Prof. Alice N. Pell
Animal Science Department
Cornell University

Missing: Women in Science

Global underrepresentation of women scientists still exists, despite persistent efforts to educate and diversify the workforce since the 1960s. Attempts at educational reform have improved the situation, but women still represent two-thirds of the population who have never attended school and who lack basic literacy. At the other end of the spectrum, women have earned only 20 Nobel prizes in chemistry, physics and physiology and medicine, about 3.3% of all awards conferred in the sciences since 1901. Why are these numbers so low and how can they be improved?

How Many Female Scientists? In 2015, only 28.8% of the world's researchers were women with wide regional and disciplinary variation in female participation. Engineering and computing, which comprise about 80% of the STEM workforce and are the backbones of the 4th Industrial Revolution, have the lowest rates of female participation. By opting out of these fields, women are foregoing the jobs with the best prospects, greatest impacts and highest salaries. The excluded women are not the only losers: the rest of the world needs their perspectives to ensure that science benefits everyone. Two examples underscore the costs of exclusion: 1) Early voice recognition systems were calibrated with male voices only, with the result that women were literally unheard by the new devices, and 2) Deaths resulted because air-bag prototypes were developed and tested using adult males only. The air bags failed to deploy in accidents involving women and children, whose size and mass were insufficient to trigger release of the bags. Usually, failure to employ a diverse workforce has less dire consequences, but exclusion often leads to avoidable social and cultural misunderstandings that affect the work environment, creativity, productivity, social equality and profitability.

Women have made considerable progress in some fields over the past 60 years. Although women still are twice as likely as men never to attend school, basic literacy has increased greatly. Global data indicate that there is gender enrollment parity at the primary and secondary levels, but closer analysis of regional and national data still reveal areas of considerable educational exclusion. Universities still enroll more men than women, especially in the STEM disciplines. In comparisons of employment data from 1960 and 2013, the percentages of female lawyers increased from 3% to 33%, physicians from 7% to 36%, and chemists from 8% to 39% (AAUW, 2015). These are encouraging numbers, but during the same period, the percentage of female engineers increased only from 1% to 12%. More distressing is that the percentage of computer scientists was the same in 1960 and 2013 (25%), but had risen to 33% in 1990 and then regressed. The least progress has been made in the disciplines which are the most likely to increase in employment and economic importance in the next few decades.

Caveats on Types of Data and Access: Before we can explore why differences in women's participation in science persist, we need to consider availability and need for different types of data. Unfortunately, important data gaps exist which make comparisons of educational performance and progress very difficult, especially at the national and international levels. These discrepancies persist because the factors that hinder women's participation in science operate at different levels including individual differences, variation in schools and teaching, national policies and cultural differences. The specialists who study each of these areas often do not communicate with each other. For example, although lack of confidence and self-efficacy, the belief that success is attainable, emerge as key factors explaining why women opt out of science, specialists concerned with self-esteem rarely are involved in discussions on the organisation and function of educational institutions, especially as related to student services and advising.

The consequences of these communication failures are evident in an example from the early 1970s in the United States when many previously all-male colleges and universities first admitted women. Once a few universities had admitted women, many of the holdouts decided to follow suit, fearing loss of students to the newly coeducational institutions. In one university, where the decision to admit women was opposed by many of the all-male students and alumni, the university enacted a policy to limit enrolment of women to 13% of the undergraduate student body. The administration also decided to assign the small number of women to all the dormitories where first year students lived, not concentrating them in one or two student housing units. The women, many of whom were the only females in several of their classes, could not easily form support networks because they did not live or eat in the same places and they did not have a critical mass. The on-going opposition to coeducation and isolation due to the small numbers of women admitted created a situation in which the women questioned whether they belonged at the university, resulting in elevated attrition. Had the university administration consulted with people knowledgeable about social integration and determinants of student success, the undergraduate experiences for the women admitted after coeducation would have been far less traumatic. Unfortunately, as ill-advised as the decisions in this example seem, many universities have made similar choices in the ways in which they have treated women whom they have encouraged to study in traditionally male fields. There have been few role models, little consideration of the consequences of being strongly under-represented on campus and insufficient attention given to the amount and types of support needed for successful transformation.

