The Importance of Educating Girls and Women in Sciences

Verdiana Grace Masanja

Abstract

For the past decades, focus on attaining gender equality in science education has attracted a lot of attention. Governments and international community believe that girls'/women's science education is a worthwhile investment; it has many direct effects on economic growth and human welfare. In this chapter, we discuss this view as a tool for development as well as the moral aspect of creating equality. We focus on what practically is being done to promote girls'/women's science education and why their participation continues to be low despite many efforts and heavy investment.

Emphasis on Science, Technology, Engineering and Mathematics (STEM) education has been a major focus of developing countries, based on the perception that the difference between poor and rich countries is seen to lie in their levels of generating scientific knowledge and innovations, applying STEM for socio-economic productivity and services and working productively in Science and Engineering (S&E) careers (Masanja, 2018). Additionally, it is reported that S&E careers are better paid and rewarding than non-S&E ones. Since fewer women than men attain education globally due to the numerous

How to cite this book chapter:
Masanja, V. 2021. The Importance of Educating Girls and Women in Sciences. In: Randell, S., Yerbury, H. and Escrig-Pinol, A. (eds.) *Gender and Learning in Rwanda*. Pp. 77–91. Sydney: UTS ePRESS. DOI: https://doi.org/10.5130/aag.g.

barriers girls and women face based on gender biases and stereotypes, education for girls and women in general, and especially in STEM fields, has been a major concern for many decades (Masanja, 2018).

Before discussing why it is important to educate girls and women in science, I start by discussing why educational opportunity should be equal to all individuals. An educational opportunity is valued either for the intrinsic benefit of acquiring knowledge, or for its instrumental benefit, such as a greater chance of finding work (Masanja, 2018). To have this opportunity, a person should not face any insuperable barriers not directly related to a particular educational goal. Equal opportunity can be said to exist when to attend a selective school or college or university, all other things being equal, the only barrier they face is passing the entry examination. Equal opportunity does not exist if a female individual also faces other obstacles that the male individual does not.

In the next section, the discourse is presented from points of view raised by philosophers and legal practitioners in countries with stark educational disparities based on race, religion, gender and other social economic strata (Shields, Newman & Satz, 2017).

Why Educational Opportunities Ought to Be Equal

From the philosophical and legal points of views, it is widely accepted that educational opportunities for children ought to be equal (Alexander, 1985; Loury, 1987; Jacobs, 2010; Carnevale, Rose & Cheah, 2011; Sahlberg, 2011; Ryan, 2008, pp. 1232–1238; Reich, 2013). A significant assumption here is that a child's future should not be determined by so-called 'accidents of birth', such as the colour of their skin, the social or economic position of their parents or their gender. Education can have a significant influence on job opportunities, overall well-being and the possibilities of being a good citizen (Duncan & Murnane, 2011; and Shields, Newman & Satz, 2017).

Education is considered a highly valuable good; for individuals and for societies as a whole (Nussbaum, 1999). It has been argued that the main purpose of education is to develop the skills and talents of the individual, so that he or she can be fulfilled, contented and productive. In turn, there are advantages for the wider society in having educated people able to share their knowledge and skills, make informed decisions and participate in civil society.

A second purpose for education is to prepare people for the workforce. The education policies of many countries state that an instrumental goal of basic (primary and secondary) education is to support access to higher education and that a range of benefits accrue to the individual as a result, including access to interesting jobs, better health care, better decision-making skills and so on (Institute for Higher Education Policy, 1998). Research shows that the more education a person has, the wealthier he or she is likely to be and the more likely to enjoy good health. A child denied the opportunity of an education

is unlikely to be productive and to enjoy these benefits (Carnevale, Rose & Cheah, 2011; Jacobs, 2010).

Education to participate in the workforce can have significant benefits for a country, for example leading to growth in Gross Domestic Product (GDP). In this context, education is a highly ranked good in today's exceedingly competitive labour market, leading to the call to ensure equal education opportunity to all. Equal education opportunity is a matter of justice and human rights, regardless of genders (Alexander, 1985; Reardon, 2011: p. 91; Reardon, Robinson-Cimpian, & Weathers, 2015).

