IT'S ALL IN THE BRAIN: OF GENDER AND ACHIEVEMENT IN SCIENCE AND TECHNOLOGY EDUCATION

BY
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Introduction

I feel honoured to stand here this afternoon as the Inaugural Lecturer. Prior to this day, a friend had jokingly referred to me as the proverbial bridesmaid who will remain a brides maid but never a bride. I guess this is because of my role as a member of the Senate ceremonials Committee that is always packaging peoples Inaugural Lecture but have never given one. This prompted me to take the bull by the horns and I thank my friend for that joke.

I have come this afternoon to tell this august body my story, and submit my report card on my academic journey so far.

I became conscious of this journey in St Michael's primary school in Umuahia as the smallest girl in the class who could communicate in "passable" English when it was an offence to speak "vernacular". The teachers were always "sending" me. I also know that I was in the same class with my elder sister. I never got to know exactly how that came to be. All I recollect was that she came back from Zaria where she had been living with our grandfather and had to

be placed in my class. We did not have the privilege of going up to primary 6 before the outbreak of the civil war. At the end of the hostilities, every body went to secondary school except me because I had chicken pox. By the time I was healed, it was almost too late to find a school that could take me. The search took my late father to old Umuahia when he was told that an old friend of his, the late Mr. Mackay Maduagwu was the principal at Evangel High school. As a favour to an old friend, I was accepted into secondary school in the second term, on the understanding that I will start proper Class One the following year. That was not to be as I passed out with flying colours, doing better than two-thirds of the students who started at the right time.

After one year, I had to transfer back to Holy Rosary Secondary School, Umuahia for two reasons, one because it was nearer the town where we live and I will not need transport money to take a bicycle to school, and secondly, to make sure that I do not continue with the Assemblies of God way of praying which I had become adept at during my one year sojourn in Old Umuahia. At Holy Rosary, I became a house prefect in my 4th year which was also my 1st year as a boarder. I had to go to school from home because we all had to assist mama in her "akara" and "akamu" business to make enough money for our fees. There were nine of us in the house because the male child was late in coming. Thank God they eventually came as numbers 8 and 9. The following year, (1974), which was my final year, I became the Deputy Head Girl. I had the opportunity of being taught by the best crop of teachers any body could wish for. I still have fond memories of Mr.

Udeozor, my Chemistry teacher; and my Principal, Mrs. Bridget Nwankwo who also doubled as our English teacher and taught us the proper use of the English Language.

At the point when everybody was filling the forms for Entrance examinations into Universities, I could not join because I reasoned that there will be no money to see me through the University. I thank God for one of my teacher's who is now late, Mr. Imo from Aro-Ndizuogu, who obtained a form for Alvan Ikoku College of Education and encouraged me to try because for the first time in history, that great institution was going to give people with "awaiting result" an opportunity to train as teachers, thanks to the pioneering role of the late Professor B.O. Ukeje. That singular act of kindness by the late Mr. Imo took me a step further on this journey. My sojourn in Owerri was fulfilled because I had a mission, and hence I came out with credits and distinction. Here again, I had the privilege of being taught by great educators: Prof E. Akusoba (Chemistry), Prof F. Ndu (Biology), Prof Romanus and Dr Nancy Ohuche (Education); and a host of others.

After my youth service I taught in one of the new community secondary schools that were established at the time. In this school, I was the next highest qualified after the principal. Here again I enjoyed a wonderful relationship with my Principal, Mrs. Uche Dallah-Ejikeme, who housed and fed me for the two years I taught in her school. In this school, God also gave me lasting friends that included the Adirikas, especially, Prince Sir Amoo and Dr Lady Bakky Ngozi Adirika. When at the end of 2 years I told my colleagues that I was going to the University, my less

qualified colleagues, who were mostly Grade II or Auxiliary teachers were 'shocked' because in their words, "I will be too educated may not be able to get a husband". I then told them that I actually need to get that educated to ensure that I price myself out of the reach of the "husbands" that were available then. With my little savings, and promise from my cousin, Emeka who had graduated from UNN and was working in Lagos, I found my self in this great citadel.

A significant thing that happened during the Alvan years was that one of our Lecturers then, a youth corper, now Professor O.J. Jegede, the Vice-Chancellor of the National Open University of Nigeria,(who also became a life time friend) told me that I am an academic material, (what ever that meant), and that I must make sure I get a PhD. While I was in UNN, Prof Jegede who had also started a career in Academics met Prof Eunice Okeke in a conference and asked her to look out for me in her class in UNN. Let me remind Prof Okeke of her words when she came into our Biology Methodology class in 1980: "**Who is Uche Mbakwe in this class … they told me that you are an academic material, I will work with you, watch you and see whether you are serious…"** That marked the beginning of the last lap. Prof Okeke took me on and I never let go, she ended up being my supervisor as I worked for my three degrees in UNN under her tutelage, and even now, I am still stuck with her. Professor Okeke taught me and taught me very well to the extent that I can stand wherever and whenever and hold my own. She is now my friend, sister, auntie and mother. My family and close friends will always refer to her as ""MAMA GI" whenever

they have cause to refer to her. I cannot ask for a better mum. I have wondered whether our bonding was because my biological mother also has Eunice as her name. Looking back in retrospect I can see some similarities between Auntie Eunice and my mother, they are both strong women. Auntie Eu, I am very grateful and can never forget.

