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SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS: WHERE IS THE PLACE OF DEMOGRAPHY? A POSITION PAPER ON DEMOGRAPHY AND STEM

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ABSTRACT

The presentation is a position paper on the interconnections between the education policy, curriculum choices on science, technology, engineering and mathematics and the place of demography. The study is aggregate of thoughts complemented with archival review of existing literature and empirical analysis on admission trends and population growth. It was also firstly presented in one of the several departmental seminars. The study emphasised that demographic trends and growth are the main engine for technological progress. The study portrays demographic trends as crucial engine for technological progress and also works as the drivers of human capital towards achievement of economic prosperity. The result revealed wider gender gap that range from 41.4% to 51.5% in both pre-and post-STEM policy, though it finally stablised at 41.5% in 2009. The study positioned demographers as the conduit for delivery of optimum population or population explosion via assisted fertility technology e.g. in-vitro fertilization (IVF), preimplantation genetic diagnosis, human reproductive cloning, fetal DNA in maternal plasma, and genetic diagnosis). Therefore, while the pursuit of science, technology, engineering and mathematics is crucial for growth, the neglect of the sources of supply of human drivers or the demographic-based pull-and-push factors could engender wobbling and crawling structure of technological advancement. The authors however recommends adequate knowledge of these interplays for plausible

appropriate education and technological policies towards the delivery of desire sustainable economic development.

Key words: Science, technology, engineering and mathematics, STEM, demography, population size, population structure, human capital, education policy.

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1. INTRODUCTION

Despite concerted efforts by African governments to develop and improve upon their scientific and technological human-power and self-reliance, particularly through curriculum development, it is doubtful whether these goals have been satisfactorily achieved especially with the current crisis on self-reliance drive across most developing countries. Among the recent efforts is the emergence and metamorphosis of SEM or SMET (Science, Technology and Mathematics) to STEM. STEM is an acronym meant for teaching and learning in the fields of science, technology, engineering and mathematics. These teaching commonly include all education related activities across all grade levels starting from pre-school up to post-doctoral levels. These could also be either informal, formal setting or both. As a basis for the different emerging technologies, the role of STEM is crucial to the development of any economy.

STEM has popularly been adjudged as indispensable ingredient to sustainable development (1). It is expected to serve as basic supply of manpower to industrial communities towards the achievement of virile economic and national development. Specifically, by designs and possibility of self-reliant, STEM is hope to engender socio-economic development through opportunity for employment, income benefit, and welfare improvement (2). It is meant to foster scientific skills and capability and habit to solve problems coupled with imaginative creative thinking, and general mental prowess. However, it is obvious that, as at today, these lofty goals (of STEM) cannot be said to have been satisfactory achieved in most developing countries, especially Nigeria, consider the level of development and massive unemployment of graduates, the supposedly 'STEMmed' technocrats.

Human capital represents a major instrument for advancing technology (3). Demographic trends and growth therefore stands as the main engine for technological progress while the duo are good parameters for building economic prosperity of any nation. The interplay of technology and science with demographic trends and effect on economic prosperity operate through the age-sex structure of the population which lies at the bosom of demography and demographic ideas and behaviour. Neglecting such a fundamental subject or lack of its understanding could be fundamental to wobbling and crawling structure of technological advancement. New ideas is no doubt a positive function of population size and level of human capital. Specifically, human capital encompass education and health of the people. While health (a demography-component) is a crucial prerequisite for school attendance, and a vital determining factors of economic productivity of the workforce (4). The rate of change in per capita income is often proportional to the growth rates in population and human capital (4,5). So also, technological development is determined by demography-based pull and push factors. Evidences abound that most of affluent nations are countries with richer human

capital and have clear understanding of their demographic behaviour with effective population policy especially the four Asian Tigers (or Asian Dragons) Hong Kong, Singapore, South Korea and Taiwan (6–8).

