FEMALE UNDERREPRESENTATION IN SPACE SCIENCE:

A CASE STUDY OF THE AFRICAN REGIONAL CENTER FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION

Authors: URSULA EMMANUILIDIS, LUISS AND SALZBURG UNIVERSITY
IRENE MARCORA, BOCCONI UNIVERSITY
TAMARA PATAKI, FREE UNIVERSITY BERLIN
Agency: UNITED NATIONS OFFICE FOR OUTERS SPACE AFFAIRS
Mentors: MARKUS WOLTRAN
Counsels: KEVIN KESTER, HINA KURSHID

ABSTRACT

The underrepresentation of female students in STEM education is a pressing issue world-wide. In this paper we look at the example of African Regional Centre for Space Science and Technology Education in English Language (ARCSSTE-E) and pose the question what chances female students have and what challenges do they face when pursuing a career related to space science. We observe current schemes to support women at ARCSSTE-E and propose additional measures. Our suggestions are based on qualitative interviews with educators and alumni and on a survey among alumni. The theoretical basis of our analysis was drawn from gender theory and Nancy Fraser's conception of social justice. We argue, that although the issue of female underrepresentation is rooted deep beyond the reach of stakeholders of the space sector, there are a number of ways how they can still act upon it. First, a more intensive institutional support to existing outreach and counselling programmes is crucial to raise awareness among young women that a career in space science is possible. Second to build on the positive effect of role models, female scientist in the field should be acknowledged and their accomplishments advertised to young students. Third, there should be more networking opportunities for actors and organisation in the region working on increasing female participation in space science. Fourth, there is a need for chang in the institutional culture: the issue of gender discrimination needs to be recognised, women should be encouraged to live up to their potentials, and men should be educated to see women as equal partners.

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1 INTRODUCTION

Female underrepresentation in science, technology, engineering and mathematics (STEM) education and employment is deeply rooted and puts a detrimental brake on the progress towards sustainable development. According to an UNESCO estimate, women represent just 35 percent of all students enrolled in higher education in STEM fields worldwide and in the US they hold less than 25 percent of all STEM-field related jobs. Whereas female participation in STEM fields has remained surprisingly lower than that of men in recent years, even in some of the world's wealthiest regions (Elan, 2012), the extent of the problem presents some particularities, as discussed by numerous authors for the case Nigeria (Aderemi, Hassan, Siyanbola, & Taiwo, 2013; Aguele & Agwagah, 2007; Udeani & Ejikeme, 2011). Despite the notable improvement in the situation in the last few decades, the gender gap in STEM is still a large problem globally and is even larger in developing countries.

The benefits of tackling the gender gap are multiple. Not only quality education and gender equality, listed as the UN Sustainable Development Goals (SDGs) four and five, but also in general, progress towards sustainable development demands taking action towards the eradication of any existing female underrepresentation in STEM-fields. The focus of our work is space science, a STEM subfield. Specifically, our aim is to understand the experience of women studying and working at the UNOOSA Regional Center of Nigeria, (ARCSSTE-E - African Regional Centre for Space Science and Technology Education in English Language). Our study will, therefore, have an exploratory character. Our main methodological instrument will be the semi-structured interview. To broaden our sample, we also conducted an anonymous survey with female ARCSSTE-E alumnae.

The contribution of our research is manifold and relevant for different stakeholders. First of all, our research relates to UNOOSA's work in general and to its *Space for Women* project in particular, through the collection of data and experiences in ARCSSTE-E in Nigeria. Our research aims at collecting additional information and at providing an academic foundation for the *Space for Women* project. The exploratory character of our study will highlight potential issues and themes regarding female underrepresentation in the Regional Centres. By using semi-structured interviews as our instrument, we are giving a voice to the individuals directly concerned with this problem.

Investigating the gender gap in space is crucial not only for UNOOSA, but for the UN and societies at large. Regarding the part strictly related to education, our contribution adds to the UNESCO and its SAGA project stream of research. More broadly, as previously stated, the impact of closing the gender gap in space science goes beyond SDGs four and five. Space-related technologies do in fact have a broad range of application.

Our contribution to the academic literature is twofold. First, although the STEM gender gap has been broadly investigated, nothing has been said about the space field specifically. Our research, by focusing on the space field and, in particular, on the female participation in UNOOSA' s Regional Centres, is aiming at shedding some light on this aspect. Second, although many scholars have focused on Western countries, there is a dearth of literature on developing countries. Having chosen Nigeria as focus of our research, our article attempts to add some information to the paucity of research in this area.

Our argument is put forward in the following way: The next section contains a brief introduction of our approach and our case, the Regional Center. In the third chapter, we show how the insights of gender theory, the concept of social justice and global inequalities can help us to understand the position of women in space science at ARCSSTE-E. The fourth chapter explains our methodology, how we used semi-structured interviews and a survey in order to offer a deep comprehension of personal experiences of women involved. In the fifth chapter we analyse the collected data and show that the experience of our interviews partially supports the theoretical assumption put forward by the literature, but also offers us more perspectives on the possibilities of enhancing female participation in space science. Chapter six is devoted to elaboration on the recommendations, which are based entirely on our empirical findings: the experiences and wishes of female teachers and alumni of ARCSSTE-E.