When I finished my first degree in Education Biology, Prof Amobi, the then HOD of Botany Department invited me to his office and tried to convince me to do my Post Graduate work in Botany. This was because I did better in my Botany courses than in my Education courses. Here again I have fond memories of my teachers: Profs JNC Maduewesi, D. Eboh, E E Ene-Obong, C.O.C Agwu, G.C.Uju , V N Chiejina and a host of others. I told Prof Amobi that my mind was made up for Education since I desire to be a teacher. At the time, I was not too sure how to go about getting a higher degree in Education or actualizing my dream of ending up as a lecturer in Education. I wanted to first get a teaching job, be posted to a school in Nsukka and then take it from there. The late Professor R. O. Ohuche who was the Head of the then omnibus Department of Education invited me to his office and told me that I was the second best graduating student from the Science Education discipline, even though I made a second class upper. The best graduating student in my set being Boniface Ginikanwa Nworgu (now Prof BG Nworgu) who made a first class in Education Physics. Professor Ohuche then took me by the hands to the late Professor GBI Onuoha, the Director of the Institute of Education and told him that the Department cannot absorb

the two good students they produced in Science Education and that he should find a place for me in the Institute of Education. This marked the start of my career in this University as a Graduate Assistant in November 1982, having graduated in July 1982.

When I got to the Faculty of Education, I wanted to go into Guidance and Counselling which was a fairly new course in the Faculty of Education at the time. I thank God for Professor Eunice Okeke, the late Prof R.O. Ohuche and Prof Emeritus OC Nwana who insisted that I remain in Science Education. I thank God I did, because here I am.

MY RESEARCH EFFORTS

Over these years, I have joined efforts with others to work in the area of improving students' achievement in Science Education. I have studied some of the theories propounded on how students learn science. I have worked with others in trying to unravel the mysteries behind achievement in Science. It is in the quest of these studies that I came to understand the level of under representation of females in the area of Science Technology, Engineering and Mathematics (STEM). Further investigations in this area led me to the conclusion that achievement in STEM is all in the brains. I am using brains here as a direct translation of the Igbo word "ISI AKWUKWO". This brings me to my Lecture topic, and an issue on which I have worked with other colleagues to unravel: WOMEN AND ACHIEVEMENT IN SCIENCE, TECHNOLOGY, ENGINEERING ANT MATHEMATICS (STEM), hence my topic: IT IS ALL IN THE BRAIN. The questions I can hear agitating people's mind will include:

WHAT IS IN THE BRAIN, IS IT THE CAPACITY TO DO SCIENCE? IS IT THE FACT THAT FEMALES CAN NEVER BE GOOD ENOUGH IN SCIENCE? IS IT … IS IT…?

My lecture will be organized under the following headings

- **Science Education and Education in Science**
- **Assumptions of Science**
- **Science Process Skills**
- **Ethics of Science**
- **Science Learning and Scientific Literacy**
- **How do we learn Science**
- **Gender Issues in Science Education**
- **Factors that negatively influence Female Participation and Performance in Science & Technology**
- **Research evidence to show that it is all in the brain**
- **Encouraging Female Participation and Achievement in Science Education**

Science Education and Education in Science

The word science has been variously defined by many. For our purpose, we shall look at Science as the study of natural phenomena. It is distinguished from other fields because it relies on the hypothetical-deductive approach. It also limits itself to the physical, measurable and observable realm. Although this has greatly increased its reductionist approach, it operates at the safe level of the accountable. In its quest to observe, describe and explain natural

phenomena, it has amassed a great deal of knowledge and facts. Over the years, these have become formalized into systematic bodies of knowledge in the fields of biology, chemistry, physics and geology.

Man as a social being transmits knowledge and ideas from one person to another and from one generation to another. Science is one of such areas of knowledge that needs to be constantly and continuously transmitted. This job of transmitting science knowledge falls on the science educator. The science educator is influenced by the scientific community, but is not bound by the sub-cultural characteristics and ideologies of the scientific community. He transcends the boundaries to understand the more varied vistas, which practice of science opens. The science educator understands the nature and processes of science, and appreciates the sociological, philosophical and epistemological aspects of the scientific enterprise. This understanding is extended to technology. Reference to Science education is now almost synonymous with Science, Technology, Engineering and Mathematics Education, popularly called STEM.

Science education, according to Okeke (2007) is an integrated field of study which considers both the subject matter of science disciplines such as Biology, Chemistry, Physics, Agriculture etc. as well as the processes involved in the learning and teaching of science. It can be said to embody all education processes aimed at providing unlimited opportunities for learners to understand and utilize necessary knowledge, skills and attitudes required to operate effectively in a scientific and technological society.

In other words, science education implies exposing learners, usually prospective teachers of science, to scientific and technological knowledge, to the nature of science and scientific processes, to scientific attitude as well as equipping them with professional skills of a science teacher.

