love.

Finally, my GOD given children – Chukwudi and Ndidiamaka. Ndidiamaka went to be with the Lord 14 years ago but Dr. Chukwudi Udeani is here with his wife Afooma. My son in whom I am well pleased. Thank you for your love, support and for making me a proud mother always. With God, the grandchildren are on their way. I pray that they will make you proud like you have always made me. I also appreciate my-in-laws the Jideonwos' for giving me their beautiful and dutiful daughter.

Vice Chancellor, Sir, distinguished ladies & gentlemen the bible did tell us that it is not he that runneth or willeth but God who shows mercy. What I have achieved thus far, is by His mercy. I have really enjoyed God's favour in my life and I appreciate Him even more, for today's event.

Thank you all for honouring the invitation to this lecture and for listening.

TO GOD BE THE GLORY

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