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Women in STEM: Closing the Gender Gap to National Transformation

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Abstract: *The study examined the differences between enrolment and completion of students admitted into science, technology, engineering and technology based undergraduate courses in Michael Okpara University of Agriculture, Umudike. The population consists of all students admitted into the university from 2004/2005 to 2005/2006 academic sessions upwards who started graduating from 2008/2009 to 2010/2011. All members of the population were used for the study. Three research questions were asked and three hypotheses tested to guide the study. Percentages were used to answer the research questions while t-test was used to test the hypotheses. Results showed significant differences between male and female students' enrolment, graduation and non-completion rates in STEM disciplines in Michael Okpara University of Agriculture, Umudike. It is recommended that greater attention be given to ameliorate the factors that militate against female participation in STEM.*

Keywords *– Gender gap, STEM, National Transformation, Women.*

I. Introduction

Globally, Science and Technology is acknowledged as the pivot of any nation's development. Nations touted to be the most developed (world powers) such as the United States of America, Germany and France are nations who boast of several scientific and technological inventions and achievements. These nations' scientific and technological prowess are associated with rapid economic development as well as modern gadgets to make their citizens live comfortably, have a longer life-span and, having other nations depend on them for the existence of their own people. In recognition of this all-important function of Science and Technology, developing and developed nations around the world are increasingly relying on the development of their human capital in Science, Technology, Engineering and Mathematics (STEM) for attaining their long-term prosperity. Contemporary policy makers consider widespread STEM literacy, as well as specific STEM expertise, to be critical human capital competencies for a 21st century economy. This is evidenced by their making the production of a robust STEM-proficient workforce a priority (National Science Foundation (NSF) 2010, Gonzalez and Kuenzi 2012; Indiana Department of Education (IDOE) 2012; Osama, 1995).

The Nigerian nation also acknowledges that education, particularly education in STEM is the most crucial factor in stimulating its socio-economic development and transformation. The provisions of the National Policy on Education (FRN 2004) and the Science, Technology and Innovation Policy (FRN 2012) provide strong platforms for Science and Technology development for the purpose of promoting sound economic transformations that are citizen centred. Furthermore, the National Policy on Science, Technology and Innovation (ST&I) (FRN 2012), seeks to evolve a nation that harnesses, develops and utilises ST&I to build a large, strong, diversified, sustainable and competitive economy that guarantees a high standard of living and quality of life for Nigerian citizens. This mission statement translates to Nigeria desiring to be a self-sufficient nation. These aspirations clearly indicate that the Nigerian nation recognizes Science and Technology as an instrument for national development and transformation – which is a complete change and growth towards improvement of the attitudinal, behavioural, conceptual, patriotic, psychological, mental, physical, material, institutional and organizational orientation and wellbeing of the nation (Walter 2008, Okafor 2012).

STEM is an approach to teaching and learning that integrates the content of Science, Technology, Engineering and Mathematics with behaviours needed for success in the 21st century workforce. These behaviours include: engagement in inquiry, logical reasoning, collaboration, communication, investigation and creativity (A^+ Educators, 2012). STEM Education typically includes educational activities across all grade levels – from pre-school to post-doctorate – in both formal (classrooms) and informal (after-school programmes) settings. Tsupros 2009 in Okpala (2012), refers to STEM education as an interdisciplinary approach to learning where rigorous academic concepts are coupled with real life lessons with a view to ensuring that students apply science, technology, engineering and mathematics in contexts that make connections among school, community, work and the global enterprise maximally harnessed to enable the development of STEM literacy and with the ability to compete in the new economy. For Rider-Bertrand 2007 in IDOE (2012), STEM education is an intentional, meta-disciplinary approach to teaching and learning, in which students uncover and acquire a

cohesive set of concepts, competencies, and dispositions of science, technology, engineering, and mathematics that they transfer and apply in both academic and real-world contexts, in order to be globally competitive in the 21st century. Thus, STEM education provides individuals with strong scientific, technological, engineering and mathematical background to enhance skills development across STEM disciplines for the future workforce. STEM requires that students become knowledgeable in many areas and be able to readily transfer this knowledge in various scenarios.