It may be necessary at this point to draw a distinction between Science Education and Education in Science. Education in Science refers primarily to understanding and applying of scientific concepts and principles; while Science Education includes the development and acquisition of processes/procedures required to help others acquire scientific and technological knowledge for ready application to everyday living.

The job of the science educator can be seen from a three-fold perspective of

- Preparing students in the scientific discipline (Education in Science)
- Providing the education background for students to enter into Science and Technology profession (Education and Science)
- Providing a means through which students can appreciate the contributions of Science to society and modern civilization (Education through Science).

I will also want to dwell a little on an issue that is of interest in this presentation. This is Education through Science as a component of Scientific Literacy.

Education through Science as a component of Scientific Literacy

Teachers are educators. Education is the area of focus for science teachers and science is merely the vehicle for this. The term "education through science" is proposed by Holbrock (2009) to express the intentions for the teaching learning approach. The proposed emphasize is thus NOT about stressing the ways of the scientist, any more than history is taught for students to become historians, or language is taught to become linguists. The proposal hinges on the fact that science in school is part of the total education provision and any science content is gained so as to enhance scientific literacy. The consequence of this Education through Science (EtS) model for science education is

1. The acquisition of the 'big' ideas in science is relegated to building a concept of the nature of science and/or the promoting of personal intellectual thinking. (This does not mean that knowledge is excluded from the teaching of science, but it is recognition that useful basic knowledge is tentative, liable to regional variations and best included on a need-to-know basis).
2. The key driving force for EtS is the need for students to acquire social skill, supported by personal skills, thus enabling students (and later as adults) to play a responsible role within society.
3. Ensuring students are able to function within the world of work at a skill or responsibility level, commensurate with the student's aptitude and ability.

4. Possessing conceptual background, or skills of learning to learn to cope with a need-to-have relevant public understanding of science and technology in a changing society.

This science literacy trend is thus towards:

- Inclusion of issue-based or context-based teaching as a major thrust to "set up" the scientific problem to be investigated;
- The need to go beyond scientific problem solving to also encompass socio-scientific decision making (related to responsible citizenry)
- Recognition that scientific literacy relates primarily to enabling citizens to effectively participate in the real world and is thus a social rather than an individual consideration.

The table below illustrates a comparison of "education through science" with "science through education" –

Table 1: Similarities and differences in philosophical emphases between "Science through Education" and "Education through Science"

Science through Education	**Education through Science**
Learn fundamental science knowledge,	Learn the science knowledge and concepts important for

concepts theories and laws.	understanding and handling socio-scientific issues within society
Undertake the processes of science through inquiry learning as part of the development of learning to be a scientist.	Undertake investigatory scientific problem solving to better understand the scientific issues within society.
Gain an appreciation of the nature of science from a scientist's point of view.	Gain an appreciation of the nature of science from a societal point of view
Undertake practical work and appreciate the work of scientists	Develop personal skills related to creativity, initiative, safe working, etc
Develop positive attitudes towards science and scientists	Develop positive attitudes towards science as a major factor in the development of society and scientific endeavors
Acquire communicative skills related to oral, written and symbolic/tabular/ graphical formats as part of systematic science learning	Acquire communicative skills related to oral, written and symbolic/tabular/ graphical formats to better express scientific ideas in a social context
Undertake decision making in tackling scientific issues	Undertake socio-scientific decision making related to issues arising from the society
Apply the uses of science	Develop social values related

to society and appreciate ethical issues faced by scientists	to becoming a responsible citizen and undertaking science-related careers.

Assumptions of Science

- Certain assumptions underlie the study of Science. Science believes that the universe can be understood and ordered. For instance, science does not believe in the supernatural nor does it attempt to explain it. It does not believe in the alteration of its facts and principles by a deity. It rests on the fact that the supernatural is beyond scientific proof. Other views outside the realms of science may assume that a supernatural being can alter the natural world. (Ryan and Aikenhead, (1992). Hence it believes in empirical confirmation. Causality thus forms a strong part of the scientific endeavor.
- Scientific knowledge must be reproducible. To be accepted as science, laws, principles, theories and generalizations must lend themselves to further investigations that must confirm the observed. Thus it throws away that which cannot be explained by observational and experimental manipulations as superstitious and therefore spurious. It does not lend itself to speculations nor does it accept anything based solely on logic and commonsense.

- Scientific processes can be replicated. This distinguishes it from other sources of knowing, and claims that cannot be replicated and are viewed with suspicion. Science therefore demands openness.
- Science advocates cause and effect in trying to explain natural phenomena. It believes that every natural phenomenon can be explained because it has a cause. In dealing with knowledge, science aims at simplification and comprehensiveness; and also attempts to reduce natural processes to wide generalizations.

Science Process Skills

Science cannot be science without its process skills. These are skills that are essential and required in science. They include:

- Questioning
- Observing
- Measuring
- Inferring
- Manipulating instruments
- Controlling variables
- Classifying
- Interpreting data
- Communicating
- Formulating hypothesis
- Experimenting
- Counting
- Predicting
- Formulating models, and
- Making operational definitions

Ethics of Science

Ethics of science are the principles guiding the behavior of scientists, and include:

- Rationality
- Suspended judgment
- Honesty
- Patience/Persistence
- Skepticism
- Open-mindedness
- Carefulness, and
- Objectivity

Science Learning and Scientific Literacy

Education can be viewed as the transmission of the mores, values and totality of the culture of a given group of persons to the younger generation. It implies a permanent change in behavior. Applied to science with its mores, values, ethos and norms, science education is the transmission of scientific culture to the recipients.

