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Tackling Gender Stereotypes in STEM Educational Resources

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***Abstract*— This research-to-practice full paper examines stereotypes in government recommended textbooks in science, technology and mathematics textbooks in Nigeria. Globally, more men are studying and working in Science, Technology, Engineering and Mathematics (STEM) fields than women. This imbalance is also the case in Nigeria. One contributor to this imbalance is stereotypical gender representation of scientists, mathematicians, engineers and technologists in popular media and career advertisement. Previous research indicates that stereotypes are also prevalent in educational materials used with young people. Given that the aspirations of young people are formed early in their educational journey, it is particularly pertinent to examine the gender bias in educational materials. As part of the DIGISTEM project, a World Bank-sponsored project in Nigeria, the aim of this study was to explore the level of gender bias in the images and language contained in the most frequently used science, technology, and mathematics textbooks recommended by the Nigerian Education Ministry. This study evaluated a total of 2116 visual and text references from 25 government recommended instructional materials. The analysis shows that males are significantly more represented in these resources than females. This study highlights that there is a stereotypical representation of scientists and engineers in primary school instructional materials as demonstrated by the imbalance portrayed in the examined textbooks. This paper concludes with an exploration of the implications of these findings on the educational sector and the need to provide a more inclusive approach to educational resources to enable young people to realise that STEM careers and subjects can be for people like them. This study took place in Nigeria; however, we recognise similar challenges and opportunities in a number of other jurisdictions which provides a foundation for replicability, portability and extension to this work.**

Keywords—STEM, Gender, Stereotypes, Nigeria, Education

I. INTRODUCTION

This paper reports the outcomes of a research study carried out to discover gender representation in STEM learning materials in Nigeria. The DIGISTEM (www.digistem.ng) project is a World Bank sponsored outreach project aimed at embedding practical STEM education and digital literacy in primary and secondary schools in Ekiti State, Nigeria. Its key aim is to widen the aspirations of young people with regard to STEM careers and provide them with the practical skills and understanding to open up STEM opportunities for them. As part of the wider project, this research study was specifically commissioned to examine the gender balance in government recommended STEM textbooks that are commonly used in Nigeria. The study was motivated by the need to contribute through empirical studies towards Nigeria's attainment of Sustainable Development Goals 4 – Quality Education and 5 - Gender Equality, and 8 – Decent Work and Economic Growth [1]. More specifically, the DIGISTEM project was aimed at the following SDG targets: Goal 4: Quality Education:

- By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.
- By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations

Goal 5: Gender Equality:

- Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women

Goal 8: Decent Work and Economic Growth

- By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value
- By 2020, substantially reduce the proportion of youth not in employment, education or training
- Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high value added and labour-intensive sectors

For many developing countries like Nigeria, unemployment, persistent poor-quality employment and working poverty pose a major challenge with women and young people most commonly affected [2]. In Nigeria, the National Bureau of Statistics shows a rise in unemployment from 9.9% in 2015 to 18.8% in 2017 (NBS, 2017). This is despite investment by the Nigerian government in a number of skill acquisition programmes sector [3], [4] and a key objective of Nigeria's future plans for economic transformation are to be focused on strengthening its capacity in science and technology [5]. With a growing national labour population that has risen to over 85 million, it is critical that the country addresses these challenges. However, there is

growing evidence of a widening skill gap and a mismatch between the education system and the needs of employers and the workplace [6].

Research has shown that education is one of the most powerful and proven vehicles for sustainable development [7]. Specifically, STEM education and jobs are key to driving national development through opportunities for employment and income generation and advancement in economic growth [8]-[9]. However, Nigeria along with many other developing countries struggles to educate its teeming population and equip young people with the skills needed for their future careers [10]. In sub-Saharan Africa, 32.6 million children and 25.7 million adolescents currently do not attend school [11]. Nigeria has the highest number of out of school children in the world – 13.2 million in 2018, up from 10.5 million in 2015 [12] with the majority of these being female. With respect to work, the majority of workers in Nigeria are in lower skilled jobs, and most of these workers are female. To secure a better future, there is a need to invest in developing skills among its population and particularly its young people, to help them gain decent and meaningful employment and seize the opportunities arising from newer and emerging technologies. This requires a change in schools from rote learning to match the way people need to increasingly work and collaborate for the future. It includes updating the quality of Science, Technology, Engineering and Mathematics (STEM) education at the primary and secondary level and opening up these opportunities to attract more females into education and employment in STEM.