Because of the complexity of factors that affect women's participation in science, there is a high probability that gaps in the availability of the information needed to understand the underlying causes for the underrepresentation of women at the national level will exist. International comparisons where differences in culture, languages, curricula, educational access, school system organization, national policies and funding are even greater than at the national level are even more complicated.

There are a few widely used international tests like the Programme for International Student Assessment (PISA) that provides school-level comparisons in science, reading and mathematics. The PISA tests, which are taken by 15-year olds and are administered every three years, were given in 79 countries with India joining in 2021. Although the need for regular data collection on variables that affect

women's participation in science is clear, UNESCO's recent publication, Cracking the Code shows that availability of data from parts of Asia and Africa is limited. Whether PISA is an appropriate solution to African data needs is debatable, but the need for regular, quantifiable assessment of the factors affecting women's participation in science is necessary to monitor progress locally, nationally and internationally. Clear plans with quantifiable goals, assignment of responsibility for implementation and an adequately-funded evaluation strategy, including data collection, are essential to determine whether meaningful progress has occurred.

Data on educational outcomes from survey data, such as the percentage of women working in different fields, does not necessarily agree with data on achievements, usually obtained through testing. The educational results from Saudi Arabia underscore this point. Men from Saudi Arabia outnumber women in terms of university enrolment and degrees granted in STEM fields, but women's achievements based on test results in mathematics and science are much higher than those of their male peers. The extent to which the Saudi women out-perform their male counterparts is greater than the results from any other country studied in both math and science. If our concern is with increasing STEM enrolment, the Saudi model may not be the most appropriate, but if we want more highly competent female scientists, we need to understand why the Saudi women are so accomplished. The top ten countries where women's achievement results are higher than those of men are Saudi Arabia, Bahrain, Oman, Kuwait, Qatar, United Arab Emirates, Finland, Iran, Morocco and Indonesia (UNESCO, 2017). In Indonesia, 48% of the country's engineers are women. Further exploration of why diverse Arab countries are so dominant in this area merits further attention.

The data on the percentage of women employed in R&D by country in Africa reveal wide variation: women comprise 55.4% of the research work force in Tunisia and 4.8% in Chad (Table 1). In Chad, where about 87% of the population still is involved in agriculture and where the research infrastructure is in the early stages of development with few employees, it is not surprising that few women work in the science sector. However, it is harder to understand why the percentage of women employed in R&D are 18% in Ghana, 31% in Zambia and 40% in Sudan. It is critical that we understand the factors that influence these employment figures if the goal is to improve the participation of women in the STEM disciplines. Unless we understand why women prefer to work in some scientific R&D environments and what factors are most important in women's decisions to study STEM fields and to seek related employment, it will be difficult to improve women's participation.

Factors that deter women from science: The UNESCO project has developed a useful framework to look at issues related to gender and STEM participation by considering factors related to the individual, family and peers, schools and society. RUFORUM focuses primarily on universities, but many of the most important influences on women's attitudes to STEM develop early in life due to experiences in primary school and at home. By age 2, children actively emulate their same sex gender mates and by age 4, these behaviors' have been internalised. Within the family, mothers have considerable impact on their daughters' perceptions of their abilities and options. Universities have responsibility for teacher training and for preparing students for their lives after graduation, including parenthood.

During adolescence, gender differences in self-perception and self-efficacy become apparent with women becoming less confident in their ability to succeed and more concerned that science is a masculine career, not for them. This lack of confidence is often evident, even when girls out-perform their male counterparts, a common occurrence during secondary school. At the secondary school level, men more frequently teach science than women so female students lack role models to encourage them to become scientists. Science camps are effective for secondary students, especially those that include South-South collaborations with leaders from regions with high participation of women in science such as Malaysia where women earn 57% of the degrees in science and 50% of the degrees in computer science.

At the university level, gender image is an important determinant of whether women study science. Beliefs that women lack the ability to become competent scientists, that science careers are for men, and that women in science are unfeminine and unattractive are unfounded stereotypes that persist and deter women. Recruitment of female faculty and student recruitment are activities that should be coordinated at the university level to ensure that all incoming students, male and female, have female role models. The stereotypes of female scientists negatively affect the perceptions of male faculty and students as well as the women on campus.