Science Education a Human Right or a Development Tool?

Support for the importance of educating women and girls in science draws on two arguments, the right to education on the basis of non-discrimination and the contribution of women to economic and welfare development. The right to education, based on equality and free from discrimination is a recognised right under human rights law. Non-discrimination on the grounds of gender has been a critical concern in education, especially in STEM education and careers globally, and particularly in sub-Saharan Africa (SSA) countries. Women and girls lag behind in education; they face multiple obstacles to equal rights to quality education based on gender, and other factors, such as age, ethnicity, poverty and disability.

For decades, this became a global concern resulting in women's groups and feminist movements being established to advocate for education as a right, claiming for girls and women the right to education on the basis of non-discrimination and equality. By the 1960s the international community began to recognise the equal right to quality education and committed to achieving gender equality in education, through the acceptance of a number of UN and African Conventions (Convention against Discrimination in Education (CADE), 1960; International Covenant on Economic, Social and Cultural Rights (ICESER), 1966; Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), 1979; Convention on the Rights of the Child (CRC), 1989; Article 12 of the Protocol to the African Charter on Human and Peoples' Rights on the Rights of Women in Africa (ACHPR), 2003) obliging governments legally to remove all discriminatory barriers and undertake positive measures to bring about gender equality in education.

In the 1980s, another argument began to emerge, advanced by development aid agencies, where gender and education became central elements in debates about development aid. It resulted in the inclusion of a gender perspective as a tool for development in all development aid agendas.

In gender and development, the most dominant view of the importance of female education is that investment in girls' and women's education is worthwhile due to the many direct effects it has on economic growth and

human welfare (e.g. Bysiewicz, 2018; Madu, 2013). The image created by this view is that girls' and women's education is important when it has a positive effect on development. In other words, education has no use if girls and women do not use it for something that has an economic or human welfare effect. Such an emphasis has an implication that if it can be proved that girls' and women's lack of education would lead to economic growth and wellbeing, then action would be taken to ensure girls and women do not get education.

Women's and girls' education is often viewed by aid agencies and organisations which invest in female education as the solution for developing countries that will change everything, such as delivering them from poverty (e.g. Thousand Girls Initiative, 2018). This discourse dominated the Millennium Development Goals (MDGs) whose emphasis was on poverty reduction where arguments about educating women especially in STEM fields was on their contribution to economic development. Less emphasis was put on girls' and women's own right to education and thus to enjoy the benefits of education for themselves and to explore their full potential.

What do People Think about the Importance of Female Education?

Between October and November 2018, I conducted a short survey of various individuals to get their views on what they perceive to be the importance to educate girls and women in STEM. I sent the following two questions to 987 men and women who are on my various WhatsApp groups: Question 1: Do you think it is important to educate girls and women in STEM? Please pick one of the answers: yes or no or don't know. Question 2: If yes, explain why? The WhatsApp groups include fellow mathematicians from Africa; my current and former colleagues at universities where I worked full-time and part-time in Rwanda, Tanzania, Uganda and Kenya; family members; and members of some women associations in Africa. I received answers from 822 respondents. All said 'yes' to the first question, and all gave as many reasons as they wished to the second question. All their responses fall into the two categories discussed above: (i) it is a human right on the basis of equal opportunity and non-discrimination, and (ii) it is a development tool because of women's and girls' effect on economic growth and human welfare. In the following section, the responses are summarised.

