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WHITE PAPER:

STEM ISSUES IN GENDER AND DISADVANTAGED GROUPS IN THE MEMBER COUNTRIES AND INSTITUTES

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FAST4FUTURE

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ABSTRACT

The future prosperity of Africa depends on its ability to increase STEM education, including Planetary and Space Science Technology (PSST). PSST requires the inclusion of the right set of skills in Higher Education Institutes (HEIs) to deliver the workforce necessary for the development of this technology. Strengthening the HEIs capacity in PSST is needed to help address some of Africa's greatest 21st-century developmental challenges. This will bring considerable economic and societal opportunities, sustainable economic growth, and boost the digital transformation toward the 4th industrial revolution and the Knowledge Economy.

The PanAfrican Planetary and Space Science Network (PAPSSN) was established in 2021. This initiative is focused on enhancing the development of skilled graduates in the fields of planetary and space sciences within Africa. The network aims to create mobility opportunities for students and academic staff across several African universities, fostering collaboration and skill development in these specialized fields, including Botswana, Ethiopia, Nigeria, South Africa and Zambia. The project is funded by the Intra-Africa Mobility Scheme of the European Education and Culture Executive Agency (EACEA).

The follow-on project from PAPSSN is FAST4Future, which started in 2023. FAST4FUTURE stands for "Focus on Africa Space Science and Technology 4 Future development". The project also aims at strengthening Science, Technology, Engineering and Mathematics (STEM) in Africa Higher education by:

i. Increasing the accessibility to STEM in African Higher Education (HE);

ii. Modernizing existing PSST programmes in collaboration with industry and policy makers;

iii. Fostering the internationalization of partner HEIs by promoting mobility of staff;

iv. Promoting standardization of PSST in Africa in support of students' mobility.

FAST4Future will also analyse the conditions of women in STEM in partner countries, and make recommendations on how this could be improved.

In this white paper, we analyse the accessibility and equality of STEM education and research environment to female, disabled and disadvantaged groups across some of the African countries

and institutions member of the PAPSSN and FAST4Future consortia. These include the University of Botswana and Botswana International University of Science and Technology; the University of Zambia and Copperbelt University; and the University of the Witwatersrand in South Africa.

CHAPTER ONE: INTRODUCTION AND BACKGROUND

1.1 Global context

According to the United Nation Educational, Scientific and Cultural Organization (UNESCO), gender disparities and gender-related discrimination in science, technology, engineering and mathematics (STEM) continue to be a serious developmental challenge at national, sub-regional, regional and global levels. Statistics indicate that there is unequal representation in STEM, with women and disadvantaged groups having less access. Recent statistics show that women accounted for 28% of engineers and 40% of computer scientists and 33.3% of STEM researchers globally (UNESCO, 2021).

Additionally, the share of women engineers is lower for many members countries of the Organization for Economic Co-operation and Development (OECD - 38 countries in total) than the global average, including Australia (23.2%), Canada (19.7%), Chile (17.7%), France (26.1%), Japan (14.0%), the Republic of Korea (20.1%), Switzerland (16.1%), and the USA (20.4%) (Azoulay, 2021). Within OECD, Arab States record the highest proportions of women engineers worldwide. The records are as follows; in Algeria (48.5%), Morocco (42.2%), Oman (43.2%), Syria (43.9%) and Tunisia (44.2%) (UNESCO, 2021).

Further, women and disadvantaged groups are also underrepresented in scientific research (Phiri and Mwaanga, 2021). For instance, in France, Germany and the Netherlands only one out of every four science researchers are a woman (UNESCO, 2021). Statistics from 121 countries revealed that women make up to 29%, while men make up to 71% of science researchers (UNESCO, 2018). It was also revealed that the proportion of female researchers is 18% in Republic of Korea, 15% in Japan, 8% in Nepal and 1.4% Saudi Arabia (UNESCO, 2015).

1.2 Sub-Saharan context

According to Amegah et al (2023), the Sub-Saharan region is experiencing numerous challenges to advance in science, technology and innovation. One of the major problems is that the region has a weak stance in STEM fields, with less than 25% of higher education students pursuing courses in STEM fields, of which less than 30% are women (UNESCO, 2021). Further, women account for only 18% to 31% of science researchers (Amegah et al, 2023).

Available statistics show that men continue to outnumber women in STEM in Sub-Saharan Africa, especially at higher professional levels. For instance, in Lesotho, women representation in STEM dropped from 76% to 31% between 2002 and 2011. From 2011 to 2013, the percentage of women researchers was 43.7% in South Africa, 42.8% in Egypt, 30.2% in Morocco, 24.9% in Senegal, 23.3% in Nigeria, 21.8% in Rwanda, 21.8% in Cameroon, 13.3% in Ethiopia and 10% in Togo (UNESCO, 2015). In specific fields such as engineering, female graduates accounted for 34% in Mozambique, 27% in South Africa, 24% in Lesotho, 22% in Zimbabwe, 21% in Burkina Faso, 18% in Rwanda, and 15% in Eswantini in 2015 (UN, 2022). In 2018, only 19% of female students were enrolled in STEM fields compared with 39% male student in Zimbabwe (World Economic Forum 2018). As for Botswana, the enrolment proportion of females was 41.43% in agricultural science, 29% in engineering, 42.6% in technology and 48.3% in natural sciences and mathematics in 2019 (OECD, 2021).

1.3 Definition of key terms

Disadvantaged groups: in this publication it refers to the populations or communities that face social, economic, or systemic disadvantages that limit their access to resources, opportunities, and social mobility. These disadvantages can stem from factors such as income inequality, discrimination, limited educational access, and lack of representation. Disadvantaged groups often include individuals from low-income backgrounds, ethnic minorities, women, people with disabilities, internally displaced communities and other marginalized populations (UNDP, 2014).

Gender: gender hereafter refers to the cultural definition of behaviour considered appropriate for men and women, or boys and girls in a given society. Gender is either feminine or masculine (we do not consider gender non-conformity in this study because of a lack of historical records in the partner universities). Gender identifies social differences as reflected in roles, activities, duties, responsibilities, social behaviour between men and women, and boys and girls. Gender is culturally and socially constructed, which means that for men and women, society prescribes different roles, social qualities or characteristics, and forms of behaviour. These prescribed standards and norms of behaviour that are transmitted from generation to generation through the process of socialization and change over time (United Nations, 1997).

1.4 Global and Regional Efforts to Address Gender Issues

Gender issues are part of the global and regional agenda as evidenced by the proliferation of summits and conventions that cite gender issues as core for development:

- Resolution of the UN's Economic and Social Council passed in 1946 to promote women's economic, social and political rights which resulted in the establishment of the Commission on the Status of Women;
- Nairobi looking forward strategy 1975 – 1985 which declared this period (1975 – 1985) a Decade for Women.
- Convention on the Elimination of all forms of Discrimination against Women (CEDAW 1979) which was the first instrument to define discrimination against women.
- The 1981 OAU member states summit held in Nairobi which adopted the African Charter on Human and People's Rights.
- The African Charter on Human and People's rights that was adopted by the Organization of African Unity (OAU) member states in Nairobi in June 1981. This Charter combines individual rights with group rights;
- UN Conference on Environment and Development held in Rio de Janeiro in 1992. This Summit emphasized the linkage between women and environment;
- International Conference on Population and Development held in Cairo, 1994 which highlighted maternal health as a priority issue;
- Fourth World Conference on Women held in Beijing in 1995. This resulted in the formation of the Beijing Platform of Action with twelve priority interventions aimed at improving the legal, educational, political, social and cultural rights of women.
- The 1997 Southern African Development Community (SADC) Declaration of 30% of female representation in decision-making positions.
- The 2000 AU Declaration on 50% women's participation in decision-making positions.
- In 2000, UN Millennium Declaration adopted 8 Millennium Development Goals (MDGs). Goal 3, of the MDGs focuses on the promotion of gender equality and elimination of gender

disparities in primary and secondary schools by 2005 and for all levels of education by 2015.

In Africa, through the Southern African Development Community (SADC) and Common Market for Eastern and Southern Africa (COMESA), work on gender issues has continued to influence development programs and policies. A good number of countries in the region have programs and policies that have incorporated gender issues.

1.5 Aim of the paper

This paper investigates the size of female, disabled and disadvantaged groups throughout the PAPSSN and FAST4Future member countries and institutions. The paper also summarises efforts to assist these groups in order to grow their numbers in STEM subjects.

1.6 Data sources

Data for this paper are sourced from relevant articles and grey literature, including government acts and NGOs white papers and internal university reports.

The data collection posed some challenges as some of the data sets were incomplete or not available and/or the format in which it was provided did not render itself easy for analysis. There was scarcity of data with regards to disadvantaged groups in STEM.

CHAPTER TWO: RESULTS AND FINDINGS

2.1 Botswana

2.1.1 Botswana International University of Science and Technology (BIUST)

Established in 2005 as a research-intensive university that specializes in Science, Engineering and Technology, BIUST has two faculties each made up of five departments. The faculty of Engineering and Technology comprises of (1) Chemical, Materials and Metallurgical Engineering, (2) Civil and Environmental Engineering, (3) Electrical, Computer and Telecommunications Engineering, (4) Mechanical, Energy and Industrial Engineering, and (5) Mining and Geological Engineering. A breakdown of the Faculty of Science include (1) Chemical and Forensic Sciences, (2) Computer Science and Information Systems, (3) Earth and Environmental Sciences, (4) Mathematics and Statistical Sciences, and (5) Physics and Astronomy. Programs under these faculty departments cover a wide range of qualifications such as Bachelor of Science (BSc), Bachelor of Engineering (BEng), Master of Science (MSc), Master of Engineering (MEng) as well as Doctor of Philosophy (PhD) programs under both Science and Engineering.

2.1.2 University of Botswana

The University of Botswana was established in 1982 as the first institution of higher education in Botswana. As of 2023, the university has eight faculties among which four are STEM-centered offering BSc, BEng, MSc, Meng, and PhD programmes. These faculties include the Faculty of Engineering and Technology, the Faculty of Health Sciences, the School of Medicine, and the Faculty of Science. The Faculty of Engineering is comprised of (1) Civil Engineering, (2) Construction Engineering and Management, (3) Electrical and Electronics Engineering, (4) Geomatics (5) Industrial Engineering and Industrial Design, (6) Mechanical Engineering (7) Mineral and Mining Engineering, and (8) Urban and Regional Planning.

There are four departments in the Faculty of Health Sciences, namely (1) Cytotechnology & Histotechnology, (2) Environmental Health, (3) Medical Laboratory, (4) Nursing Science, and (5) Pharmacy. The Faculty of Science has five departments including the Department of (1) Biological

Sciences, (2) Chemistry, (3) Computer Science and Information Systems, (4) Environmental Science, (5) Geology, (6) Mathematics and Finance, and (7) Physics. Finally, the School of Medicine is comprised of (1) Anaesthesia, (2) General Surgery, (3) Medicine, (4) Obstetrics and Gynaecology, (5) Paediatrics and Adolescent Health, (6) Psychiatry, and (7) Public Health Medicine.

