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Gender and Science Education

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WOMEN AND SCIENCE

BY

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B.Ed (Physics), M.Ed, Ph.D (Edu. Evaluation) (Ibadan)
Gender and Science Education

36TH INAUGURAL LECTURE

OLABISI ONABANJO UNIVERSITY,
AGO-IWOYE

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DEDICATION

To the memory of my mother

Mrs. Ruth Ebun Popoola

For her invaluable contribution to my life and support for my education

Preamble

The Vice-Chancellor, The Deputy Vice-Chancellors, Principal Officers of the University, Provosts and Deans, Heads of Departments, Distinguished ladies and gentlemen

It is a privilege and great honour to deliver the 36th Olabisi Onabanjo University Inaugural lecture on behalf of the Department of Curriculum Studies & Instructional Technology (CSIT) of the Faculty of Education. This is the fourth OOU lecture by a woman, the 6th from the Faculty, and the first in the Department of CSIT.

I started my career as an assistant lecturer in the Department of CSIT on October 1st, 1985 and rose through the ranks to become Head of the Department between 1999 and 2001. Thereafter, I was appointed the Ag. Director of the Institute of Education in June 2001. I served as the substantive Director of the Institute after promotion to Professor from October 2002 and successfully completed my term in October 2004.

I acknowledge with deep appreciation the incalculable support of the Vice-Chancellor, Professor 'Folabi Soyode for my achievements as Director of the Institute. I also recall with gratitude the support of Professors O.Y. Oyeneye and 'Layi Ogunkoya (both former VCs) during my tenure as the Head of CSIT Department.

To the glory of the Almighty God, I have had a fulfilled and an exciting academic career; teaching young minds in general and working to promote the importance of girls in science. I garnered support from: (1) The

Rockefeller Foundation of New York (through the Nairobi, Kenya, regional office), for a three-school-year study of girls' behaviour patterns in high school science; (2) The International Development Research Centre (IDRC), Dakar, Senegal, for a study on the profile of women undergraduate and professional scientists; (3) The African Academy of Sciences, Nairobi, Kenya, for analyses of sexism in school science texts; (4) The Forum for African Women Educationists (FAWE), Nairobi, Kenya, for promoting active science learning among girls; (5) The African Forum for Children's Literacy in Science, AFCLIST based in Durban, South Africa and University of Malawi, Zomba, for contextualising school science in the community; and (6) The Association of African Women for Research and Development (AAWORD), Dakar, Senegal along with Drs. Piping Fawole and Yinka Aderinto of the University of Ibadan for work on women and cooperatives.

I also enjoyed travel grants to attend international conferences from:

- The Association of African Women Scientists and Engineers (AWSE), Nairobi, Kenya;
- International Conference of Women Engineers and Scientists (ICWES), Ottawa, Canada;
- Third World Organisation of Women Scientists (TWOS), Trieste, Italy;
- The Association of African Women for Research and Development (AAWORD), Dakar, Senegal;
- The African Forum for Children's Literacy in Science, Durban, South Africa

- Women in Technology and Science (WITS), Oxford, England; and
- Olabisi Onabanjo University

Moreover, I appreciate the contribution to, and impact of my teachers on my academic career. They are Professors Joseph Obemeata (my supervisor), Tunde Yoloye, Wole Falayajo, Pai Obanya, Tunde Bajah, and all of my teachers at the Departments of Physics and Teacher Education, as well as the Institute of Education at the University of Ibadan.

I have enjoyed and/or continued to enjoy the support, cooperation, and goodwill of:

- Late Professor Bode and Mrs. Olufunmilayo Akindele, my sister and her husband;
- My father Prince Olarinoye Popoola and mother, both deceased;
- All my siblings, and in particular my youngest sister, Fehintola, who lived with me for over fifteen years while I was charting my career and raising a family;
- My colleagues in the CSIT Department, Institute of Education, and Faculty of Education of the Olabisi Onabanjo University;
- My colleagues in administration within the faculty and in the wider university community; and
- Friends and professional colleagues locally and internationally.

Finally, I extend my warmest appreciation and gratitude to my husband, Professor Layi Erinosho for mentoring me; and our wonderful children-Temitope, Bolanle, Bisola and Babatomiwa - for their cooperation with daddy in providing an excellent home support for me to flourish in my career. May the Almighty Father take all glory and adoration.

Mr Vice-Chancellor, today's lecture is not intended to depict a paradigm on the oppression of women by men, but to examine the facts about women as "critical" missing actors in science and technology. It is undeniable that some accomplished female scientists have been produced, but many potential promising ones are still being discouraged. Even though women are increasingly facing the need to use scientific knowledge and technological skills in today's high tech world, only a few are studying the relevant subjects that could help them to hold the right key that opens the door and/or gain control of the field. The sad truth is that science and technology is still largely a men's enterprise – leaving out a significant proportion of women from 'taking part in shaping the modern world'.

The 21st century is witnessing tremendous changes that require an understanding of the technological advances that benefit humankind. There are challenges in Biotechnology, Information and Communication Technology (ICT), Spatial Information Technology, Reproductive Technology, HIV/AIDS, and Environmental Management that necessitate the need to harness the capacity of all human resources for innovative research. Consequently, with our future becoming increasingly defined by science, society must strengthen the scientific and technological skills of its citizenry within a framework of equity in order to 'empower all' to participate in the development agenda. Women, as much as men, should control technological innovations and applications to ensure balanced perspectives, experiences and equal enjoyment of the benefits. Moreover, all students must have unrestricted access to the knowledge of science to

gain insight into the foundation of many of the achievements of humanity (Lederman, 1992).

