



Girls in STEM and ICT Careers: The Path toward Gender Equality

ICTs shape our world. But even though ICTs touch almost every aspect of modern life, girls are steering clear of careers in science and technology at a time when their talent and perspectives might serve as a foundation for IT innovation and improved quality of life potentially for billions of people.

This paper takes a look at a crisis that is brewing worldwide, and offers a number of recommendations for getting girls interested in STEM.

Executive Summary

ICTs shape our world. They help to drive economies, reduce labor burdens, support human rights, and serve as stepping-stones out of poverty. ICTs, in fact, touch almost every facet of our lives – from health care to employment and from the use of natural resources to social connections.

But in both developed and developing nations, women face difficult challenges regarding ICTs. In some regions, they must battle myths that deem ICT careers as taboo for women. They lack access to ICTs. They even lack the time to use them.

In addition, the number of young women majoring in computer science in college is dwindling, and women and girls are underrepresented in science and technology. In the United States, young women earned 37% of computer science degrees in 1985; today the number has plummeted to 18%. Some 22% of software engineers at tech companies are women. Also, only 6% of the CEOs of top 100 tech companies are women, on telling statistic on the under-representation of women in ICT decision-making and leadership. This underutilization of talent and perspectives only serves to dampen ICT innovation, slow economic development and contribute to women's economic and social marginalization.

Gender discrimination impedes women's empowerment and blocks progress at a societal level. Yet governments, NGOs, academics and businesses haven't adopted adequate or holistic strategies that build women's equality regarding ICTs and encourage girls to move toward STEM careers.

By focusing on four areas, we can foster the growth of women and girls in science and technology: ICT access and skills, relevance to their lives, empowerment, and combatting stereotypes about women and girls in science.

Foster an enabling environment

The importance of ICTs cannot be overestimated. ICTs propel the world economy, inform our lives, shape the world of work and play (the latter often via social media), and set the stage for future innovation. They play a fundamental role in supporting human rights and reducing labor burdens, while serving as stepping-stones out of poverty. And both men and women are beneficiaries of ICT innovations across a range of areas: in health and reproductive rights, employment opportunities, natural resources management, transportation, energy, personal security, and food security.

In fact, ICTs touch almost every aspect of our lives. They offer a means for social connection, serve as vehicles for cultural expression and help tie us to time-honored traditions. Information and communication technology are also employed as vehicles for participation, advocacy, and activism, and as a means to hold government accountable to the publics they serve.

Our social and economic progress depends on these technologies, in part because the potential for economic development is linked to access to broadband Internet and to a nation's capacity to function as a knowledge-based society. In China there's an estimated 2.5% increase in GDP for every 10% increase in broadband penetration and World Bank research indicates a 10 percentage point rise in broadband penetration adds a 1.38% rise in economic growth for low and middle income countries.

As the world changes, and as science and technology and media continue to converge, women are increasingly viewed as the potential linchpin in a global economy built upon ICTs. Half of the world's population is female, and women are playing an increasingly important role as economic drivers. According to Ernst & Young, over the next decade, the impact of women on the global economy – as producers, entrepreneurs, employees and consumers – will be at least as significant as that of China's or India's one-billion-plus populations, if not greater. Women's sheer economic clout, coupled with the fact that an estimated 9 out of 10 future jobs will require ICT skills, puts a global spotlight on the role of women in the new information economy.

But as both developed and developing nations seek to realize the benefits of ICTs – while mitigating their risks – women face difficult and unique challenges regarding ICTs.

Countries that are slow to develop information technology are finding themselves on the wrong side of the digital divide – the side of digital have-nots. According to the International Telecommunication Union, by the end of 2011, 70% of total households in developed countries had access to the Internet, compared to 20% of households in developing countries.

Within this digital divide lies a gender divide, evidenced by women's lack of access to technology and lack of education, skills, and also driven by lack of access to economic resources and due to cultural and social norms. Two-thirds of the world's nearly one billion illiterate adults are women.

They are underrepresented in science and technology at the level of primary and tertiary education, in vocational training, in technology leadership positions in the sector and in science, technology and industry sectors of government. Women are also under-represented in leadership positions. Only 17% of the U.S. Congress and only 4% of CEOs of the Fortune top 1,000 companies are women.

The under-utilization of female talent and perspectives has no doubt dampened innovation and slowed economic development. Moreover, it – and a lack of ICT access overall – has denied women and girls a source of empowerment and opportunity, and contributes to female economic and social marginalization.

The issue of women and girls in STEM and ICTs is high on the global "gender agenda." In February and March of 2011, the 55th session of the Commission on the Status of Women convened in New York City. A priority theme was the access and participation of women and girls in education, training, science and technology.