The Nigerian education system recognizes the vital role of STEM Education in achieving sustainable growth and development. This is evidenced by government's commitment to ensuring that learning outcomes emphasize STEM skill acquisition at all levels of the educational system. The National Policy on Education (FRN, 2004) stipulates the compulsory teaching and learning of Mathematics, Basic Science and Basic Technology, computer education, and agricultural science among other subjects for the first nine years of compulsory schooling. For the 3 years of senior secondary schooling, students are expected to be taught Mathematics, Biology, Chemistry, Physics, Agricultural Science, Applied Electricity, Electronics, Technical Drawing, Computer Education, Auto mechanics, Food Science and Nutrition, Health Science, Building Construction amongst other subjects. At the tertiary level, the policy specifies that a greater proportion of expenditure shall be devoted to science and technology; the admission ratio into technology and business courses shall be weighed in the ratio of 70:30, and that 60% of admissions into conventional universities shall be allocated to STEM oriented courses, while at least 80% of admissions into universities of technology shall be allotted to STEM-oriented disciplines.

Despite the NPE (FRN 2004) specification that every Nigerian Child shall have a right to equal educational opportunities irrespective of any real or imagined disabilities - each according to his or her ability, gender differences in enrolment in STEM careers show a lot of disparity, with females being underrepresented (Abe 2012; Salman, Olawoye, & Yahaya 2011). UNESCO (2009) and Abe (2012) report that at the primary school level, enrolment of boys and girls is almost equal, except in Northeast and Northwest zones. However the population of girls gradually dwindles with progression through the educational ladder (Okogie 2001 in Danjuma 2010, Abe 2012). This gap is most worrisome considering the demographic dynamics of Nigeria's population. As at 2012, Nigeria's population stood at 16.62 million. It is currently estimated to be 17.85million with a ratio of 1.04 males to each female (World Population Review 2014). The 2011 Global Gender Gap Report of the World Economic Forum ranked Nigeria 120 out of 135 nations in Gender Gap index. Gender gap refers to the differences between women and men, especially as reflected in social, political, intellectual, cultural or economic attainments or attitudes. The report's gender gap sub index pertaining to education is presented in the table below.

Table 1: Gender Gap Sub indexes – Nigeria 2011

Gender Gap Sub indexes	Rank out of 135 countries	Score	Sample Average	Female	Male	Female to male ratio
Educational Attainment	125	0.809	0.928			
Literacy Rate	122	0.69	0.86	50	72	0.69
Enrolment in Primary Education	125	0.90	0.98	58	64	0.90
Enrolment in Secondary Education	124	0.77	0.90	22	29	0.77
Enrolment in Tertiary Education	111	0.70	0.86	8	12	0.70

Source: World Economic Forum (2012). Global Gender Gap Report 2011

Furthermore, Research reports indicate apparent differences in the curriculum choices made by boys and girls. These differences result in consistent under-representation of girls and women in science and scientific careers (Hill, Corbett and St Rose, 2010). According to Alade 2006 in Alade (2012), there is a wide disparity in enrolment and academic achievement of boys and girls in some areas of specialization. Female students tend to drift or be guided towards areas of studies regarded as feminine and thus shy away from scientific and technological fields. Nnaka & Anaekwe's (2006) report bears witness to this observation. Students' enrolment in the 2004 Senior School Certificate Examination indicates a disparity in male and female students' enrolment in science and technology inclined subjects. The table below culled from Nnaka & Anaekwe (2006) shows that at the secondary school level, males prefer technical subjects while female enrolment was skewed towards home sciences.