The key question is: what makes science less welcoming to women? In order for us to address the question, this lecture will attempt to examine women in science; the forces that act as barriers against them as active players, including those that facilitate their participation in science. This lecture is premised on the fact that formal education is a pre-requisite for the empowerment of women in the development process while science and technology education sharpens their contribution to technological transformation. The education of women and gender parity in science education are therefore cross cutting issues in the promotion of the development agenda.

Empowerment and Women

Empowerment is human development. It is about helping both males and females to become accomplished human beings with capacity to analyse the roots of their own problems and choose appropriate actions on the basis of their own analyses. Empowerment is the core of gender equality and the pathway to "equitable access to power, resources and decision making" (Linkages, 2004) at the household, institutional and societal levels. Empowerment of women entails a process of building their resource capability and skills for leadership, rights, and meaningful participation in all spheres of society.

The last decade witnessed commendable progress on women empowerment and gender equality worldwide, but to varying degrees in all the sub-regions of the world. The good news today is that women, most especially in developing countries, have more freedom, are more educated, more productively employed while many more of them occupy managerial positions than before. They now participate more than ever before in decision-making at the domestic and national levels while many more are in the public spheres, holding political positions. For example, more than two-thirds of countries in the world record significant increase in the number of seats held by women in their parliaments. In addition, gender-related development indices (GDI) increased significantly to over 0.7 in about 105 countries in the world (Human Development Report, 2004). The following international human rights instruments have also strengthened the legislation on women empowerment and equality agenda:

- International Convention on the Elimination of All Forms of Racial Discrimination, 1965
- International Covenant on Civil and Political Rights, 1966
- International Covenant on Economic, Social and Cultural Rights, 1966
- Convention on the Elimination of Discrimination Against Women, 1979
- Convention Against Torture and other Cruel, Inhuman or Degrading Treatment or Punishment, 1984
- Convention on the Rights of the Child, 1989
- Convention on the Elimination of Sexual Violence and Sexual Discrimination, 1995

Despite the gains, women still enjoy far less opportunities than men, especially in Sub-Saharan Africa (SSA). Almost all countries in the region including Nigeria rank low on Human Development Index (HDI) while Gender Development Index (GDI) is generally below 0.5. The stark reality is that women's low status has not changed substantially in SSA. Their annual earned income is less than US$1000 in about 2/3 of the countries, and lesser than men's. There are still large gender disparities on basic human rights and access to economic opportunities while gender power relations have not been significantly altered. The disparities between men and women in some key institutions in Nigeria are illustrated in Table 1.

There is no doubt that women still play an insignificant role in the exercise of power in the country. Are there not enough qualified women? Why are women's achievements invisible and not being adequately recognised and/or celebrated? Distinguished ladies and gentlemen, we must ponder on these questions if we want to change our society for the better.

Table 1: Women's Participation in Key Positions in Nigeria

	Total	Female	%Female
Vice Chancellors	50	2	4.0
Registrars	50	7	11.9
Pro-Chancellors	50	1	2.3
Appointed Council Members (Federal Universities)	161	3	1.2
Seats in Parliament (Lower House)	450	30	6.7
Seats in Upper Houses	108	3	2.8
Ministerial level	72	16	22.6
Speakers of State Houses	36	2	5.6
National Political Reform Conference	375	31	8.0
Appointed Council Members, OOU 1983-2005	41 (5 sets)	5 (1 per set)	12

Our society is still overburdened by a variety of unwholesome practices, laws and customs that undermine the well-being of women. They constrain women's access to jobs, livelihoods, opportunities, basic facilities, rights, and entitlements. Or else, how can we explain that in the 21st century women must seek consent of their spouses (if married) or fathers (if single) to obtain international passports, bank credits and loans? What about those customary practices like widowhood rites, disinheritance, female genital mutilation, "*oro/agemo*" festivals etc that are still deep-seated in our culture that undermine women's freedom and good life? Even religion that should normally provide consolation seems not to be helpful. Discriminatory verses in the Holy Scriptures are invoked to limit equitable partnership between men and women in society. For example, Timothy (2v11) says "Let the woman learn in silence with all

subjections…But I suffer not a woman to teach, nor to usurp authority over the man, but to be in silence". Mr. Vice-Chancellor, as much as one endeavours not to stretch the examples too far, I believe that this is the way that we can appreciate the barriers against women today. Can we afford the opportunity cost of not ensuring equitable power relationship that would strengthen their role in key decision-making institutions in the society? How do existing social and political institutional structures limit and/or support their access to power? These and other questions should also bother our minds in the quest for sustainable development, peace, and social justice.

Women, Science and Development

Science is basically about becoming aware, exploring, understanding, and exercising some degree of control over the environment through the senses, and personal exploration. It is a system of procedures for generating knowledge about the physical nature and the living aspects of nature- in fields such as physics, chemistry, biology and earth science. The practical outcomes of the knowledge and experience broadly describe technology. Correspondingly, science education entails the intellectual activities that are concerned with teaching and learning science to lead students to "know, understand and practice the scientific methods in their daily interactions with nature and natural phenomena" (Yoloye, 1998), while technology education sharpens their skills, knowledge and experience to develop products to meet human needs. Science and technology education provides fascinating experiences, knowledge and understanding about our natural system" (Wandiga, 2000), promoting creativity and innovations, and facilitating rational understanding of nature's secret. Scientific information creates powerful tools for technological innovations and inventions that could translate into creative use for the advancement of humanity.