The overall enrolment shows that UB had an intake of 37 072 students in the 2018-2023 time frame, of which 46 % were female students (Table 1). From the six year period, UB experienced the highest number of female students in the year 2023 which recorded 3 632 making about 50 % of the total enrolment. BIUST had a total enrolment of 19 225 students in the years 2018 to 2022 which comprised of 34 % female students. The university registered its highest female student enrolment in 2019 with 1 390 female students (Table 1), making up 33 % of the total student enrolment. This percentage went up to 46% in 2021, however, the total number of students, and number of females had decreased. The numbers listed in Table 1 are summarized in Figure 1.

Table 1. Enrolment Percentages in STEM at Botswana International University of Science and Technology (BIUST) and University of Botswana (UB), segregated by gender from 2018 to 2022

		UB			**BIUST**	
	No. students	**No and % males**	**No and % females**	**No. students**	**No. and % males**	**No. and % females**
2018	4787	2805 (59 %)	1982 (41 %)	3938	2597 (66 %)	1341 (34 %)
2019	5004	2875 (57 %)	2129 (43 %)	4176	2786 (67 %)	1390 (33 %)
2020	5775	3169 (66 %)	2606 (34 %)	3808	2502 (55 %)	1306 (45 %)
2021	6874	3679 (65 %)	3195 (35 %)	3777	2450 (54 %)	1327 (46 %)
2022	7296	3757 (51 %)	3539 (49 %)	3526	2278 (65 %)	1248 (35 %)
2023	7336	3704 (50 %)	3632 (50 %)			
Total	**37072**		**17083 (46 %)**	**19225**		**6612 (34 %)**

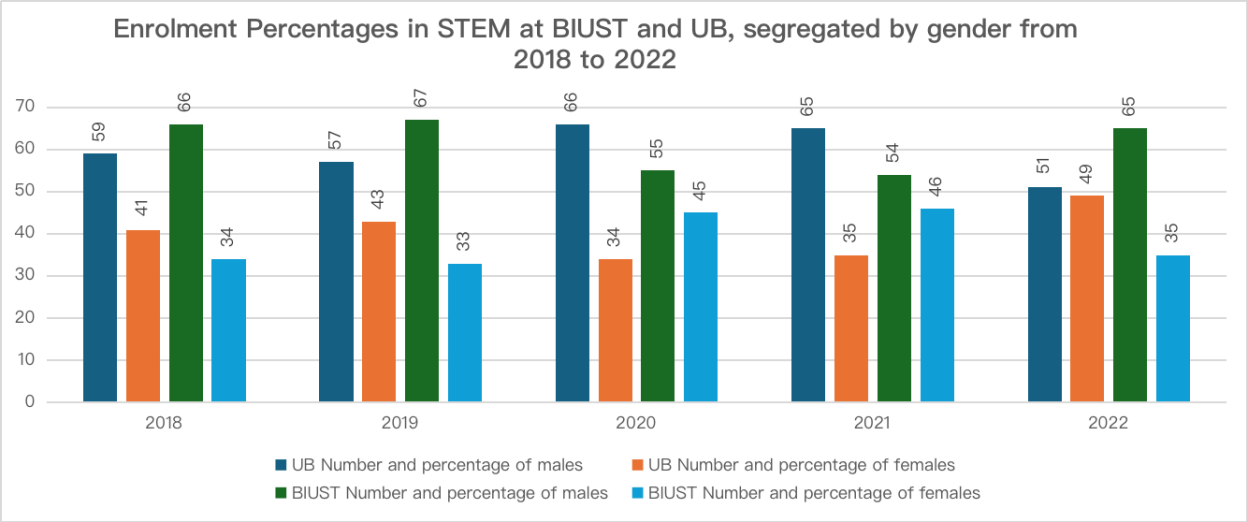

Figure 1. Enrolment percentages in STEM at BIUST and UB, segregated by gender from 2018 to 2023.

These numbers are further subdivided by degree at BIUST in Figure 2. The Master of Science (Figure 2) has proven to be a female-dominated program having registered 57 %, 79 %, 59 %, 59 % and 61 % to 2018 to 2022. The percentage of females in BSc (undergraduate), PhD of Science, in general, are >45%. Of all the programs at BIUST, the lowest female student enrolment was in BEng, MEng and PhD (Engineering) programs (<25%).

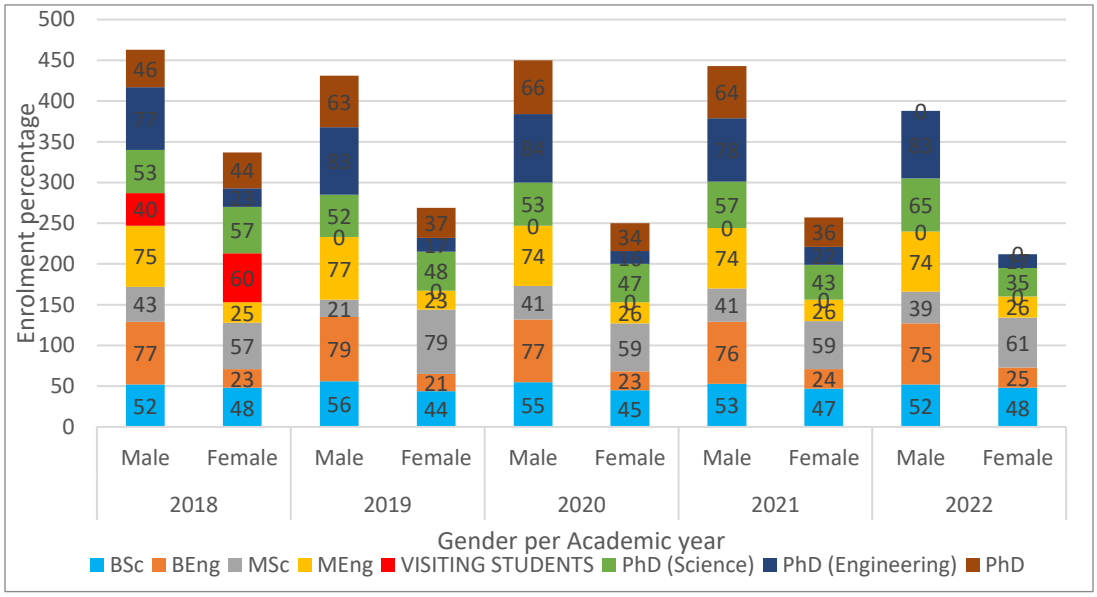

Figure 2. Enrolment percentages in the different programs at BIUST from 2018 to 2022.

These numbers from Figure 1 are further subdivided by faculty at UB in Figure 3. The Faculty of Engineering and Technology showed the lowest percentage of female registrations across the study period of around 30%, while the Faculty of Health Sciences had the highest of around 60%. The Faculty of Health Sciences values range from 58 %, 59 %, 60 %, 61 % to 63 between 2018 and 2022. The Faculty of Science and School of Graduate Studies (postgrads) fluctuate, but average out around 50%. Faculty of Science registered an equal percentage of students in the years 2022 with both male and female enrolment at 50 %.

From Figure 2 and Figure 3 female representation is lowest in the Engineering fields. Generally, the percentage of male enrolled from 2018-2022 is higher than percentage of female at both BIUST and UB (Figure 2 and Figure 3). There however, is an improvement in 2022 at UB.

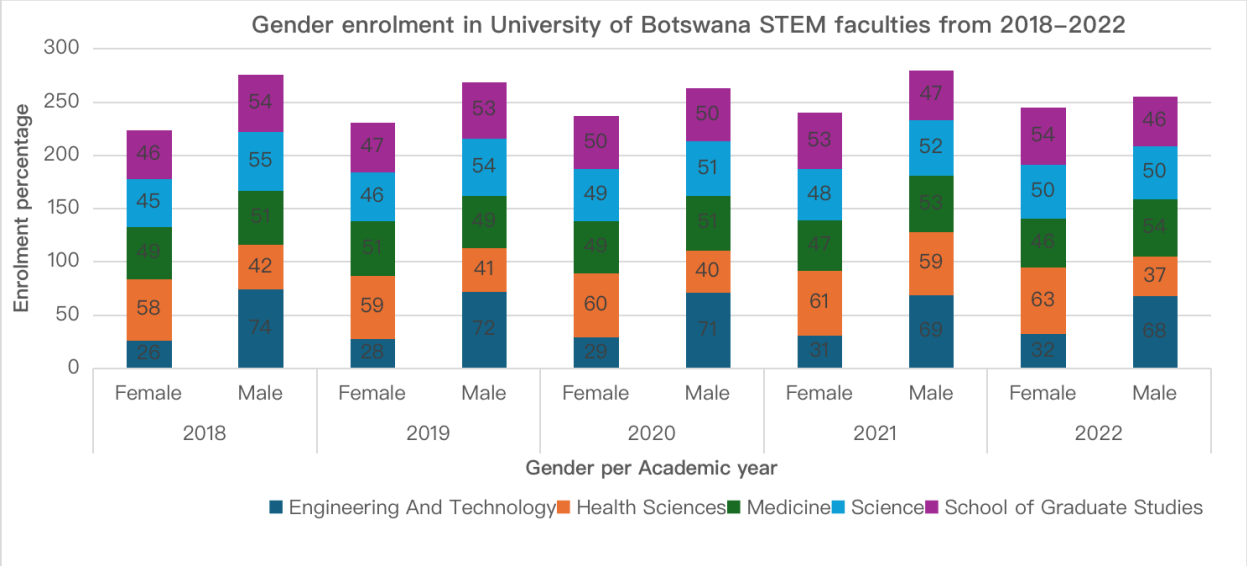

Figure 3. Enrolment percentages in the different STEM faculties in UB from 2018 to 2022.

2.1.3 Botswana Government efforts to close the gender gap

The last R&D Survey (2013/14) administered by the Department of Research, Science and Technology (DRST), indicated that the proportion of women researchers to total researchers' population in Botswana is 30%. To reduce the gap, several efforts/measures to support women in STEM in Botswana were implemented at policy level. These included the incorporation of the gender lens/thrust in the RSTI Policy and research Call 2024 with compulsory inclusion of women researchers in the Research teams, as well as an award for best female researcher during the 2023 Research Excellence Awards.