2 APPROACH

2.1 INTRODUCTION TO THE PROBLEM

Reports and papers provide useful documentation of the status quo of the gender gap in STEM. "Cracking the Code" (2017), "Telling Saga" (2018) and "I'd blush if I could" (2019), three reports commissioned by UNESCO, describe past trends and the current situation of gender equality in STEM education. By combining national data, past literature and results of standardized cross-

sectional surveys (TIMSS, PISA, TERCE etc.), it is found that women represent only 35% of all students enrolled in higher education in STEM-related fields of study. In 2019, women were 25% less likely than men to know how to leverage digital technology for basic purposes, four times less likely to know how to program computers and 13 times less likely to file for a technology patent.

The study "Cracking the Code" (2017) makes a distinction between the gender gap in participation, in learning achievements and in salaries. Specifically, this report argues that, although the gender gap in STEM education participation already exists in early childhood care and education, it widens in the secondary and higher education. Moreover, the attrition rate in every step is higher for females. Although, on average, the enrolment gap is at the expense of girls, there are heavy variations according to the specific STEM field and to the region. The gap is generally lower (or even at boys' expense) for science and mathematics, while it is higher for engineering and IT. Obviously, a low proportion of female STEM graduates translates into a low proportion of women in STEM jobs. According to "Women in STEM: A Gender Gap to Innovation" (2011) women hold less than 25% of STEM jobs in the US. The gender gap is not confined to enrolment differences. Xu's findings show a significant deviance between the salaries of men and women within the first ten years of employment. Moreover, findings indicate that women in STEM occupations encountered multiple earning penalties while dealing with their growing family obligations (Xu, 2015). Surprisingly, this participation and salary gap is not justified by a gap in abilities. In fact, it is on average not true that boys outperform girls in STEM-related studies (Hill, Corbett et al. 2010, p. 19).

The benefits of tackling the gender gap in STEM are several. Intuitively, ensuring that girls and women have equal access to STEM education and careers is a prerequisite to reaching gender equality. As pointed out by "Jobs Lost, Jobs Gained" (Manyika et al., 2017), the advent of the Fourth Industrial Revolution is driving and will be driving the demand for technological skills, making a STEM education a fundamental tool towards finding a well-paid job. We consider this momentum, in which demand for high-skilled labour force is reaching a high point, the correct context to stress the need for more female to become more involved in sectors related to STEM, like space science. We argue that more women in STEM occupations could significantly contribute to the world economy and we speculate impressive outcomes, based on existing research, if equality is reached in time.

Indeed, the effects of closing the gender gap could boost the economy of a country. According to several studies, education, and in particular, STEM education is fundamental for the development of a country. “The power of parity,” (Woetzel, 2015) a study performed by the McKinsey Global Institute, shows that the potential economic benefits of reaching the full gender equality is estimated to add 28 trillionUS dollars to the global GDP by 2030.

As mentioned above, we chose to focus this work on a specific sub-field of STEM: the space sector. In particular, we will investigate the current situation of females in the Nigerian Regional Centre. In the following section we will provide a brief description of what these Regional Centres are. However, the impact of closing the gender gap in STEM goes beyond SDGs four and five. Science, technology, engineering and mathematics are, in fact, crucial in dealing with all the greatest challenges of the 2030 Agenda for Sustainable Development. Technological advancements are critical for reaching sustainability with respect to many areas such as agriculture, climate change, disaster response, transportation, health and communication.

Our case study aims to provide additional qualitative data to these global surveys. By looking at the single case of ARCSSTE-E, we were able to explore the position of actors involved in the field as managers, teachers, researchers and students and to understand their motivations in pursuing a degree in space science and their take on the roots and causes in gender underrepresentation.

2.2 REGIONAL CENTRES

The history of the Regional Centres for Space Science and Technology Education began two decades ago with the resolution 45/72 of the 11th of December 1990. In that resolution, the General Assembly stated that the United Nations should lead, with the active support of UNOOSA and other international organizations, an international effort to establish Regional Centres for Space Science and Technology education in existing national/regional educational institutions in developing countries. After several evaluation missions, six Regional Centres were established respectively in India (CSSTEAP), Morocco (CRASTE-LF), Nigeria (ARCSSTE-E), Mexico and Brazil (CRETALC), Jordan (RCSSTEWA) and China (RCCSTEAP).

The purpose of these Centres is to enhance the capabilities of Member States at the regional and international levels, in various disciplines of space science and technology that can advance their scientific, economic and social development. To fulfil this aim, each of the centres provides postgraduate education, research and application programs and short-term courses in the fields of

remote sensing, satellite communications, satellite meteorology and space science for university educators.

We decided to restrict our analysis to the ARCSSTE-E Regional Centre which is located in Nigeria. The case of the Nigerian center is particularly interesting, as we are talking about one of the youngest regions of our planet, with high ethnic and religious diversity. The trajectory of women in space sciences is further defined by the overlap of gender norms put forward by the educational system with a British imperial heritage and that of ethnic and religious groups (Abidogun, 2007; 2018). These dynamics cannot only be observed in Nigeria, but in the whole Region (case studies to different countries, can be found in Naidoo et. al., 1998).

The history of the African Regional Centre for Space Science and Technology Education in English began a few years after the first centre of this kind, namely the Centre for Space Science and Technology Education in Asia and the Pacific region (CSSTEAP) was inaugurated in New Delhi, India. ARCSSTE-E was inaugurated in Nigeria on the 24th of November 1998 and has been hosted ever since by the Obafemi Awolowo University (Ile-Ife, Nigeria). The participants who attended postgraduate programs at ARCSSTE-E from the start of its activity until 2017 came from 17 of the 24 English speaking countries in Africa, namely Ghana, Liberia, Congo DRC, Uganda, Kenya, Ethiopia, Zambia, Tanzania, Sudan, South Africa, Malawi, Zimbabwe, Gambia, Sierra Leone, Cameroon, Botswana and Nigeria. Note however, that the vast majority of students (more than the 75%) of PG-Diplomas came from Nigeria.