The potential of science and technology for improving the quality of lives and the socio-economic development of nations has been largely demonstrated in various innovations. Health care has improved as a result of sophistication of medicines and supporting systems in hospitals. Modern bioengineering has improved farming systems even as they are just emerging in developing countries. ICT has advanced globalisation while the increasing complexity of transportation has promoted socio-economic activities. Finally, reproductive technologies have reduced infant mortality and maternal deaths.

Nigeria appears to appreciate the role of S&T as key to national development and is committed to S&T education. For example, science and technology has featured prominently as a distinct sector with specific budget since the 3rd National Development Plan of 1975-80, culminating in the creation of the Ministry of S&T in 1979 to take responsibility for the: (1) promotion and development of science and technology research in the country; (2) formulation of National Policy on S&T; and (3) promotion and administration of technology transfer programmes. Also, science and technology education has been in school curricula over decades with lofty objectives in the context of general science at the primary level, integrated

science at the junior secondary level, and specialised subjects at the senior secondary level. The philosophy of education as contained in the National Policy on Education also emphasises "the need for scientific and technological progress of Nigeria as a nation…"

Despite the lofty goals, policies, and budgetary allocations, science and technology is yet to make significant impact on national development. Nigeria lags behind in the utilisation of technology for the well-being of the people and is still very far from occupying the "driver's seat" or even sharing in driving the high-tech revolution. Science and technology in the country falls short of the expectations to meet the needs of the majority of people. After more than four and half decades of independence, the general state of people whether in the towns or villages is still one of deprivation and underdevelopment. Today, many Nigerians, mostly women and children, live in inhospitable rural communities, using fire wood to generate energy for cooking; fetching unclean water from streams and rivers; riding *'okada'*; ploughing with hoes and cutlasses; and lacking access to modern health and communication facilities. Yet, the country is richly endowed with the human and material resources needed to achieve great strides in S&T. So long as our nation fails to maintain a high-level scientific and technical workforce, it would remain under-rated within a generation. Therefore, the challenge to develop and maximally utilize human capacity to practice science and technology makes demand on the nation to address the under-representation of women scientists and engineers. Leaving women as unutilised and untapped resources in our population will keep the nation's S&T profile at its lowest.

While women constitute about 50% of the general population, they make up less than 20 % of practising scientists and engineers. Our women are also not participating equitably as professionals in the industry. They are grossly under-represented in top management posts and in key technical jobs in the industry. The picture is gloomier for women in academia. Of the total faculty in the sciences, the females constitute just about 10%. For every female in the different disciplines, twenty-six males are in engineering, fourteen in environmental sciences and seven in the sciences (NUC data, 1998). Even then, relatively few women reach professorial and leadership positions.

Data on female participation in university education (Table 2, Figs. 1&2)) shows the disparity across disciplines. Females are fairly under-represented in the sciences and grossly under-represented in engineering/technology and environmental sciences. They are more in the medical sciences (38.9%), followed by pure sciences (29.1%) and fewer in environmental sciences (24.0%) and in engineering (11.6%). For every female that is enrolled for courses during the period (i.e. M:F in 00-04), eight males are in engineering, three in environmental sciences, and two in natural sciences and in medicine (compare with law, arts and education that recorded near parity).

Moreover, female participation is still lower than male at the level of secondary education. The trend is for girls to show preference for biological sciences than physical when choices are made. For example, girls formed 32% of arts students, 28% of social science students, and just

17% among the natural science students at the secondary level in 1996 (i.e based on entries at the SSCE).

Consequently, if the rank of women in S&T will be enlarged, there is a need to tackle the factors that turn girls from prsuing scientific fields in order to enable them as much as boys to enjoy a welcoming climate in S&T. Of priority is the need to improve also the quality of science curricula at all levels so that all students can experience exciting, relevant and worthwhile science education that will sharpen their skills for technological innovations.

Table 2: Student Enrolment in the Universities by Discipline, Gender and Year

Discipline	00/01			01/02			02/03			03/04			00/04		
	M	F	%F	M	F	%F	M	F	%F	M	F	%F	F	M:F	%F
Arts	9747	7655	44.0	11808	10466	47.0	8287	7456	47.4	4530	4007	49.3	29584	1:1	46.3
Education	12292	11045	47.3	14777	13625	48.0	9452	7749	45.0	4441	4463	50.1	36882	1:1	47.7
Eng./Tech	24244	3278	11.9	41920	4376	9.5	14442	2783	16.2	7567	1079	12.5	11516	8:1	11.6
Environ. Science	3278	956	22.6	6877	2168	24.0	3862	1266	24.7	553	199	26.5	4589	3:1	24.0
Medical Science	10340	6826	39.8	14180	8794	38.3	6395	42082	39.7	5912	3678	38.4	23476	1.6:1	38.9
Science	25658	10608	29.3	31409	15465	33.0	20022	9415	32.0	10822	5183	32.4	36001	2.5:1	29.1
Soc. Scs.	21811	11600	34.7	21503	14025	39.5	13753	7791	36.2	8922	6535	42.3	39954	1.7:1	37.7
Law	5109	4002	43.9	6342	4730	42.7	4081	3144	43.5	2688	2646	49.6	14522	1.3:1	44.4

