ORIGINAL RESEARCH ARTICLE

Science, technology, engineering and mathematics enrolment patterns and factors influencing the choice to study science among female secondary school students in Nigeria

DOI: 10.29063/ajrh2021/v25i5s.8

Olabode A. Onile-ere[1, 2], Oghenevwairhe P. Efekemo[1, 2], Angela O. Eni[1, 2]*

West African Virus Epidemiology (WAVE) for root and tuber crops, Covenant University Hub, KM 10 Idiroko Road, Canaanland, PMB 1023 Ota, Ogun State, Nigeria[1]; Department of Biological Sciences, College of Science and Technology, Covenant University, KM 10 Idiroko Road, Canaanland, PMB 1023 Ota, Ogun State, Nigeria[2]

***For Correspondence:** Email: *angela.eni@covenantuniversity.edu.ng*

Abstract

Access to education has been listed as one of the Sustainable Development Goals (SDG4). Achieving this goal, however, is predicated upon the elimination of widely prevalent gender disparities in education. In this report, we first examine the differences in enrolment in STEM-related courses between the genders then we proceed to explore the factors that may affect the choice of STEM in pre-university female students in Ogun state, Nigeria. Two publicly available datasets, the Joint Admissions Matriculation Board (JAMB) enrolment data for 2012 – 2015 and data on the performance of students enrolled in Covenant University from 2010-2014 were used in this study. A survey of pre-university students in Ogun state, to examine factors that influence career choice was also conducted and used in this study. Our findings showed that men were more likely to be enrolled in a STEM discipline than women. This disparity was, however, not observed for non-STEM disciplines were both genders were equally likely to be enrolled. Responses from our survey of female secondary school students showed that a good number (47.6%) were not confident to take pre-university STEM subjects and were likely to enrol in non-STEM courses at the university. These findings emphasise the need to sensitise junior secondary school level girls to take on more technical courses in a bid to have adequate representation across the STEM disciplines. *(Afr J Reprod Health 2021; 25[5s]: 91-97).*

Keywords: Gender; STEM; education; Nigeria

Résumé

L'accès à l'éducation a été répertorié comme l'un des objectifs de développement durable (SDG4). Toutefois, la réalisation de cet objectif repose sur l'élimination des disparités entre les sexes largement répandues dans l'éducation. Dans ce rapport, nous examinons d'abord les différences d'inscription à des cours liés aux STEM entre les sexes, puis nous explorons les facteurs qui peuvent affecter le choix des STEM chez les étudiantes préuniversitaires de l'État d'Ogun, au Nigéria. Deux ensembles de données accessibles au public, les données d'inscription du Joint Admissions Matriculation Board (JAMB) pour 2012-2015 et les données sur les performances des étudiants inscrits à l'Université Covenant de 2010 à 2014 ont été utilisées dans cette étude. Une enquête auprès d'étudiants préuniversitaires de l'État d'Ogun, pour examiner les facteurs qui influencent le choix de carrière, a également été menée et utilisée dans cette étude. Nos résultats ont montré que les hommes étaient plus susceptibles d'être inscrits dans une discipline STEM que les femmes. Cette disparité n'a cependant pas été observée pour les disciplines non-STEM où les deux sexes étaient également susceptibles d'être inscrits. Les réponses à notre enquête auprès des étudiantes du secondaire ont montré qu'un bon nombre (47,6%) n'étaient pas confiants de suivre des matières préuniversitaires en STEM et étaient susceptibles de s'inscrire à des cours non-STEM à l'université. Ces résultats soulignent la nécessité de sensibiliser les filles du premier cycle du secondaire à suivre des cours plus techniques dans le but d'avoir une représentation adéquate dans toutes les disciplines STEM. *(Afr J Reprod Health 2021; 25[5s]: 91-97).*

Mots-clés: STEM éducation; Nigeria

Introduction

Science, Technology, Engineering and Mathematics (STEM) play pivotal roles in driving economic development of any nation. In many ways, a nation's ability to thrive and ensure the wellbeing of its people is dependent on its scientific and technological prowess. Motivated by the recently adopted sustainable development goals, specifically, Goal 4 which calls for increased access

to education for all, considerable progress has been made in Nigeria towards achieving increased enrolment rates for girls at all levels of education. Currently, 40 – 48% of all persons at all levels of education in Nigeria are girls however women are still significantly underrepresented in most STEM disciplines save for the fields of medicine and biological sciences where women are at par or even exceed men[1–3]. Authors have attributed this gap to a host of factors such as the need for women to satisfy communal goals, a lower STEM self-efficacy in women, family influences, amongst other things[4–8].