On Table 1, we report some statistics drawn from UIS (Unesco Institute from Statistics) that summarize the situation of women in STEM in the countries from which students of the Nigerian Regional Centres come from. Note, however, that there are some drawbacks. First of all, the data are available for just some of the countries.

Aderemi et al. (2013) provide some useful data about the situation in Nigeria, a country for which there is no official data. By means of stratified simple surveys and data provided by firms and institutions, they found a positive trend in female enrolment in STEM higher education. Specifically, the percentage of women enrolled in science-based faculties increased from 32% to 40% over the period 1996-2006, while for engineering it increased from 17 to 25%.

2.3 RESEARCH QUESTION

The gender gap varies according to the specific STEM-related fields of study. Astronomy and space science are particularly interesting examples. Space-related science, technology, innovation and exploration are, in fact, critical for reaching sustainability within many areas, such as agriculture, climate change, disaster response, transportation, health and communication. Moreover, as McBride et al. (2018, 511) state, "the fusion of the philosophical, cultural and inspirational aspects of astronomy on the one hand, with the cutting edge of science and technology on the other, [...] affords astronomy a unique advantage to foster socioeconomic development."

In the last few decades and especially in the advent of the New Space Age, astronomy and space science have seen an unprecedented advance. UNOOSA, having recognized the importance of closing the gender gap in STEM, has launched the *Space for Women* project and works towards increasing the presence of women in space research and related studies (UNOOSA, 2019). This program is currently in its initial phase. Our aim is to explore the situation of women working and studying in UNOOSA's regional center in Nigeria in order to provide further insights for enhancing the project.

We argue that, effectively providing equal opportunities and representation to both genders requires a better understanding of the reasons that encourage, as well the ones that discourage young women from choosing an astronomy and space science educational path. This research focuses on these questions:

i. To what extent are women involved in space research today and what are the chances for women to pursue a career in astronomy and STEM-related fields?
ii. What is the situation women face while pursuing an astronomy and STEM-related career (factors that encouraged or discouraged them) in Nigeria?
iii. What initiatives are currently in place in the regional centers and what additional schemes could be introduced to support women in space sciences?

Exploring answers to these questions helps us understand the challenges and issues to be tackled, which can provide a foundation for further research and action to be undertaken by UNOOSA and the regional centers.

3 THEORETICAL FRAMEWORK

Our point of departure in observing issues and challenges faced by women in the Regional Centers is the insight of gender theories, according to which the assigned gender determines one's expected role and behaviour in society (Oakley, 1985). Based on that, we expect to find that women´s experiences in higher education centers are different than these of men. This socially constructed difference between men and women has significant consequences for girls' and women's education chances and career choices. In most societies, like in Nigeria and other partner countries of the regional centers, educational systems are designed primarily for male students and participation of women in science education and research is often discouraged or hindered by institutionalized obstacles (Dillabough, 2006). Gender stereotypes embedded in the respective societies create obstacles for female participation in universities (Aderemi et al., 2013; Ogunjuyigbe, Ojofeitimi, & Akinlo, 2006). The construction of gender norms has serious implications on how science is conducted in most societies and how educational systems are organised to cater those assigned with a female and male gender differently (Dillabough, 2006).

An educational system which is designed to prefer men over women has serious implications. On the one hand, it can deny women the opportunity of learning and improving their skills, which minimizes their consequent chances in the job market and leads to un- and underemployment, as observed in the case of Nigeria by Robertson (1985.). On the other hand, as Schiebinger argues, the masculine hegemony in education often leads to the exclusion of female voices from knowledge production and results in a "lost dimension" of human knowledge (Schiebinger, 1987). We argue that this "lost dimension" needs to be restored by enhancing women's representation and participation in space science in order to achieve a more just society and unlock potentials to enhance scientific knowledge. Our notion of a just society will be based on the social justice theory put forward by Nancy Fraser.

According to Fraser (Fraser, 2008; Fraser, 2009), social justice requires social arrangements which make it possible for all to participate on an equal footing in social life, something she calls 'participatory parity.' Social justice from Fraser's perspective is three-dimensional, including economic, cultural and political factors. The first accounts for recognition and misrecognition, the second for redistribution and maldistribution and the third for representation and misrepresentation (Nancy Fraser, 2009, 2013). She suggests a 'perspectival dualism' where both issues of redistribution and recognition have to be studied at the same time (Fraser, 1998). This means that,

when analysing female experiences, we need to focus on issues regarding the redistribution of resources between men and women as well as on the way women are represented at the Regional Centre.

Nigeria is influenced by a history of being colonized by the British Empire, and the educational system bears the traces of that past, as institutions were constructed with the mindset of providing education for the western white male student (Odejide, 2003; Bagchi et al., 2014). Therefore, together with gender theory, post-colonial theories allow us a further understanding of the contexts in which women in UNOOSA's Regional Centre works. These theories show that research here takes place in an unequal global context (Bagchi 2014, Abidogun 2018). 'Hard' sciences are considered as a symbol of Western Enlightenment and bear the traces of a characteristic Western epistemology (Abidogun 2018). The regional centers operating in the Global South are not only confronted with the challenge of breaking through epistemic dominance but also face institutional issues. Collyer defines two problems researchers and students in the Global South are confronted with. First, theories and scientific standards tend to be produced by the Global North and are expected to be followed by scientists working in the Global South (Collyer 2018, p. 65). Second, scientists and scientific organisations situated in the Global South often face economic disadvantages, as they tend to have comparatively less funding and economic resources than their counterparts working in the Global North (Collyer 2018, p. 67). These are two issues which are also encountered in the space sciences and are relevant to the experience of female students and researchers. Therefore, when arguing for social justice, an additional, post-colonial factor of oppression also needs to be taken into account.