Source: National Universities Commission, 2004

Fig. 1: Students' Enrolment in Nigerian Universities, 00-04

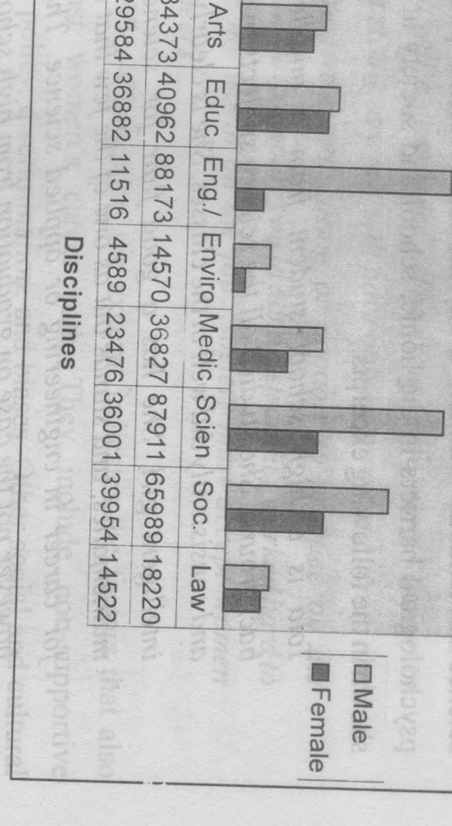
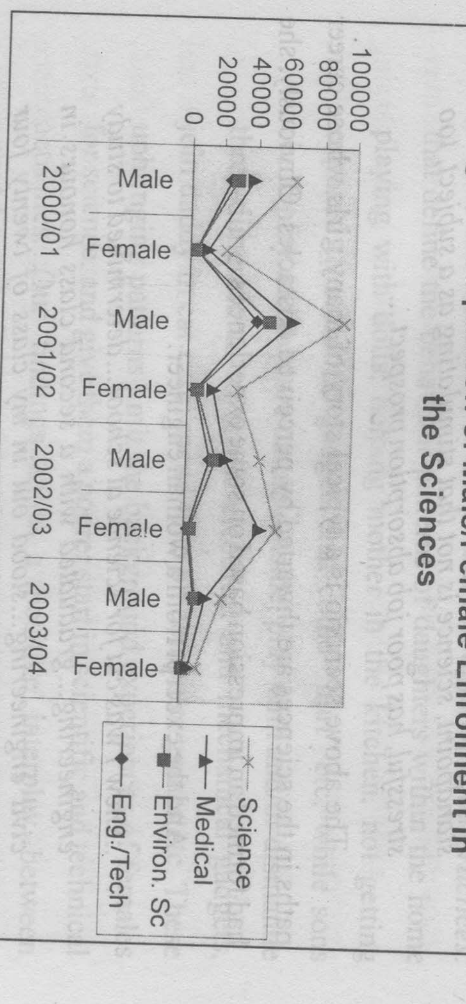


Fig.2: Comparison of Male/Female Enrolment in the Sciences



What Are the Critical Filters?

What is heartening today is that research has proved that the long-standing misconception about women's lack of intellectual capability for science is tenuous. Rather, a myriad of evidence points to socio-psychological barriers in the home, school and society at large. This is shown in the following excerpts:

Tola is a high school student from a middle class background. She studied all the science subjects in school, and consistently did well in the classes. She is clearly a very intelligent girl. She has a good flair for science and mathematics, and stands out as one of the few that are cut for career in engineering or applied science. That was however not the case on graduation from high school. She applied to read accounting in the university. From her standpoint, science is not that stimulating as a subject, too stressful, has poor job absorption prospect ...

The above scenario is a typical story of many girls whose career paths in the sciences are thwarted by perceived obstacles. Obviously, she had formed an impression based on some experiences.

And the excerpt from a woman engineer:

..knew I was cut for science at school...determined to study engineering...graduated with a second class honours in civil engineering...stood out in my class of twenty four males and three females...constantly harassed by my

friends that I chose to stress myself unnecessarily studying a demanding, difficult course which might not pay off afterall, especially when we had to stay on late in the engineering workshop...bent on my ambition... Almost blackmailed to find a willing employer... The excuses are many - a woman is not stable at work, will have babies, go on maternity and excuse leave, not strong or capable to practice on the field...like to employ you in administration...worked hard to prove my worth on the job...society must accept women engineers...