One may be tempted to argue that any science education that does not allow all who are exposed to it to acquire science concepts has failed in its goal. This is not the case, as science education cannot be equated with amassing of concepts of the different science disciplines. Science education involves a holistic understanding of science as an inquiry process, a way of making sense of and understanding the physical world. This in effect, means that the main goal of science education is for the acquisition of scientific literacy.

Scientific literacy is the ability of individuals to live satisfactorily and conveniently in the modern society. This implies an ability to think critically, understand socio-scientific problems, take part in collective decision-making and communicate effectively in a science and technology culture.

The requirements for scientific literacy include the ability to:

1. **Think critically-** this implies the ability to weigh the advantages and disadvantages of the options available and to choose the best alternative.
2. **Solve problems-** this requires going beyond the immediate and available mental resources to develop new insights.
3. **Make decisions on socio-scientific issues-** this requires the individual understanding the meaning, interactions and ramifications of science, technology and society. The individual also needs to develop appropriate social cognitive structures; and is able to respond to such issues as where to locate a nuclear power plant; who should work in an asbestos company; and where and how toxic waste should be disposed.
4. **Communicate-** this is the ability to identify interested and relevant groups, develop appropriate programme and language and surmount extraneous and intervening hurdles in getting across one's informed decision.

A scientific literate person will thus not wallow in ignorance, and in the words of Okeke (2007), will "understand that eating groundnut or melon or fatty food does not cause malaria". Such a person would thus have been equipped to deal with the misconceptions and alternative conceptions that abound in Science. For instance, students regard force as a kind of substance an object possess and consumes, whereas force is a kind of constraint-based interaction between two objects, that is, a process. Also students think that force is a kind of impetus imparted to a body or as an intensive property that a body possess and believe that this impetus can be used up and this is why in Newton's law of motion they assume that when there is no force there is no movement.

How do we learn Science?

The process of learning science has been the subject of study by many psychologists, philosophers and educators. Pioneers in studies on how we learn science include Piaget, Ausubel and Gagne. Piaget's study on children's explanation of natural phenomenon and causality has been particularly important in understanding the processes involved in learning science. It is believed that learning is an active interaction of the learner and his/her environment. Other emerging theories and paradigms include the positivism/ constructivism paradigm, and the psychosocial environment consideration.

Cognitive psychologists have shed some light on the learning process and proposed the constructivist model as a method that may accommodate all students. According to Nwosu and Nzewi (1997), Constructivism is a term that

expresses the dynamic and interactive conception of human learning. It proposes that students actively learn and construct their world view. Learners build conceptual frameworks that are complex, highly organized and strongly tied to specific subject matter. In the constructivist view, dialogue among children is an important strategy for encouraging them to construct new conceptual framework. Also the inquiry approach to learning as well as the important role of prior knowledge in concept formation is highly emphasized. According to Bybee (1989), the constructivist view of learning is linked to three related ideas: prior learning, students' learning styles and concentration of teaching depths and understanding rather than on breadth of coverage and knowledge of vocabulary.
Constructivism therefore represents a model of instruction and learning as an interactive process in social settings. It is problem solving oriented, allows students to explore and work in groups, making meaning of tasks and setting out to solve problems that are perplexing to them (Tobin1993a and 1993b). Evidence from the constructivist view point thus indicates that once the science classroom or learning environment is problem solving oriented, students allowed to explore, work in groups and make meaning of tasks, that all students should be able to learn science. Why then does it appear that female students do not learn as much science as their male counterparts? This brings us to the next issue which is:

GENDER ISSUES IN SCIENCE EDUCATION

Women's access, participation and progression in Science, Technology, Engineering, and Mathematics have been a subject of discourse and concern to educators. Over the

years, women have been underrepresented in STEM, and in some cases denied access. The question is: Are there reasons why women cannot do well in, and participate fully in Science? Going by the nature of science and the way people learn, are there natural reasons why women cannot participate fully in science and do well in it? What are the factors that negatively influence females' participation and achievement in science?

Factors that negatively influence Female Participation and Performance in Science & Technology

Females are grossly under represented and many of them are noted to underachieve in the Science and Technology discipline. According to Okeke (2000) the under-representation and under-achievement of females in the S&T disciplines are historical and have been brought about by several inter-related socio-cultural and interacting school factors which act singly and jointly to depress female interest, enrolment, participation and achievement in S&T subjects at various levels of Nigerian education system.

These factors will be discussed under two major headings, the non-school factors and the school factors.