To encourage more girls and women in the region to study and pursue jobs in science, technology, engineering, and mathematics (STEM), the Southern African Development Community (SADC) Women in Science, Engineering, and Technology Organisation was founded and is now governed by a charter. It seeks to create a regional database of women in STEM, assist in the formation of fully operational networks, advocate for increased representation of women in STEM positions and decision-making bodies, and strengthen the bonds between female scientists, engineers, and technologists and their communities

2.1.4 Efforts to Address Gender Issues at BIUST

BIUST just as the University of Botswana is guided towards its mission by the core value of equity and diversity. The University has policies, programs and festivals aimed at addressing gender disparities in STEM disciplines and careers by exposing girls and young women to mentors and suggesting targeted interventions. Such objectives are achieved through Programmes for Outreach and Engagement (PUAP) with objectives discussed at https://www.biust.ac.bw/puap-projects/ . Through PUAP, BIUST collaborates with the participation of any researcher, student or member of the public who has a STEM dream, product or service. The University believes in addressing gender issues from lower education levels and thus has programs that encourage and drive young girls toward STEM oriented careers.

One of these programs is the Girls Excelling in Mathematics and Science (GEMS) Mentorship program. This initiative is currently running in six (6) senior secondary schools in Botswana as a mentorship and motivational program for passionate Form 4 students who would love to embark a STEM career. The BIUST-GEM program is aimed at contributing to the improvement of participation, performance and retention of girls and women in STEM professions which are a critical part to any country's economic development. With the leadership of BIUST female representatives and collaborators from other institutions, parastatals and the industry, the program strives to find solutions to problems that affect girls' ability to be attracted to and retained in STEM-focused careers.

2.1.5 Efforts to Address Disability Issues at BIUST

In a proposition to provide equal opportunity, BIUST guarantees that the rights of students with disabilities are exercised without discrimination of any kind based on disability as outlined in the university website at https://www.biust.ac.bw/special-needs-services/. The university has a responsibility to provide services to students with disabilities to ensure that the nature and scope of their education is of the rest of the student population. Therefore, the university has a unit mandated to support students with disability or health conditions that hinder them from performing

academic activities and day-to-day duties. The primary function of this unit is to ensure that students with disability have equal access to learning and assessment opportunities taking into consideration their needs. This is achieved through provision of specialized tailor-made accommodation, lecture theatres accessible to individuals with disability, and comfort during examinations. BIUST also advocates for students with disabilities in all expects that impact their stay in the University.

2.1.6 Efforts to Address Gender Issues at University of Botswana

In undertaking its mission to provide quality education, research, innovation and engagement for sustainable national development and global impact, the University is guided by core values which defines its behaviours and underpin all its actions. One of these values is equity and diversity by ensuring equal opportunity and non-discrimination on the basis of personal, religious, gender or other social characteristics. The University of Botswana therefore intends to support gender equity and thus eradicating gender inequality completely.

University of Botswana's efforts to promote gender equity and equality have been achieved through the establishment of the Gender Policy and Programme Committee (GPPC). The GPCC is a structure established in 1992 with a primary goal to overview the implementation of the university gender policy (Losike-Sedimo, 2015). In an attempt to achieve equality, the GPCC has made concerns and experiences of both male and female students an integral dimension of the design, implementation, monitoring and evaluation of university policies and programs.

2.1.7 Efforts to Address Disability Issues at University of Botswana

The University of Botswana endeavours to promote equitable access and seamless participation for all students in the different courses and programs. As such, the university has a Disability Support Services Unit (DSSU) that was established in 1982 with an aim to coordinate support services and academic accommodations for enrolled students with disabilities. The DSSU offers a

wide assortment of services which incorporate but are not limited to: Educational and psychological support, academic accommodations, learner support, alternative examinations, assistive technology devices, and specialized transport (e.g. motorized wheel chairs). Through the Disabilities Policy Taskforce, a policy for students with disabilities was framed that mandates the DSSU to create an environment that promotes access and participation of students with disabilities in both the curricula and co-curricular activities. The University of Botswana policy on students with disabilities covers the following aspects and can be found online at https://www.ub.bw/sites/default/files/2024-04/APPENDIX_6

Policy_for_Students_with_Disabilities_First_Draft_November_24_2020_%28002%29.pdf .

This policy outlines the rights of students with disabilities to (1) equal access opportunity to participate in and benefit from all programs and services of the University and urges the Departments of Sports, culture and recreation should play a key role here in facilitating access and inclusion in these areas, (2) request reasonable accommodations for equitable and fair chance of success in the course and/or program, (3) confidentiality of all information pertaining to their disability conditions. Reserve the right to decide persons whom information about their disabilities should be disclosed to, and (4) denote their grievance as per the university's grievance procedures. Therefore, the DSSU is not only tasked to coordinate but to monitor and evaluate implementation of reasonable accommodations provided to students to facilitate access, participation, inclusion, retention and success of students with disabilities.

The policy applies to all University undergraduates and post-graduates, visiting students, exchange students, teaching, learning and assessment processes that facilitate responsiveness to this policy edicts as well as physical plant and related logistical complications where inequities in norms and physical capital can have a pronounced effect on students' ability to equitably access and engage with their learning and living. Furthermore, the University's quest is to create a barricade free living and learning equitable setting where students with disabilities matter and are treasured. Proactive collaborations with key campus partners has yielded an accessible, equitable and inclusive living and learning campus environment. Thus, service delivery is informed by the Critical Disability, Universal Design and Human Rights Models.

2.2 South Africa

2.2.1 The University of the Witwatersrand (Wits)

South Africa hosts 26 public universities, and numerous private institutions. The University of the Witwatersrand in Johannesburg opened in 1922 and is over 100 years old. At present the university has around 40 000 students enrolled. The university has always been one of the more progressive universities in South Africa, at the forefront of apartheid protests in the 1980s and 1990s.

Three different university faculties are investigated in this study: Engineering and Built Environment, Health Sciences and Science. Health Sciences includes the following schools: Anatomical Sciences; Clinical Medicine; Oral Health Sciences; Pathology; Physiology; Public Health and Therapeutic Sciences (nursing, occupational therapy, pharmacy studies and physiotherapy). The Faculty of Engineering and the Built Environment include Architecture and Planning; Civil and Environmental Engineering; Chemical and Metallurgical Engineering; Construction Economics and Management; Electrical and Information Engineering; Mechanical, Industrial and Aeronautical Engineering and Mining Engineering. The Faculty of Science includes Animal, Plant and Environmental Sciences; Chemistry; Computer Science and Applied Mathematics; Geography, Archaeology and Environmental Studies; Geosciences; Mathematics; Molecular and Cell Biology; Physics; and Statistics and Actuarial Science.

The transformational policies of the South African government and university are reflected in the number of female students registered in Science fields at the university. Table 2 shows that from 2018 to 2022 (5-year period), the average number of females in the following field remained relatively constant: 36% in the Faculty of Engineering and Built Environment (~7600 total students), 60% in the Faculty of Health Sciences (~7000 total students), 50% in the Faculty of Science (~5500 total students). Engineering has the lowest % of females and is historically a male dominated profession.

Table 3 outlines the number of disabled students. In the Faculty of Engineering and the Built Environment and the Faculty of Science, 5% of approximately 5500 students (male and female) are disabled, which equates to around 275 students; whereas for the Faculty of Health Science it is around 3% of approximately 7000 students (male and female), which equates to around 210 students.

Table 2. Undergraduate and Postgraduate Students Enrolled in Different Schools from 2018 to 2022 at WITS.

	2018			2019			2020			2021			2022		
	Total	**Female**	**%**	**Total**	**Female**	**%**	**Total**	**Female**	**%**	**Total**	**Female**	**%**	**Total**	**Female**	**%**
Faculty of Engineering and the Built Environment	7 939	2 744	**35**	7 895	2 769	**35**	7 778	2 798	**36**	7 666	2 857	**37**	7 458	2 875	**39**
Faculty of Health Sciences	6 781	4 445	**66**	7 028	4 615	**66**	7 184	4 741	**66**	7 516	5 062	**67**	7 566	5 175	**68**
Faculty of Science	5 355	2 566	**48**	5 537	2 628	**47**	5 475	2 572	**47**	5 508	2 674	**49**	5 595	2 773	**50**

Table 3. Undergraduate Disabled Students Enrolled in Different Schools from 2018 to 2022 at WITS.

Faculty	**Gender**	**Enrolled**	**% Disabled Students**	**Enrolled**	**% Disabled Students**	**Enrolled**	**% Disabled Students**	**Enrolled**	**% Disabled Students**	**Enrolled**	**% Disabled Students**
Faculty of Engineering and the Built Environment	Female	1 813	5.1	1 793	5.7	1 811	4.5	1 874	4.	1 880	3.8
	Male	4 076	6.8	4 036	6.4	3 925	5.6	3 802	5.4	3 620	4.4
Faculty of Engineering and the Built Environ		**5 889**	**6.3**	**5 829**	**6.2**	**5 736**	**5.3**	**5 676**	**4.9**	**5 500**	**4.2**
Faculty of Health Sciences	Female	4 445	3.4	4 615	3.4	4 741	3.3	5 062	3.2	5 176	3.1
	Male	2 336	3.4	2 413	2.8	2 444	2.7	2 455	2.6	2 394	2.9
Faculty of Health Sc		**6 781**	**3.4**	**7 028**	**3.2**	**7 185**	**3.1**	**7 517**	**3.**	**7 570**	**3.**
Faculty of Science	Female	2 566	4.5	2 628	4.2	2 572	4.	2 674	4.2	2 773	3.8
	Male	2 790	7.2	2 910	6.4	2 904	5.1	2 835	4.8	2 823	4.
Faculty of Science		**5 356**	**5.9**	**5 538**	**5.3**	**5 476**	**4.6**	**5 509**	**4.5**	**5 596**	**3.9**
Grand Total		**18 026**	**5.1**	**18 395**	**4.8**	**18 397**	**4.2**	**18 702**	**4.**	**18 666**	**3.6**

2.2.2 Efforts to Address Gender and Financial Issues in South Africa

Shortly after democracy in 1994, the South African government adopted a White Paper on Science and Technology (in 1996). This white paper detailed how the government would commit to using science, technology and innovation (STI) to develop the country and overcome the legacy of apartheid.

The next big development was the South African Department of Education's 2007 White Paper on Education. This paper represented a pivotal effort in transforming the nation's educational landscape. This comprehensive policy document aimed to address historical inequalities entrenched by the apartheid regime, focusing on creating an inclusive and equitable education system. Key elements of the White Paper include broadening access to quality education for all learners, improving infrastructure in under-resourced schools, and promoting professional development for educators. The transformation agenda also emphasized the importance of curriculum reform to better reflect the diverse cultural and social contexts of South African society. By prioritizing these objectives, the 2007 White Paper sought to lay the foundation for a more just and cohesive educational framework, fostering long-term social and economic development.