Mr. Vice-Chancellor, the excerpt indicates the factors that also work against women's career path. They include non-supportive institutional policy, discrimination, and biases. Other social and cultural factors thatundermine women's behaviour pattern in science are:

a) *Family socialisation processes and sex-differentiated practices:* that define the behaviour patterns of daughters within the home playing with dolls, helping mother in the kitchen, not getting exposed to scientific gadgets that could "hurt" etc; while sons could play and explore nature outside, play with and/or dismantle three-dimensional toys; use electrical and mechanical gadgets, join daddy in car care, spend time on computer games etc. These upbringing patterns limit the background experiences of females for science, and give them a poorer start in scientific and technical activities. Our findings show a positive interplay between scientific experiences and girls' science participation (Erinosho 1999).

b) Polarisation in interest and experiences among boys and girls:

Research shows that girls' interests are around academic and life science activities, which also reflect their interest in biology and medical-related fields whereas boys get more involved in tinkering activities that stimulate their interest in applied sciences.

c) Socio-economic factors: Many families, because of the burden of costs of S&T education and the societal attitude towards the education of girls in S&T, are wont not to encourage theirdaughters' interest in this field.

d) Inadequate role models/mentors:

There is gross under-representation of women S&T teachers at all levels that can serve as motivation and/or mentor for young girls. Even the few women scientists that have blazed the trail in their career are poorly documented and sometimes misrepresented inrelation to the field.

e) Poorly resourced science learning environment: with over-crowded and/or large science classes, lacking basic learning resources, and taught by teachers that have not developed the appropriate teaching techniques (Erinosho et. al.2004).

f) Gender insensitive curriculum and school texts:

Research reports and anecdotes indicate that the curriculum and texts in science tend to misrepresent women in relation to the field.. As children learn what is expected of them mainly through texts, the extent to which they internalise these images will influence their behaviour patterns.Our analyses of 79 science texts (with a

total of 1258 chapters) in use in secondary schools show the biases (Erinosho, 1997): they almost exclude females in the examples and illustrations; omit the actions of women; cite more male generic nouns/pronouns; show females in restricted roles in relation to scientific activities; and link males with a wider array of scientific occupations and equipment than females. On the average, three out four references to human characters in the texts are male. (see examples).

g) Regular use of didactic teaching methods - including mainly lectures or talk-chalk methods, whereas evidence show that girls are more responsive to instructional methods that foster collaboration and cooperation or learning methods that are context-related (Erinosho, 2000).

h) Differential teacher-pupil interaction - which is less intense for girls. Anecdotes indicate that teachers are wont to give more encouragement to boys than girls, and ask more focussed questions from boys than girls;

i) Inadequate assessment techniques - focusing more on cognitive domain and multiple choice test types whereas evidence suggests that male students are at an advantage over their female counterparts on multiple-choice format while girls perform better on essay type test (Erinosho, 1994; Murphy, 1982).

j) Teachers' low expectations from girls - Evidences show that teachers tend to:

- Direct more questions to boys than girls

- Allow for longer "wait-time" for boys than girls; and
- Pass comments that are often discouraging to girls.

k) Gender insensitive science teachers on the psychology of girls- For example, it is not unusual for teachers to demarcate boys' and girls' names in the register in colours, in which case girls' names are in red that is also used for fail grades in their mark sheets. Invariably, the extent to which they internalise these biases will limit the chances of girls to realize their full potentials because it could affect their self-concept and motivation.

l) Insensitive work environment for practicing women scientists Women scientists generally have unequal opportunities for employment; and less opportunity for networking and accessing mentors because only a few of them reach positions of influence that make them visible as models. Working more against young women is the lack of integration of their needs into work conditions. For example, only few organisations have child care supporting facilities for young women scientists during child-rearing.

m) Biases and misconceptions about women and science

- Science is male enterprise - that can be successfully practised only by "men" or those who possess manly attributes. Traditionally, scientific traits are believed to include "remoteness, abstractness, impersonality, detachment and objectivity, which more often than not, are traits that are readily associated with societal conception of masculinity, possessed by male in society;

whereas feminine attributes are held to include "feeling, concern for nature, coyness, nurturance and subjectivity " (Birke, 1986; Manthorpe,1982). This masculine misconception of science has therefore been found to produce "difficulties for women intending to work as scientists" (Kennedy, 2000).

- Women lack the ability for science – because it is assumed to be difficult and abstract" field. The misconception is that women do not possess the constitution regarding their capacity for the analytical and visual-spatial skills needed for abstract reasoning. The claims are that genetic factors (Gray 1981), hormonal factors (Boverman et al. 1985), and brain lateralisation (Sherman 1979) are deficit in females, making them to be naturally ill-equipped to pursue science. However, these have been proved to be tenuous. There is no scientific evidence that females have lower IQ than males, or that non-science subjects require lesser intellectual ability.

- Marriage and scientific practice are incompatible. Largely because science-related careers have in-built inflexibility in work schedules, requiring those involved to be taken out of their homes to the laboratory or in the field, they are perceived to be incompatible with women's responsibility to meet the dual-role demand of home and work. However, of 209 women scientists and technologists whose career paths we studied, close to 70% of them reported to have had exciting career and successful marriage, complimented by strong spousal support (Erinosho 1993).

- Special women study science. The misconception is that science is a difficult field, requiring special IQ, and appropriate for persons with certain attributes. However, like any other field, the attributes could be developed over time.

Mr. Vice-Chancellor, distinguished ladies and gentlemen, the foregoing are examples of challenges that are thought to be making the climate "chilly" for women and science. Therefore, we must show appreciation for these limitations on their behaviour patterns, lest we continue to 'second-rate' women in S&T fields.