Among the many recommendations of high-level panels was this: Encouraging girls' interest in math, science and technology and combatting gender stereotypes, including by exposing girls and boys to female role models; recruiting female science teachers and professors; equipping teachers with gender-sensitive teaching methods, curricula and material; and sensitizing parents, teachers and other educational personnel to gender-quality issues.

Session participants, including representatives from 51 governments, called for targeted action in 6 key areas: strengthening national legislation, policies and programs; expanding access and participation in education; strengthening gender-sensitive quality education and training, including in the field of science and technology; supporting the transition from education to full employment and decent work; increasing retention and program of women in science and technology employment; and making science and technology responsive to women's needs.

"As noted in the agreed conclusions, quality education and equal access and participation in science and technology for women of all ages are not only imperative for achieving gender equality and the empowerment of women – they are also an economic necessity, providing women with the knowledge and understanding necessary for lifelong learning, employment, better physical and mental health, as well as full participation in social, economic and political development," said Michelle Bachelet, Under-Secretary-General and Executive Director of UN Women.

"Although there has been important progress, women still do not have a strong enough voice in decision-making," said UN Secretary-General Ban Ki-moon. "Women make up just a fraction of all chief executives of the world's biggest companies. Fewer than one in ten presidents or prime ministers are women, and less than one in five parliamentarians are women."

He added: *"Gender discrimination blocks progress. Equality makes it possible to achieve huge breakthroughs. We are moving on all fronts to invest in women so they can reach their full potential, drive development and lead us to a better future."*

His statement builds on one made by Larry Summers when he was chief economist of the World Bank: *"Investment in girls' education may well be the highest-return investment available in the developing world."*

It has already been documented that nations with greater gender equality, and higher proportions of educated women, have more robust economies than others.

Indeed, some nations are beginning to assess the power of women to change the course of regional history. *"There's a growing recognition among everyone from the World Bank to the U.S. military's Joint Chiefs of Staff to aid organizations like CARE that focusing on women and girls is the most effective way to fight global poverty and extremism,"* wrote New York Times op-ed columnist Nicholas D. Kristof and Sheryl WuDunn in an article entitled "The Women's Crusade."

"Women and girls aren't the problem; they're the solution," Kristof and WuDunn continued.

The prescription for positive change lies in the grand-scale adoption of strategies that build on women's equality, especially regarding ICTs – strategies that promise to be most effective when coordinated among governments, NGOs, and private enterprise.

To formulate effective strategy, we must ask a few basic questions:

- What fosters growth of women and girls in science and technology?
- What obstacles do they face?
- How can these obstacles be overcome?

The purpose of this paper is to delve into these issues and related factors.

Research indicates that success in growing the numbers of women and girls in science and technology depends on progress in the following areas: Access & Skills, Relevance, Empowerment, and Combatting Stereotypes. Each of these factors presents unique challenges. They are covered below, along with possible solutions.

Access & skills

With the world's population at 7 billion people, one person in three uses the Internet, and 45% of Internet users are under age 25, according to a 2011 International Telecommunications Union (ITU) report.

Globally, women are in the minority of Web users, with nearly 46% of the Web-using population, 18 or older, according to Media Metrix Worldwide. Regionally, 42% of Internet users in Asia-Pacific countries are girls or women, 47% in Europe, 50% in North America, and 48% in Latin America. There are no regional statistics for women and girls' Internet use in Africa. In fact, reliable statistics on their Internet use are difficult to obtain, because standard indicators are not disaggregated by gender.

But the story of access to information technology isn't just a "numbers story," or a simple matter of women's ability to log onto the Web. Women's access is much more complicated than whether there's a computer at hand; it is measured by two other factors:

- Whether women understand the significance and transformative power of ICTs, and
- Whether they know how to use ICTs, not just for meeting basic needs, but also as a tool for improving their quality of life, participation in all aspects of society, or giving them access to quality education, formal or non-formal, technical or vocational.

Moreover, it is also about women's ability to actively participate in the production and direction of ICTs (e.g. content, applications, devices, etc.). So, while to a degree the above factors may be met through increased digital and information literacy initiatives, women's increased and active participation as producers of ICTs is also a critical component. Access and relevance of ICTs also depends on priorities and investments within government and the private sector, and this is where women are notably absent. We get women into these positions through proper development of ICT skills, including via improved approaches to STEM.

Certainly, a tech education firmly grounded in math, programming languages, systems and theory is a must in order to work as a computer scientist, engineer, or designer. But today, women are underrepresented in ICT. Worldwide, they comprise less than 30% of the ICT workforce.