4 METHODS

Our aim is to understand the experiences of women working in the UNOOSA Regional Centre in Africa and our study will, therefore, have an exploratory character. In our research, we will focus on the experiences of women pursuing STEM careers in Nigeria. Our case study, in particular, encompases women studying and working in the UNOOSA Regional Centre in Africa. Whereas our main focus is restricted to ARCSSTE-E, in our data analysis section, we will occasionally present findings derived from CSSTEAP. The choice of ARCSSTE-E as our main focus was motivated by the relativity of this center to the UNOOSA *Space for Women* project and essentially, by the fact that Nigeria is a developing country, in which more awareness regarding the STEM

field in general as well as female participation in STEM related education and jobs is considered crucial in the economic and social development of this country. The additional interest on CSSTEAP is complementary to our main focus, in the sense that some references to the Indian center may offer the possibility to glance at the 'larger picture' of a similar case of another UNOOSA center and the choice of this was motivated by the fact that the two institutions share many common points. First of all, both Regional Centres teach in English and the two institutions were inaugurated roughly at the same time (1995 and 1998 for India and Nigeria respectively). Moreover, both hosting countries had been British colonies for a significant amount of time, a heritage that is represented in their respective educational systems.

For the purposes of our research, we have chosen interviews as our methodological instrument. Our primary source of data consists in five qualitative interviews that we have conducted with senior staff and female professors as well as students at ARCSSTE-E, as well as one interview with a senior staff from CSSTEAP, the contacts of which we received through snowball sampling. The data collected include descriptions of events, behaviours, ideas, plans, impressions, interactions, feelings. Concretely, our questions revolve around the three important theories presented above, yet, during our interviews we remained open to new insights and thereby additional possibly fitting theories to explain our future data. To support the data derived from the interviews, surveys were sent to a number of female students of the two regional centres.

Specifically, we chose to conduct semi-structured interviews (Lune & Berg, 2016). Open-ended questions were posed, and clarifications were made to elaborate on topics regarding the representation of women at the centres. Questions maintained the flexibility to be reordered during the interview, the wording of questions remained flexible, the language occasionally had to be adjusted to the interviewees, so that they were able to provide answers to questions. Clarifications were provided by the interviewers when this was considered necessary as well as probes were added to or deleted from the interview between subsequent subjects. Whereas the choice of this methodological instrument was motivated by this exact flexibility and possibility of giving space to the interviewee to share her/his input based on personal experiences and views, we recognize that these same advantages which serve the purposes of this qualitative study do present some constraints. It is clear that, the generalization of our findings is not pursued; on the contrary, our research aims at providing in depth explanations of a particular case, which will enable concrete actions in a particular setting to be taken. As has been argued above, a better understanding of the

concrete problems causing female under-representation at the ARCSSTE-E in Nigeria could lead to a more effective response which would tackle the issue from the root.

The aim of our interviews was to let interview partners speak as freely as possible, allowing them to give their own viewpoints and understanding about the crucial question why there are so few women working and studying at the centres, as well as to explain their motivations and experiences. In doing so, we were able to understand which aspects of gender discrimination our interview partners are confronted with, how they perceive them and how they explain their experiences. For our questions, see the appendix.

To broaden our sample of responses, we have designed a survey for female alumnae of the centres. The survey is based on the same theoretical underpinnings and in the same lines with the interview questions, our aim was to test whether or not the experiences and reflections of the senior staff and of the teachers are similar to those of students. The survey is composed of twenty five questions, the majority of which are closed-ended. We chose narrow, multiple-choice questions both to heighten the expected number of completed replies and to facilitate a quantitative analysis. Nevertheless, we included open-ended descriptive questions, in order to balance the survey. We distributed the survey through anonymous links via email.

For analysing the interview and survey data we developed a code-system based on the three main strains as emerged from both the literature and the responses. In order to understand why there are so few women studying space sciences in the regional centers in question, one of the central topics brought up by our interview partners was motivation. That is important for both applying for space science courses and succeeding in them. We know from education research that student motivation is more decisive when it comes to academic success than their pre-existing knowledge or capabilities when entering the course (Hill, Corbett et al. 2010, p. 31). Gender theory shows us how a person's motivation is ultimately gendered: as different sexes are treated differently by society, girls face a different set of expectations and support during their education, which has a decisive impact on their motivation to pursue a degree (Fan 2011, p. 160). Meece et al. show that parental influence, treatment in school (e.g. teachers' assumption about the abilities of their students) and sociocultural influences all feed into the motivation of women during their education (Meece 2006). When coding the factor motivation, therefore, we pay attention to which of these three influences are thematised by our respondents.

The second code which thematizes discrimination also derives from the assumption that the experience of female students is inherently different from that of their male counterparts. Here we analyse which examples of discrimination against women the staff of the regional center are aware of and what strategies they have in place to counteract them. The third gender-related code we used, is that of institutional obstacles, which originates in the argument mentioned above, that institutions of higher education are primarily designed for men, and that women face challenges when trying to navigate them.