Women as Scientists

Against the backdrop of the foregoing, what factors facilitate women's entry into the field? We attempted to answer the question by listening to the voices of those in the field (Erinosho, 1994, 2005). The following excerpts illustrate the portrait of girls/women in science and technology:

MS A, 24 years old studying computer engineering:

My father is an engineer, mother a nurse.. two of my brothers are engineers, one a computer scientist. I am last of the family... think I am influenced by them...always busy talking engineering language at home...I also like to be like them... successful engineer, and I have the flare for it. Like to work on machines, .play on electronic gadgets, read manuals and find out how gadgets work.. My brothers have been supportive in my school work...they explain things to me and encourage me to do well. Daddy and mummy are also supporting me... mummy is so much involved in my work...she knows much about my program.... I

was doing very well in physics and mathematics, not too well in biology even though I passed the final exam...We had good teachers in the subjects, the physics teacher was a woman... friendly and I like her confidence when teaching...The other teachers also tried...Who says women can't be good engineers.. cannot even see what is difficult about it once you understand the principles...people respect you when you say you are studying engineering...don't see myself different from the boys...like them more as my friends...they dare not look down on me...People say I am tough...I am friendly, just that I like to get things done well... I have enjoyed my program...and will recommend it for many girls and boys. I think girls always like to give way to boys, that's why they say engineering is for them...just be confident and move forward when assignments are given or practical work is on...and you will be respected. Well, I hope it will be as exciting too when I start working..

MS B, 20 years old studying computer engineering:

My father is a pharmacist and my mother an architect. My father is strict, and will not allow you to be lazy both at home and at school...We had good time growing up and we had good support from our parents...mummy visits us regularly in school and even in the university...she sees to our welfare...they are both good parents, and like us to do well...daddy tells us "work hard, and don't be dependent on people" We had home teachers in school ...I liked science subjects in school and was doing well...like to work on the computer.. Nothing is difficult for girls...people say engineering affects women when they marry...but my mother is a scientist, and she is happy...the more reason I am determined to study engineering and do well…think I am blunt, and don't easily give up when I want to get things done…I think its good for girls to be strong otherwise people will overrun you...I know am strong willed, and do not like failure..I am highly independent and that's the way my parents raised us..even when we were young, they made us to do things by ourselves. I like challenges, and also like to take part in competition…the fact that I don't like to loose makes me to work harder..I don't like people to stand on my way when I determine to do something… I enjoy the company of girls and boys in our class…I don't know what the climate of engineering profession is for women, but when I get there, I will cross the bridge…just let them give me a chance.

MS C., Ph.D. Mathematics, in her fifties and happily married with children

I developed interest and showed flare for mathematics from my youth. I place on record the support and encouragement that I received from my parents, which enabled this trait to manifest. My parents were educated and they also appreciated the value of education... I attended a girls' secondary school where I had all the opportunities to develop my mathematical skills. It was with dogged determination that I pushed my way through school to the doctoral level despite mounting pressure from people around that as a career mathematician, I might not find a husband. Today, I have succeeded in raising a family as well as chart a career path in mathematics for myself.. I have had a pleasant experience. some of

my weapons for success include calmness in the face of mounting pressures and tension, dedication and hard work, sound training and an understanding spouse.

MS.D, Ph.D civil engineering, I her forties and a mother of three

I did not suffer any discrimination or deprivation resulting from my sex in the midst of my brothers. There was the encouragement, and going to school was a matter of compulsion. I knew that I had the flare for mathematics and physics. So naturally, it occurred to me to take straight courses that had some application of mathematics and physics. Even though my brother who was reading engineering in the United States tried to remind me that engineering was not for females, I ventured into it undaunted. Just because of the natural flare for what I wanted to do, I did not really think of what the future would be like. The fact that I was the only female in the class did not discourage or deter me neither did it have an intimidating effect. My recollection of my experiences is one of confidence and respect, especially as I was maintaining high academic performance, and the men were friendly. In fact I was relaxed in their midst. I have enjoyed my working life and cannot say that I have suffered deep discrimination. For women, it is always there, but for me as a person, I have refused to acknowledge it. The course has given me a lot of pleasure.

The portraits show that women have to be placed in special circumstances before they can excel in S&T. They must enjoy the support of their parents in their formative years, support of spouse after marriage and possess certain personal attributes - assertiveness, determination, hardwork, strong-will, confidence etc. Besides, they must show interest in, and be confident of their ability for science nd mathematics. Finally, the importance of role models for interaction and assurance of career in the fields cannot be downplayed.

Supporting Girls in Science

The evidences over time show that the present trend on the status of women and science can be reversed by 'catching girls young'; stimulating their interest in science; confidence-building; making the subjects less difficult and abstract; and providing supportive school and home environment.

Mr. Vice-Chancellor, Sir, I observed in the course of my research that loss of confidence is a critical factor among Nigerian girls. Lack of confidence arising from poor performance deters them from choosing science majors. The challenge is therefore to increase their confidence and improve the methods of teaching science at the high school level.

I initiated two programmes to attract girls into the study of science: (1) "Learn Science by Doing" (1999) for beginners in science to build confidence, interest and achievement; and (2)"Linking School Science to Community" (2001) to improve the teaching method in senior classes.

Learn Science by Doing is a manual developed in conjunction with Dr. K. B. Olurin of OOU, Mrs. K. Banjoko, Mr. Femi Adepitan and T. Fasunwon (all of Tai Solarin University of Education). It adopts a pedagogical approach that emphasises a shift from teacher talk-and-chalk to cooperative/collaborative "hands-on, minds-on", activity-based learning and skills development. The manual has an approach to science

instruction that is characterised by six features:

(a) *Discussion,* which allows for collaborative and active interaction between teachers and students as well as give students a sense of responsibility to the group and to the learning goals.