Truthfully, as there are emerging massive assertions that STEM education system and STEM acquired skills are propellers of technological advancement (9,10), there are also perceived notions that the curriculum is wanting in creativity (1,11), including the personal ideas of the lead author and group opinions of the authors, particularly as it relates to developing countries. This missing creativity (and perhaps other components that are related) that are crucial parameters to foster competitive skills and innovative workforce could be found in the 'Arts' subjects or curricula (12). As illustrated by Gonzalez and Kuenzi (2012), while technology or science is a fundamental, the cultural creativity that would sell those technologies are equally indispensable. Similarly, culture has also been identified to have impact on academic performance of students (13–15). The creative industries, the graphic artists, TV campaign, the demographic profiles of citizens who are operators and mostly the end-users should always be available for plausible appreciable productivity among the contemporary industries.

Basically, technological development can only be successfully built or studied with models that have human beings as the drivers rather than other units at the core of their analysis (16). Demography, which is the mathematics of people should be apposite discipline to the study of both human and technological development across the world. It also remain a potent medium through which the efforts and results of other educational fields, and economic sectors can be evaluated. The science of demography contains understanding of its (population) dynamics and process of birth, migration, and mortality, including aging, how people form societies, form nations, develop culture, and how they populate the earth (17,18). Upon the backdrop that the present STEM seems to be inadequately preparing students or graduates for self-reliance world of work (19,20), there were recommendations for the introduction of entrepreneurship (11,21,22). The perennial challenge of unemployment in Nigeria could be better reduced or eliminated through education. Education is considered as the process that people undergo or acquire knowledge/skills or abilities, and attitudinal behaviour that are required for successful living in the society. The achievement of this would produce individuals that are enterprising, either as employees, employers or entrepreneurs (11). This presentation is to re-echo the importance of STEM but emphasise the indispensable connection between STEM and demography, demographic analysis including other social sciences and studies in the humanities.

2. METHODS, SEARCH STRATEGY AND SELECTION CRITERIA

Although the presentation is position paper, larger information were based on personal opinion though complemented with substantial archival review of relevant literature and quantitative analysis. The data were extracted from a 2002-2009 longitudinal data on students admitted into certain engineering programs of a private university (23). These are: Engineering programs are Electrical and Electronics, Chemical, Civil, Computer Engineering, Information and Communication Engineering, Mechanical Engineering, and Petroleum Engineering of a private university, particularly Covenant University. Data for the empirical information were extracted and analysed using only descriptive statistics. In Nigeria, data linking university enrollment with population growth or fertility level is scarce or not readily available for this study. The study therefore supplement the data with archival review. In this regard, the search engines included Google Scholar, AJOL and other online journals. The search also included unpublished reports and seminal presentation papers. Articles reviewed excluded articles published prior to emergence or before the beginning of popularity of

Science, Engineering and Mathematics (SEM) in Nigeria. Therefore, only articles published after 2004 reviewed of National Education Policy were reviewed (19,20,24). The study also noted that the first known indigenous National Policy on Education in Nigeria came into being in 1977 (19,20,24). Articles were limited to Nigerian issues only. The search terms were simply education policy, demography, demographic analysis, population studies, science, technology, engineering, mathematics, population growth, gender education enrollment and nation's development.

3. RESULTS AND DISCUSSION

3.1. Demographic trends and admission trends into engineering courses

A simple empirical illustration shows that the trends in admission into engineering courses in the University for which students' enrolment data were available for this study covering year 2002 to 2009. The first graph (fig. 1) represents a 4-year interval projected population growth from 1960 (25). The graph shows consistent increase in population from 1960 to 2017. Other available data on population growth revealed a growth rate of 3.2% for Nigeria (26). The current population of Nigeria **is** 195.9m and represents 2.6% of the world population based on the estimates of the United Nations (26). The country ranks 7th among the world most populous countries. The current education system is 9-3-4 called Universal Basic Education (UBE) implies that every child spend the first 9-years of basic and compulsory education up to the Junior Secondary School (JSS-3) level, another 3 years in the senior secondary school, and 4-years in the tertiary institutions (27–29). The basic education covers children aged ≤ 11 years. The senior secondary school covers mostly adolescent aged ≤ 14 years. Nigeria population median age is relatively 17.9 years. This simply indicate that over 50% of the population are expected to be in college-age bracket.