The 2007 White Paper by the South African Department of Education placed significant emphasis on the advancement of female students, recognizing the critical need to bridge the gender gap in education. Acknowledging the systemic barriers that girls and young women faced, the White Paper outlined strategies to ensure equal access to educational opportunities. This included initiatives to combat gender-based violence and discrimination within schools, provide gender-sensitive training for educators, and promote female participation in STEM (Science, Technology, Engineering, and Mathematics) fields. Additionally, the policy called for improved facilities, such as safe transportation and sanitary resources, to create a conducive learning environment for female students. By focusing on these measures, the 2007 White Paper aimed to empower female learners, ultimately contributing to gender equality and the overall socio-economic upliftment of the nation.

These policies at school level, then feed through, with time, to university levels. The South African Department of Higher Education has also implemented several policies aimed at improving the

success rates of underprivileged and female students. A 2019 White Paper on Science, Technology and Innovation emphasised the core themes of inclusivity, transformation, and partnerships.

These policies include the National Student Financial Aid Scheme (NSFAS), which provides financial support to students from low-income backgrounds, enabling them to access higher education. Additionally, the department has introduced the Funza Lushaka Bursary Programme, which specifically targets prospective teachers, with a strong focus on recruiting females and individuals from disadvantaged communities. To further support female students, initiatives such as gender-sensitive counselling and mentorship programs have been established, fostering an inclusive academic environment. Furthermore, the department has promoted the expansion of campus facilities to ensure safe and supportive living and learning conditions, addressing the unique challenges faced by these student groups. These comprehensive policies aim to create an equitable higher education system that enhances the academic success and overall well-being of underprivileged and female students.

2.2.3 Efforts to Address Gender and Transformation Issues at University of the Witwatersrand

The information below is extracted from the Wits "Policy and Disciplinary Procedure On Sexual and Gender-Related Misconduct":

The Gender Equity Office (GEO) was established at the university in February 2014 in response to recommendations of the August 2013 "Report of the Independent Inquiry into Allegations of Sexual Harassment at the University of the Witwatersrand" (Independent Inquiry Report). "The Independent Inquiry Report found that the University's functions in relation to sexual or gender-related misconduct were too decentralised and fragmented to offer an effective mechanism of prevention, intervention and accountability. The Report consequently recommended the establishment of a single office institutionally located in the Vice Chancellor's Office (VCO) to deal with all sexual or gender-related misconduct affecting employees or students, and to do so through dedicated advocacy, counselling and complainant-centred interventions, including disciplinary hearings."

"In addition to the GEO, the University also established a Gender Equity Advisory Committee (GEAC) in 2013, which comprises experts on sexual or gender-related misconduct from across the university community. The main role of GEAC is to support and guide interventions regarding sexual and gender related misconduct, and specifically to provide advice to the GEO."

"The University has also introduced additional policies and procedures to address sexual or gender-related misconduct, which is how the University defines and codifies sexual or gender-related misconduct. These include the Policy on Sexual and Romantic Relationships between Staff and Undergraduate and Honours Students (C2016/611) and the Policy on Declaration of Interests (C2014/294). These policies are embedded within the University's rules pertaining to misconduct, as well as other relevant University policies, including policies on HIV/AIDS; Anti-Discrimination Policy and Procedures (C2015/24); and Disability."

"In addition to introducing these specific measures, the University is also committed more broadly to creating and maintaining a safe institutional environment in which sexual and gender-related misconduct is not tolerated, and all may learn, work and go about their activities free from gender-based harm and sexual misconduct."

"This policy and disciplinary procedure is designed to provide a framework for responding effectively to complaints of sexual or gender-related misconduct, and to provide appropriate support to victims wherever sexual or gender-related misconduct takes place, either within or outside of the University environment, or in relation to South African society more broadly. In order to encourage the reporting of complaints and the uptake of support, a complainant-centred approach is pursued in which complainants are supported without compromising the rights of respondents."

The university also has the Transformation and Employment Equity Office, that works "with students and staff groups across the University to implement programmes and projects in support of the University's transformation agenda. The transformation agenda is framed by national development goals and equity legislation, as well as the United Nations Millennium Declaration. At the heart of the process of transformation are the values enshrined in the South African Bill of Rights."

In 2022, the university appointed a new Deputy Vice-Chancellor: People Development and Culture to "oversee Human Resources, Transformation and Employment Equity, the Disability Rights Unit

and other related units. He will occupy this reconfigured post as Deputy-Vice Chancellor: People Development and Culture. The post seeks to address the current and future challenges related to people development and institutional culture at the University…to address the intersection between technology, transformation, diversity and inclusion within the South African higher education context."

2.2.4 Efforts to Address Disability Issues at University of the Witwatersrand

The Wits policy on students with disabilities is outlined below and can be found online at: https://www.wits.ac.za/media/wits-university/students/disability-unit/documents/policies/Policy-Students-with-Disabilities-(ver-3.0).pdf

"The University of the Witwatersrand (Wits) values diversity and is committed to creating equal opportunities for students with disabilities. The principles contained in this Policy will be applied and adhered to in order to ensure equitable representation of students with disabilities and their full integration into all areas of student life.

1.1. Wits recognises that access to higher education is a national imperative in South Africa and that it is imperative that higher education, and Wits specifically, puts measures in place to redress the inequalities and disadvantages created by prejudice and discrimination, and contributes to a democratic vision which is respectful of human rights.

1.2. The University accepts its responsibility to remove or limit the barriers to participation, especially for students with disabilities.

1.3. In this regard Wits will ensure that knowledge production, transfer and dissemination that support the advancement and empowerment of persons with disabilities are reflected in its academic, research and social engagement plans.

1.4. Wits commits to sustainable transformation initiatives and governance mechanisms that value the diversity of its student population and the community it serves. Disability equity is an important component of the Wits transformation and diversity agenda."

See website for more details.

2.3 Zambia

At national level, research findings indicate that females are under-enrolled in major public universities in Zambia. Statistics from major public universities in Zambia in 2018 (Table 4) show that the number of enrolled males students outnumbered the number of enrolled female students (Masaiti and Simuyaba, 2018). However, it should be noted that at 5 of the 6 universities, there is 56% or less males compared to females, and at Chalimbana university there is only 30.5% males. This is obviously linked to the speciality of each university.

Table 4. Student enrolment by gender in public universities in Zambia in 2018.

Name of University	Number and percentage of males	Number and percentage of females	Total
University of Zambia	13,406 (54.3%)	11,270 (45.7%)	24,676
Copperbelt University	8,010 (68.7%)	3,650 (31.3%)	11,660
Nkrumah University	4,710 (53%)	4,173 (47%)	8,883
Mulungushi University	2,644 (55.7%)	2,107 (44.3%)	4,751
Chalimbana University	1,442 (30.5%)	3,279 (69.5%)	4,721
Mukuba University	1,023 (43.7%)	1,320 (56.3%)	2,343
Total	31,235	25,799	57034
Percent	55%	45%	100%

2.3.1 University of Zambia

The University of Zambia (UNZA) was opened in 1966, through its vision of being an equal opportunity employer both in the country and region, it has made provisions to promote gender equality at the institution. However, lack of a gender policy and enabling environment has constrained its efforts to address gender-related concerns among its members of staff and students University of Zambia, 2008). This gap is evident in Table 5, Table 6 and Table 7 respectively.

Table 5 shows that the enrolment proportion of females compared to males in STEM fields at UNZA has been fluctuating. Equally, the number of students registered is highly variable during this period.

Agricultural Sciences has approximately 43% females, though female student numbers ranged from 23 to 412. Engineering has approximately 17% females, though this went up to 28% in 2022. The number of female students over this period ranged from 23 to 575. Medicine has approximately 48% females from 2019 to 2022, though this was at 37% in 2018. The number of female students ranged from 90 to 2077. Mines has the most variable percentage, from 11% to 26%, with the number of female students ranging from 17 to 149. Natural Sciences had approximately 36% students, with a low of 25% post covid. Registrations for Natural Sciences ranged between 301 and 1985 female students during the time period.

A more detailed analysis is included below:

- From 2018 to 2019, the representation of female students in agricultural science slightly increased by 0.5% and continued to increase by 2.2% in 2020 but later dropped by 1.2% in 2021. Additionally, as of 2021 to 2022, the representation of female students in agricultural science increased by 5.4%.
- As of the faculty of engineering, the trend of female representation decreased from 16.2% to 13% from 2018 to 2019.
- Additionally, from 2019 to 2020, the trend increased by 6.2% but reduced by 0.4% in 2021 and later increased by 8.8 in 2022.
- As of the faculty of medicine, the trend of female representation increased from 37% to 49.5% from 2018 to 2019 and it remained constant to 2020 but reduced by 2% in 2021 and increased by 0.9% in 2022.
- As of the faculty of mines, the trend of female representation increased 11.4% to 47.5 from 2018 to 2019, but decreased by 33.1% in 2020. Further, the trend increased by 3% in 2021 and continued to increase by 8.7% in 2022.
- As of the faculty of natural science, trend of female participation slightly increased from 39.6% to 40% from 2018 to 2019 but reduced from 40% to 33.3% to 25.2% in the year 2020 and 2021 respectively. Later, the trend increased by 12.6%.

These results implies that the participation of females in STEM fields such as agricultural science, engineering, medicine, mines and natural science has been fluctuating from year to year without consistent increase.

Table 5. Students Enrolled in Different Schools from 2018 to 2022 at UNZA.

School	**Year 2018**		**Year 2019**		**Year 2020**		**Year 2021**		**Year 2022**	
	No. students	**No. Female students (%)**	**No. students**	**No. Female students (%)**	**No. students**	**No. Female students (%)**	**No. students**	**No. Female students (%)**	**No. students**	**No. Female students (%)**
Agricultural Sciences	326	132 (40.5%)	56	23 (41%)	273	118 (43.2%)	648	272 (42%)	870	412 (47.4%)
Engineering	615	100 (16.2%)	181	23 (13%)	954	183 (19.2%)	1756	331 (18.8%)	2086	575 (27.6%)
Medicine	766	283 (37%)	182	90 (49.5%)	2653	1313 (49.5%)	4908	2333 (47.5%)	4285	2077 (48.4%)
Mines	167	19 (11.4%)	122	58 (47.5%)	118	17 (14.4%)	351	61 (17.4%)	570	149 (26.1%)
Natural Sciences	1532	607 (39.6%)	4985	1985 (40%)	2605	867 (33.3%)	1195	301 (25.2%)	1394	527 (37.8%)

Table 6 shows the representation of disadvantaged groups in different faculties. Results indicates that disadvantaged groups are underrepresented in STEM fields. For instance, from 2018 to 2022 disadvantaged groups were represented by 3 males and 1 female in agricultural science, 2 males in engineering, 2 females and 8 males in medicine, 2 males and 1 female in mines, and 3 females and 2 males in natural science. This implies that disadvantaged groups are not well represented in STEM fields. Further, the results imply that more male disadvantaged students are enrolled in STEM fields than females.