(b) *Investigation,* which helps students to develop science investigative abilities and to carry out practical activities.

(c) *Hands-on Activity,* which encourages students to become involved in practical assignments or projects through which they are assigned tasks that stimulate their senses and give them roles in the learning process.

(d) *Minds-on Activity,* which encourages students to apply and link their science knowledge to everyday phenomena.

(e) *Formative Test,* which gives students opportunity to express, through non-threatening and non-graded assessment, their ideas and knowledge about a topic.

(f) *Continuous Assessment,* which gives teachers and students opportunity to assess level of conceptual learning.

The strategy introduced fun and excitement into science learning, increased participation and girls' interest in beginners' science (see fig.3).

Fig. 3: Girls doing science

Collaborative/Cooperative learning technique was found to be beneficial to girls because it helped them to work and teach one another. In addition to promoting group work, it facilitated discussion and encouraged students to imbibe the spirit of "doing science". Previous studies found that collaborative learning is effective for promoting group work (Solomon, 1994) and mastery of science materials (Davis, 1995). It also facilitates effective discussion and encourages students to imbibe other essential elements that are beneficial to teaching and learning. A cooperative learning environment fosters:

- *Positive interdependence:* Individual contribution affects the work and success of others. Therefore, students enjoy the benefit of sharing information among themselves;
- *Face-to-face interaction:* Students help and support one another to learn because they depend on each other;
- *Individual Accountability:* Each individual's work is taken into account and assessed.
- *Social Skills:* Students learn to use the necessary social skills such as leadership, communication, trust-building and conflict management.
- *Group Process:* during which students are made to analyse the achievement of their goals and maintain working relationship (LaComber, 1992).

More importantly, collaborative/cooperative learning technique is an effective strategy for ensuring quality science learning among girls because it promotes the use of scientific skills such as observing, manipulating, inferring, and experiential learning. It had salutary impact on students' confidence in science because of the non-imposing, non-threatening and non-competitive environment under which learning took place. Over 65% of the girls chose physics/chemistry in the schools at the end of the 2-year study, which was much higher than about 58% in the previous years.

The initiative on *Linking School Science with Community* introduced "relevance and reality" into science learning. It adopted the social constructivist learning model that enables high school students to contextualise science learning in their immediate community. Rooted in the works of Piaget (1970) and Vygotsky (1978), constructivism is based on the assumption that learning is a process of knowledge construction that occurs through interaction in the social world in which the child is situated (Van Glasenfeld, 1986). Within this framework, science learning is governed by a knowledge base that consists of a conceptual domain built by using pupils' background experiences, drawing relevant experiences, devising skills and linking learning to the dominant cultural worldview of the learner (Resnick, 1989; Prawat, 1993; Jegede, 1998). The experience and the learner's socio-cultural background "provide the platform for cognition in science, which is influenced and determined by prior knowledge that is in turn determined by cultural beliefs, traditions, and customs" (Jegede, 1998).

Taking a cue from this view of knowledge construction, the initiative on *Linking school science to community* exposed the students to informal scientific activities at the local level and also enabled them to see the interplay between school science and indigenous scientific knowledge in the community.

We gathered interesting experiences from this project. The base-line survey involving 220 senior high school science students showed that even though they interacted with common indigenous technologies on a daily basis, they did not show awareness for the scientific principles that guided their operations. Only about 10% were familiar with all the technologies; 35% had interacted with at least four of those technologies; but none of them could identify at least two operational steps that have link to their school science. These outcomes provided useful insight into the

students' lack of understanding of the practical connection and relevance of school science to community science.

The intervention took students out to interact with science in the community (see fig. 4). Not only was interest of the students kindled as they were confronted with real applications of scientific concepts and principles out-of-the-classroom; exposing them to the grassroots also had a salutary impact on their orientation for traditional science. For example, the visit to "*gari*" and *fufu* production sites enabled students to have direct practical experience of the different stages of fermentation, and the concept of bacteriostatis in biology, pH and acidity changes in chemistry. Still in the same technology, application of pressure/thrust in physics was demonstrated in the "presser" for dewatering cassava paste. It was also a challenging experience for students as they assisted the women in the frying process, and had a feel of the discomfort of smoke from incomplete combustion of firewood. At the *aso oke* weaving site, students were confronted with applications of machines. The concept of circular motion (which is often taught by mere definition and memorization of equations) was illustrated with the spinning system for reeling threads. By spinning the central axis of the four-sided wooden structure that is mounted on a short bottle, the system is set in circular motion around the vertical axis. Then, allowing students to try pulling the threads inwards towards the axis or outwards from the axis or just changing the direction in different ways enabled them to experience how speed and radius affect rotation. The principle of providing the gravitational force that keeps the motion is explained by the height of the bottle at the base. The blacksmithery was another exciting site for students to learn about tools production and the links with lever system and moment in physics or flames, combustion and calorific value in chemistry (Erinosho et.al., 2001).

Fig.4: Students learning science in community (cassava presser)

A resource manual on *Science in Action in Community* was compiled in collaboration with Drs. K.B. Olurin (Biological Sciences), A. Babarinde (Chemical Sciences), B. Fasunwon (Physics), and K. Alebiosu (Chemistry Education). The manual: (i) highlights the scientific processes in eleven different technologies in food, textile, metal and household technologies; (ii) establishes the link with concepts in school science; and (iii) organises the materials to provide for easy reference in their application in science teaching.