Several reports have highlighted the gaps between male and female enrolment in schools, as well as in the STEM career fields [13]. According to [14], 82.7% of the population sampled disagreed that it was important for girls to study industrial and technical education courses. [15] reported that in a study across the six geo-political zones in Nigeria, the undergraduate enrolment in STEM courses for all academic sessions indicated a very low participation of females. [16] stated that women in Nigeria hold less than 25% of the country STEM jobs while only 14% of women aspire to become a scientist.

According to the World Bank, 2.5 million more engineers are needed in sub-Saharan Africa to address the development challenges the continent is facing [17]. Statistics also shows that Africa produces just 1.1% of the global scientific knowledge, with 79 scientists per million Africans compared to 4500 per million people in the United States [18]. To fill this skills gap, the STEM workforce should be attracting talent from the female pool in order to meet the demand. Furthermore, a more gender-diverse workforce will result in a wider range of views and ideas [19]. These new ideas from diverse teams have been found to be related to positive organisational outcomes such as increase in stock price value [20], [21] innovation [22], [23] and better overall financial performance [24].

Until recently, many of the initiatives commissioned to close the gender gap in STEM education and workforce have been focused around upper secondary and tertiary institutions [25]. However, research has shown that young people make career decisions earlier [26] as there are significant differences between the aspirations of boys and girls as early as in primary schools [27]. This has resulted in calls for more initiatives to focus on primary school science education as currently girls are less interested in school science, science careers and events [28]. Consequently, more initiatives are now focusing on fixing the *leaking pipeline* and encouraging more girls and women to consider science as a career [29].

Gender stereotypes and discrimination against females contributes to fewer girls than boys choosing a STEM career [30]. Dele-Ajayi et. al., [31] describes stereotypes as blanket simplistic assumptions, attitudes or opinions that assign certain characteristics hinged on little information or evidence regarding a particular group of people, place or thing. Considerable development occurs in young people aged between 6 and 12 years. During this time, they are exposed to media, culture and their general environment, all of which are embedded with different stereotypes. Through these exposures, they form perceptions about different aspects of their lives including possible career choices. These stereotypes are known to have a direct impact on the affinity a person has for the subject or career represented stereotypically [32]. These influences can often be career limiting particularly for females how become lead down gendered pathways based on what the young person has come to believe as true or normal. According to [33], an individual's interest in a subject (or career) is higher when there is a positive correlation between what the stereotype is and the individual's self-image. STEM courses and scientists are usually represented by masculinity [34]. This ends up suggesting that 'science is for males' picture in the minds of young people [35] which has the consequence of ends up making females less interested in following a career in science. One of the ways in which gender has been stereotypically represented with respect to science is in instructional materials such as textbooks that are used in primary education. Researchers argue that these textbooks play a vital role in the formation of young peoples' career interests and aspirations [36].