'Female Education is a Human Right'

I summarise and cluster responses on female education as a human right into six most frequently advanced reasons:

1. Responses from about 86% (707 out of 822) can be summarised as follows: There is a massive gender imbalance that persists in STEM-related fields. According to the United Nations, Scientific and Cultural Organisation (UNESCO, 2017) ground-breaking report 2017, only 35% of STEM students in higher education globally are women, and differences are observed within STEM disciplines with Mathematics, Statistics and Computer Sciences being as low as 16%. This leads to having very few women in STEM related jobs in industry (hovering between 10% and 30%). Therefore, it is important to increase their representation in tertiary education.
2. About 65% (534 out of 822) responded that having a more equal combination of men and women in leadership and STEM jobs would improve creativity and innovation and consequently lead to sustainable positive economic and socio-cultural change. Therefore, it is important to increase women's representation in tertiary education.
3. About 55% (452 out of 822) contend that women are creators and problem solvers. The STEM fields help to create solutions and solve problems. Women's (girls') education in these fields will help further the already inbuilt skills and thus equip and empower them.
4. All 822 (100%) respondents are of the view that too many girls and women are held back by biases, social norms and expectations influencing the quality of the education they receive and the subjects they study. There is no evidence that girls are less capable in STEM fields, but rather that they often 'feel' less capable, partly due to stereotyping. Such self-perception contributes to girls and women missing out on STEM education. Through the biases and stereotypes which lead to women's (girls') low self-efficacy in STEM, girls and women are denied the chance to explore their potential in STEM and to capitalise on their inbuilt skill as problem solvers. This is a social injustice which must be rectified.
5. About 93% (764 of the 822) responded that there is a tendency for STEM jobs to be higher paid, meaning that the lack of women in these roles is contributing to the gender salary gap.
6. All 822 (100%) respondents said that the lack of women in STEM fields means having fewer female role models, both for current female STEM employees and for girls still forming choices, thus this necessitates increasing the number of women/ girls in STEM careers and studies.

'Female Education Creates Wealth and Health'

Below I cluster responses on female education as a development tool into three reasons:

1. Responses of nearly 23% (189 of 822) can be summarised as 'when you educate a woman, you educate the whole society, or the country, or the world'.
2. About 15% (133 of 822) said educating women in STEM has higher returns economically and socially.
3. Responses of about 8% (66 of 822) can be summed as 'if women are educated in STEM there will be less disease, less malnutrition and their families will be healthier'.

Although this survey cannot be termed a scientific study in the sense of research, these findings give an indication about current perceptions on why girls and women should get access to science education. The majority of responses hold the view that girls' and women's education is a human right. Very few respondents still hold the formerly widely held views that women's education is good when it has a positive effect on development and social welfare. Girls' and women's science education is important foremost because of their own right to the science education for them to enjoy its benefits for themselves and to explore their full potential and be able to also contribute to economic and welfare development.

In the next section, I explore whether the gender gap in STEM education (and careers) exists and if so, how wide the gender gap is.

Is the Gender Gap in STEM Education and Careers Narrowing?

Tremendous efforts have been made by various stakeholders to achieve gender equality in education, and female progress has been registered in education and the workplace during the past 50 years. Data from the UNESCO Institute of Statistics (UIS) for 110 countries with available data, show that women have made great strides in higher education, slightly outnumbering men overall at bachelor and master's level. In 2013, the share of female graduates with bachelor's degrees was 53%; that of female master's degrees' graduates was also 53%. However, that of PhD graduates dropped to 44%, and the share of women engaged in postdoctoral research dropped even more sharply to 28% (UNESCO Science Report, 2015, p. 86). Despite efforts to bridge the gender gap in STEM subjects, women remain underrepresented in STEM fields. For example, 2014 data from the USA collected by the National Science Foundation, National Center for Science and Engineering Statistics (NCSES), show that although the number of women earning degrees in engineering has increased in the 20 years from 1995 to 2014, women's participation remains well below that of men at all degree levels in Engineering, as well as in Computer Science and Physics. In 2014 women earned fewer than 23% doctorates in Engineering, 21% in Computer Science, 29% in Mathematics and Statistics and 19% in Physics

(NCSES, 2017). However, women earned more than 50% of the degrees awarded in Biosciences (58% bachelor, 57% master and 53% PhD). Studies ascertain that such gaps, are not the result of differences in intellectual ability.