However, the foregoing savoury reports on the initiatives notwithstanding, teachers are wont not to sustain the strategies due to:

- *Examination-driven curriculum* - the teachers were under pressure to rush through the facts and principles in order to meet examination requirements;
- *Overloading of the curriculum and the teachers* - the learning contents are heavily overloaded and the teachers are overburdened by excess workload;
- *Large science classes:* - with as many as 100 students in a class. It is therefore difficult for the teachers to implement the innovations in the teaching and assessment methods; and
- *Poor commitment to change* because of lack of motivation and encouragement for teachers, they could not be overburdened with the extra demands of the initiatives.

This is a challenge for curriculum developers and policy makers in education to address the issues that undermine effective adoption of initiatives in science teaching.

Concluding Remarks

Mr. Vice-Chancellor, distinguished ladies and gentlemen, my submission is that change in the *status quo* of women and science is possible because the barriers are social. The reality is that we need to do things differently if we want better results. We need systemic change and deliberate commitment to promoting women in the sciences. All the agents of change must therefore develop strategies and practices that help their scientific interests. By this I mean:

1. *Homes* – Parents must be flexible and less stereotypic in the upbringing and exposure of children. They must encourage and support their daughters' interests in science right form their formative years. Spouses must support women to face the challenge of combining career and family. Couples should draw inspiration from 1st Peter, 3(1) - *Wives, fit in with your husbands plans... and Verse 7.. You husbands must be careful of your wives... Be thoughtful of their needs...Remember that you and your wives are partners in receiving God's blessings. If you don't treat her as you should, your prayers will not be answered".*

2. *Education System* – Science Education units in the Ministries at all levels must put in place effective implementation and monitoring frameworks for a review of science curricula and instructional materials for all biases. Tertiary institutions should establish and support Centre for Gender Studies to monitor gender in university curricula and to initiate mentoring programmes for female S&T undergraduates. *An example is the Douglas Hall Initiative Project at Rutgers University (USA) that devotes an entire residence hall to women in math, engineering and science. Graduate students are supported to mentor and hold peer study groups for the female undergraduates. The initiative has reportedly made positive impact on sustaining women in science (Stinson, 1990).*

3. *Government* – at all levels must review S&T policies for balance in satisfying the needs of males and females; put in place appropriate policy implementation and monitoring frameworks; increase

expenditure on science education for quality assurance; and provide resources through loans and bursary for girls' science education. Besides, there is need to establish '<u>Science Initiatives and Research Unit</u>' in S&T ministries at the state and national levels that will coordinate among others, research and initiatives for implementation in schools. More importantly, science teachers need motivation for them to be responsive to changes in their classroom practices. Therefore, science teachers' allowance must be reintroduced, and there must be enhanced salary placement of science graduate teachers. In addition, they must be provided resources to develop their careers.

4. *Labour Markets* – Industries and businesses must expand absorption of graduate scientists, re-examine employment policies to guarantee that they are women-inclusive, and provide work conditions that mainstream the needs of women. All organisations must put in place quality child care facilities and possibly some form of child care support allowance in order to minimize the toll that raising children can take on a female scientist's career.

5. *Teachers* – play an impotant role in making science attractive especially at the elementary and secondary levels. They need to adopt teaching strategies that provide cooperative, hands-on and context-related learning. They must also provide intense classroom interactions for both girls and boys, and be responsive to gender sensitive teaching and balanced assessment strategies.

6. *Schools* – Educational institutions must put in place structures that

ensure:

- *Gender-responsive learning environment* with unrestricted opportunities and relevant experiences for girls as much as boys.
- *Gender-balanced curricula* and classroom experiences.
- Gender sensitive teachers in- and out- of - classrooms
- *Supply of textbooks and learning materials for students.* Research shows that availability of textbooks and learning materials is consistently a positive predictor of school achievement (Heyneman et. al., 1978). A cursory review shows however that many students have no access to S&T learning materials and depend solely on teachers. Therefore, government should support schools to reintroduce the 'school texts loans scheme' for all students, with small rental charges to ensure its sustainability.

Finally, I like to advocate Special Girls'Science Schools. While I appreciate the benefits of mixed-sex schools for promoting cross-sex relationships, evidence supports all-girls science schools (Erinosho, 1993, 1994). It was found that girls excel more in science in all-girls than mixed-sex schools, and are likely to pursue a career in science. Besides, laboratory observations suggest that when placed in a mixed-sex group, girls tend to assume passive role, leaving the experiments to boys. Therefore, while not undermining the present policy of mixed-sex schools, I suggest (even if only for affirmative action) that the few existing girls' schools should be redesignated as Special Girls' Science Schools, with all the necessary facilities in place to support quality science learning.

Mr. Vice-Chancellor, Principal Officers of the University, distinguished ladies and gentlemen, I like to conclude this lecture with the

excerpt from the 1999 World Conference on Science: *Unless there is a general commitment to making science a shared asset benefiting all peoples on a basis of solidarity (and equity), there will be no globalisation with a human face (Mayor, 1999).* And I also re-echo the women slogan: NO WOMEN, NO DEVELOPMENT!!!!!

On a final note, I express my deep appreciation to everyone for the honour of being here today to grace this occasion. Your presence individually and collectively has added colour to this programme. May the Almighty Father honour you too, and grant you His blessings and journey mercies to your destinations.

THANK YOU FOR LISTENING

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