Table 6. Number of Disadvantaged Students by School and Gender 2018-2022 at UNZA

School	**Year 2018**		**Year 2019**		**Year 2020**		**Year 2021**		**Year 2022**	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Agricultural Sciences	0	0	0	0	1	0	0	0	2	1
Engineering	0	0	0	0	1	0	0	0	1	0
Medicine	4	1	0	0	1	1	2	0	1	0
Mines	0	0	0	0	1	0	0	0	1	1
Natural Sciences	0	0	0	0	0	1	1	1	1	1

Table 7 shows the distribution of students' performance by school and gender from 2018 to 2022 at UNZA. The results indicate that the total percentages of female students who graduated between 2018 and 2022:

- Faculty of agricultural science 42.5%, 39%, 54.5%, 43% and 56%
- Faculty of engineering:16.4%, 17.3%, 12.6%, 22.6% and 26.3%
- Faculty of medicine: 40.7%, 37.2%, 31.2%, 44.3% and 36.1%
- Faculty of mines: 9.8%, 17.9%, 3.3%, 9% and 13%
- Faculty of natural sciences: 44%, 47.7%, 39.1%, 40.4% and 43.7%

These fluctuations in the percentages of females that graduate in STEM fields are as a result of the fluctuation in the enrollments of students in respective years.

Table 7. Students' Performance at Graduation by School and Gender from 2018 to 2022 at UNZA

	Performance of students in 2018									
School	**Pass**		**Credit**		**Merit**		**Distinction**		**Total**	
	No. students	No. Female students (%)	No. students	No. Female students (%)	No. students	No. Female students (%)	No. students	No. Female students (%)	No. students	No. Female students (%)
Agricultural Sciences	17	7 (41.2%)	29	12 (41.4%)	18	9 (50%)	9	3 (33.3%)	73	31 (42.5%)
Engineering	14	1 (7.2%)	111	20 (18%)	44	7 (16%)	2	0 (0%)	171	28 (16.4%)
Medicine	61	24 (39.3%)	56	22 (39.3%)	5	4 (80%)	1	0 (0%)	123	50 (40.7%)
Mines	21	0 (0%)	14	1 (7.1%)	6	3 (50%)	0	0 (0%)	41	4 (9.8%)
Natural Sciences	61	25 (41%)	40	19 (47.5%)	7	4 (57.1%)	1	0 (0%)	109	48 (44%)
Performance of students in 2019										
Agricultural Sciences	41	13 (31.7%)	16	9 (56.3%)	2	1 (50%%)	0	0 (0%)	59	23 (39%)
Engineering	77	17 (22.1%)	46	5 (10.9%)	15	2 (13.3%)	1	0 (0%)	139	24 (17.3%)
Medicine	66	28	84	30	21	6	1	0	172	64

		(42.4%)		(35.7%)		(28.6%)		(0%)		(37.2%)
Mines	20	3 (15%)	8	1 (12.5%)	1	1 (1%)	0	0 (0%)	28	5 (17.9%)
Natural Sciences	70	34 (48.6%)	33	15 (45.5%)	3	2 (66.7%)	1	0 (0%)	107	51 (47.7%)
Performance of students in 2020										
Agricultural Sciences	29	19 (65.5%)	31	15 (48.4%)	6	2 (33.3%)	0	0 (0%)	66	36 (54.5%)
Engineering	57	9 (15.8%)	37	3 (8.1%)	9	1 (11.1%)	0	0 (0%)	103	13 (12.6%)
Medicine	61	24 (39.3%)	53	12 (22.6%)	11	3 (27.3%)	0	0 (0%)	125	39 (31.2%)
Mines	29	1 (3.4%)	1	0 (0%)	0	0 (0%)	0	0 (0%)	30	1 (3.3%)
Natural Sciences	62	30 (48.4%)	18	2 (11.1%)	7	2 (28.6%)	0	0 (0%)	87	34 (39.1%)
Performance of students in 2021										
Agricultural Sciences	28	11 (39.3%)	23	11 (48%)	7	3 (43%)	0	0 (0%)	58	25 (43%)
Engineering	72	16 (22.2%)	32	10 (31.3%)	8	0 (0%)	3	0 (0%)	115	26 (22.6%)
Medicine	122	59 (48.4%)	92	39 (42.4%)	16	4 (25%)	0	0 (0%)	230	102 (44.3%)
Mines	13	1	8	1	1	0	0	0	22	2

		(7.7%)		(12.5)		(0%)		(0%)		(9%)
Natural Sciences	54	22 (41%)	34	15 (44%)	8	2 (25%)	3	1 (33.3%)	99	40 (40.4%)
Performance of students in 2022										
Agricultural Sciences	10	6 (60)	23	13 (56.5%)	8	4 (50)	0	0 (0%)	41	23 (56%)
Engineering	26	5 (19.2%)	33	8 (24.2%)	18	6 (33.3%)	3	2 (66.7%)	80	21 (26.3%)
Medicine	41	14 (34.1%)	69	27 (39.1%)	13	3 (23.1%)	0	0 (0%)	122	44 (36.1%)
Mines	14	2 (14.3%)	6	0 (0%)	3	1 (33.3%)	0	0 (0%)	23	3 (13%)
Natural Sciences	74	39 (52.7%)	47	19 (40.4%)	13	1 (7.7%)	1	0 (0%)	135	59 (43.7%)

2.3.2 Efforts to Address Gender Issues in Zambia

Zambia as part of the global community has actively participated in international summits and conventions which provide directions for governments and institutions in addressing gender issues in development. The government's vision and mission as it relates to gender issues in the education sector is captured in the mission statement in the National Policy on Education Document 'Educating our future' (1996) which states: "…. to guide the provision of education for all Zambians so that they are able to pursue knowledge and skills, manifest excellence in performance and moral uprightness, defend democratic ideals, and accept the value of other persons on the basis of their personal worth and dignity irrespective of gender, religion, ethnic origin, or any other discriminative characteristic."

Further, the Government of Zambia developed a vocational training policy that provides for gender equity in the provision of skills training and entrepreneurship development. The Strategy Paper for the Technical Education, Vocational and Entrepreneurship Training (TEVET) Policy of 1996 aims at integrating gender in TEVET.

PAGE (Program for the Advancement of Girls in Education) was launched between 1994 and 1996) – and ended in 2002 but efforts continue under the gender and equity units in the Ministry of Education. Under PAGE, there was the Affirmative Action Intervention aimed at increasing the number of women to management positions in the Ministry of Education.

The 1996 Education Policy – "Educating our Future" states that "The Ministry will ensure that management positions in the systems are shared equitably between deserving men and women."

The International Conventions and Summits influence developments gender issues in Zambia and government has continued to strive to localize some of these conventions and declarations. In 1997, the Government introduced the re-entry policy which allows pregnant girls to go back to school after delivery.

To address gender issues, the government in 2000 adopted the National Gender Policy which takes cognizance of the African Charter on Human and People's Rights (ACHPR 1981) and the SADC Declaration on Gender and Development (1997). In this SADC Declaration, all member states committed themselves to ensuring equality through equal representation of both women and men in decision making positions with a 30% target share of women in political and economic decision-

making positions by the year 2005. Also, the declaration addressed the issue of quality in education services, health, and sexual rights of women and girls, repealing and reforming gender insensitive laws and taking measures to reduce gender violence.

To address the gender imbalances and inadequacies in the provision of education, in 2000, the Government of Zambia developed a National Gender Policy which aims at promoting equality of access at all levels to both formal and non-formal education through: (i) through training and ensuring that 25 % of available bursaries are reserved for female university students while the rest are competed for by both female and male students, (ii) employment of affirmative action in the appointment of deserving female managers to vacant management positions, (iii) development of mechanisms that will ensure that teacher development, deployment and upward mobility take into account the gender concerns in the system and (iv) making the curricula and teaching/learning materials gender sensitive.

In addition, the government developed a comprehensive Science and Technology Policy which is conducive to the development of gender sensitive science and technology. The policy addresses gender concerns particularly the need to increase the number of girls in science and technology subjects at all levels of learning.

In 2001, the government, through the Gender-in-Development Division (GIDD) developed the guidelines and checklists for mainstreaming gender in the public sector.

Go Girls Go Campaign was launched in 2004 to help girls who had dropped out of school go back to school.

The Ministry of Lands has an Affirmative Action of 30% land allocation to women while the 70% will be competed for between men and women.

In 2005, the Government of Zambia passed the Amendment Act No. 15 of 2005 which introduced stiffer punishment for sexual offenses such as abduction, indecent assault, defilement, and child pornography.

In 2005, the government also launched the Fifth National Development Plan (FNDP) which re-affirms Zambia's commitment to promotion and implementation of gender equity in the public sector as a cross-cutting issue.

In 2006, the government formed the Ministry of Women Affairs which was later renamed Ministry of Gender and Development.

Development of the HIV and AIDS Response Program Strategic Plan 2006-2010 which emphasizes equality and non-discriminatory to information on HIV and AIDS to all at UNZA.

2.3.3 Measures and strategies to promote equality and equity in STEM

To address the gender policy, the University of Zambia has made few strides forward in improving access of males and females to education at all levels, and in promoting gender equality within the education system. According to the University of Zambia Strategic Plan, one of the objectives of the plan is to mainstream gender issues in all university programmes namely at under graduate, post-graduate and research programmes. According to the UNZA collective agreement both "male and female academic staff shall be appointed on the same terms and conditions related to their qualifications (UNZA Collective Agreement, 2009). According to this written agreement, there is no discrimination on the basis of the gender of the employee or applicant and the conditions of services in terms of salary and other benefits. According to the condition of service for females, "every female employee who has served for a continuous period of not less than twenty-four months shall be entitled to maternity leave on full pay not exceeding ninety (90) days". The collective agreement further states that "the university shall grant unpaid maternity leave for a period not exceeding 90 days in respect of a female employee who has served the university for less than two years on condition that she returns to work after leave". UNZA has also made certain affirmative action to promote gender equity and equality among students. According to the affirmative action, 30% of first year admissions are reserved for female candidates while the remaining 70% were equally shared by males and females. Furthermore, UNZA has made affirmative action to recruit students from rural high schools. They are recruited based on the minimum requirements. In addition, the Government also supports with bursaries. According to this policy, 25% of the bursaries are reserved for female students and the remaining 75% is equally competed for by both males and females. Furthermore, UNZA published Sexual harassment policy report in 2007 and HIV/AIDS policy in 2009.

According to Phiri and Mwaanga (2021), affirmative action by the Government of Zambia led to the creation of the Ministry of Gender to promote gender related issues in development. In promoting STEM, the Government of Zambia is implementing the following strategies:

• Reviewing of educational curricula in schools, colleges and universities to make it gender sensitive for female participation.

• Establishment of special funds and scholarships for female education in STEM fields through the High Education Loans and Scholarship Board (HELSB)

• Promotion of science, technology, engineering and mathematics subjects in girls' schools such as making the subjects compulsory, and girls' technical secondary schools have been created in all provinces of the country.