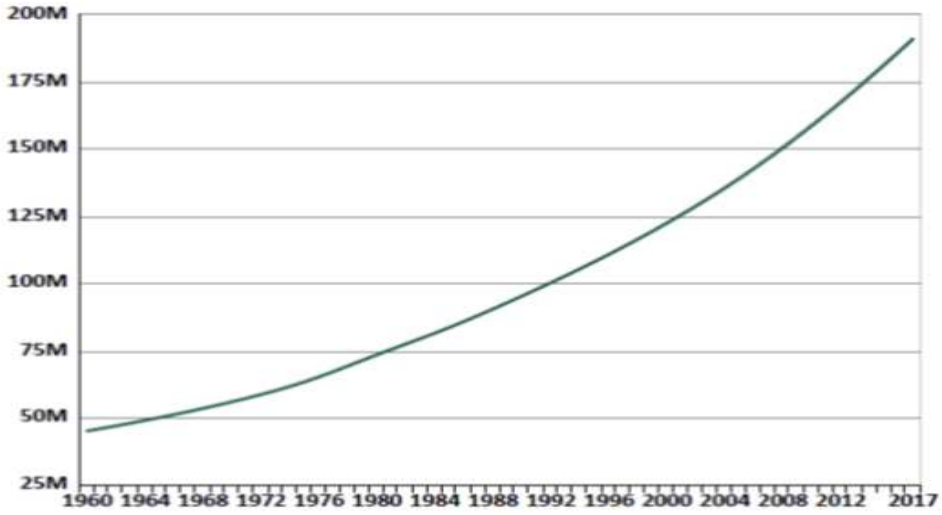


Figure 1 Nigeria Population growth 1960-2017

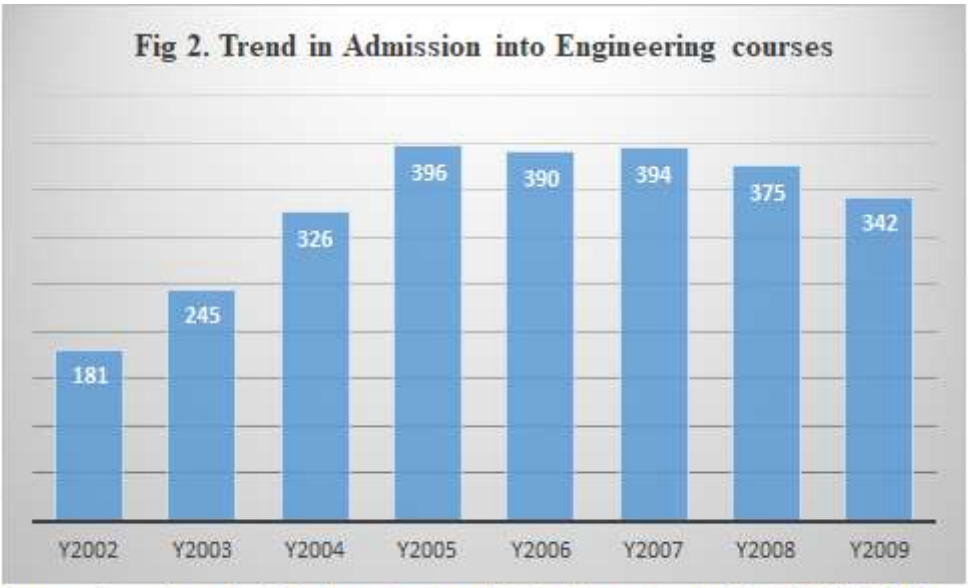
Source: Knoema (2018). Nigeria, Total Population. https://knoema.com/atlas/Nigeria/Population

The trend in students admission into engineering courses in the university with the data analysed for this student is presented in Table 1. The data also revealed a consistent rise in the number of candidates admitted to read engineering courses. The gender analysis also shows that more male candidates were admitted (within the data period, 2002-2009) than the female candidates. The pictorial representation (fig 1) shows upward movement in the admission rate for both gender.