This belies a rich tradition of women in computers. Women have been deeply, if not widely, involved in computers since English mathematician Charles Babbage proposed the analytical engine, a mechanical general-purpose computer first described in 1837. Ada Lovelace (1815-1852), the daughter of Lord Byron, is regarded as the mother of computer programming.

But today, the number of young women entering computer science worldwide is dwindling. In the United States, young women earned 37% of computer science degrees in 1985; today,

the number has plummeted to 18%. Also, while young girls and boys use the Internet at roughly the same rate, girls are five times less likely to consider technology-related careers.

Only 10% of electrical engineers are women in the U.S., and the U.S. Bureau of Labor Statistics reports that only 19% of software developers are women.

Meanwhile, globally only 5% of the members of national academies in science and technology disciplines are women. In the 121 countries where data is available, women account for 29% of researchers and only 15 of these countries have achieved gender parity.

Why is this happening?

Obstacles to Access & Participation on the ICT Sector

- *Lack of literacy and numeracy.* Such skills provide a foundation for reading and writing electronic messages, executing software commands, navigating the Internet, and writing programming code. But for a majority of women and girls in developing countries, education is simply out of reach.
- *The language barrier.* This is the top barrier to Internet use by women in Latin America, the Middle East and Francophone Africa. The language of ICTs is predominantly English. This serves to exclude a majority of the world's population who do not speak this language.
- *Social and cultural norms.* The geographic location of ICT facilities can pose an obstacle to training or regular use of ICTs, resulting in a gender gap in access. In many developing countries, women do not have the same freedom to move about the community as men, due to social or religious customs. In some countries in the Middle East, women are not allowed to travel without a male companion.
- *Costs are prohibitive.* In developing countries, yearly Internet dialup fees can be even higher than the annual per capita income, putting access out of reach for most women. According to the ITU, fixed broadband penetration is below 1% in many of the world's poorest countries, while access costs can be more than 100% of monthly average incomes. (In contrast, in the world's most developed economies, around 30% of people have access to broadband at a cost of less than 1% of their income.)
- *Limited infrastructure.* Internet connectivity is frequently limited to capital cities in developing countries, even though the majority of the population lives in rural areas. This urban bias impedes women's progress in ICT education and deprives them of their ability to communicate via the Internet.

Potential Solutions

- *Develop women-centered ICT policies.* Government policies, regulations and investments should be responsive to women's specific needs and seen through a gender lens.

- *Shift perspective.* ICTs must be regarded as essential tools for the masses and for daily life, rather than as a vehicle reserved mainly for elites' leisurely pursuits.
- *Develop specialized training.* This is considered essential if girls and young women are to develop ICT skills commensurate with their needs as full-fledged participants in knowledge-based societies. Some nations take advantage of digital literacy initiatives such as summer camps for girls and adolescents in math, science and technology, operated by public-private partnerships.
- *Build community empowerment centers in areas where there's a high demand for ICTs among girls and women.* Rural areas where girls and women are the majority of the population often need resources and infrastructure for ICT education and business development. In addition, cities globally must do more to ensure the safety and security of women and girls as they make use of ICTs at such empowerment centers.
- *Use gender-sensitive teaching methods.* Adopt best practices to promote an environment in science, engineering and technology education that encourages females to take up STEM occupations and prevent job pipeline leakage during the transition from education to career. This includes sensitizing teachers to girls' needs, increasing the number of women teachers, and revising curricula and educational materials to make STEM more relatable and interesting to girls.

Relevance

Government ministers, NGO officials, academics and others contend that women in developing countries have a more pressing need for safe water, adequate food, improved health, and better education than for information technology.

But in the drive to empower women and girls, information technology is crucial because it can end the isolation felt by rural women and girls, while stimulating economic development, bringing improved health services, and throwing open a window to the outside world, among other benefits. As one researcher, Marie-Helene Mottin-Sylla, of ENDA (Dakar, Senegal), put it: *"The freedom to have access to spaces other than the bedroom and the kitchen, and to fully and safely be able to act in other public spaces, is the key to women's participation in the world's future."* A report from IDS also cited the exposure of women to new ideas and knowledge as a critical pathway to empowerment.

Yet there is a disconnect between the myriad of opportunities from ICTs to improve women and girls' lives, the development of relevant applications and the interest and opportunities for girls and young women to pursue these by going into STEM.

What prevents STEM from being relevant in women's lives?