Drawing on the idea of social justice by Nancy Fraser, we aim to grasp issues around unequal distribution of resources and the representation of women. These two categories help us understand both economic and cultural aspects of gender disparity (Fraser 1998, p. 2). The third type of coding is connected to post-colonial theories, based on the arguments like these by Collyer, who points out that in a world of unequal power relations, institutions on the global South face structural difficulties in academia. Statements regarding the global place of the regional centers are coded in this last category.

In order to situate our research within a broader context, we also used complementary data sources and methods. In particular, these additional references allow us to give background information on the situation of women in STEM beyond the UNOOSA's Regional Centres. First of all, when possible, we complemented our research by exploiting the UNESCO Institute for Statistics Database. On the same lines, we made use of the data from the two national statistical offices (the National Bureau of Statistics and the Indian Statistical Institute for Nigeria and India respectively).

As the official data are incomplete, we also made use of less representative results obtained in the literature. The lack of official data raises a particular concern reflecting the absence of the notion of necessity by part of the national offices to keep official data that make female participation in STEM career paths visible. We highlight this and clearly, while doing this, we recognize the specificity and the limited external validity of these studies.

As our research involved human participation both in the form of interviews and surveys, we conducted these methods in accordance to ethical recommendations put forward by the European Commission (European Commission, 2018) and we are fully aware of our responsibilities towards our respondents; it is important for us to preserve their anonymity in order to avoid any personal consequences. All of our interview partners agreed on a recorded interview and allowed us to use the data provided by them for our analysis. In order to protect our respondents' identities, we only

refer to them by a pseudonym given by us and offer only a minimum amount of biographical data. The data are presented in the following table. The sections "ethnicity" and "religion" represent the direct wording of the answers given to our questions by the respondents: "What is your ethnicity?" and "What is your religion?"

Pseudonym	Gender	Institution	Position[1]	Education	Age	Ethnicity	Religion
Koinsola	Male	ARCSSTE-E	Senior Manager	PhD	60-80	Yoruba	Islam
Yemisi	Female	ARCSSTE-E	Senior Manager	PhD	40-60	Yoruba	Christianity
Uchenna	Female	Government Agency Nigeria	Alumna	Post-Graduate	40-60	Igbo	Christianity
Omolara[2]	Female	Teaching Hospital	none	PhD	40-60	Yoruba	Christianity
Manish	Male	CSSTEAP	Senior Manager	PhD	60-80	Indian	(no answer)
Deborah	Female	ARCSSTE-E	Alumna	Post-Graduate	40-60	ESU	Christianity

Table 1: interviewees demographics

For what regards the survey, of the 72 contacts to which we initially sent our survey, 19 e-mail addresses were no longer valid. We received a total of 16 answers out of the 53 alumni that successfully received our link, achieving a rate of response close to one third. Although 16 observations are far from the standards required for conducting a solid quantitative analysis, we believe that the answers are nonetheless very useful in providing insights on the experience of ARCSSTE-E alumnae.

Demographically speaking, the sixteen respondents all come from African countries. The age spans from 26 to 41 years, while the ARCSSTE-E graduation year ranges from 2007 to 2019. With just one exception, all of the alumni have a Christian Catholic background. The majority of the respondents, precisely 13 out of 16, have not left the African continent: five of them live in Nigeria, five in Cameroon, two in Kenya and one in Uganda.

[1] Position in connection to the Regional Center

[2] Although Omolara is not directly connected to ARCSSTE-E, we have decided to interview her because of her involvement in outreach programs

5 RESULTS

The results of our interviews and surveys mostly support the theories and existing findings in the literature: we can clearly see that men's and women's experiences working and studying in the field of STEM as well as perceptions of the gender gap issue are different at ARCSSTE-E. There is a significant difference between the answers of male and female respondents regarding the gender disparity in space science, the scope of the issue and the possibilities of tackling it. Generally, women with more personal experiences of discrimination saw bigger issues than our male interview partners, who did not report ever feeling disadvantaged based on their sex or gender.

The gender gap is present in ARCSSTE-E, among the students in the post-graduate programmes, as well as among the instructors. According to our interview partners, in this institution, female participation is 14-40% among students and only 20% of the staff is female. Notably, this percentage encompasses staff of all the levels of hierarchy; we speculate that the number of the senior staff representation by women would be much smaller, as multiple interviewees mentioned that females in position of e.g. directors would constitute rather the exception and crucially, would be generally not supported. However, the center observes an upward trend in female participation, which resembles the impact of new hiring strategies by UN in favouring women for new positions, as is the case for the Nigerian center.

There are not only fewer women admitted to ARCSSTE-E courses, but the disparity can already be observed among the applicants. ARCSSTE-E receives a significantly lower amount of female applications. Our respondents saw different reasons for the low amount of applications. The most common answer was that young women seem to show little interest and lower motivation in pursuing a science degree than men. A variety of reasons for that were indicated among our participants. Some interviewees and survey participants mentioned some of the factors also brought forward by Meece (2016) and explained that young women often are not even aware of the possibility that they could pursue a career in science, let alone in space science. While the female educators we talked to argued that young girls need strong support already during their secondary education, in order to understand that they can pursue a career in STEM, the male respondents treated the factor of low female motivation as being a given fact. One respondent explained to us that women's lack of interest in science is a global phenomenon, which is out of

reach to be tackled by a regional center. Manish argued that the pressure women face when choosing to further their studies is due to pressures by family and environment.