Beyond being used to teach students how to read and write, textbooks directly or indirectly influence the beliefs and norms among learners. They play a vital role in young people' socialisation and in the creation of attitudes and behaviours [37], [38]. This submission is based on Bandura's social learning theory [38] that much human behaviour is modelled upon the observed behaviour of others. People remember what they have observed, and this contributes to future decisions and actions. The theory explains human behaviour in terms of repeated interactions between cognitive, behavioural and environmental influences [39], [40]. Hence, any gender stereotyping about the roles of females and males that are presented in textbooks will be consumed, internalised and imitated by young people [39]–[41]. Another reason why textbooks are critical to shaping young peoples' beliefs and attitude is that they are considered by learners and their influencers (parents and teachers) as authoritative and reliable [37], [42]. According to [43] there are two major reasons why young people can be easily influenced by what they see and read in educational materials like textbooks. First, young people are led to accept whatever is presented to them in the classroom and are not very likely to challenge it. Second, given that much of a young person's learning time is spent reading textbooks, consuming whatever the textbook presents are easy. Therefore, there is a tendency that the ideas and opinions presented in textbooks will be accepted by learners and their influencers without much critical evaluation. Lee maintains that "*repeated exposure to the written texts and visual images, consciously and subconsciously, will result in*

students' internalisation of the textbook authors' gender perception" [43, p382].

II. AIM OF THIS STUDY

The aim of this study is to examine and compare gender representation of females and males in the most used textbooks for STEM education in Nigeria. In developing countries like Nigeria, textbooks are the most used instructional material and hence have a degree of primacy. In part this is because of the paucity of digital skills make it hard for teachers, pupils and parents to use online searches to find more diverse materials to study. Hence, there is heavy reliance on textbooks. Typically, teachers write their lesson notes from textbooks and pupils do their homework and private study using textbooks, Secondly, textbooks are considered authoritative in a country like Nigeria. In part this is because the Federal Ministry of Education recommends a list of books to teachers and pupils based on the national curriculum, and most schools – public and private follow the recommendations of the government as to what they ask learners to buy. This makes it easy for a textbook to serve as the sole custodian and transmitter of "*social rules and standards regarding behaviour and gender roles'* [44, p48]. In this current study, the visual and textual content of key textbooks widely used in the Nigeria under the lenses of gender representation were examined. The focus was upon three major subjects: Mathematics, Basic Science and Basic Technology as subjects where stereotypical views and images of STEM can originate from. Following the findings of [36] on how the consciousness of stereotype of young people increases rapidly between the ages of 6 and 10, we focused our research on textbooks used in primary and junior secondary schools.

III. SAMPLE AND ANALYSIS

This study sample consisted of STEM education instructional materials which comprised three sets of subject textbooks (Mathematics, Basic Science and Basic Technology), educational posters (depicting varieties of jobs) and teachers' lesson notes. The research team acquired the most popular textbooks used for these subjects for classes ranging from Primary 1 and 5: 'Understanding Mathematics textbook' by Dr. Maria N.David-Osuagwu for the Mathematics subject and 'Basic Science and Technology textbook' by Nigerian Educational Research and Development (NERDC) for the Basic Science and Technology subjects for the Junior secondary classes 1 -3: Basic Science textbook which had contributions from F.O.C Ndu, L.O. Ndu, A.O. Olarenwaju and Femi Somoye ; Basic Technology textbook which had contributions from G.N. Nneji, E.J. Okon, V.C. Nwachukwu, and T.C. Ogbuanna. These textbooks are the instructional, materials recommended by the Universal Board of Education (UBE) and for the last ten years, have enjoyed huge patronage from both private and public schools in the country. These materials were collected in their printed English versions. Two coding activities were undertaken to analyse the visual and text content of the selected resources. Each of the selected resource was scanned for the presence of visual and text content depicting genders. The number of males or females represented in visual content was noted down along with the activity each identified person is doing. The aim of the selection is to determine whether there is equality in the number of males and females portrayed to be carrying out scientific/STEM activities.

IV. RESULTS

A total of 2116 people portrayed in 25 resources were coded, both in the visual and text content. The results showed that males are portrayed more often (66%) than females (35%). Figure 1 shows the graphical distribution of gender in different categories as derived from the instructional materials. According to Table 1, of the 2116 people portrayed in the instructional materials, a total 1536 people are depicted in visuals while a total of 580 people are depicted in text. 66% of those depicted in visuals are male while 34% are female. Of those depicted in text 61% are male while 39% are female.