Non- school factors

a) Child rearing practices

Child rearing practices in different part of the world especially Nigeria, contribute to the values held by girls as to what they can do and what they are to be in life. Often one can hear parents using certain adjectives to describe their children. These adjectives betray their belief of the

personality characteristics of their children. For example the words **hard, strong, independent, daring etc** may be used to describe a boy's behaviour, while **soft, fragile, dependent, fearful, and weak**, qualify girls' behaviour. Maccoby (1970) in her article "Feminine intellect and the demands of Science" noted that "***the development of the ability to think analytically is related to the development of the qualities of independence, initiative and assertiveness – qualities thought of as 'unfeminine'. … Social moulding discourages these qualities in those girls who are potentially intellectual achievers."*** From the foregoing, it follows that girls are socialized into conforming to the "unscientific behaviours" (i.e. dependent, weak, emotional), since there is no evidence to show that one is born with these traits.

Studies of girls have repeatedly shown that early in life, they develop a greater interest in other people and in what other people think of them than do boys. They also tend to be more conforming to what they perceive to be the social demands of the situations they are in. However, some girls who have been lucky to escape the routine-childrearing practice grow up to be curious, independent, exploratory and not interested in playing with dolls rather they enjoy to play with the boys, and most of the time they are labeled "tomboy". Thus child-rearing practices tend to discourage the development of self-confidence and independence in women.

b) Sex role stereotyping: This may be regarded as the most critical of all factors that affect/influence female participation and achievement in Science and Technology (S&T), since it appears to be the root of most of the other

factors**.** Sex role stereotyping is the socio-cultural classification of human activities by sex in line with what the society considers as appropriate for one sex or the other. The arbitrary arrogation of roles to either of the sexes has given rise to the masculine image of Science and Technology. These disciplines are seen as male domain. Consequently females' upbringing tends to shape them away from S&T, which are socio-culturally considered inappropriate for them. Right from the homes, dolls are bought for girls with the accompanying dressing kits and baby girls are encouraged to care for and pamper their dolls. On the other hand more rugged toys like trucks, machines and guns are bought for the boys and it is acceptable if they tear it apart. If a baby girl gets into a difficult situation, she is helped out, but a baby boy is expected to fight his way out. A boy is expected to be curious enough to want to know what makes her sisters doll talk and is 'permitted' to tear the doll apart in order to satisfy this curiosity. It is however a "taboo" for the baby girl to tear apart her doll. Hence right from the homes the boys are encouraged to acquire the science process skills that they will need to excel as scientists.

A study carried out by Nzewi, (1990) to determine children's conception of play activities revealed that right from the nursery school, the boy-child, had started to take himself very seriously and will regard what he does with his toy car, truck or gun as work; while what he does with his sister's toy, usually a doll or cooking kit is play. The boy-child also regarded all activities his mother participated in such as house cleaning and plate washing as play; while the activities with daddy such as car washing and using the vacuum cleaner are work. This was related to

the way parents socialize them by teaching the boy-child to be "serious-minded" while his sister can afford to be "frivolous". (Njoku, 2001; Njoku & Okeke, 2003).

The issue of stereotypes is carried to a ridiculous extent even by people who should know. When Isyaku & Kalgo (1996) examined the effect of sex on the academic performance of two groups of students (field Independent and field dependent) in Junior Secondary Schools in Sokoto state and found that female independent and dependent students showed superior achievement over their male counter parts, their conclusion was that the better performance of the females happened by chance and not really because they were better than the boys. They further added that the females came from schools with best teachers and learning materials than the boys. Meanwhile they had reported under the study methodology that the study sample was randomly composed.

School Factors

At the school level, females experience a lot of discouraging conditions that deter them from enjoying and achieving well in S&T subjects. These school-based factors are responsible for the observed low interest, poor participation, low aspiration and under-achievement of females in S&T (Okeke, 1990, Obianyo, 2000). These factors include:

1. **The nature of Science:** Science is often represented as abstract and it employs methods that disembody objects and matter in order to study them. This contrasts with the worldview of women that is more person-centered.

Women are more often than not concerned with the context of an activity than the inherent processes. Thus, they are responsive to their environment and social responsibilities. Women usually operate within the concrete world in their day-to-day life, thus they apply other ways of knowing and solving problems other than those espoused by science, which most often is abstract theorizing.

2. **Gender bias in curriculum materials:** Science and Technology materials used in Nigerian classrooms are grossly gender biased in favour of males and decisively against the females. (Erinosho, 1997). The content of textbooks have been shown to be biased in favour of males in terms of language used in communicating the ideas contained in the books, the illustrations, pictures, and examples. The activities depicted in the texts are male oriented. Studies done outside Nigeria has also shown that school science material such as textbooks, bulletin board display and software programmes demonstrate male biases. (Bazler & Simonis, 1991; and Biachini, 1993). In the work of Kerric (1985), chemistry textbooks commercially available in Australia were analysed for male and female identifiable images, it was found that only 15% of the identifiable images were females.

   Back home in Nigeria, Similar studies revealed almost the same pattern. Nzewi (2000) and Owolabi and Onafowokan (2001) studied gender representation in nine selected textbooks used in senor secondary schools. Findings from the studies reveal that there is no gender balance. Of the nine textbooks reviewed, seven

had between 1 – 9 female images, while male images ranged from 2-50. On a one to one correspondence, the number of male images in each text was more than the female images. The only exception appeared in a Biology textbook that had nine female images and five male images. The significance of this exception is not lost since Biology is regarded as a feminine subject. A second major finding is that in the nine textbooks reviewed, female scientists were named only once in two of the textbooks, while male scientists were named between one and forty one times. The text book that named male scientists 41 times is as expected a Physics text. The implication of this is obvious since Physics is a "hard" science and therefore a male domain.