Table 2: Enrolment Pattern of candidates in STM subjects in the 2004 Senior Secondary School Certificate Examination based on sex

STM Subjects	Total Number of Candidates	Number of males	%	Number of females	%
Further Mathematics	18557	14732	79	3825	21
General Mathematics	832689	446907	54	385782	46
Agricultural Science	656599	369893	56	286706	44
Biology	821966	439358	53	382608	47

Chemistry	269774	159533	59	110241	41
Health Science	12306	5586	45	6719	55
Physics	265262	158402	59	106860	41
Applied Electricity	389	337	87	52	13
Auto Mechanics	169	166	98	3	2
Building Construction	200	178	89	22	11
Electronics	245	200	82	45	18
Metal works	570	562	99	8	1
Technical Drawing	7490	6462	86	1028	14
Wood Work	499	488	98	11	2
Clothing and Textile	541	15	3	436	97
Food and Nutrition	16903	1196	7	15707	93
Home Economics	11066	475	4	10591	96

Source: Nnaka and Anaekwe (2006)

Furthermore, Udeani (2012) reports that by the end of schooling the number of females with the motivation and background to progress into further studies in sciences, into decision-making roles or careers in science and technology and into activities integral to the application of science and technology for development is much smaller than that of males with similar motivation and background. Abe's (2012) study on gender disparity in course offering and graduate output in Nigeria report that in the University of Lagos, girls were very much concentrated in the so-called 'female traditional subject areas' of liberal arts and a disproportionate few were found in Engineering, Medicine, and Law. This seemingly continued insignificant enrolment of women in STEM related disciplines seem to undermine Nigeria's focus on Science and Technology as the key to national development and transformation. It is against this background that the researchers sought to investigate the differences in enrolment and completion rate of male and female undergraduates in STEM disciplines in Michael Okpara University of Agriculture Umudike (MOUAU).

Research Questions

1. What are the differences in male and female students' enrolment into STEM disciplines in Michael Okpara University of Agriculture Umudike (MOUAU)?
2. What are the differences in the completion rate of male and female students' in STEM disciplines in Michael Okpara University of Agriculture Umudike (MOUAU)?
3. What are the differences in the non-completion rate of male and female students' in STEM disciplines in Michael Okpara University of Agriculture Umudike (MOUAU)?

Hypotheses

1. There is no significant difference in the enrolment of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike.
2. There is no significant difference in the completion rate of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike.
3. There is no significant difference in the non-completion rate of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike.

II. Method

The study adopted a combination of Ex Post Facto and correlation Research designs. This research design does not include any form of manipulation or measurement; rather it studies facts that have already occurred to determine if there are relationships between the variables. The study was carried out in Michael Okpara University of Agriculture, Umudike. The study sought to scrutinize data on students' enrolment (from 2004/2005 to 2005/2006) and graduation from 2008/2009 to 2010/2011 sessions to find out if there are differences in male and female students enrolment and graduation in STEM disciplines. The data was collected from the Registry of the university and analyzed using descriptive statistics.

III. Results

Research Question 1: What are the differences in male and female students' enrolment into STEM disciplines in Michael Okpara University of Agriculture Umudike (MOUAU)?

Table 3: Enrolment and graduation of male and female students in STEM inclined disciplines in Michael Okpara University of Agriculture, Umudike from 2008/2009 to 2010/2011 academic session

Session	2008/2009							2009/2010							2010/2011						
Sex		MALE			FEMALE				MALE			FEMALE				MALE			FEMALE		
College (duration of programme)	Total Admitted	Number on admission	Number on graduation	% graduated	Number on admission	Number on graduation	% graduated	Total Admitted	Number on admission	Number on graduation	% graduated	Number on admission	Number on graduation	% graduated	Total Admitted	Number on admission	Number on graduation	% graduated	Number on admission	Number on graduation	% graduated
CAFST (5 YEARS)	166	50	10	20.0	116	34	29.3	284	119	16	13.4	165	30	18.2	211	61	18	29.5	150	28	18.7
CCSS (4 YEARS)	68	55	10	18.2	13	8	61.5	51	23	16	69.5	28	20	71.4	169	98	18	18.4	71	20	28.2
CNREM (4 YEARS)	63	32	7	21.9	31	12	38.7	43	20	13	65.0	23	12	52.2	25	11	13	118.2	14	14	100
CEET (5 YEARS)	283	261	43	16.5	22	5	22.7	389	362	38	10.5	27	6	22.2	505	460	40	10.0	45	4	8.8
CAERSE (5 YEARS)	176	106	14	13.2	70	17	24.3	146	66	23	34.8	80	26	32.5	171	86	21	24.4	85	19	22.4
CNAS (4 YEARS)	497	305	78	26.5	195	56	28.7	520	337	95	28.2	183	47	25.7	396	215	87	40.5	181	48	26.5
CASAP (4 YEARS)	59	34	-	0	25	-	0	49	26	18	69.2	23	18	78.3	61	28	8	28.6	33	7	21.2