Obstacles to Increased Enrollment in STEM

- *Gender discrimination.* Girls and women's enrollment rates in science and technology trail that of men globally due to a lack of ICT access, but also due to negative attitudes toward girls once they are enrolled in college, especially as students of math, science or technology. Female professors themselves were found to be just as biased against women students as male professors, according to a study by Yale University researchers, who found that science professors at American universities regarded female undergraduates as less competent than male students with the same skills. They also found that male and female professors were equally likely to exhibit bias against female students. This bias, which researchers characterized as pervasive, perhaps reflects subconscious cultural influences rather than overt discrimination, but the effects nonetheless can be devastating; and left to accumulate over the course of a career, bias can sap a woman's confidence and undercut efforts to rise to the top.
- *Irrelevancy.* Girls themselves fail to see how these fields are relevant to their daily lives, and often view technology jobs as unattractive because they do not consider them as being applicable to their lives.
- *Misconceptions.* Many girls don't really understand what engineers actually do, and think of engineering as a dirty, manual occupation.

Potential Solutions

- *Resonate with students.* Teachers must relate to girls and young women by talking about science and technology in ways that resonate and relate to their lives and aspirations. Girls are more likely to be attracted to technology education if STEM curricula and ICT projects are tied to the real world beyond school and domestic contexts, researchers have found.
- *Increase relevancy by developing gender-specific content.* The Web contains massive amounts of information, but little of it appears useful or especially relevant to girls and women in developing countries. More must be done to address their specific needs, interests and priorities regarding ICTs and STEM.
- *Adapt ICT training.* Improvements in curricula and training materials can produce benefits. A Belgium program has been developed to sensitize teachers about girls in science tracks, and in Zambia, science camps and bursaries have been established for women entering the science field. Both programs have been successful. Also, university courses renamed to appeal to non-geeky students have seen a rise in popularity among young women.
- *Take it to the airways.* The power of television can be used to attract girls to ICTs and STEM. The Argentine government has created a public television station dedicated to science and technology, and is commissioning programming on girls and ICTs.

Empowerment

Technology and science are reshaping our world and how we interact, and increasingly STEM and ICT innovations are serving as economic drivers and as tools for realizing knowledge societies based on freedom of expression, respect for cultural diversity and access to information. Women and girls in STEM and ICT careers will be empowered to drive change in scientific, social, economic and political spheres.

Democratic movements are taking root globally, as participation in national decision-making gains adherents. In the vast majority of developing countries, women's participation in decision-making, however, is limited, weakening their rights, as well as the foundations of fledgling democracies. Women comprise only 13% of all the members of parliament in the world, and only nine out of 190 heads of state are women.

To strengthen women's participation, much must be accomplished either by women or on their behalf, including reducing poverty, eliminating illiteracy, informing women of their legal and political rights, ending violence against women, and expanding their political activities.

STEM and ICT careers can play a crucial role in all of the above, promoting the empowerment of women.

Obstacles to Empowerment

- *Isolation.* Girls and young women are marginalized and widely dispersed in rural areas, where they lack the ICT skills needed to access and share information, organize themselves, and advocate for issues that directly affect them.
- *Government inefficiencies.* Without the free flow of information, it is difficult to hold governments or politicians accountable. The political process is marred and incomplete, services are inaccessible, and education suffers.

Potential Solutions

- *Increase access to ICT.* This will enable women and girls to fully exploit the potential of ICTs and develop STEM careers. Increasing ICT access involves revamping global Internet policy, adopting national e-strategies that take women and girls into account, stimulating competition, revising ICT regulations, refining laws on intellectual property, developing infrastructure and systems architecture, and perhaps most importantly increasing STEM skills and understanding.
- *Promote women as technology content developers.* This will attract more girls to STEM and ICT careers. This involves training and developing women entrepreneurs, laborers, academics, policy makers and regulators in ICT.
- *Use ICTs to end isolation.* ICT use among girls and young women can enable them to share knowledge and information relevant to their homes, school, work, and

communities. Networking is perhaps the most common ICT usage among women in developing countries. They use ICTs to address women's rights, communicate, spread information, mobilize action in times of crisis, debate policies, voice their opinions, and discover allies or peers across the Internet. In short, ICTs promote girls and women's interaction and sharing.

- *Improve governance.* ICTs can be used to strengthen women's participation in the electoral process, share information as voters, open avenues of direct participation with government agencies, and enable government officials to research and access information on issues directly related to women and girls.
- *Improve statistics.* Increase the availability of gender-specific data, particularly in ICTs.

Combating stereotypes

In 2009, the prime minister of Iceland, Johanna Sigurdardottir, vowed to sweep aside Iceland's "age of testosterone" during which male leaders brought the nation to the verge of bankruptcy. The nation put its faith in Sigurdardottir and her cabinet, half of which was led by women.