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 representations in texts 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.

3. **Science Teaching Strategies Used by S&T Teachers (Teachers' classroom behaviours):** Pedagogically, it is believed that healthy academic competition among students would enhance achievement; hence teachers tend to sustain academic competition in their S&T

classrooms (Burns, 1987). However it has been found through research that not all the learners benefit in a competitive learning environment. Female students loose out in a competitive academic environment. They prefer cooperative academic environment for their optimal performance (Wax, 1975: Okebukola, 1985; Okeke 2000; Nzewi & Osisioma, 2000). And yet most of what goes on in S&T classrooms are competition-based. Fennema &Peterson found from their studies that the more females are subjected to competitive learning situations, the less they learn. Njoku also stated that boys always dominate science learning activities in co-educational schools when the instructional strategy adopted is competitive. Obianyo (2000) reported that teachers' overt and covert instructional behaviour influence learners' achievement. The effect is that teachers unconsciously teach science to make boys excel thereby creating the impression that the girls cannot cope.

Egglestone, Caltone and Jones (1976) from their study concluded that a greater proportion of women 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 finding of this study suggests that if the appropriate method is used, females will achieve as much as their male colleagues in S&T subjects.

Simpson and Erickson (1982) found from their study that in a typical science class, teachers tend to criticize boys much more frequently than girls and were more likely to use a harsh tone when criticizing boys. The conclusion they drew was that these boys were being pushed to achieve more. The study by Stake and Katz (1982) compared the behaviour of male and female teachers towards male and female students in 6th, 7th and 8th grade classrooms in four junior high schools during 10 hours of instruction. Their findings revealed that high achieving boys relative to others received the most favorable treatment; while low achieving boy's had the poorest contact with both male and female teachers. Girls in either of the achievement brackets were not singled out for any treatment. The conclusion they reached was that both male and female teachers tended to mete out more negative sanctions to boys than girls all in an attempt to further encourage the boys to bring out the best.

Harlen (1985) interpreted the above to be because more boys than girls are seen by the teacher to fall into the gap of highest and lowest achievement, the two gaps which require most attention from the teachers. Harlen also added that certain boys' behaviour patterns ensured that they regularly gained the attention of the whole class and girls' were much less successful in engaging in conversation with the teacher. This she attributed to the fact that boys had been socialized to be aggressive, while girls were socialized to be docile

In another study, Irvine (1986) investigated the initiating behaviour of students interaction (that is instances in which students initiate an interaction in the class) and teachers' reaction to such interactions, (that is the quantity and quality of teachers verbal feed back 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 strive harder. Similar findings were made in a study by Onimisi (2005).

Brophy and Good (1994) also reported a study by Etaugh and Harlow that studied the relationship between teachers gender, behaviour and attitudes to students in class using $8^{th,}$ $7^{th,}$ 6^{th} and 5^{th} graders who were taught concurrently by two male and two female teachers throughout the school year. Findings from the study revealed that boys were scolded more often than girls (by both male and female teachers), called on more often than girls (by male teachers) and praised slightly more than girls (by female teachers). Such comments as 'you have tried Mary, let John conclude' are common expressions in our classrooms. The girls are made to believe that their little efforts are good enough. Not so

for the boy who will be asked to act in a more 'manly' way, by persevering until a solution is found.

According to Okeke (2001), Science Technology & Mathematics teachers come to school loaded with a high dosage of sex related stereotypes, which make them treat boys and girls differently. She made reference to a study by Whyte (1984) which show that teachers consider education as being of greater importance to boys than girls. Whyte also reported that in a co-educational school, boys dominate the class discussions, ask more questions and interact more with the teacher than the girls. Boys are always made leaders in group activities, partly because of the confidence they exhibit having had more out-of-school familiarity and experiences with science subject matter.

Still along the same line, 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. The study by Nzewi and Onimisi (2008) threw up the same pattern of interaction in science classes. Adigwe then concluded that male and female students have unequal opportunities for learning science in Nigeria classrooms. He added that the low number of females offering biology, chemistry and physics might be a direct result of their experiences with their science

teachers. And I am quick to add that it is not because their brains cannot take in the subject matter of science, but because of other extraneous obstacles thrown in their way.

4. **Teacher Expectation of Female Students:** Due to sex role stereotyping it is generally believed that S&T subjects are suitable for boys and not for girls. Consequently S&T teachers, whether they are males or females do not expect the girls to perform well in S&T subjects

   Tsayang and Nguako (1989) reported a study carried out in Botswana on teacher expectation of students. Teachers who participated in the study were given the school report card of a form 3 student and asked to write their expectations for the student. Half the group was given the report card with the name "Patrick" and the other half with "Patricia". Results of the study showed that there were some similarities in the way the "two" students were perceived. For example, Patrick or Patricia could become lawyer or a teacher. In other areas however, there were marked differences. Patrick on one hand could become a diplomat or manager: while Patricia could become a secretary, wife, or mother. Generally, a greater range of jobs were mentioned for Patrick; the expectations for Patricia were not only lower, but were vague. For example one of the recommendations made for Patricia was that she could 'do all sorts of work and study all sorts of subject'. Tsayang and Nguako (1989) concluded that if such result reflects real career advice, we could see a boy encouraged into specific and higher levels of

occupation or training while a girl with identical attribute might receive lower level, more stereotyped or less pursued career or training advice.