• Establish and/or strengthen career counselling programmes to address problems which hinder girls' progression in STEM.

• Provision of incentives to female teachers in STEM and those willing to work in rural areas to work as role model.

The Government of the Republic of Zambia is the main sponsor of students at the University of Zambia. Others include families, private companies, development partners and non-governmental organizations. The University of Zambia also sponsors students under its in-house scholarship programme is committed to achieving gender equality in student admissions and enrolment. Available data demonstrate that, despite the reservation of 25% of available scholarships by the Government, the allocation of these scholarships continues to be heavily in favour of males (UNZA Computer Centre Records, 2010). In order to redress the gender imbalance, Phiri and Mwaanga (2021) suggested that such should be done:

• The Higher Education Lands and Scholarship Board (HELSB) should come up with strategies to promote female applicants secure scholarship and loans in Science, Technology, Engineering and Mathematics programmes. This would increase female students' enrolments and number of females in tertiary education sector and labour force in STEM.

• Gender mapping and statistics in STI systematically compiled and used to promote quality in Higher Education instead of focusing on gender-based violence (GBV) which is currently the focus of gender mainstreaming. Therefore, participation of females in Science, Technology, Engineering and Mathematical Sciences (STEM) and STI should be prioritized.

• Promote more women leadership in science and technology and innovation-oriented careers so that women act as role models for young females, i.e., as Vice Chancellors, Professors, Principals

and in Industry, etc. Currently, the census for staffing in Higher Education is underway to provide capacity and status of staff and qualifications in tertiary education.

• Promote the Science-Policy interface. While many policies have been developed on gender, there is little effort in actualising such interventions on the ground. Government should come up with additional STI instruments to actualize the needed interventions, for example, creating small STI pilot projects to solve community problems and to promote the science-policy interface in national development.

• Create platforms for STI disseminations such as National workshops, seminars, conferences and create opportunities for dialogue with the female scientific community.

• Enhance transnational/regional and multidisciplinary approach on integrating STI in socio-economic development aspects including policy formulation. Additionally, encourage intra-Country scientific cooperation and collaboration across African region and developed world to promote technology transfer and knowledge exchange.

• Establish a dedicated office for provision of information relating to available STEM scholarships with special reference to gender so that there can be a balance in accessibility of the scholarship.

• Sensitise the public on the importance of giving equal opportunities to both males and females in family sponsorship to study in STEM fields at tertiary level.

• Publish, update and widely distribute to both students and members of staff information relating to STEM scholarships through various channels such as publications, for instance directories, brochures, flyers and hand books and various educational website.

• Harness regional and continental platforms to build gender balanced capacity in STEM in Africa.

• Promotes pro-female initiatives in regard to cut-off points and upward career mobility in tertiary institutions

2.4 Nigeria

2.4.1 University of Nigeria Nsukka

The University of Nigeria Nsukka always referred to as UNN is a federal owned university located in Nsukka, Enugu State, Eastern Nigeria. It was founded by Nnamdi Benjamin Azikiwe (the first black governor general and president during the first Nigerian Republic between 1960-1963 and 1963-1966 respectively) and his colleagues in 1955 and was formally opened on 7th October 1960. The university has three campuses namely, Nsukka, Enugu and Ituku-Ozalla campus. The university has fifteen (15) Faculties and one hundred and two (102) academic departments offering one hundred and eight (108) undergraduate programs and two hundred and eleven (211) postgraduate programs. The University is the first full-fledged indigenous and first autonomous university in Nigeria modeled upon the American educational system. It was also the first land-grant university in Africa and the fifth reputable university in Nigeria.

The faculties that fall under Science, Technology, Engineering and Mathematics (STEM) are:

- Faculty of Agriculture (Agricultural Extension),
- Faculty of Biological Sciences (Microbiology, Molecular Biology, Molecular Genetics and Biotechnology, Zoology and Environmental Biology, Plant Science and Biotechnology),
- Faculty of Engineering (Electronics Engineering, Electrical Engineering, Mechanical Engineering, Mechatronics Engineering, Biomedical Engineering, Metallurgical and Material Engineering, Agricultural and Bio-Resources Engineering, Civil Engineering),
- Faculty of Physical Sciences (Physics and Astronomy, Pure and Industrial Chemistry, Geology, Mathematics, Computer Science, Science laboratory Technology),
- Faculty of Education (Science Education: Education Physics, Education Chemistry and Education Biology)),
- Faculty of Medical Sciences (Medicine and Surgery, Nursing Science, Medical Radiography, Medical Laboratory Science, Human Anatomy, Physiology) and
- Faculty of Pharmaceutical Sciences (Pharmacy).

Assessing the undergraduate admission status of both male and female students in UNN from 2018 to 2022 will help to understand the gender gap in STEM. Table 8 is the released data showcasing the number of students (male, female) enrolled in different departments in STEM from 2018-2022:

- In 2018, it is evident that minimum number of male students enrolled in STEM is 34, maximum number is 857 and total number is 6814 whereas the female students have minimum of 30, maximum 834 and total of 6268. The enrolment of male students in 2018 takes almost 60% in all the departments higher than that of female. The majority of female students are registered in biological sciences, with lower number in other sciences associated with Physics and Chemistry.
- In 2019, the least number of male admitted is 64, highest number is 937 and total number is 7334 while female enrollment takes 34 minimum, 957 maximum and total 7062.
- The minimum number of admitted male students in 2020 is 86, maximum is 955 and 7769 is the total number. The female students were enrolled with minimum number of 39, 980 maximum and 7824 as the total number.
- 2021 enrolment status for male has minimum number of 100, maximum of 1087 and total of 8087, the female number has minimum number of 35, maximum of 1168 and total 7987.
- STEM admission 2022 enrolled minimum number of 87 male students, maximum of 1083 and total of 7384 whereas the minimum number of female students admitted is 33, maximum of 1200 and total of 7743.

Hence there is need to curb societal factors and systemic barriers that hinder the access of women and girls to certain scientific careers. These barriers include social, cultural and gender norms which guide expectations and roles and which generate low levels of self-efficacy, lack of visible role models, underrepresentation in leadership roles, poorly qualified teachers, unsupportive learning environments and inadequate professional structures and work cultures. Society should develop gender sensitivity culture in all spheres of human endeavors ranging from education, administration, training/workshop, employment, churches, companies, to community leadership. Figure 4 is percentage bar chart showing the percentage value each category (male and female) contributes across the specified year

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Table 8. Admission offered in STEM at UNN from 2018 - 2022

Department	2018		2019		2020		2021		2022	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Engineering										
Electronics Engineering	521	106	519	104	519	97	538	79	489	69
Electrical Engineering	444	49	458	51	474	52	506	55	497	50
Mechanical Engineering	491	34	521	39	542	46	555	49	518	44
Mechatronics Engineering	1	NA	41	9	60	10	68	11	104	15
Biomedical Engineering	NA	NA	NA	NA	NA	NA	11	6	29	32
Civil Engineering	498	44	541	51	541	53	594	61	555	56
Metallurgical & Material Engineering	244	31	302	38	300	42	297	38	254	33
Agriculture										
Agriculture and Bio-Resources Engineering	239	30	277	34	265	39	251	38	180	36
Physical Science										
Physics and Astronomy	214	59	196	49	157	48	113	35	98	39
Pure & Industrial Chemistry	231	209	251	241	253	271	244	258	192	230
Geology	185	54	177	60	172	61	153	54	123	49
Mathematics	139	76	137	78	131	75	101	55	87	42
Science Laboratory Techn.	141	169	185	282	202	343	247	417	214	419
Computer Science	498	128	534	110	592	130	692	131	723	140
Agricultural Extension	134	226	138	275	151	289	118	228	90	166
Education										
Science Education	392	769	169	566	145	522	188	603	136	519
Medical										

Molecular Genetics and Biotechnology	34	39	64	102	86	173	100	200	100	210
Microbiology	409	574	401	612	384	657	380	598	339	601
Zoology and Environ. Biology	177	220	205	253	167	231	144	180	119	145
Plant Science Biotechnology	223	278	238	331	199	342	206	302	142	281
Medicine and Surgery	840	538	937	640	955	637	1087	766	1083	822
Nursing Science	91	834	105	957	103	966	111	884	105	966
Medical Radiography	559	301	665	353	823	486	1002	658	1060	721
Medical Laboratory Science	498	635	590	799	730	980	816	1168	822	1200
Human Anatomy	106	136	167	194	260	297	285	343	248	327
Physiology	105	144	148	202	218	305	252	335	241	332
Pharmacy	857	774	907	835	935	877	706	635	473	409
Average	**309.73**	**284.91**	**333.36**	**321**	**353.14**	**355.64**	**367.59**	**363.05**	**335.64**	**351.96**
Minimum Value	**34**	**30**	**64**	**34**	**86**	**39**	**100**	**35**	**87**	**33**
Maximum Value	**857**	**834**	**937**	**957**	**955**	**980**	**1087**	**1168**	**1083**	**1200**
Total	**6814**	**6268**	**7334**	**7062**	**7769**	**7824**	**8087**	**7987**	**7384**	**7743**