Science education is compulsory for all at primary and lower secondary level in most education systems in the world. The gender gap in education at those levels also means a gender gap in science education. The 2015 Statistics from the UIS database show that except for tertiary education, the world taken as whole has achieved the target of gender parity at basic education levels (primary, lower secondary and upper secondary). World gender parity indices are: 1.00, 0.99, 0.98 and 1.12, respectively, for primary, lower secondary, upper secondary and tertiary education levels. However, gender disparity exists at regional and country levels. For SSA, the gender parity indices are 0.94, 0.90, 0.84 and 0.70, respectively, for primary, lower secondary, upper secondary and tertiary education levels. The 2015 UIS Statistics show the percentages of countries in the world which have reached gender parity to be: 66% in primary, 45% in lower secondary, 25% in upper secondary and 4% in tertiary education while 36% of SSA countries have achieved gender parity in primary education, 26% in lower secondary and 9% in upper secondary education (Global Education Monitoring (GEM) Report, 2018: p. 11). Gender disparity at tertiary level is very stark worldwide and in all regions. A very small percentage of countries in various regions have achieved gender parity in tertiary education where the World average is 4%. No country (0%) in four regions (Caucasus and Central Asia, Northern Africa and Western Asia, Pacific and SSA) has reached gender parity in higher education, but: in the regions of Europe and Northern America as well as Latin America and the Caribbean 5% of the countries have reached gender parity in tertiary education. While in the Eastern and South-eastern Asia region 7% countries have attained gender parity, in the Southern Asia region the percentage is 22%.

Based on household survey data in 2010–2015 (GEM Report, 2018, p. 15), the world completion rates were 83% for primary, 69% for lower secondary and 45% for upper secondary education. Globally, gender parity has been achieved in completion rates at the three education levels: primary, lower secondary and upper secondary, with gender parity indices of 1.01, 1.01 and 0.99 respectively. But disparities exist between regions. For example, 86 girls completed the lower secondary education level for every 100 boys in SSA, while in Latin America and the Caribbean, 93 boys completed the level for every 100 girls.

In tertiary education, only 4% of countries have achieved parity, with most countries reporting more female students than male. Overall, there are more women than men in tertiary education in five of the seven regions. The Southern Asia region is approaching gender parity where the index is 0.95. SSA is the only region where women still do not enrol in or graduate from tertiary education at the same rates as men (gender parity index in 0.70). However, in many countries, although women outnumber men as graduates, they lag behind men in completing STEM degrees. In Chile, Ghana and Switzerland,

women account for less than 25% of all STEM graduates, while more women than men in Albania, Algeria and Tunisia earned a STEM degree. In Algeria, 63% of all tertiary graduates and 54% of all STEM graduates are women (GEM Report, 2018, p. 15, Figure 4).

The situation arising from the gap between men and women in STEM is not confined to SSA, being particularly acute in many high-income countries. In Australia, for example, women are under-represented among graduates from degrees in Engineering and Technology. In 2016, the share of women completing degrees in natural and physical sciences was 52.3%. However, only 17.0% and 15.6%, respectively, earned degrees in Information Technology and in Engineering and related technologies (Australian Government, 2016: p. 127, 137). In the same year, 2016, women accounted for only 12.4% engineers in Australia's labour force and as of 2017, women made up 20.7% of those employed in computer systems design and related services (Kaspura, 2017, p. 32; Australia Bureau of Statistics, 2017).

Caranci, Judge and Kobelak (2017) described the situation in STEM education for women as 'a weak pipeline'. Data from Statistics Canada (2015–2016) show that women are less likely to seek work in the higher paying STEM fields such as Engineering and Computer Science. The share of women enrolled in tertiary level institutions in 2015–2016 was 54.7% in Physical and Life Sciences and Technologies, 26.5% in Mathematics and Computer and Information Sciences and 20.3% in Architecture, Engineering and related technologies but in the same year, women accounted for 23.1% of Computer and Information Systems professionals and 13.7% of Civil, Mechanical, Electrical and Chemical engineers. Additionally, women who graduated with bachelor's degrees in STEM in Canada in 2015, earned only 82.1% of the salaries of their male counterparts (Statistics Canada, 2015–2016 cited in Frank, 2019).