A further look into the people depicted both in text and in visuals with a focus on those related to STEM careers, it was observed that a total of 1291 people are depicted in visuals of which 66% are males and 34% are females, whilst a total of 378 are depicted in the text of which 91% are males and 9% are females.

The results demonstrate two obvious stereotypes: (1) males are generally portrayed more in teaching materials in relation to STEM and non-STEM fields; and (2) for STEM fields, this portrayal becomes even more pronounced.

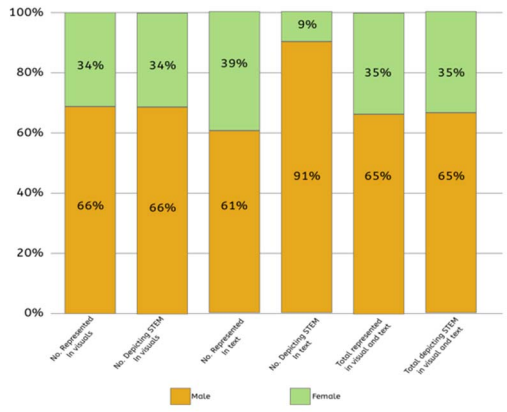

Figure 1. Gender distribution as represented in visuals and text

Description	Male	Female	Total
Number represented in Visuals	1020	516	1536
Number depicting STEM in visuals	852	439	1291
Number represented in text	356	224	580
Number depicting STEM in the text	346	32	378
Number of visual and text representation	1376	740	2116
Number of visual and text STEM representation	1198	471	1669

Table 1. Breakdown of visual and textual representations

A look at gender distribution based on profession only, shows that a total of 674 people are depicted in relation to their choice of profession. Figure 2 below shows that there are considerably more men than women in a science profession (71% versus 39%, respectively), and fewer men than women are depicted as teachers (40% versus 60%, respectively). There are slightly more men than women depicted in fields other than science and teaching (592% versus 41%, respectively).

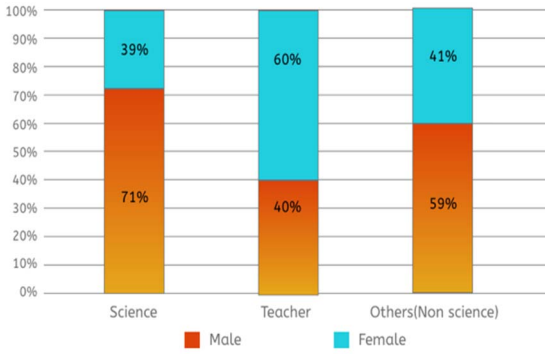

Figure 2. Gender Distribution for Profession type. N(people) = 674

A chi-squared test was performed on the three profession categories with the aim of identifying whether is a significant difference between the distribution of males and females in each category. This shows a significant difference between the three profession types ($\chi 2\ (2, N = 674) = 51.0606, p < 0.0001$). Hence there are statistically significantly more males than females depicted in the sciences and other professions, whilst there are more females depicted in the teaching profession. Overall males are depicted more frequently than females (65.0% versus 35.0%, respectively).

A second test was performed comparing the ratio of males and females portrayed with a science profession (*males = 71% and females = 29%*) against the third category i.e. the non-science and non-teaching professions, (males = 59% and females = 41%), and also the teaching profession (males = 40%, females = 60%), compared against the third category i.e. the non-science and non-teaching professions, (males = 59% and females = 41%). The non-science and non-teaching professions present a suitable baseline for distribution of male and females represented in the studied resources. Thus, this analysis allowed a comparison to be performed against this baseline. The result ($\chi 2\ (1, N = 414) = 2.3154$) show significant differences for sciences ($p<0.001$) and teaching ($p<0.001$). The implication being that there are statistically significantly more males than females portrayed in the sciences and significantly more females than males depicted in the teaching profession even after amending the surplus representation of males depicted in the visuals and texts.