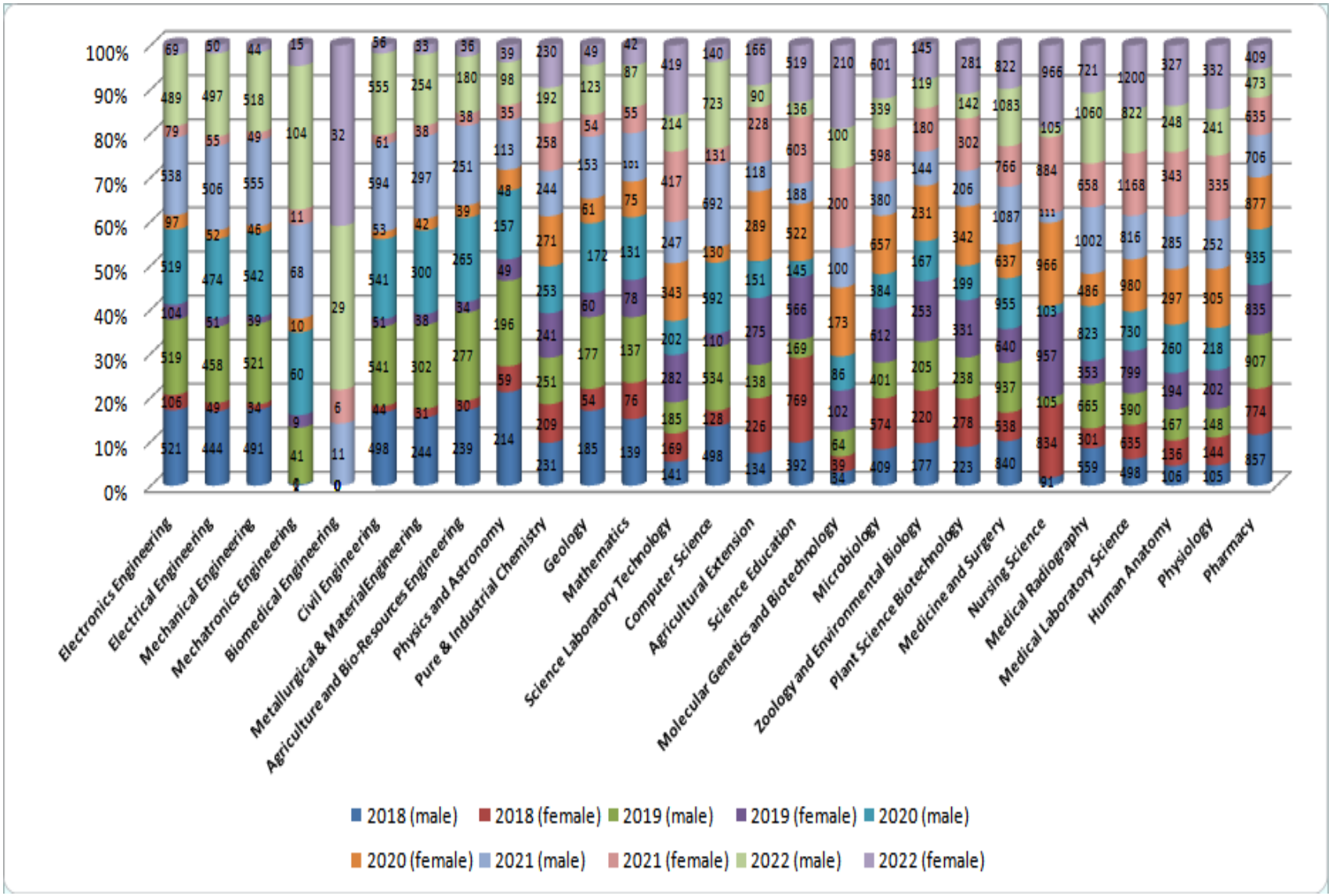

Figure 4. Enrolment of male and female students in STEM UNN from 2018-2022.

2.4.2 Enugu State University of Science and Technology

The Enugu State University of Science and Technology (ESUT) is a State-owned university founded on 30th July 1980 by the then Executive Governor of the State Chief Dr. Jim Ifeanyichukwu Nwobodo. The university has three campuses namely: ESUT Agbani, Enugu State College of Medicine and ESUT Enugu campus. The main campus of the University is located on a 671 hectares of dry savannah in Nkanu town about eighty (80) kilometers east of Enugu. It comprises of ten (10) Faculties (Agricultural and Natural Resources Management, Applied Natural Sciences, Education, Engineering, Environmental Sciences, Law, Management Sciences, Pharmaceutical Sciences, Social Sciences and Medicine). Due to challenges in the technical issues and documentation in admission unit ESUT, the data released for this study is only the gender disaggregated list of Industrial Physics department in the Faculty of Applied Natural Sciences only. This enrolment list was compared with the summary admission list from Physics and Astronomy department UNN. Table 9 shows the disaggregated number, total and percentage of male and female students admitted to study Physics in ESUT and UNN from 2018-2022. It is clearly seen from the table that there is a large variation in the enrolment status of the two institutions, where the number of students admitted to study physics in the state ESUT is lower and greater in UNN. Statistically, the total number of male student in Physics UNN is 778 out weighing the female student's number of 230 and a total of 1008, giving percentage of 77 % and 23 % respectively. Also in ESUT, the total number of male students enrolled in Physics is 61 and female is 43 with a total of 104 between 2018 to 2022, and respective percentages of 59 % and 41 %.

Table 9. Enrolment and percentage of students admitted in Physics Department in UNN and ESUT

	University of Nigeria Nsukka			Enugu State University of Science and Technology		
Academic Study year	**Number and percentage of males**	**Number and percentage of females**	**Total number of students**	**Number and percentage of males**	**Number and percentage of females**	**Total number of students**
2018	214 (78 %)	59 (22 %)	273 (27 %)	16 (59 %)	11 (41 %)	27 (26 %)
2019	196 (80 %)	49 (20 %)	245 (24 %)	14 (52 %)	13 (48 %)	27 (26 %)
2020	157 (77 %)	48 (23 %)	205 (20 %)	13 (52 %)	12 (48 %)	25 (24 %)
2021	113 (76 %)	35 (24 %)	148 (15 %)	13 (72 %)	5 (28 %)	18 (17 %)
2022	98 (72 %)	39 (28 %)	137 (13.6 %)	5 (71 %)	2 (29 %)	7 (7 %)
Total	**778 (77 %)**	**230 (23 %)**	**1008**	**61 (59 %)**	**43 (41 %)**	**104**

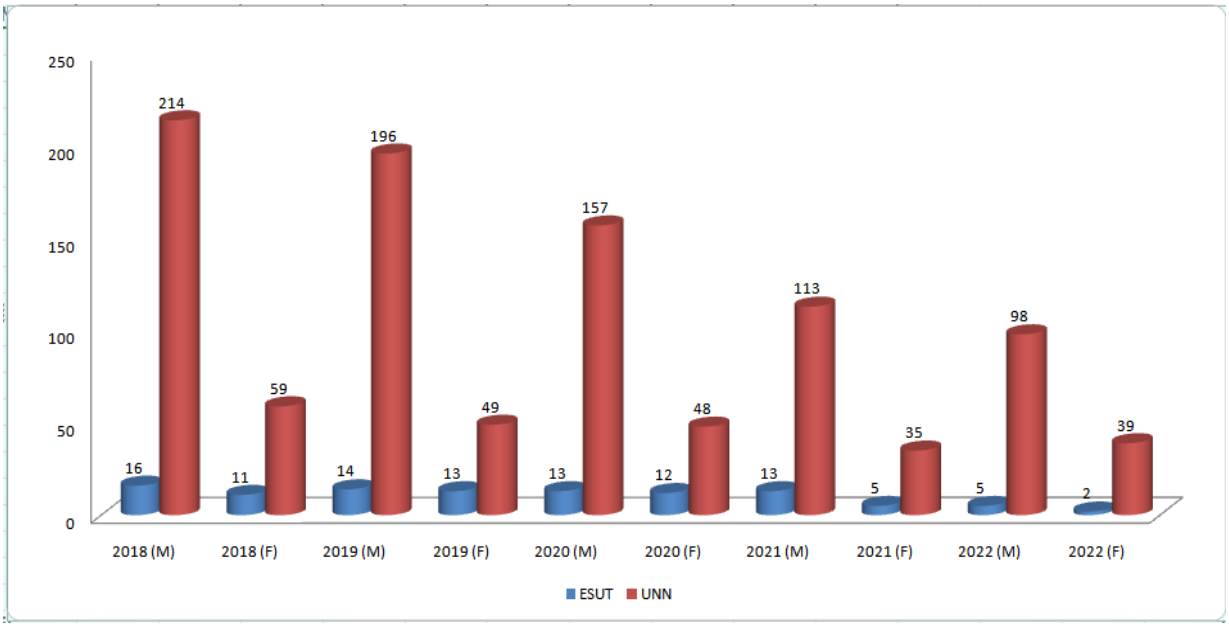

Figure 5. Comparison of male and female students enrolled in Department of Physics in UNN and ESUT

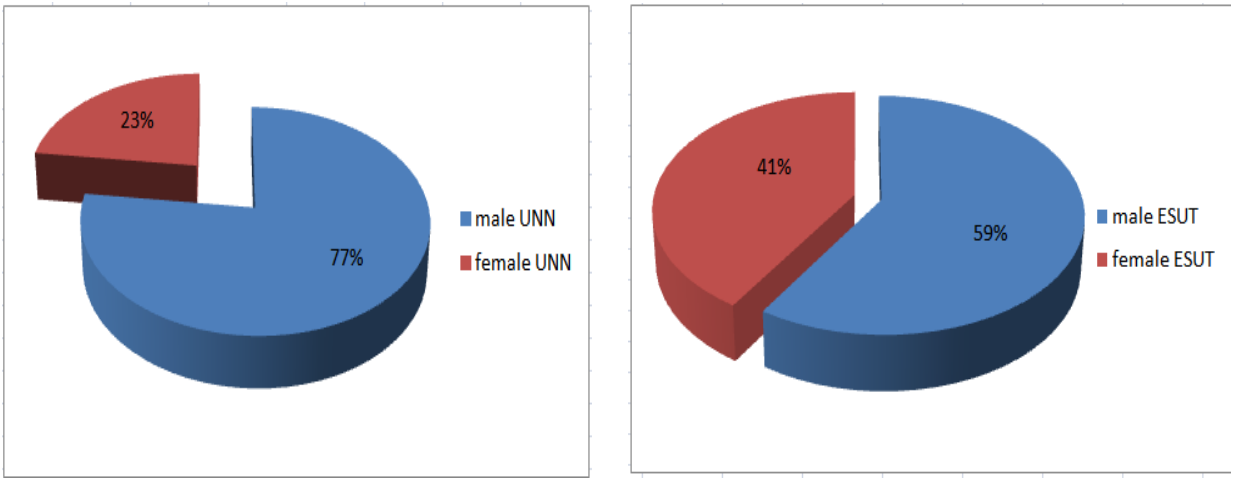

Figure 6. Pie chart showing the Percentage distribution of male and female admitted in Physics in UNN and ESUT

From Figure 5, the distribution and variation of the number of male and female students in both institutions show the number of male students admitted to study Physics is greater than the number of female student enrolled. In Physics UNN from 2018-2022, the percentage of male is 77% whereas female students takes 23% (Figure 6), which remains very poor and needs to be balanced to accommodate and encourage women in Sciences and STEM. Hence, in ESUT, while the numbers are lower, the percentage of male is 59% compared to 41% female students enrolled to study Physics (Figure 6). In order to dismantle gender biases in Sciences, gender balance is highly recommended when enrolling female students in STEM in higher institutions in Nigeria and this could be achieved through opening educational pathways for girls in sciences, sensitizing parents and female secondary school students on the need to science inclined, discouraging early marriage and advising parents against forcing their girls to leave school and marry, employing more qualified, experienced and passionate science teachers in grade schools, increasing the opportunity to assess research, scholarships, training and workshop grant for women scientist and finally by creating enabling environments in schools and research institutes that will attract, retain and advance women in sciences.

CHAPTER THREE: DISCUSSION

3.1 Gender and Disadvantaged Groups' Cross-cutting Issues in STEM

Global, regional and national research consistently shows that disadvantaged groups, including women and ethnic minorities, are underrepresented in STEM fields. The NSF's report on Women, Minorities, and Persons with Disabilities in Science and Engineering highlights the persistent underrepresentation of these groups, particularly at higher academic and professional levels (NSF, 2017). This is due to several barriers that females and disadvantaged groups face in accessing and succeeding in STEM fields. These includes biological, psychological, environmental, economic, social and cultural factors (Ceci, Williams & Barnett, 2009).