Self-efficacy, a concept of the social cognitive theory, as popularised by Bandura[9], implies an individual's belief in their abilities to succeed in a particular sphere of life. Self-efficacy is often shaped by one or a combination of four major factors; experience gained through mastery, observation of other persons similar to oneself, verbal persuasion and one's physiological and emotional states[9]. Studies aimed at understanding factors that influence career choices among men and women have shown that people tend to lean towards domains or disciplines in which they feel competent and away from those in which they feel incapable[5,10]. Women studying STEM courses are particularly affected by self-efficacy compared to their male counterparts despite often earning similar, and in some cases, better grades[5].

One study among first-year engineering students showed that perceived difficulty in comprehension, drive and motivation were correlated with lower self-efficacy in women[5]. In a similar but longitudinal study by Hardin and Longhurst[11] among first-year students in different STEM courses, similar patterns were observed even after controlling for grades with self-efficacy reducing in female students as the semester progressed. Hardin and Longhurst also found that significantly more males than females received support from loved ones for obtaining a STEM degree, an indicator of the role of external influences in mediating self-efficacy among females[11].

Self-efficacy, while a good angle from which to explain the underrepresentation of women in some STEM fields, does not provide a complete outlook of the problem. Self-efficacy, for example, does not explain the underrepresentation of men in certain fields such as biology or the tendency of women to lean towards careers that afford them communal goals. Role congruity theory, an extension of the Social Role theory, implies that the career choices of men and women are a function of social expectations. For example, women traditionally lean towards caretaking roles with communal benefits while men lean towards roles that help them fulfil agentic goals such as self-assertion and independence[10].

To explain the difference in choice of vocation between men and women, Prediger [12] building upon previous work, proposed the people-thing bipolar dimensions of interest. The people-thing orientation explains the extent to which an individual leans towards impersonal roles or activities over those that involve working with people[7,13]. For example, women are more likely to choose a career such as healthcare where they work with people while men are more likely to select jobs oriented towards working with things such as engineering and computer science. Studies have consistently shown gender differences in STEM-based on people-thing dimension irrespective of age and ethnicity[7,14].

The present study

In this paper, we first examine the gender differences in university enrolment rates in Nigeria using publicly available datasets. We evaluated the performance of male and female students in STEM, and then we attempted to explain such differences by assessing the determinants of the choice of STEM among secondary school students in Nigeria. We explained the observed disparities in university enrolment by employing the role congruity theory and then showed that the underrepresentation of female students in STEM is due primarily to a lack of self-efficacy found amongst secondary school students.

Methods

This paper used two publicly available datasets, and a third one obtained directly during a survey. The first dataset was obtained from the Joint Admissions Matriculation Board (JAMB)[15]. Data was scraped from annual enrolment rates into Nigerian universities as reported on the JAMB website and entered into an excel sheet. The dataset contained application and enrolment rates for four years, 2012-2015, stratified by gender in nine (9) major disciplines in Nigerian Universities as classified by JAMB. The JAMB dataset reports application and enrolment rates by major disciplines which are mostly an aggregation of many sub-disciplines. For examples, the Science category comprises the Natural sciences amongst other Disciplines; the natural sciences include such sub-disciplines as Biology, Physics, Chemistry amongst others. Furthermore, application rate as used here connotes the number of post-high school students who applied to a Nigerian university through JAMB while enrolment rate is a subset of the applicants who got admission into a Nigerian university.