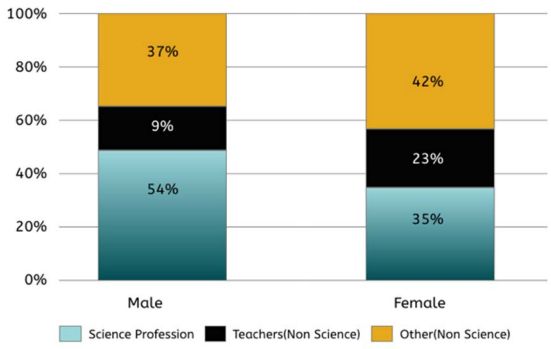

Figure 3. Distribution of Profession by gender N(male) = 422, N(female) = 252, N(total) = 674.

Figure 3 above shows the distribution of profession type for each gender. The results show that a larger number of males depicted in the coded resources are in the science professions (54%) while 36.5% are depicted in other non-science professions and just 9.5% depicted in the teaching profession. For females, most are depicted in other non-science professions (42%), followed by 36% for science professions and lastly, the teaching profession being the least with just 22%.

V. DISCUSSION

This study set out to determine if the most used science, technology, and mathematics textbooks recommended by the Nigerian Education Ministry contained gender-biased visuals and languages. Considering two of the popular stereotypes: scientists are males, teachers are females [45]–[49], our research confirms that the Nigerian Government recommended textbooks align with and continue to reinforce these stereotypical images. The findings from this study demonstrate that males are generally more frequently portrayed than females in the STEM text materials used in Nigerian schools. However, this finding is not just unique to Nigerian textbooks. A similar pattern has been found in several studies of texts and instructional materials across other countries. In a study into gender stereotypes by [44], they found that males (70%) were significantly more portrayed than females (4%) in Greek computer science teaching materials. Analysis of the visual contents depicting STEM in the investigated resources show that the male gender is represented more in the educational resources used in schools. With respect to STEM activities, males are depicted 852 times compared to 439 times for females. These findings are similar to what [36] found out in their content-visual analysis of science resources in two online database – scientix and OERcommons. The analysis of the online materials showed that the ratio of men and women depicted with a science profession was 75% to 25%.

The bias in gender representation can also be seen from the aspect of classification by profession. Males are depicted 230 times in science related professions compared to 90 times for females. Images portraying the teaching profession are 1.5 times more likely to be female. This supports the opinion of [50] that females place a higher value on the humanistic and people□oriented aspects of their. Similar bias was also observed in the text content, with 346 instances of males depicting STEM in the text compared to 32 for females. With school textbooks being the main tool for instruction, gender role portrayals in these teaching materials affect how learners think, feel, and behave regarding these two genders and can reinforce stereotypical gendered concepts of subjects and careers [44]. Young people are greatly influenced by their cultural and educational environments and these often inform their thoughts and aspirations about future opportunities and careers. As they often do not have prior experience and knowledge of STEM and science disciplines and careers, they rely on their cultural and educational environments to help develop their own perceptions and opinions [31]. The impact of this on young people in Nigeria using these textbooks is that girls will tend to have fewer role models than boys and thus are less likely to believe that a STEM/science career is for them. This is also likely to affect their future aspirations. [51] stated that in the absence of real-life role models, children may construct an understanding of the role of women in science based largely on images of women scientists they see in the media. This statement portrays the powerful impact that visuals can have in shaping the mindsets of females right from an early age. Studies have suggested that girls and young women develop a “masculine image of science” [34] from what they learn in school, at home and even the mass media.

Analysis of gender stereotypes is not only a matter of imbalance in number but also of the quality of representation. The issues portrayed by the gender bias that exist in educational resources is not just limited to the girls and women being largely absent, but also that the pictures they were portray in, often showed them as passive observers of science being done by boys and men [52].