Source: Registry, Michael Okpara University of Agriculture, Umudike

Legend: CAFST-College of Food Processing and Storage Technology; CCSS-College of Crop and Soil Science; CNREM-College of Natural Resources and Environmental Management; CEET-College of Engineering and Engineering Technology; CAERSE-College of Agricultural Economics, Rural Sociology and Extension; CNAS-College of Natural and Applied Sciences; CASAP-College of Animal Science and Animal Production.

Table 3: Male and female enrolment trends in STEM-oriented disciplines in Michael Okpara University of Agriculture, Umudike

COLLEGE	TOTAL ENROLMENT 2008-2011 SESSIONS	MALE ENROLMENT (%)	FEMALE ENROLMENT (%)
CAFST (5 YEARS)	661	230 **(34.8%)**	431 **(65.2%)**
CCSS (4 YEARS)	288	176 **(61.1%)**	112 **(38.9%)**
CNREM (4 YEARS)	131	63 **(48.1%)**	68 **(51.9%)**
CEET (5 YEARS)	1177	1083 **(92.0%)**	94 **(8.0%)**
CAERSE (5 YEARS)	493	258 **(52.3%)**	235 **(47.7%)**
CNAS (4 YEARS)	1416	857 **(60.5%)**	559 **(39.5%)**
CASAP (4 YEARS)	169	88 **(52.1%)**	81 **(47.9%)**
TOTAL	4335	2755 **(63.6%)**	1580 **(35.4%)**

Table 3 shows that generally, there were more males **(63.6%)** enrolling in STEM-oriented disciplines than females **(35.4%)**. Notably, **92%** of all enrolments into the college of engineering were males. However, there were consistently more females enrolling into the College of Food Processing and Storage Technology for the three sessions.

Research Question 2: What are the differences in the completion rate of male and female students' in STEM disciplines in Michael Okpara University of Agriculture Umudike (MOUAU)?

Table 4: Male and female graduation trends in STEM-oriented disciplines in Michael Okpara University of Agriculture, Umudike

COLLEGE	TOTAL GRADUATION 2008-2011 SESSIONS	MALE (%)	FEMALE (%)
CAFST (5 YEARS)	136	44 (32.4)	92 (67.6)
CCSS (4 YEARS)	92	44 (47.8)	48 (52.2)
CNREM (4 YEARS)	71	33 (46.5)	38 (53.5)
CEET	136	121 (89.0)	15 (11.0)

(5 YEARS)			
CAERSE (5 YEARS)	120	58 (48.3)	62 (51.7)
CNAS (4 YEARS)	411	260 (63.3)	151 (36.7)
CASAP (4 YEARS)	51	26 (51.0)	25 (49.0)
TOTAL	1017	586 (58%)	431 (42%)

Table 4 shows male and female graduation trends in STEM-oriented disciplines in Michael Okpara University of Agriculture, Umudike

Generally, more males (58%) than females (42%) graduated successfully within the stipulated duration of the various STEM programmes. When considered separately, based on ratio of male to female enrolments, more males graduated/completed their programme within the set duration of the programmes; except in CCSS (2008-2011 sessions), CAFST (2008-2010 sessions), CAERSE (2008/2009 session), CASAP (2009/2010 session) and in CNAS (2008-2010 sessions) where there were significantly more females graduating.

Research Question 3: What are the differences in the non-completion rate of male and female students' in STEM disciplines in Michael Okpara University of Agriculture Umudike (MOUAU)?