Table 1 Trends and gender analysis of undergraduate admission into engineering courses

Year of admission	Y2002	Y2003	Y2004	Y2005	Y2006	Y2007	Y2008	Y2009
Male	128	177	236	293	288	289	284	242
Female	53	68	90	103	102	105	91	100
Total	181	245	326	396	390	394	375	342

Source: Popoola, et al, 2018. Datasets on demographic trends in enrollment into undergraduate engineering programs at Covenant University, Nigeria. *Data in brief, 18*, 47-59. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5996132/.



Source: Popoola, et al, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5996132/.

Gender gap in undergraduates admitted into engineering programs

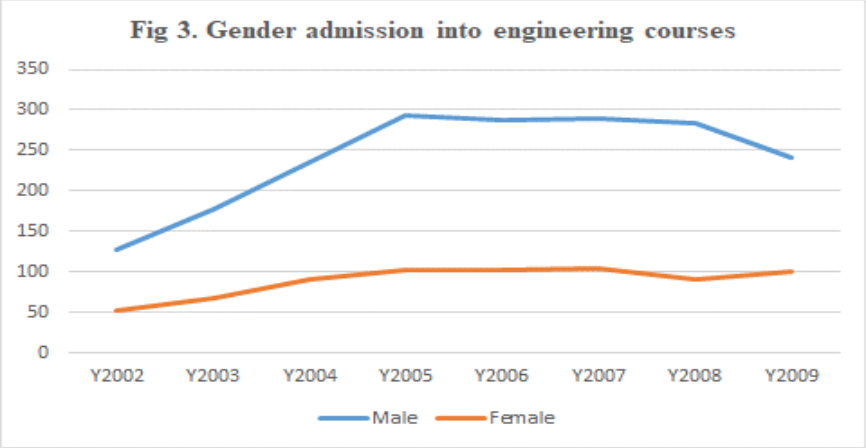
The gender gap revealed increasing wider gender gap in admission up to 2005, perhaps due to reviewed of education policy and the introduction of STEM. Specifically, the pre-STEM revealed a gap of 41.4% (2002), 44.5% (2003), 44.8% (2004) and 48% (2005). The post 2005 has been mixed results (Table 2). While the gap were 47.7% and 46.7% in 2006 and 2007 respectively, a reduction from preceding two years; it increased to 51.5% in 2008 and finally stablised at 41.5% in 2009 as shown in Table 2.

Table 2. Gender gap in undergraduates admitted into engineering programs (in %)

Year of admission	Y2002	Y2003	Y2004	Y2005	Y2006	Y2007	Y2008	Y2009
Male (%)	70.7	72.2	72.4	74.0	73.8	73.4	75.7	70.8
Female (%)	29.3	27.8	27.6	26.0	26.2	26.6	24.3	29.2
Gap (%)	41.4	44.5	44.8	48.0	47.7	46.7	51.5	41.5
Total	181	245	326	396	390	394	375	342

Source: Computed for this study using Popoola et al (2018) dataset

The attempt to juxtapose the population trend with admission shows a relatively similar pattern in the rise of population and increase in the total number of candidates (both sexes) admitted candidate of female candidates. The enrollment of students into Nigerian universities like other universities in the world is a function of population growth rate and the structure of the population (30). Nigeria with annual population growth rate of 2.6% should be expected to have increase annual increase in candidates aspiring for higher institution.