According to Eurostat, there are still more male STEM graduates in higher education, although the gender gap is being closed. In the European Union (EU-28), in 2015 women made up 42.2% of the tertiary graduates in the Natural Sciences, Mathematics and Statistics and Information and Communication Technologies combined (Eurostat, 2017). However, the gap is wide in Engineering, Manufacturing and Construction, with women graduates in Engineering, Manufacturing and Construction making up 27.4% in EU-28, 22.3% in Finland, 26.2% in France and 23% in the United Kingdom. In the job market, according to EU She Figures, (2016) women made up 40.1% of scientists and engineers in the EU-28 in 2016, but they were only 32.2% of those employed in high-tech manufacturing and knowledge-intensive high-tech services (Eurostat).

The situation in Japan is worse, according to the Japanese Ministry of Education, Culture, Sports, Science and Technology data. Only 14% of undergraduate students majoring in Engineering in 2016 were women and women researchers in Science and Technology accounted for only 15.3%

in 2016 according to the Statistics Bureau, Ministry of Internal Affairs and Communication (Yoshikawa, Kokubo & Wu, 2018).

The same picture emerges in the USA, except in the Life Sciences, with fewer women earning degrees in other STEM fields than men. In 2015, in the USA, women made up 24% of those employed in STEM occupations (Noonan, 2017). In 2016, in Computer Science and Mathematical Occupations, the share of women was 25.5% while in Architecture and Engineering occupations, women accounted for 14.2% of the workforce. Even fewer women are found in the high-tech occupations. For example, they account for 20.0% as software developers, working on applications and systems software, 9.7% as computer network architects; and 7.8% aerospace engineers. Additionally, in the high-tech highly paid jobs women are less well-paid than men in the USA. For example, women in computer, engineering and science occupations were paid an estimated 79.2% of men's annual median earnings in 2016. Even though women earn less than their male counterparts in STEM jobs, they still earn 35% more than women in general and 40% more than men in non-STEM jobs (Noonan, 2017).

The global figures mask wide inter-country variations in women enrolled in STEM disciplines. For example, in 2015–2016, in India women were at or near parity among undergraduate degree earners in science (50.1%) and IT and computer (47.7%), but remain underrepresented in engineering and technology (31.9%) (Government of India, 2016: p.T-103). While 50% of engineering graduates are women in Cyprus, 38% in Denmark and 36% in the Russian Federation, for instance (UNESCO Science Report: towards 2030, 2017).

In some developing countries, the number of engineers is sizable, for instance, in Costa Rica, Viet Nam and the United Arab Emirates (31%), Algeria (32%), Mozambique (34%), Tunisia (41%) and Brunei Darussalam (42%); Malaysia and Oman, 50% and 53%, respectively. Of the 13 SSA countries reporting data, seven (Benin, Burundi, Eritrea, Ethiopia, Madagascar, Mozambique and Namibia) have observed over 5% increases in women engineers since 2000. Studies show that women in the tech industry constitute only 28% of professionals in the sector worldwide, and just 30% in SSA.

Implications for the Context of Sustainable Development

It is clear that girls and women are less represented in STEM education especially at tertiary level and consequently in STEM research and STEM careers. To achieve equality of educational opportunity, therefore, it is clear that more investment should go into female education in STEM fields. Given the importance of education, especially STEM to individuals and to society, it needs to be available equally to both women and men.

Indeed female education has a lot of positive effects, however, the main reason as to why girls and women should be educated should be foremost the rights of the girls and women themselves and not just the effect their education can have on their family, community and country's social economic development. As discussed above, gender disparities in STEM education still exist and they are even starker in rich, developed countries. It is thus not a phenomenon of poor countries only. The importance of women's and girls' education should be to create equality among the genders by removing discriminatory barriers. Equal educational opportunity and non-discrimination should be the main issues in need of a solution, and not merely because educating women and girls is valued when it has a positive effect on others.