Back home in Nigeria, Nzewi (1990) investigated the assertions made by Tsayang and Nguako(1989) in relation with Science students. In this study, a report card of a science-based Senior Secondary Class II student was reproduced and given to forty-five teachers and counselors. Twenty two of them received the report card with the name Patrick, while the other half received the same report card with the name Patricia. The teachers were asked to advice the student and recommend possible future careers.

The finding of the study revealed that 80% of the respondents recommended that Patrick or Patricia could become a medical doctor, pharmacist, teacher, or could study Zoology, Botany, and Microbiology or combined Biological Sciences. There are however other marked differences. Ninety percent of the respondents indicated that Patrick could become an Engineer in the area of Electrical, Electronic, Mechanical or Civil Engineering. Other careers or jobs listed for Patrick include Mining Engineering and Geology. On the other hand such careers as Food Scientist, Dietician, Nutritionist, Nurse and Medical Laboratory Technologist were reserved for Patricia.

An interesting deduction from the above study is that while “Patrick” and “Patricia” are science-oriented with the same grades in the same secondary school subjects, some courses were reserved for “Patrick” and some for “Patricia”. For instance, no respondent suggested that

"Patrick" should train to become a Nurse, Dietician or Nutritionist, nor did any of them suggest that "Patricia" could become an Engineer. The above findings suggest that girls move away from sciences not necessarily because they cannot do science but because they are pointed away from science by the people who should encourage them.

The above finding is in line with the comments made by Osibodu (1991) that teacher expectation is a crucial factor of change in the direction of increased participation of girls in STM. She expressed the view that to develop a positive feeling about their academic activities, students need the nurturing environment of a positive school and classroom climate, and that although there are many variables influencing the climate in a classroom, a teachers belief is most probably one of the leading ones.

Okeke (2001) 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 communicated verbally or non-verbally to the students what behavior and achievement the teacher expects of 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 teacher's expectation. It follows that teachers having overtly or covertly conveyed to women a lower level of expectation, force them to fit into such expectations which is lower achievement. Because of this negative expectation, S&T teachers do not encourage the females in their class to work hard and improve on their performance.

5. **Gender biased Guidance and Counseling Services to Girls in S&T subjects:** School guidance counselors give boys and girls' gender- biased counseling with regards to S&T subjects (Okeke 1996). School guidance counselors are known to encourage the boys to enroll and work hard in the physical sciences because of the relevance of the subjects to future studies in the disciplines of engineering, technology, basic sciences and mathematics. Conversely, the counselors discourage the girls by telling them that physical sciences and mathematics are difficult and are meant for boys; that they would not need the subjects in future since they would invariably not be in the disciplines of science and engineering; and that they can easily make good grades in art subjects and the humanities. This point is further buttressed by the findings from the study cited earlier (Nzewi, 1990), where no teacher or counselor found "Patricia" fit to study to become an Engineer in spite of the fact that it was the same result that was presented for the two students named "Patrick" and "Patricia".

Research evidence to show that it is all in the brain

Over time, we have carried out studies to investigate the effect of different teaching strategies on students' achievement in S & T. In these studies, we have always investigated the gender component. The findings of some of these studies are reported.

In a study to find out the effect of continuous and partial reinforcement on secondary class one pupils' achievement in Integrated Science, (Nzewi 1988), findings indicated that male and female students in the continuous reinforcement group were equally affected positively, and they performed better than their counterparts in the partial reinforcement group. The only observable difference in the male and female groups was in their choice of reinforcers where more females (15%) than males (9%) preferred chewing gum and sweets to pen.

The study that investigated the effect of prior knowledge of behavioral objectives and study questions on achievement in biology, (Nzewi & Okeke, 1990), reported a facilitative effect of the treatment procedure on achievement in biology of both boys and girls. This effect was the same for the boys and girls. A related study, investigated the effects of prior knowledge of behavioral objectives and study questions on attitude to biology (Nzewi, 1993). The report indicated a more positive attitude in the experimental group. No group of student, male or female had an edge over the other. In another study Nzewi (1994), investigated the use of behavioral objectives and study questions to increase students' motivation to study biology. Findings from the study revealed that students taught biology with behavioral objectives and study questions were more

motivated to study biology. Male and female students within the experimental group were motivated equally.