The differences in opinions between our male and female respondents were very clear regarding experiences of discrimination in the regional centers. In the case of Nigeria, our respondents pointed out that women experience multiple forms of discrimination during their education. This supports the belief of the gender theory that women's experience in higher education is radically different than that of men. Our respondents reported discrimination by secondary school teachers, who do not take their female students' interest in science seriously. A particular description in which Uchinna, in a schoolchildren reach-out program walks in the class portrays the situation well: "The first question from the head teachers is: *are you an engineer?* Those are the questions they ask us. *You studied mathematics?* And when I tell them that I am doing my PhD they are like *wow*! And I say, *let me solve mathematics for you*. When I teach them, I start from there. They asked me: *so you still remember mathematics?* And I say *yes, that is what I wanted to do*. And when we start to talk to them about the rockets, and all the things we put in space, they become very excited, even the teacher." This scene reflects both the existing stereotypes developed among Nigerian secondary school children and their teachers, but also an illuminating 'way out': this of the 'role-model effect.'

Although respondents have listed personal interest as the main reason that motivated them to pursue a career in space (11 out of 16 alumni selected this option), the importance of role models cannot be disregarded (eight women out of sixteen mentioned it). Moreover, fourteen out of the sixteen women mentioned that they always wanted to become scientists, suggesting that the interests developed as children have an enormous impact on one's adulthood choices. These findings highlight the importance of motivation: in order to increase women participation in STEM, it is crucial to help girls develop and continuously support an interest in science since early childhood. This is consistent with the insights of our interview partners.

Regarding the 'role-model effect' in particular, Yemisi reports that "there are not many role models, especially in physical sciences. So, most of them, when you ask the girls what they would like to become, it is most common to answer medical doctor or lawyer. These are professions where they have seen role models all over. But hardly anybody says, I want to study physics. Because they believe that if they study physics, they will have to be a teacher. And they think, that in the teaching profession there is no money there, so they do not want to do that." An alumna of

the regional center, Deborah, also stressed the relevance of role-models and told us, that she also became interested in attending a course at ARCSSTE-E after talking to alumni from the center. Hence, it would be fair to claim that the importance of raising awareness would remain deficient if there were no role models to represent, to show the actual realization of this possibility to enter STEM fields. As Uchinna reports: **"**During the summer camp in Abuja, I was once told by a young girl how to draw a rocket, how to make a satellite. We did a lot of things. And I told them, *you can do these things*, and, in fact, the mothers that came were so surprised." It becomes obvious that raising awareness to the young generation of potential future female students, as well as their parents of their possibilities to indeed choose a field like space engineering too, causes at times a positive reaction to the addressees, whether these are school children or teachers, which, in turn is a first step towards change, possibly towards more gender equality.

Moreover, exposure to the object in the early stages of secondary education can be crucial: as Deborah put it, "If these girls are not exposed, they will not know about it." The same point stressing the importance of "role models, that they can trust and then they follow and encourage them," in driving "more girls to be interested in the physical sciences" has been also supported by Yemisi as well as Omolara who stated that "if these careers are exposed, if we talk to them and we let them know that this exists, that they can become this and this, that there are various options, I think it would generate interest for more female to come in."

On the other hand, female professors of the center face discrimination by "the male students, they think they are superior and that they have superior brains," as Yemisi argued. Discrimination, moreover, not surprisingly, goes both ways - an interviewee reported the fact that "a lot of times, the girls would tell you that the teachers who teach them maths and especially physics, they are not communicating effectively with them. So, they lose interest in science, in maths and physics" (Yemisi). This point stresses the result of absence of motivation, counselling and role-models. Overally, the importance of tackling discrimination which lies within the culture first is stressed by multiple interviewees: "in Nigeria and Africa at large [discrimination] is a very serious problem. We have this mindset that a girl and a boy are not supposed to work together and knowing that engineering and science at large is a man's cause, so it has always made them to believe that is not for girls. The culture itself has a lot play in us not being represented in the science and STEM education" (Uchinna).

Moreover, female researchers argued that their family life and marital status has impacted their career path. According to Yemisi, some of the students "would tell you that they believe that the physical sciences are for men and they would like to have a family. So, they do not want to go along that line." The expected role in society is a further repeated motif throughout our interviews; Koinsola explains: "That has to do with culture, we can say, that across the world you can find a kind of system, where the man is the master of the house, the man is the one who takes care of the house. And usually, women take care of the home. In that sense, the position is that the men go out more than women and women take care of the children. Men need to work more and need to work harder." Arguments such as "it is very difficult to take care of a home. Because the first link for the baby is the mother" need to be looked at with much attention, since they too reflect the cultural dimension of restricting women to their role as mothers and nothing further than that. Alarmingly, the issue of discrimination is not taken seriously by some of the senior staff. One has argued that there are no issues of unequal treatment of women at the centers. They argued that, women and men have not only the same treatment but also the same chances as men, disregarding some of the core arguments of gender studies as well as contradicting their own statistics. A certain contradiction has been encountered in one of the Koinsola's s claim, according to whom "these days now, we have career women, who feel that, no, they need to do as much as men do. They want to close the gap". This answer implies the ignorance of the extent of the problem and stresses the need for better information of the actors involved in programmes like ARCSSTE-E.

The assumption that an education which is designed for male students contributes to women facing serious obstacles (Robertson 1985) can also be supported by our findings. Our interviewees reported that there is a clearly identifiable point in the secondary schooling, between the age of 14-17, where the gap between female and male students starts and girls seem to lose interest in natural sciences. This fact is in line with the assumption that the ARCSSTE-E too is designed for the male students and does not provide the same treatment to all genders.

The most cited factors are that, according to respondents, prevent women from pursuing a STEM career are the lack of support by the system (e.g. regarding child care), the discouragement by the environment, stereotypes and natural predisposition, mentioned respectively ten, eight, five and four times. These results suggest that the institutions in place and the environment are not fully supporting women to undertake a STEM career. We find the fact that natural predisposition was chosen by four women surprising. The sentiment that women are not naturally suited for the STEM field is spread even between women that work in the space sector.