As discussed above, women's and girls' education in STEM has preoccupied and continues to preoccupy various groups which seek to see the gender gap in STEM education opportunity removed. Women and feminist activists advocate for the opportunity for STEM education as a right for girls and women, for their personal success in life and for competitiveness in the labour market, moving beyond the expectations and demands inherent in the MDGs. The international community approves conventions and laws on women's rights to education and gender equality for countries to observe and it monitors progress on the extent to which countries are addressing the challenge of gender disparity in STEM education. Countries ratify the international conventions/laws, enact their own laws and create the environment to ensure goals and targets they set to bridge this gender gap are met by all institutions dealing with education, including schools, colleges and universities. Aid agencies support female education financially as a development tool, on the proposition that committing to women's and girls' education is a worthwhile investment which will lead poor countries to economic growth and wellbeing.

The efforts have borne positive results, much has been gained. Today more girls go to school, college and university, however, their share in STEM subjects and careers is still very low. Besides access to schools, colleges and universities, educational opportunities are also in apprenticeships, professional development and training and in many informal types such as public debates and lectures, time spent on reading, practicing, or thinking outside of a school context. There are numerous programmes such as Coding for Girls that are undertaking informal high-tech focused initiatives to increase the number of girls and women in STEM fields.

The commitment of the 2030 Agenda for Sustainable Development, i.e. the Sustainable Development Goals (SDGs), is to 'leave no one behind'. This has implications for STEM education for girls and women. This commitment is based on the premise that boys and girls, men and women should benefit equally from development on the presumption that all human potential is essential for achieving all the SDGs and that this cannot happen if one half of humanity continues to be denied its full human rights and opportunities.

The SDGs contend that progress toward gender equality in education can have important effects on equality in employment, health and nutrition. SDG 4 on education, (Ensure inclusive and equitable quality **education** and promote lifelong **learning** opportunities for all) explicitly recognises gender equality as a guiding principle linked to the realisation of the right to education. It states clearly that girls and boys, women and men, must be equally empowered 'in and through education'.

SDGs and Gender Parity

In the transition from the aspirations of the MDGs to the commitment of the SDGs, countries are moving from the focus on poverty reduction to a broader perspective combining socio-economic and environmental priorities, for example in areas such as food security, health, water and sanitation, energy, the management of ocean and terrestrial ecosystems and climate change. All the SDGs focus areas are very much gendered; but women and men are not affected the same way. Women are more affected and they are marginalised when it comes to decision making on these focus areas.

The focus in the MDGs on health and healthcare was on women's and girls' health needs as a consequence of their biology of reproduction. The SDGs, however, need also to be concerned with addressing socially related issues and conditions that promote inequality between men and women in relation to vulnerability to ill health and disadvantages in health systems that in turn lead to gender differentiated access to and use of health and health care services. Attaining food security requires sustainability and security of agriculture, forestry, aquaculture and fishing and thus natural resources management. These are very much gendered especially in SSA due to ownership issues (land, property, money and so on), gender stereotypes, differences in income levels by men and women and societal views, all of which put women in marginalised positions. Energy production and use is very much gendered, for example in access to energy technologies, in perception of technologies and their risks, energy needs and energy use. Environment, Climate Change and Disaster Management are gendered; men and women play different roles, they access natural resources differently and there are differences in how they use the natural resources and biodiversity. Having educated women working in these fields is essential and gender parity in STEM education must be seen as inevitable to ensure SDGs will achieve the objective of leaving no one behind.

References

Alexander, L 1985, 'Fair equality of opportunity: John Rawls' (best) forgotten principle', *Philosophy Research Archives*, vol. 11, pp. 197–208. Available at: https://doi.org/10.5840/pra19851111 [Accessed 03/32/20].

Australia Bureau of Statistics 2017, 6291.0.55.003 Labour Force, Australia, Detailed, Quarterly, August 2017, Time Series Spreadsheets, Table 6: Employed Persons by Industry Subdivision of Main Jobs (ANZSIC) and Sex.