Table 5: Non-completion rate in STEM disciplines as at stipulated programme duration

Session	2008/2009				2009/2010				2010/2011			
Sex	Male		Female		Male		Female		Male		Female	
College (duration of programme)	Number on admission	Number not-graduating (%)	Number on admission	Number not-graduating (%)	Number on admission	Number not-graduating (%)	Number on admission	Number not-graduating (%)	Number on admission	Number not-graduating (%)	Number on admission	Number not-graduating (%)
CAFST (5 YEARS)	50	40 (80)	116	82 (70.7)	119	103 (86.6)	165	135 (81.8)	61	43 (70.5)	150	122 (81.3)
CCSS (4 YEARS)	55	45 (81.8)	13	5 (38.5)	23	7 (30.5)	28	8 (23.6)	98	80 (81.6)	71	51 (71.8)
CNREM (4 YEARS)	32	25 (78.1)	31	19 (61.3)	20	7 (55)	23	11 (47.8)	11	-2 (-18.2)	14	0 (0)
CEET (5 YEARS)	261	218 (83.5)	22	17 (77.3)	362	327 (89.5)	27	21 (77.8)	460	420 (90)	45	41 (91.2)
CAERSE (5 YEARS)	106	92 (86.8)	70	53 (75.7)	66	43 (65.2)	80	54 (67.5)	86	65 (75.6)	85	66 (77.6)
CNAS (4 YEARS)	305	227 (73.5)	195	139 (71.3)	337	242 (71.8)	183	136 (74.3)	215	128 (59.5)	181	133 (73.5)
CASAP (4 YEARS)	34	0 (0)	25	0 (0)	26	8 (30.8)	23	5 (21.7)	28	20 (71.4)	33	26 (78.8)

Table 5 shows non-graduation trends of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike

Hypothesis 1: There is no significant difference in the enrolment of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike.

Table 6: Summary of t-test analysis of difference in male and female students' enrolment into STEM disciplines in Michael Okpara University of Agriculture, Umudike.

Variable	N	mean	t-cal	t-crit	Remark
Male	2755	393.5714			
female	1580	225.7143	16.77	1.895	significant

The calculated t-test value of 16.77 is greater than the tabulated t-test value of 1.895 at degree of freedom of 6 and 0.05 level of significance. Since the critical t-value is less than the calculated t-value, the null hypothesis that there is no significant difference in the enrolment of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike is rejected and the alternative hypothesis that there is a significant difference in the enrolment of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike is upheld.

Hypothesis 2: There is no significant difference in the completion rate of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike.

Table 7: Summary of t-test analysis of difference in male and female students' completion rate in STEM disciplines in Michael Okpara University of Agriculture, Umudike

Variable	N	mean	t-cal	t-crit	Remark
Male	586	83.71	4.744	1.895	significant
female	431	61.57			

The calculated t-test value of 4.744 is greater than the tabulated t-test value of 1.895 at degree of freedom of 6 and 0.05 level of significance. Since the critical t-value is less than the calculated t-value, the null hypothesis that there is no significant difference in the completion rate of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike is rejected and the alternative hypothesis that there is a significant difference in the completion rate of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike is upheld.

Hypothesis 3: There is no significant difference in the non-completion rate of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike.

Table 8: Summary of t-test analysis of difference in male and female students' non-completion rate in STEM disciplines in Michael Okpara University of Agriculture, Umudike

Variable	N	mean	t-cal	t-crit	Remark
Male	2138	305.43	17.65	1.895	significant
female	1024	146.28			

The calculated t-test value of 17.65 is greater than the tabulated t-test value of 1.895 at degree of freedom of 6 and 0.05 level of significance. Since the critical t-value is less than the calculated t-value, the null hypothesis that there is no significant difference in the non-completion rate of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike is rejected and the alternative hypothesis that there is a significant difference in the non-completion rate of male and female students in STEM disciplines in Michael Okpara University of Agriculture, Umudike is upheld.