Following on the work of Yang and Barth[13], each major discipline was labelled with one of three categories; disciplines likely to lead to careers providing communal goals i.e. helping people or working with people were labelled as 'people-oriented' (PO), disciplines less likely to lead to careers providing communal goals i.e. working more with things than with people were labelled as 'thing-oriented' (TO). To accommodate the peculiarities of the JAMB dataset vis-à-vis major disciplines such as 'Science' which contain a wide variety of sub-disciplines, we created a third category, 'Both Orientation' (BO), for major disciplines with sub-disciplines that lean toward both people and thing orientations.

The second dataset used was from a publicly available data source[16]. The dataset contained academic performance, measured as grade point average (GPA), of 3046 students in STEM disciplines in a Nigerian university across five years. The dataset also contained the GPA of students at entry (SGPA) and is stratified by gender. Again, disciplines were categorised into people or thing orientation as described above. This dataset was used as a way to assess the performance of male and female students across disciplines throughout their stay in the university.

The third dataset was survey dataset obtained during a mentorship session for 63 female high school students in the science (Pre-STEM) class facilitated by the African Women in Agricultural Research and Development (AWARD). The survey was conducted in 2016 using a 17-item open-ended questionnaire as a study instrument. The study instrument was targeted towards understanding factors motivating the career choices of the students. Content analysis was performed for obtained responses; responses were coded around unifying themes. For example, when asked who their biggest influence to study science was, responses such as 'Father', 'Mother' were recoded as 'Parents' while responses such as 'Aunt', 'Uncle', 'Siblings' were recoded as 'Other family members'. All data were analysed using descriptive statistics; independent Student's t-test was used to assess the difference in performance between gender. $P<0.05$ was considered statistically significant for all analysis. The analysis was performed using IBM SPSS version 25.

Results and Discussion

The dataset obtained from JAMB contained enrolment information for 1,392,858 students from 2012 – 2015. Of all students enrolled in a Nigerian University from 2012 – 2015, 58% were male, and 42% were female resulting in gender parity of 1.38 indicating that women are less likely than men to attend a higher institution in Nigeria. A more in-depth look into the gender gap in enrolment revealed two somewhat extreme situations with the one side (non-STEM disciplines) showing an almost perfect gender parity of 1.04 and the other (STEM Disciplines), a significantly wide gap of 1.80 (Table 1). We found that out of the four STEM disciplines covered in the JAMB dataset, females only dominated in one, Medicine (Table 1). The field of medicine is primarily oriented towards helping and working with people ergo the large number of females. This is consistent with the role

Table 1: JAMB application and enrolment in universities 2012-2015 in STEM related and non-STEM courses

	Application		Enrolment	
	Female (%)	Male (%)	Female (%)	Male (%)
Agriculture	64,388 (49.75)	65,029 (50.25)	21,475 (48.73)	22,591 (51.27)
Eng/Tech/Env	103,589 (12.20)	745,825 (87.80)	27,294 (12.90)	184,326 (87.10)
Medicine/Pharmacy	605,381 (59.48)	412,362 (40.52)	108,140 (54.65)	89,752 (45.35)
Sciences	352,116 (38.70)	557,726 (61.30)	91,910 (37.98)	150,073 (62.02)
Sub Total	1,125,474 (38.72)	1,780,942 (61.28)	248,819 (35.77)	446,742 (64.23)
Administration (Business & Public)	363,973 (52.13)	334,179 (47.87)	63,359 (50.88)	61,179 (49.12)
Arts/Humanities	221,400 (51.54)	208,144 (48.46)	58,122 (51.93)	53,797 (48.07)
Education	174,065 (57.53)	128,513 (42.47)	63,176 (56.24)	49,150 (43.76)
Law/Legal Studies	180,190 (51.30)	171,040 (48.70)	39,246 (52.29)	35,810 (47.71)
Social Sciences	626,154 (43.66)	807,997 (56.34)	117,873 (43.10)	155,585 (56.90)
Sub Total	1,565,782 (48.69)	1,649,873 (51.31)	341,776 (49.01)	355,521 (50.99)