Australia Office of the Chief Scientist 2016, Australia's STEM Workforce: Science, Technology, Engineering, and Mathematics, Australian Government, Canberra. Available at: https://www.chiefscientist.gov.au/sites/default/files/Australias-STEM-workforce_full-report.pdf [Accessed 03/31/20]

Bysiewicz, I 2018, Importance of Girls' Education around the World, the Bogen Project, July 14, 2018. https://borgenproject.org/importance-of-girls-education/. [Accessed 12th October 2018].

Caranci, B, Judge, K and Kobelak, O 2017, 'Women and STEM: bridging the divide', *TD Economics*, September 12, 2017. Available at: https://economics.td.com/women-and-stem-bridging-divide [Accessed 03/31/20].

Carnevale, A, Rose, S and Cheah, B 2011, *The College Payoff: Education, Occupations, Lifetime Earnings*, Washington, DC: Center on Education and the Workforce.

Convention against Discrimination in Education (CADE), UNESCO, December 1960. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000132598 [Accessed 03/31/20].

Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), UNESCO, December 1979. Available at: https://www.un.org/womenwatch/daw/cedaw/text/econvention.htm [Accessed 03/31/20].

Convention on the Rights of the Child (CRC), UNESCO, December 1989. https://unesdoc.unesco.org/ark:/48223/pf0000101215 [Accessed 03/31/20].

Duncan, G and Murnane, R (eds) 2011, *Whither Opportunity?: Rising Inequality, Schools, and Children's Life Chances*, Russell Sage Foundation, New York.

European Commission, Directorate-General for Research and Innovation, 2016, She Figures 2015, http://data.europa.eu/88u/dataset/she-figures-2015-gender-in-research-and-innovation. [Accessed 28 October 2018].

European Commission, Eurostat, 2017, Graduates by Education level, Programme Orientation, Sex and Field of Education, Eurostat Database (2017).

Frank, K 2019, 'A gender analysis of the Occupational Pathways of STEM Graduates in Canada', Analytical Studies Branch Research Paper Series, Statistics Canada. https://www150.statcan.gc.ca/n1/pub/11f0019m/11f0019m2019017-eng.htm

India, Ministry of Human Resources Development 2016, All India Survey on Higher Education (2015-16), Table 35: Out-Turn/ Pass-Out at Undergraduate level in Major Discipline/ Subject (Based on Actual Response". Available at: https://mhrd.gov.in/aishe-report-2015-16 [Accessed 03/31/20].

International Covenant on Economic, Social and Cultural Rights (ICESER), 1966, UNESCO https://www.right-to-education.org/sites/right-to-education.org/files/resource-attachments/ICESCR_1966_en.pdf. [Accessed 28th October 2018].

Institute for Higher Education, 1998, *Reaping the Benefits: Defining the Public and Private Value of Going to College*, Institute for Higher Education, Washington, DC. Available at: http://www.ihep.org/sites/default/files/uploads/docs/pubs/reapingthebenefits.pdf [Accessed 03/31/20].

Jacobs, L 2010, 'Equality, adequacy, and stakes fairness: Retrieving the equal opportunities in education approach', *Theory and Research in Education*, vol. 8, no. 3, pp. 249–268. doi:10.1177/1477878510381627 .

Kaspura, A 2017, *The Engineering Profession: Statistical Overview*, 13th ed. Engineers Australia, Barton, ACT. Available at: https://www.engineersaustralia.org.au/resource-centre/resource/engineering-profession-statistical-overview-13th-edition [Accessed 03/31/20].

Loury, Glenn C 1987, 'Why should we care about group inequality?' *Social Philosophy and Policy*, vol. 5, no. 1, pp. 249–271. https://doi.org/10.1017/S0265052500001345

Madu, C. 2013, 'Why we should support girls' education', July 12, 2013. Available at: https://www.voicesofyouth.org/blog/why-we-should-support-girls-education [Accessed 03/31/20].