Nine respondents affirmed having experienced discouragement during their education and four of them declared the discrimination was closely linked to their gender. Although we lack the data for men as a comparison, this supports our hypothesis of women's day-to-day discrimination. On a positive note, the number of women experiencing discrimination in work environment was less than twenty percent.

Regarding the aspect of social justice, in line with Fraser's three-dimensional social justice perspective, evidence was found in the interviews confirming that economic, cultural and political factors often leach into misrecognition, maldistribution and misrepresentation of women in the STEM field accordingly. To begin with, misrecognition of women is apparent in declarations such as "this fear of science is actually what I consider it to be the limiting factor for female, and boys instead are generally daring and the they feel they can do it. I think that is one of the things that affect the girls from getting them into the profession. The idea that is too tough but the boys because they are boys, they should be able to tackle whatever is tough" (Omolara). This way of thinking reflects that women's possibilities to take up an educational path related the STEM field is not only misrecognized by males but also by the females themselves. We consider this self-depriving attitude to be closely connected to the social and cultural norms and an effective tackling of the gender gap would necessitate the consideration of ways to uplift the self-image of young women with regard to their strengths to follow "tough" professions too. In this regard, we found statements such as this by Koinsola - "if you are good, you are good. If you are wise, there are no limits for you. If you are a lady - women have the same opportunities" as particularly misleading and worth of additional attention. The problem with the merit argument is, that it disregards the structural difficulties women face (as discussed above) and assumes that they have the same experience and chances as men. It is exactly the lack of "the same opportunities" which originate within economic, cultural and political factors that need to be closely looked at, in order for this statement to possibly reflect reality.

Moreover, with regard to maldistribution as well as misrepresentation, statistical as well as declared evidence has spoken in favour of this. Most interviewees answered that they are mostly surrounded by men in their working environment, recognizing the size of the gap in the STEM field. Teachers doing outreach noted the gap in interest between female and male students, teaching staff as well some of the senior staff confirmed that less applications come from women to participate at the regional centre. According to Manish, "it really depends on how the government organizations and agencies come forward to send their participation – the women participation

applications to us". This reflects the fact, even in cases in which the problem is recognized, maldistribution is closely related to a central distributing system which is reported as being 'out of reach' to directly influence even if the will of a senior staff was there. This too needs to seriously be taken into consideration when solutions to the gender gap are seeked.

In this regard, a positive finding which is worth mentioning is related to a notice of change in the described situation, even if it is minimal still. As noted by Omolara, "the general orientation before was that STEM should be a field for the men but overtime that has been eroded. Before it was like men are doctor and female are nurses, but that has been eroded significantly now." According to Manish, moreover, "we started the program in 1995, so we have almost 25 years since our centre's existence. So, what we have done is, in 1996-2000 we had a number of about 40 and presently we are at about 81. We have doubled, as well as the PhD courses." Yemisi also notes that "over the years most of the students were male. Over the years around 14% of the students was female. Until this year. This year had new intake, we have 40% female students. Just this year we had this increase." Manish also confirms that "they prioritize women when giving out scholarships, the staff is working on encouraging women and support them during the program." A development towards the better is, therefore, obvious, yet even if deviation in the numbers of women's to men's representation in STEM are becoming smaller, they are still largely reflecting a significant gender gap and a female misrepresentation.

Another issue which was touched upon by the majority of our interviewees, and one closely related to both arguments of the social justice and the gender theory, is that girls do not have the same amount of information at hand when choosing their educational futures as men do. As they receive little support from their family, society or school, there is a need for outreach programs and professional career counselling to explain young women's possibilities which are more openly communicated to men. The Nigerian center aims at scaling up female applications to their programmes by asking schools to send the same amount of men and female participants to their events and thus counteract the otherwise unequal distribution of information. However, there seems to be yet little awareness regarding change in the allocation of resources in this institution to support female applicants or students. As of now, there are no programs or special consultation provided to promote the career of women. Mentoring and counselling is provided by the initiative of female teachers and lack the necessary funding our wider institutional support. Both Yemisi and Uchinna argued that providing mentorship and role model schemes are seen as necessary by multiple staff members. At ARCSSTE-E and NASRDA, there are helping groups and support

programmes in place for young women, who offer mentorship and advice, but they are run voluntarily by the staff members and do not receive funding. Deborah told us, that the same is true in Cameroon.

The global position of the regional centers is not considered by the actors to be a decisive issue. They mostly argued that the UN Regional Centers are able to provide them with the necessary support to teach, learn and research and feel little impact by the unequal power relation in global academia which was described by the literature. Tensions originating from the educational system or from the global position of the region were not thematised by any of our interview partners.

6 SUMMARY AND RECOMMENDATIONS

This paper has analysed women's participation at the ARCSSTE-E. We have posed the question to what extent women are involved in STEM and especially in space research today and have argued that women are underrepresented at this field world-wide, and at the regional center as well. Gender theory suggests that, educational systems are mainly designed for men and therefore it is harder for women to succeed in them. We adopted Nancy Fraser's concept of a multi-dimensional social justice, which includes recognition, redistribution and representation to assess the situation of women at the regional center. Applying these categories allowed us to interpret the experience of female researchers, teachers and alumni, and to show that not only the low number of women in the programmes is problematic, but the ways how they are perceived by others, can relate to role models or have a access to funding. The approach of analysing qualitative interviews allowed us to talk about experiences in detail, but also to learn, what women involved in the field think could help to tackle these issues. In the following, we will present suggestions for tackling the problem of female representation.