Table 2: People-thing orientation amongst STEM related courses

	Application		Enrolment	
	Female (%)	Male (%)	Female (%)	Male (%)
Thing orientation	103,589 (12.20)	745,825 (87.80)	27,294 (12.90)	184,326 (87.10)
People orientation	669,769 (58.38)	477,391 (41.62)	129,615 (53.57)	112,343 (46.43)
Both orientations	352,116 (38.70)	557,726 (61.30)	91,910 (37.98)	150,073 (62.02)
Total	1,125,474 (38.72)	1,780,942 (61.28)	248,819 (35.77)	446,742 (64.23)

congruity theory which predicts that women are more likely to choose careers that afford them communal goals. It is important to state at this point that while some authors do not classify medicine as a STEM discipline, we choose to classify it as such because students enrolled in medicine take the same set of subjects in the secondary school level as students enrolled in other STEM disciplines. The observed advantage women have in this dataset is probably due to the fact that medicine, as reported here, includes such predominantly female sub-disciplines as Nursing and Midwifery. Such sub-disciplines may have skewed the figures in favour of women.

Furthermore, the dominance of female students in medicine, as reported here does not translate into practice as studies have reported male dominance in many core medical specialities[17,18]. One study conducted in Nigeria reported that as high as 70% of doctors are men[17]. The study also showed that female doctors were present in only one of two sub-specialities; paediatrics and gynaecology as compared to male doctors who occupied a wider array of specialities. Another study[18], investigating the reasons for the disparity in specialities amongst Nigerian doctors, found that women primarily leaned towards paediatrics and gynaecology in a bid to satisfy their communal goals vis-à-vis having more time to spend with family as opposed to roles in surgery which would require more on call hours.

We found similar enrolment patterns among students in the private school with female students dominating courses such as Biochemistry and Microbiology while being almost absent in engineering courses (Table 3). The reason for this is not clear from the data available; however, it most likely stemmed from the low self-efficacy of females in maths as compared to males[19,20]. Biochemistry and Microbiology are relatively math-light courses compared to engineering, which is largely based on mathematical concepts. This gender difference in math abilities has been well documented by many authors with most attributing the poor performance in girls to culture, nature, and nurture[21–23].

Table 3: Enrolment in STEM courses in Covenant university Ota, Nigeria

	Gender	
Programme	Female (%)	Male (%)
Biochemistry	113 (76.4)	35(23.6)
Building Technology	30 (30.9)	67 (69.1)
Computer Engineering	72 (30.4)	165 (69.6)
Chemical Engineering	78 (36.6)	135 (63.4)
Industrial Chemistry	62 (55.9)	49 (44.1)
Computer Science	120 (35.1)	222 (64.9)
Civil Engineering	24 (14.4)	143 (85.6)
Electrical and Electronics Engineering	81 (19.4)	337 (80.6)
Information and Communication Engineering	95 (38.8)	150 (61.2)
Mathematics	27 (44.3)	34 (55.7)
Microbiology	130 (79.3)	34 (20.7)
Mechanical Engineering	16 (8.7)	168 (91.3)
Management and Information System	151 (49.2)	156 (50.8)
Petroleum Engineering	70 (33.8)	137 (66.2)
Industrial Physics-Electronics and IT Applications	13 (15.9)	69 (84.1)
Industrial Physics-Applied Geophysics	7 (18.9)	30 (81.1)
Industrial Physics-Renewable Energy	4 (15.4)	22 (84.6)
Total	**1093 (35.9)**	**1953 (64.1)**

Table 4: Characteristics of secondary school survey participants

Age		Mean 14 ±0.98 (Range 12-17)	N =63
School	CUSS		14
	Faith Academy		19
	Iganmode Grammar School		10
	Iju Ebiye High School		10
	The Ambassadors College, Ota		10
Class	Year 10		22
	Year 11		38
	Year 12		3

To understand some of the differences found amongst the university students, we looked at the survey data obtained from female secondary school students. A total of 63 female students from 5 secondary schools with a mean age of 14 ± 0.98 were included in the survey (Table 4).