IV. Discussion Of Findings

The trend in undergraduate enrolment in STEM disciplines examined for the three sessions (2008-2011) showed that overall, male enrolment was higher (63.6%) than female enrolment (35.4%). However, a closer scrutiny highlights the higher enrolment of females (65.2%) than males (34.8%) in the College of Food Processing and Storage Technology and also in the College of Natural Resources and Environmental Management with 51.9% female enrolment and 48.1% male enrolment. This enrolment inclination corroborates Nnaka and Anekwe's (2006) report that females tended to enrol in home and biological sciences in WAEC examinations. Conversely, male enrolment in all the remaining five STEM-inclined colleges was consistently higher than female enrolment. The College of Crop and Soil Science had overall 61.1% male enrolment and 38.9% female enrolment while, the College of Engineering and Engineering Technology had 92% of male enrolment and only 8% of female enrolment. These male and female enrolment trends are significantly different. This finding agrees with Sowers' (2013) report that enrolment in most STEM major courses are often exclusively male dominated. It also corroborates Hassan, Boladale, Oloapa and Oladipo's (2012) report that females were underrepresented in science and technology in tertiary education as well as Ekine's (2013) report that from 1998/1999-2001/2002, women made up only 23% of students in technology courses and 26% of students in science courses in 12 Nigerian states. This report is similar to Salman's (2001) finding that the percentage of females enrolled in Mathematics and Science disciplines in University of Ilorin in 1995/96 to 1997/98 sessions were smaller than male enrolments.

A variety of factors have been blamed for women's poor participation in STEM disciplines. These factors for Alade (2012) are primarily rooted in the religious and cultural beliefs surrounding the role of women in the society. Danjuma (2010) opines that the girl-child's access to STM is hindered by large family size, poverty and parents' low educational background. Societal structures such as traditional values and practices set up social norms, social status and perceptions that place limitations on the girl-child's participation in Science, Technology and Mathematics (STM) Education. Lack of female mentors and role models in STEM has also been held culpable for the persistently low enrolment and participation of women in STEM (Harry 2014, Atuahene and Owusu-Ansah 2013).

There was also a significant difference in male and female students' graduation rate in STEM disciplines in Michael Okpara University of Agriculture, Umudike. This finding aligns closely with Hango's (2013) report that women were proportionately under-represented among STEM graduates, compared with

other fields in Canada and Boladale, Oloapa and Oladipo's (2012) assertion that only a few female graduate employees in Nigeria had science and technology background.

However, a more worrisome trend is the decline in completion rate of students, especially female students, in STEM disciplines in Nigerian Universities. Data collected on the enrolment and completion rate of students in STEM disciplines in Michael Okpara University of Agriculture, Umudike suggests that Nigeria is not only saddled with the problem of attracting females to STEM disciplines but also with the challenge of retaining females in STEM. Several studies such as Elechi (2010), Eze & Kalu-Uche (2013), Book (2011) and Hill, Corbett and St. Rose (2010) have been able to put into perspective, the marginalization of women in STEM, and have suggested strategies such as: gender stereotyping, gender mainstreaming, single-sex education and career counseling among others for improving women recruitment in STEM education and disciplines, there seems to be no documented evidence that these strategies have succeeded in retaining girls in STEM disciplines in Nigeria.

These findings suggest that the female members of the Nigerian nation are underrepresented in STEM disciplines and as such are not contributing to Nigeria's socio-economic growth. For Nigeria to attain national transformation, its teeming female population needs to participate maximally in STEM so as to close the gender gap threatening the nation's development and transformation.

V. Conclusion

In view of the similarities in female participation in STEM fields across the nation, as suggested by various research reports, more objective analyses of the factors militating against female participation in STEM are required. This will ultimately lead to the identification, formulation and enactment of policies that will assure enrolment, retention, graduation and employment of Nigerian women in STEM disciplines. Nigerian women have the potential to contribute 50% of the human capital in STEM required for Nigeria's transformation. Thus, their enrolment and retention in STEM fields should be a policy priority.

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