Biological Factors

Some scientists believe that biological factors, such as differences in genetic predispositions, brain structure and hormonal influences, can impact females and disadvantaged groups pursuit of scientific careers. Certain research has shown that there are differences in cognitive abilities between males and females, which can affect performance in STEM fields (Halpern et al., 2007). According to Ceci, Williams & Barnett (2009), due to differences in cognitive abilities, which is a result of differences in brain structure, males tend to perform better than females in STEM fields. However, this perspective has been dismissed by those who believe that biological factors do not influence gender differences in STEM (Eccles, 2009). This is because there is evidence that in some countries, female students perform as well as or even better than male students in STEM fields (UNESCO, 2010). Additionally, hormonal fluctuations and neurological development may play a role in shaping individuals' career choices and academic performance in STEM disciplines. Thus, the complex interplay of biological factors plays an important role in the understanding of the differences in the STEM community (Halpern et al., 2007).

Psychological Factors

Psychological factors play a crucial role in influencing the experiences and outcomes of women and disadvantaged groups in STEM fields. These factors can include self-perception, confidence, stereotype threat, imposter syndrome, and sense of belonging. Understanding and addressing these psychological factors is essential for promoting diversity and inclusion in STEM disciplines.

Self-perception and confidence are key psychological factors that can impact women and disadvantaged groups in STEM. Research has shown that individuals' beliefs about their own abilities and potential can influence their performance and persistence in STEM fields (Bandura, 1997).

Generally, females and disadvantaged groups lack the self-confidence to enrol for STEM fields because they believe that they are not competent enough to succeed in STEM (Eccles, Jacobs, & Harold, 1990). Females' and disadvantaged groups self-assessment of their capability to succeed in STEM fields plays a significant role in whether they will enrol for STEM courses or not. It was found that females and disadvantaged group assess their STEM abilities lower than those of well abled individuals and males. Females and minority groups are likely to believe that they must be extraordinary to succeed in STEM fields (Hill, Corbett & Rose, 2010). In the United Sates, they assessed children's beliefs about their own academic competency and found that girls rated their mathematical ability lower than boys from an early age, even though no actual difference in math achievement existed at their ages (Dasgupta & Stout, 2014). This indicated the significance of self-confidence and its effect on the capabilities of females and disadvantaged groups to pursue careers in STEM (Eccles, Jacobs, & Harold, 1990).

Further, Moss-Racusin et al. (2014) argues that women and disadvantaged groups usually have negative unconscious biases that discourages them from pursuing STEM courses. Unconscious biases can significantly impact decision-making processes, hence hindering them from pursuing STEM courses. It was found that biases can influence hiring decisions, funding allocations, and promotion opportunities (Moss-Racusin et al., 2014). Furthermore, Carnes et al. also found that an intervention aimed at breaking unconscious bias habits among faculty members resulted in more equitable evaluation and promotion practices among different individuals (Carnes et al., 2015).

Stereotype threat is another important psychological factor that can affect women and disadvantaged groups in STEM. Stereotype threat occurs when individuals feel at risk of confirming negative stereotypes about their social group, leading to anxiety and underperformance in academic or professional settings (Steele & Aronson, 1995). Stereotype threat can create additional barriers for underrepresented groups in STEM by undermining their confidence and performance. Similarly, racial and ethnic stereotypes as well as disability can affect perceptions of

intellectual ability and achievement in STEM, contributing to underrepresentation of the disadvantaged groups (Steele & Aronson, 1995).

Sense of belonging is also a critical psychological factor that can impact women and disadvantaged groups in STEM. Research has shown that individuals' perceptions of inclusivity, support, and acceptance within their academic or professional communities can influence their engagement and success in STEM fields (Hurtado et al., 2012). Fostering a sense of belonging is essential for retaining diverse talent in STEM disciplines.

Environmental Factors

Environmental factors play a crucial role in shaping the experiences of females and disadvantaged groups in STEM. Access to quality education, mentorship opportunities, and supportive work environments can significantly impact the success of individuals in STEM fields. Studies have shown that the lack of supportive environments and gender bias in STEM disciplines can deter women and minority groups from pursuing careers in these fields (Moss-Racusin et al., 2012). Lack of role models and limited access to mentorship opportunities makes it harder for females and disadvantaged groups to envision themselves in STEM careers (Thoman et al., 2015). Findings indicate that mentorship programs and supportive communities play a vital role in the retention and advancement of underrepresented groups in STEM fields (Eby et al., 2008). Additionally, Estrada et al. also found that African American STEM students who had access to supportive networks and mentors were more likely to persist and succeed in their studies than those who did not have (Estrada et al., 2011). Other cross-cutting issues that contribute to gender differences in STEM include females' general preference for non-STEM courses and negative attitude toward STEM. The negative preference and attitude of females towards STEM is a result of the environment, social relations and parents' expectations that socialize children's academic trajectories. Further, peer acceptance, where same-sex friends' interest can also influence adolescent girls' pursuit of STEM (Herbert & Stipek, 2005). Further, National Academy of Sciences found that science faculty members exhibit subtle biases favouring advantaged groups such as males and abled people in hiring and evaluation processes (Moss-Racusin, 2012).

Economic Factors

Economic actors, such as financial constraints and job opportunities, can also affect females and disadvantaged groups in STEM. Limited access to resources, scholarships, and funding can create barriers for individuals from underprivileged backgrounds to pursue education and careers in STEM. Furthermore, disparities in salary and career advancement opportunities based on gender and ethnicity can further marginalize these groups in STEM fields (Xie & Shauman, 2003). The National Science Foundation (NSF) found that students from low-income backgrounds have fewer opportunities to participate in rigorous STEM coursework and lack access to advanced STEM programs (NSF, 2017). Additionally, other studies highlighted the importance of equitable access to technology and internet connectivity, as the digital divide can further exacerbate disparities in STEM education (Warschauer & Matuchniak, 2010). Therefore, addressing economic barriers through increased financial support, mentorship programs, and career development initiatives can help level the playing field and promote diversity in STEM.

Social Factors

Social factors, including stereotypes, discrimination, and lack of representation, can have a significant impact on the experiences of females and disadvantaged groups in STEM. Studies have shown that societal expectations and biases can influence individuals' self-perception and confidence in their abilities, particularly in male-dominated fields like STEM (Correll et al., 2007). According to Steele and Aronson (1995), social factors such as negative stereotyping has a negative impact on females' and disadvantaged groups' access into STEM fields. Through stereotypes, females are forced to believe that they cannot suit in STEM. This instils negative threats on females by influencing their focus from performing the STEM tasks to worrying about how low performance will prove that they do not suit in STEM due to their negative stereotype (Steele and Aronson, 1995). Research consistently indicates that stereotype threats have an influence on the gaps in STEM field enrolment as well as in the academic performance between males and females in those fields. Negative stereotypes about the ability of females to succeed in STEM can substantially lower their test performance as well as aspirations for science, technology engineering and mathematics careers over time (Howes, 2002).

In elementary, middle, and high school, girls and boys take math and science courses in roughly equal numbers. Thus, many girls as boys leave high school prepared to pursue STEM courses at

tertiary level. However, fewer females than males pursue STEM courses at tertiary level. This is because people are socialized to learn about gender in early years in life as they encounter gender roles and expectations (Steele & Aronson, 1995). Girls are often oriented to be communal for instance, to be involved in socially skilled and helpful, focus on children and family, and are more likely to be engaged in activities that emphasize interpersonal relationships (Brown, 2000). Contrary, masculine gender role stereotypes orient boys to acquire mastery, skills and competence, explore the physical world, figure out how things work, and are likely to be involved in activities that emphasize problem solving, status, and financial gain (Howes, 2002). It is therefore likely that masculine gender roles align with popular cultural representations of STEM-related courses than feminine gender roles (Gonzales, Blanton & Williams, 2002). Multiple findings point to a trend where children often hold stereotypical views about STEM courses being for males and non-STEM ones for females. Therefore, this results in a situation where more men than women continue to access good paying STEM jobs in society (Ekine, Samati, & Walker, 2013).

Cultural Factors

Cultural factors, such as values, beliefs, and traditions, can shape the attitudes of females and disadvantaged groups towards STEM. Cultural norms and expectations regarding gender roles and career choices can influence individuals' decisions to pursue STEM fields. For example, certain cultures may prioritize other career paths over STEM disciplines, leading to underrepresentation of women and minority groups in these fields.

In many African countries, sociocultural beliefs and practices greatly connected to the construction of feminine identities, ideologies of domesticity and gender stereotypes discourages females from pursuing STEM courses (O Brien & Crandall, 2003). Sociocultural norms and gender expectations about the role of females in society significantly affect their educational opportunities, learning outcomes and decisions about what to study and where to work (Ekine, Samati, & Walker, 2013). Furthermore, it was found that gender incongruencies in STEM are a result of biasness and discrimination against females. Due to gender roles expectations, most people associate STEM fields with male while education, humanities and arts fields with female. In addition, some other societies hold negative opinions when females and disadvantaged groups are engaged in STEM fields. They usually ascribe STEM fields as being masculine fields for well abled people, which

females and disadvantaged groups are not suited to engage in. Such beliefs and ideologies create a bias that discriminates and discourages females and disadvantaged groups from pursuing STEM courses (Hill, Corbett & Rose, 2010). In a randomized double-blind study, science faculty from research-intensive universities rated the application materials of a student who was randomly assigned either a male or female name for a laboratory manager position. Results indicated that faculty members rated the male applicant as significantly more competent and hireable than the female candidate to become a laboratory manager (Konrad et al., 2000).

CHAPTER FOUR: CONCLUSIONS

In conclusion, this paper revealed that females and disadvantaged groups are underrepresented in STEM fields at global, regional, national and institutional level. It was found that there are several factors that contribute to the underrepresentation, these include biological, psychological, environmental, social, economic and cultural. By identifying and understanding the factors, barriers and challenges that females and disadvantaged groups face in STEM, interventions can be developed to promote equal opportunities in STEM fields. This is important to ensure a diverse and inclusive STEM workforce that can effectively address complex societal challenges. Further, the promotion of equal opportunities and participation in STEM can lead to enhanced innovation and creativity in the field through diverse perspectives and experiences, allowing organizations to tap into a wider talent pool and benefit from the unique insights and problem-solving abilities of males, females and disadvantaged groups from diverse backgrounds. This can lead to breakthrough scientific discoveries and solutions to complex challenges. Furthermore, promoting diversity and inclusion in STEM has economic benefits and innovation that can help organizations and policymakers to make informed decisions to create inclusive policies and practices that contribute to economic growth and development. Adoption and domestication of the UNESCO Call to Action: Closing the gender gap in science (2024) by member countries is essential for improved and sustainable participation of females in STEM.

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