Masanja, VG 2018, "What can be done at university level to bridge the gender gap in STEM in Africa", in Fernandez Polcuch, E, Brooks, A, Bello, A and Deslandes, K (eds) *Telling SAGA: Improving Measurements and Policies for Gender Equality in Science, Technology and Innovation Working Paper 5*, UNESCO, Paris, pp. 56–59. https://liseo.ciep.fr/index.php?lvl=notice_display&id=42998

National Science Foundation, National Center for Science and Engineering Statistics (NCSES), Women, Minorities, and Persons with Disabilities in Science and Engineering, 2017, Arlington, VA, NSF 17-310, January 2017. https://www.nsf.gov/statistics/2017/nsf17310/static/downloads/nsf17310-digest.pdf

Noonan, R 2017, Women in STEM, 2017 Update (USA Department of Commerce, Economics, and Statistics Administration, Office of the Chief Economist, November 13, 2017). https://www.commerce.gov/news/fact-sheets/2017/11/women-stem-2017-update

Nussbaum, M 1999, *Sex and Social Justice*, Oxford University Press, New York.

Protocol to the African Charter on Human and Peoples' Rights (ACHPR) on the Rights of Women in Africa 2003, Article 12. UNESCO. Available at: https://www.un.org/en/africa/osaa/pdf/au/protocol_rights_women_africa_2003.pdf [Accessed 03/31/20].

Reardon, S 2011, 'the widening academic achievement gap between the rich and the poor: new evidence and possible explanations', in Duncan, G and Murnane, R (eds) *Whither Opportunity? Rising Inequality, Schools, and Children's Life Chances*, New Russell Sage Foundation, New York, pp. 91–116.

Reardon, S, Robinson-Cimpian, J and Weathers, E 2015, 'Patterns and trends in racial/ethnic and socioeconomic academic achievement gaps', in Ladd, H and Goertz, M (eds) *Handbook of Research in Education Finance and Policy*, 2nd ed., Routledge, New York, pp. 497–516.

Reich, R 2013, 'Equality, adequacy, and K12 education', in Allen, D and Reich, R (eds) *Education, Justice, and Democracy*, University of Chicago Press, Chicago, IL, pp. 623–648.

Ryan, J 2008, 'Standards, testing, and school finance litigation', *Texas Law Review*, vol. 86, pp. 1223–1262.

Sahlberg, P 2011, *Finnish lessons*, Teachers College Press, New York.

Shields, L, Newman, A and Satz, D 2017, 'Equality of educational opportunity, in Zalta, E (ed.) *The Stanford Encyclopedia of Philosophy*. Available at: https://plato.stanford.edu/entries/equal-ed-opportunity/. [Accessed 03/31/20]. 2

Thousand Girls Initiative (n.d.), Cooperative Education, Why Girls?, https://www.thousandgirlsinitiative.org/about/why-girls/. [Accessed 10/12/18].

UNESCO 2017, Cracking the code: girls' education in science, technology, engineering and mathematics (STEM); report of the UNESCO International Symposium and Policy Forum. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000253479 [Accessed 03/31/20].

UNESCO, Global Education Monitoring Report Gender Review, 2018, Meeting our commitments to gender equality in education, UNESCO and United Nations Girls Education Initiative (UNGEI). http://www.ungei.org/GEM_Report_Gender_Review_2018(1).pdf. [Accessed 03/31/20].

UNESCO Science Report: towards 2030. Is the gender gap narrowing in science and engineering? 2015, https://en.unesco.org/sites/default/files/usr15_is_the_gender_gap_narrowing_in_science_and_engineering.pdf [Accessed 28th October 2018].

Yoshikawa, K, Kokubo, A and Wu, C-H 2018, 'A cultural perspective on gender inequity in STEM: The Japanese context', *Industrial and Organizational Psychology*, vol.11, no. 2, pp. 301–309.

Contributor Biography

Verdiana Grace Masanja is a Professor of Mathematics at Nelson Mandela Institution of Science and Technology, Tanzania. She holds a Doctorate in Fluid Mechanics from the Technical University of Berlin (TUB), Germany attained in 1986. She has taught and held leadership positions in universities in Tanzania and Rwanda and on short-term assignments in Finland and several African countries. She has gathered wide experience in gender in Education, and Science, Technology, Engineering and Mathematics (STEM).