Table 5: Sources of influence to study science and choice of career among secondary school girls in Ogun state Nigeria

		Frequency (%)
Source of influence to study science	Parents/Family	31 (49.2)
	Self	24 (38.1)
	Peers	1 (1.6)
	Teacher	2 (3.2)
	Others	3 (4.8)
	No Response	2 (3.2)
	Total	63 (100.0)
Choice of career	Medicine and Related Courses	40 (63.5)
	Biological Sciences	12 (19.0)
	Law	2 (3.2)
	Business Courses	3 (4.8)
	Math/IT/Comp Science	2 (3.2)
	Agric related	2 (3.2)
	No response	2 (3.2)
	Total	`63 (100.0)

About half (49.2%) of the students cited their parents and family members as the major source of influence in studying science at the secondary school level (Table 5), 47.6% had at one time considered changing from the science class due to difficulties in comprehension (72.4%) and fear (10.3%). Most students (77.8%) had a friend who had changed from the science class mostly due to difficulty in comprehension (56.5) and lack of interest (15.2%). Medicine (63.5%) and Biological Sciences (19.0%) were the preferred career choices for most students with only 2 girls (3.3%) picking a career choice in a math-based field such as computer science (Table 5). The results obtained from the survey are consistent with the enrolment rates found among the university students where girls leaned towards the biological science and medicine. Since most girls had either considered leaving the science class or knew someone who had left due to difficulties, it follows that most respondents have low self-efficacy for most STEM careers hence their choice of medicine and biological sciences. The choice of career amongst the secondary school girls surveyed in this study also aligned with people-thing dimension as most persons (82.5%) opted for people-oriented courses as opposed to thing-oriented courses.

Conclusion

In this study we have shown that gender differences exist across STEM disciplines in Nigeria, we have also shown that career choices in girls are formed at the secondary school level and are influenced by the people and circumstances surrounding the female. Reaching gender parity in education would require intervention at the secondary level to increase STEM self-efficacy and encourage girls to take on STEM courses at the university level.

Acknowledgements

The authors are grateful to the management of Covenant University for their support through Covenant University Centre for Research, Innovation, and Discovery (CUCRID) towards this study, and its publication.

Declaration

AOE conceived, designed the study, and approved the final draft of the manuscript. OPE proofread the manuscript and performed content analysis. OAO analysed all the data and prepared the manuscript.