Source: Popoola, et al, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5996132

Gender gap analysis is also intertwined with sex ratio at birth, a function of traditional sex preference of which education attainment (though, of parents and policy administrators) is a strong determinant. Better-educated adults would have relative risk of exposure to diseases, low mortality risk that can ensure longevity and better opportunity for their children survival. Therefore, a balance educational policy pursuit could have significant future consequences, not only on education, but future population growth including other aspect of progress in human development (4,16).

4. POPULATION STRUCTURE AND ACHIEVEMENT OF STEM

Every achievement from one discipline is a strategic product of conglomerate of disciplines. In African education context, a Chemist must have passed through mathematics, biology even religious study. Similar case apply to science, technology, engineering and mathematics. Besides, most subjects have real applicable value in the contemporary social spheres. Demographic trend is key to the achievement of STEM goals. In the first instance, the enrolment into STEM is contingent upon the size and distribution of population, which though could be natural, but are often intermediated by family planning, birth control, marriage patterns, cultural practices, and so on (13,14). We therefore wonder if demography is not the bedrock of all sciences. Demography is destiny, the concept earlier ascribed to Auguste Comte, 1798-1857 (13,17,31). The most crucial events in life are births, deaths, migration, marriages and divorces and the changes in them are of great technological and biological salience. Demographic analysis enjoys reality and makes as much use of advanced mathematics in the measurement of biological, socio-economic characteristics such as place of usual residence (either rural or urban), educational level, employment status, marital status, ethnicity, migration status, income group and health or disability status (4).

Demographic models project the future supply of labour, level of education or simply put human capital (4,5,12). Demographers could guide the world into optimal population or encourage population explosion via assisted fertility technology such as in-vitro fertilization (IVF), preimplantation genetic diagnosis, human reproductive cloning, fetal DNA in maternal plasma, genetic diagnosis, including counselling, and so on. For example, some countries such as Singapore, South Korea and Taiwan are currently facing zero birth rates or fertility below replacement level (26). Demographic behaviour and advice of today therefore determine the population size, structure and distribution of tomorrow. Why then should the policy makers and development stakeholders be looking far to address huge unemployment situation, without utilizing demographic principles as always suggested by population experts? Actually, it will not be prudent to disallow increment in the number of new entrants

into STEM that would play crucial roles in economic and national development and demographic principles provides the solutions.

Demographic analysis of school enrolment and employment revealed persistent gaps between male and female enrolment in schools, employment in industries especially in the engineering and technological fields (32–36). Persistent factors contributing to these challenges have been parents' negative attitude towards the education of their daughters, and the attitudes towards the gender roles of women and men (34). The challenges could be better addressed through social sciences subjects of which demography is key. In order to get women into the mainstream of STEM and empower them for national development without jeopardizing the involvement of men, parent's education on the change in parenthood role is essential. Involving women in strategy to actualize the objectives of STEM is crucial and has immediate gains for family wellbeing, community and the country at large.

Also, the traditional sex-role stereotype has implications for the choice of discipline even at higher colleges. Education in nursing, economics and management are traditional perceived as women's disciplines, while engineering, architecture, are often considered as men's jobs. The understanding and mobilization of candidates towards the subjects of STEM are also better situated in humanities and social sciences. Lutz and Samir (2013) indicated that the changes in demographic composition of a society in terms of fertility and mortality will greatly influence the future outlook of her education and consequently the population heterogeneity of that society. So, the understanding of demographic analysis of fertility and mortality could aid proper planning of our education system geared towards sustainable development. On the other hand, morbidity and mortality put checks on the extent to which human capacity can go in enhancing development. This important reason has made demographic applications to the parameter of human survival as the greatest goal around the globe (17). Thus, objective linkage of demography and demographic analysis with whatever education system intended, would direct investment and training on empowerment, realization of better health, technological development, poverty reduction and sustainable development.