According to [18], textbooks play an important role in the transmission and internalization of values, and the acquisition and development of knowledge, skills and attitudes and may be central to the way learners shape their understanding of themselves, others and the world. Therefore, in order to counteract gender stereotypes in science education resources, it is important that the number and roles of males and females in the visual and textual content of educational resources is balanced [36] and forms part of a more inclusive approach to educational resources that can encourage all young people irrespective of their gender or background to be able to see that a wide range of subjects and careers are open to them. This is particularly important in developing countries such as Nigeria where women are often less educationally qualified and more likely to be in low paid and/or part-time work.

VI. IMPLICATIONS FOR PRACTICE

While this study maintains that stereotypes exist in most of the mathematics and science textbooks recommended by Nigerian government for primary and early secondary education, it is not enough to posit that simply increasing the representation of females will result in an increased number of young females choosing STEM. The gender gap in STEM education and profession is a complex concept that is a result of a multiple of factors. However, as Good et. al suggested [53], attempts to eliminate gender stereotypes from textbooks it is a good place to start to address the STEM aspiration gap of underrepresented groups like females. Existing literature [54]–[56] also agrees that exposing young females over time to *people like them* in instructional materials will increase their interest in STEM. An approach to tackle this issue in primary and secondary education is to work with stakeholders – parents, teachers, school leaders, publishers of educational materials and the government. Appropriate Governmental institutions (such as Ministries of Education) should raise awareness of the role of gender stereotypes on the STEM aspirations and attainment of young people. This awareness will ensure they select and recommend textbooks that are free of gendered materials. Teachers and school leaders should also introduce unconscious bias trainings and sensitisations for classroom teachers – on race, ethnicity, gender, disability and other factors. This training will raise the awareness teachers have and help them in creating lesson materials that are more inclusive and diverse, reaching all the members of their classes. Publishers also need to be more aware of the need to continue to work towards eliminating gendered images and texts from their materials. The authors are currently working with some stakeholders in Nigeria to develop a plan to address the issues identified from this research.

VII. LIMITATIONS AND FUTURE WORK

In terms of limitations, this research did not investigate invisibility (total or relative exclusion of a particular gender), cosmetic bias, fragmentation and isolation and unreality [18]. It also did not examine intersectionality. These are further areas that could be examined to provide a more comprehensive overview of the nature of gender stereotypes in instructional materials and environments. Further work could also be undertaken to analyse the specific nature of the roles depicted by males and females. For example, are the female science roles typically more health related, again reinforcing societal stereotypes. The authors did not consider to what degree do textbooks contribute to the social stereotypes more generally. This study exclusively looked at STEM-based subjects. It would be interesting to look at other subjects such as civic education, literature and so on to examine if the same pattern holds. A further limitation of this work is that a single context was studied. Gender representation is a popular study and a number of previous authors have examined this concept in several contexts. This work investigated one jurisdiction (Nigeria). However, gender balance in terms of STEM study and career choice is not a issue limited to solely that jurisdiction. As such investigating, gender, and other biases in critical learning resources in other jurisdictions is potentially a productive area for further investigation. This may be more challenging in other jurisdictions, particularly those were the access to digital resources is more ubiquitous and hence it may be more challenging to define the resources being used by teachers, children, and parents.

VIII. CONCLUSION

This study aimed at exploring if there was gender bias in the educational resources recommended by the government and commonly used by young people in Nigeria. The aim was to generate the evidence and start the conversation around possible ways to address this. It found that there is considerable bias in both the visual and textual images with women featuring less overall and this becoming even more apparent in the STEM/science disciplines. Furthermore, they were often depicted in a passive rather than active role. These findings align with others showing that educational resources often have a gender bias within them and reinforce rather than allay stereotypical images of STEM subjects and careers. It is clear that the educational sector needs to address this issue and present a more inclusive set of educational resources. This paper provides some practical ways in which stakeholders can start to address this issue. These challenges are replicated internationally e.g. STEM study and careers being perceived in a more inclusive manner. We thus recognise similar challenges and opportunities in a number of other jurisdictions which provides a foundation for replicability, portability and extension of this work.

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