References

1. Ojokoh BA, Owoseni MT, Akinsowon OA and Isinkaye FO. Gender Gap in Career Progression in Stem Fields in Two South Western States of Nigeria Publications. In: 2nd International Conference and Exhibition (OWSD-FUTA). Akure; 2015. p. 568–73.
2. Akanwa UN and Kalu-Uche. Women in STEM: Closing the Gender Gap to National Transformation. IOSR J Res Method Educ Ver III [Internet]. 2015;5(2):2320–7388. Available from: www.iosrjournals.org
3. Knoema. Nigeria-Education [Internet]. 2020 [cited 2020 Aug 6]. Available from: https://knoema.com/atlas/Nigeria/topics/Education
4. Brown ER, Thoman DB, Smith JL and Diekman AB. Closing the communal gap: The importance of communal affordances in science career motivation. J Appl Soc Psychol. 2015;
5. Hutchison MA, Follman DK, Sumpter M and Bodner GM. Factors Influencing the Self-Efficacy Beliefs of First-Year Engineering Students. J Eng Educ [Internet]. 2006 Jan;95(1):39–47. Available from: http://doi.wiley.com/10.1002/j.2168-9830.2006.tb00876.x
6. Diekman AB, Steinberg M, Brown ER, Belanger AL and Clark EK. A Goal Congruity Model of Role Entry, Engagement, and Exit: Understanding Communal Goal Processes in STEM Gender Gaps. Personal Soc Psychol Rev [Internet]. 2017 [cited 2018 Aug 9];21(2):142–75. Available from: http://journals.sagepub.com/doi/pdf/10.1177/1088868316642141
7. Graziano WG, Habashi MM, Evangelou D and Ngambeki I. Orientations and motivations: Are you a "people person," a "thing person," or both? Motiv Emot. 2012;
8. Ekine A and Abay NA. Enhancing Girls' Participation in Science in Nigeria: A Driver for National Development and Social Equality [Internet]. 2016 [cited 2020 Aug 6]. Available from: https://www.brookings.edu/wp-content/uploads/2016/07/ekine_girls_education.pdf
9. Bandura A. Self-efficacy: The exercise of control. Macmillan; 1997.
10. Tellhed U, Bäckström M and Björklund F. The role of ability beliefs and agentic vs. communal career goals in adolescents' first educational choice. What explains the degree of gender-balance? J Vocat Behav [Internet]. 2018 Feb 1 [cited 2018 Aug 9];104:1–13. Available from: https://www.sciencedirect.com/science/article/pii/S000187911730115X
11. Hardin EE and Longhurst MO. Understanding the gender gap: Social cognitive changes during an introductory STEM course. J Couns Psychol. 2016;
12. Prediger DJ. Dimensions underlying Holland's hexagon: Missing link between interests and occupations? J Vocat Behav [Internet]. 1982 Dec 1 [cited 2018 Aug 10];21(3):259–87. Available from: https://www.sciencedirect.com/science/article/abs/pii/0001879182900367
13. Yang Y and Barth JM. Gender differences in STEM undergraduates' vocational interests: People–thing orientation and goal affordances. J Vocat Behav [Internet]. 2015 Dec 1 [cited 2018 Jul 12];91:65–75. Available from: https://www.sciencedirect.com/science/article/pii/S0001879115001062
14. Cheryan S, Ziegler SA, Montoya AK and Jiang L. Why are some STEM fields more gender balanced than others? Psychol Bull. 2017;
15. JAMB. Jamb Statistics [Internet]. 2018 [cited 2018 Jul 24]. Available from: http://www.jamb.gov.ng/statistics.aspx
16. John TM, Badejo JA, Popoola SI, Omole DO, Odukoya JA, Ajayi PO, Aboyade M and Atayero AA. The role of gender on academic performance in STEM-related disciplines: Data from a tertiary institution. Data Br [Internet]. 2018 Jun 1 [cited 2018 Jul 10];18:360–74. Available from: https://www.sciencedirect.com/science/article/pii/S2352340918302579
17. Ebuenyi ID, Ikuabe PO, Ufondu CC, Onubogu CU and

Onyeka IN. Gender variations in specialties among medical doctors working in public healthcare institutions in Bayelsa State, Nigeria. Niger J Med. 2017;26(1):18–22.

18. Makama JG, Garba ES and Ameh EA. Under representation of women in surgery in Nigeria: by choice or by design? Oman Med J [Internet]. 2012 Jan [cited 2018 Aug 22];27(1):66–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22359731
19. Lin L, Lee T and Snyder LA. Math Self-Efficacy and STEM Intentions: A Person-Centered Approach. Front Psychol [Internet]. 2018 Oct 23 [cited 2020 Aug 7];9(OCT):2033. Available from: https://www.frontiersin.org/article/10.3389/fpsyg.2018.02033/full
20. Ayotola A and Adedeji T. The relationship between mathematics self-efficacy and achievement in mathematics. Procedia - Soc Behav Sci. 2009 Jan 1;1(1):953–7.
21. Contini D, Tommaso ML Di and Mendolia S. The gender gap in mathematics achievement: Evidence from Italian data. Econ Educ Rev [Internet]. 2017 Jun 1 [cited 2018 Aug 22];58:32–42. Available from: https://www.sciencedirect.com/science/article/pii/S0272775716303466
22. Nollenberger N, Rodríguez-Planas N and Sevilla A. The Math Gender Gap: The Role of Culture. Am Econ Rev [Internet]. 2016 May [cited 2018 Aug 22];106(5):257–61. Available from: http://pubs.aeaweb.org/doi/10.1257/aer.p20161121
23. Fryer RG and Levitt SD. An Empirical Analysis of the Gender Gap in Mathematics. Am Econ J Appl Econ [Internet]. 2010 Apr [cited 2018 Aug 22];2(2):210–40. Available from: http://pubs.aeaweb.org/doi/10.1257/app.2.2.210.