STEM has since been enjoying good and massive support from both governments and other stakeholders in terms of funding, scholarships, and availability of facilities. STEM education approach is to spur revolution in academic curriculum through the teaching of subjects such as mathematics and science with bias in technology and engineering. It is actually meant to drive student's capability to solve problem, discover and explore. It is a key to transform the traditional typical teacher-centered classroom to problem-solving meeting of the students and the teachers. According to Gonzalez and Kuenzi (2012), the STEM approach allows students to think critically, apply the skills learned and explore in-depth the problem covered towards providing solution to the problem (1).

In a study of school administrators that comprises of executives and superintendents, it was found that quite a number of companies are in dire need of skills in their new employees but which are more related to creativity arts than stereotype science, technology or mathematics related (1,37). According to the report, what most companies want is, workers who can contribute or communicate new ideas, problem-solving worker, who can brainstorm, and creatively collaborating (1). In Nigeria, for example, the first indigenous National Policy on Education came into being in 1977 (19,20). It was reviewed couple of times before the 2004 that emphasised science, Engineering and mathematics (SEM) which later metamorphosed into STEM. The overriding objective was to launch the country into world of technology and emerging industrialized country (19,20,24). The policy specifically emphasised a 60:40 ratio of admission ratio of 60:40 between sciences and humanities into the university. However, the STEM and the education policy that brought it failed to yield satisfactory results at higher education level, as the universities were unable to meet the

prescribed science-humanities admission ratio in terms of 60:40 science-humanities requirement (19,20). Some other challenges of STEM have been inadequate human resources (such as lack of qualified teachers; poor attitude of the operators such as teachers, administrators, low and irregular remunerations) and inadequate funding and corruption.

Education, is no doubt, the surest basis for public happiness but what happens when it is supported or pursued disproportionately? Education ranks higher in development of any nation. It is the most potent instrument of change but paradoxically, it is influenced greatly by demographic situation and trends of the society. Demographically, STEM and gender analysis cannot be overemphasised. Considering the shortage of women in these fields (i.e. Science, Engineering, Technology, and Mathematics) (38). While education of women, has implication for healthy motherhood, healthy children and good family wellbeing, increase in women engineers, mathematicians, scientists portends improved welfare status, higher socio-economic status and again good maternal and child health and productive nation. On the other hand, the overwhelming burden on the part of men concerning STEM subjects also should be assessed particularly in terms of welfare, and men's health.

Women constitute almost half of Nigeria population and over 50% of the global population, but among their notable characteristics are lower economic status and are under-represented in the fields of science, technology and mathematical courses even in tertiary institutions (2,32,35,36,39,40) and this has been a cause for concern in Nigeria. The women are however not underrepresented in life and social sciences (2,32,35,36,39–41). The training of a women is synonymous with education of the entire nation (13,33,42). Thus, some attempts have been made by governments to close the gender gap in education and further attempts are currently underway to close the gap also in the gender imbalance in science, technology, engineering and, mathematics. This include compulsory basic education and policy supporting female education up to secondary school.

5. CONCLUSION AND POLICY RECOMMENDATIONS

Since national development is contingent upon skills, political will, and capacity to harness the resources available including human, material and economic resources, which are not sorely domiciled within STEM, but inherent in humanities, population understanding, political studies, the underestimation of these disciplines could render the objectives of STEM non-achievable. The highlighted the interconnection between study in demography and sciences technology, engineering and mathematics. The study attempted to illustrate that no discipline in independent of each other and the idea of official support for few ones could deprive the society of greater values of interconnectedness with others. Rather than tagging the philosophy of STEM as slow or unrealistic, it could possibly be enhanced by engaging also the social sciences, humanity and arts. While the pursuit of technological advancement is crucial for growth, the neglect of the suppling sources of human drivers of these technology is fundamental for sustainable development. Adequate knowledge of these interplays could engender appropriate education and technological policies for long desire for sustainable economic development.

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