Take Home Messages

- There are areas in which impressive progress has been made in improving the status of women in science and areas in which limited advances and backsliding have occurred. Global society cannot afford to lose the intellectual contribution of half of the world's population.
- The underlying causes for under-representation of women in science include factors that operate at the individual, family, school, and societal/cultural levels simultaneously. All of these levels must be considered in developing solutions. Universities have roles to play at all four levels.
- The success of programs to increase participation of women in science depends on careful planning, development of implementation strategies, assignment of responsibility and regular data-based evaluation of progress. In many cases, needed data are lacking.
- Gender programmes cannot be restricted to women only. Male attitudes towards women in science also affect participation of women.

References

AAUW. 2018. The simple truth about the gender pay gap. Fall 2018 edition. AAUW, Washington, DC. https://www.aauw.org/files/2018/10/AAUW-2018-SimpleTruth-nsa.pdf and the 2019 update https://www.aauw.org/aauw_check/files/2016/02/Simple-Truth-Update-2019_v2-002.pdf. (Accessed 26/11/2019).

UNESCO. 2019. Cracking the code: Girls' and women's' education in science, technology, engineering and mathematics (STEM). UNESCO, Paris. https://unesdoc.unesco.org/ark:/48223/pf0000253479. (Accessed 26/11/2019).

UNESCO. 2018. Women in Science. UNESCO Institute for Statistics. Fact Sheet 51. UNESCO. Paris. http://uis.unesco.org/sites/default/files/documents/fs51-women-in-science-2018-en.pdf. (Accessed 26/11/2019).

Table 1. Women (%) Working in Research and Development (2016 or most recent data available). (UNESCO, 2018)

Country	% Women	Country	% Women	Country	% Women
Tunisia	55.4	Tanzania	29.8	Zambia	20.0
South Africa	45.0	Uganda	29.8	Malawi	19.5
Egypt	44.1	Botswana	29.6	Ghana	18.3
Cent. African Rep.	41.5	Senegal	29.3	Côte d'Ivoire	16.5
Eswatini	41.4	Mozambique	28.9	Burundi	14.5
Sudan	40.0	Angola	27.1	Ethiopia	13.3
Cabo Verde	39.8	Kenya	25.7	Congo	12.8
Namibia	38.7	Zimbabwe	25.3	Mali	10.4
Lesotho	36.4	Libya	24.8	D.R. Congo	10.3
Seychelles	34.9	Nigeria	23.3	Togo	10.0
Algeria	34.8	Mauritania	23.1	Guinea	9.8
Morocco	33.8	Gabon	22.4	Chad	4.8
Madagascar	33.2	Rwanda	21.8		
Zambia	30.7	Cameroon	21.8		

This is our seventh issue in a series of articles we are releasing as part of our RUFORUM AGM 2019 Digests. You can get more details about the meeting at http://www.ruforum.org/AGM2019/ and more information about RUFORUM at www.ruforum.org. You many also join us online using Social Media for real time updates. Our Official hashtag is #AGMGhana2019.

About the Author:

Prof. Alice Pell has been a faculty member in the Animal Science department at Cornell University since 1990. She directed Cornell's International Institute for Food and Agricultural Development, a university-wide centre for sustainable agriculture and development, and was Cornell's Vice Provost for International Relations. She served on panels of the Rockefeller Foundation, the African Academy of Science, the Gates Foundation, the U.S. National Academy of Science and the MacArthur Foundation. Pell was a fellow at the Stellenbosch Institute for Advanced Study and an Extraordinary Professor at the University of the Free State and at the University of the Western Cape. She has worked on research and graduate training programs in Botswana, Ethiopia, India, Indonesia, Kenya and South Africa. Currently, she is a trustee at Zamorano University in Honduras and a visiting professor at the University of Pretoria affiliated with the Future Africa program, an interdisciplinary campus focused on African research and education. She has degrees in Architectural Science, International Education and Development, and Animal Nutrition.