Nzewi and Osisioma (1994) investigated the relationship between formal reasoning ability, acquisition of science process skills and science achievement. Irrespective of the students' gender, findings from that study indicated that the relationships between students' formal reasoning ability and process skill acquisition; acquisition of science process skill and science achievement, and formal reasoning and science achievement are all positive. The study by Agomuo and Nzewi (2004) on the effect of video-taped instruction on secondary school students' achievement in Physics revealed that the experimental group (both boys and girls) had an improved performance in physics than the control group. Another study by Agomuoh (2010) revealed that when male and female students were taught physics concepts using the Prior knowledge, Exploration Discussion Dissatisfaction with prior knowledge and Application method (PEDDA), and The Learning Cycle (TLC) Constructivist model, both groups improved in their mean conceptual change scores. PEDDA and TLC methods facilitated the conceptual change of both male and female students from alternative conception and no conception to accepted scientific conception or partial conception. The study also revealed that there is almost uniform pattern in conceptual change for both males and females. The implication here is that PEDDA is efficacious in changing students' conception and it did not matter whether the students were males or females.

Earlier studies by other researchers had indicated that gender does not combine with instructional approaches to affect students' conceptual change (Onyegegbu, 1999;

Iloputaife 2001; Mode, 2004; Agomuo, 2004: Agomuo and Nzewi, 2004; and Ogbonna, 2004).

If all the studies reported above show that under normal circumstances, females have the capacity to learn as much science as their male counterparts, it follows that there is nothing in the nature of females that make them not do science or not do well in science. It also follows that whatever hinders them is something that is done to them. How then do we encourage females to participate and excel in science?

Encouraging Female Participation and Achievement in Science Education

Girls interest in S&T activities need to be sustained for a considerable period of schooling time in order to obviate the accumulated poor learning readiness acquired through pre-school child-rearing practices, and sustained through biases in S&T curriculum and instruction (Fennema and Peterson, 1985, Shapiro et al, 1981).

Njoku (2006) had found from his study that the removal of gender biases in S&T curriculum and instruction is effective in improving the achievement of girls in these disciplines. This implies that if gender biases were removed from the conventional S&T curriculum and instruction, the girls who have hitherto been disadvantaged or excluded by these biases would have the opportunity to learn science and technology on the same learning and social environment as the boys. Consequently, both girls and boys would learn and perform well in science and technology to their greater benefits and that of the society

in which they live. Some of the strategies that have been tried and found to have positive impact in increasing female students' participation in S&T include:

- Creating awareness and sensitizing students and teachers about gender issues in S&T education: The effects of the pervasive masculine image of S&T should be discussed among students and teachers so that every one understands them and becomes able to identify his/her own roles in the perpetuation of the stereotypes.
- De-Sexing S&T curriculum/scheme of work and teaching/learning resources: This is done through identifying and pointing out gender biases in S&T curriculum contents and language of communication with a view to modifying them and thereby making the curriculum materials gender sensitive and acceptable to both females and males.
- Adopting gender-inclusive guidance and counseling services for all S&T students: Males and females and given similar guidance and counseling advice, encouraging them to enroll in as many S&T subjects as they can, and working really hard to perform well in each of the subject.
- Placing emphasis on the relevance of S&T education to learners: This can be done by the S&T teachers during all lessons when they point out the areas of application of the S&T concepts they are teaching to life outside the school. Making science relevant to the everyday life of the learners will increase their learning motivation and interest and participation in the subjects irrespective of gender. This is because

they will start experiencing science from the point of problem-solving and wealth creation.

- On the home front, parents should be more careful about the role they play in pointing their female students away from science and technology. **AFTER ALL, THERE IS NOTHING IN THE NATURE OF SCIENCE THAT MAKES IT IMPOSSIBLE FOR FEMALES TO STUDY SCIENCE. THERE IS ALSO NOTHING IN THE NATURE OF FEMALES THAT SAY THAT THEY CANNOT STUDY SCIENCE EFFECTIVELY. WHAT EVER BARRIERS THAT EXIST ARE MAN AND WOMAN MADE AND CAN BE SO EASILY REMOVED.**

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My late father SIR P.O.E MBAKWE was a great inspiration. He believed in me, encouraged me and made me know early in life that education can open any door and is a great equalizer. I caught the dream and ran with it and here am I today.

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My parents were not able to come up with a male child "early enough", my COUSIN EMEKA, a lover of education stood in the gap and became a real big brother. In my town at the time, if you are not engaged to marry by your final year in the secondary school, you are considered a pariah; Emeka told me that I need not think of marriage until after I acquired a university degree because that is when the type of husband I deserve will surface. I listened and obeyed and see where I am today.

I bless the Lord for the day I met and eventually married my husband OBIORA NZEWI. When I look back on the 25+ years we have been married, all I can say is thank You God for making it possible for me to meet and marry my friend, brother and lover. I don't know where I would have been as an academic without his support. For someone who is not in academics, he understands the nitty-gritty and the challenges, and is always there for the kids and I, and taking the kids off my hand when he had to. Thank you for those meals and the tea/coffee in bed. They all added up to make the real difference.

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by “school run” except on rainy days. They learnt early to fix their meals and also carry a plate to mummy in spite of their being mostly males. Today, OBIAJULU is an Electronic Engineer working with Fidelity Bank Plc.; KENTY has written his final exams as a student of Political Science; NAMDY has also written his final exams in Computer Science and NNEOMA is a third year student of Mass communication. They told me that they will not like to do my kind of job because they will leave me working while they go to bed and wake up to see me still working. Ajulu, Namdy, Kenty and Nomsky I want to tell you that all those long working hours have paid off. We now leave in a big house but you are the ones that have moved out.

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