Before doing so, it is important to note that the exploratory character of our research and the chosen method of qualitative interviews has its own limitations and calls for further investigation. There is a need for broadening the scope of research regarding the time frame and the number of participants. We have only concentrated on current developments regarding female participation at ARCSSTE-E, while an inquiry into a longer time-period could offer a deeper understanding of the role of the changes and reforms in the education system or hiring strategies by research and teaching institutes. Our study has explored crucial themes and issues regarding women in space science, but there is a need for more research involving a higher number of participants. Further

research opportunities in this particular field and regional centres context could involve e.g. a comparison of the state of gender gap in the several regional centres which are affiliated to UNOOSA in different parts of the world. A comparison of the situation in regional centres between further developing countries, as well as between developing and developed countries could lead to interesting conclusions with regard to the enjoyment of equal opportunities in close relation to the country of origin and could provide for additional recommendations towards eradicating global inequalities.

In order to achieve sustainable change and support female participation in the regional centers, the following part puts forward several recommendations. Although female underrepresentation in STEM is deep rooted, actors need to be aware that it is not an external factor beyond their reach of acting upon. Our interviewees made several proposals that could be implemented in the short-medium term.

The already existing outreach programs, counselling activities and summer camps promoting space science, have been proved to be effective in increasing girls' interest in the field. Replicating these programs on a larger scale will possibly increase the flow of women in the space sector. In particular, these programs are helpful in so far as they aim at creating awareness of space science opportunities. As stressed by Uchenna, "one thing about Nigeria is that most of us don't even know about space science and technology." Uchenna, further, mentions that "we need to catch girls young" so that, as Deborah asserts, "if these girls are exposed to space science at an early age, [...] they can be oriented towards it; girls can only move towards to what they are exposed to." Following the example of the mentorship project implemented by Yemisi, some programs should also aim at encouraging young women's participation in STEM by providing them financial and tutoring help. Other measures address both teachers and the teaching methods. According to Uchenna, due to the low salaries offered, science teachers in public schools are often underqualified. Short training programs for teachers can contribute to overcome this problem. Interestingly, many of our respondents suggested that both in schools and in tertiary education a more "hands-on" approach should be promoted.

To overcome the lack of female role-model and underdeveloped network, some alumni suggested that "ARCSSTE-E should introduce workshops [...] that give the female students a platform to rub minds together and bounce ideas about" and "should have a hall of fame at the space museum where portraits of women who have achieved great feats in the science world will be hung." It is,

furthermore, crucial to keep the senior members of these centres up-to-date and constantly informed about the existing gap, about the positive effects of tackling this issue and to offer them trainings on best practices to minimize the gender gap to the extent of their own reach.Based on our interview conversations, we also call for an increase in collaboration between the different actors and initiatives. There is a great potential in networking researchers and staff who are looking to design schemes to enhance female participation. During our discussions, female teachers and researchers involved in outreach programmes expressed the need for knowing more about each-others' activities, to network and learn from the experiences of others. UNOOSA could enhance this process by offering a platform to interconnect.

A long-term perspective on the circumstances in which women under-representation develops is necessary. As stated by Uchenna, "Africa doesn't allow their women to come out." A diffuse and long-term battle against prejudices could reshape the society's view of women thwarting cultural stereotypes which are proven to be harmful towards gender equality, keeping women 'one step behind.' For that, the efforts need to be on two fronts. On one side, women should be encouraged to release their potential, on the other men need to be educated, in Uchenna's words, "to see the girl as a partner in development and not as an object for the kitchen." Lastly, there is a strong need for policy changes towards a fair and equal treatment that recognizes women's needs and aspirations.

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Appendix A

Country	STEM graduates / Total graduates (%)	Female graduate in STEM/ Total Graduates in STEM (%)	Researchers per million inhabitants	Female researcher (%)
Botswana			173.9006	28.63514
Gambia		45.65712		
Ghana	13.28681	21.28098		
Kenya	16.47824	30.72713		
South Africa	19.20847	41.47977	447.3403	43.95242
Sudan	22.32281	44.79792		
Uganda			26.46695	28.12804
Zimbabwe	27.27655	27.85563	88.72377	25.45204

Table 2: women in STEM in English speaking African countries.
Source: UIS Statistics. The values are the average over the period 2002-2018

Appendix B

Interview Questions

1. What do you think are the reasons that so few women are pursuing a STEM Career nowadays?
2. At which stage of education do you think the gender gap in STEM starts?
3. What do you wish young girls would know before applying for a program / pursuing a STEM career?
4. What is the ratio of female staff or students in your institution?
5. Is there a tendency of change?
6. Do you receive more applications from men? Do men that apply have on average a better curriculum than women applicants?
7. Is there any kind of support programme at your institution which is specifically targeted to help women in pursuing a STEM career? If yes, what kind of programmes?
8. Reflecting on gender differences within your working environment, how has it affected you?
9. If so: by whom did you experience discouragement: family / teachers / friends / workplace / community?
10. Do you have more male or female contacts in your professional environment?
11. Have you ever been excluded from an event on grounds of your gender?
12. Do you think that the global position of your country plays a role in the opportunities to further women´s careers?
13. What type of programmes, do you think, can be introduced to enhance women´ s career in the STEM field? What could be done at your institution?
14. Is there a different way of thinking about this topic which we might have not considered?
15. Demographic questions (regarding age, ethnicity, religion, parents' occupation)