Some believe Iceland is a forerunner of things to come – a world in which women leaders are increasingly called upon as perceptions of gender roles evolve and as women in some countries shatter "glass ceilings." Much is now being published about women's changing role in society. Journalist Hanna Rosin's book, "The End of Men: And the Rise of Women," published in 2012, points out that women form the majority of students in colleges and professional schools on every continent except Africa.

Rosin adds that women in poor parts of India are learning English faster than men in order to meet the demands of global call centers; that women own more than 40% of private businesses in China; and that if the global recession has revealed anything, it's that there has been a profound economic shift as women make their presence felt in the workforce and outnumber men in certain job categories. Of the 15 job categories projected to grow the most in the U.S. during the next 10 years, primarily women occupy 12.

Furthermore, unlike in industrial economies, our new service and informational economies do not reward brawn so much as social intelligence, communication and a knack for being able to focus – areas that are not the sole province of men. All of these changes are inspiring a march forward in the pursuit of equal gender rights, while creating culture shock among men who cling stubbornly to conservative traditions that constrain women.

But for all that has been written about women's pivotal role in society, a myth that girls don't do well in science and technology persists. As a result, some people believe, the software programming industry is rife with gender discrimination. Dr. Madeline Heilman, a

psychologist at New York University who studies gender stereotypes, has gone on record saying: *"There's bias in the system. It affects women's willingness to go into these situations because they know what they're in for."* She added: *"There's the perception that women somehow don't have the right stuff to fulfill these roles, and that colors everything. It's very hard to crack, and has consequences for selection, promotion and task assignment."*

Gender stereotypes are relatively common among male university STEM faculty and students. A 2011 Massachusetts Institute of Technology report on the status of women faculty included the following comment by a woman faculty member: "Undergraduate women ask me how they should deal with their male classmates who tell them that they only got into MIT because of affirmative action." In response, the report noted, some women faculty remarked that when they win an award or other recognition, it is not uncommon for a judge on the selection committee to say, "it was long overdue that the award be given to a woman," as though gender were a significant factor in selecting the winner. "These kinds of statements deprive the awardee of the satisfaction of knowing that it was purely because of respect for her accomplishments that she got the award."

These stereotypes can be toxic for female STEM students. In a 2012 study on the role of stereotypes in undermining girls' performance and interest in STEM, Jenessa R. Shapiro and Amy M. Williams, of the psychology department at the University of California, Los Angeles, concluded that "parents' and teachers' gender-related math attitudes – including their stereotypes and anxieties – can transfer to girls and play a critical role in girls' development of math attitudes and interests." This transfer, Shapiro and Williams noted, puts girls at risk for self-imposed "stereotype threats" – a concern that poor performance could confirm in one's own mind that the stereotypes are indeed true of oneself or the group.

These stereotypes play out globally, affecting aspirations for STEM careers. The imbalance in computer science favors men; for women, the pipeline leading to the industry has been called "a veritable sieve."

More must be done to end gender discrimination in STEM.

Obstacles to Eliminating Gender Myths

- *Trapped in a stereotype.* The myth of male superiority in science runs deep. By the time students reach middle school, basic ideas about perceived gender differences in STEM subjects have already been established among students, primarily through societal influences, according to Janelle Wilson, who teaches earth science in Gwinnett County, Georgia. In some countries, it is considered culturally taboo for a woman to pursue a STEM career.
- *Unfulfilling careers.* Many girls view ICT careers as "solitary," "passive," and "sedentary," according to a study by the American Association of UN Women.
- *Few role models.* There's little gender diversity in tech industry leadership. Just 6% of the CEOs of top 100 tech companies, and 22% of software engineers at tech

companies are women, according to the U.S.-based National Center for Women and Information Technology. Also, women own 40% of the private businesses in the U.S., but they create only 8% of venture-backed startups, according to Astia, a nonprofit group that advises women entrepreneurs.

Potential Solutions

- *Award and reward success.* One way to counter prevailing myths is to recognize women for STEM accomplishments. “Many young women I know who are pursuing STEM careers say that notable awards they won for achievement in science—and the recognition they received from their communities and the news media as a result—had a real impact in boosting their confidence to pursue and excel in STEM fields,” Jeniffer Harper-Taylor, president of the Siemens Foundation, which supports K-12 STEM education, has been quoted as saying.
- *Educate the educators in order to stop “blaming the victim.”* African women, particularly in rural areas, have the lowest participation rates in the world in science and technology education. The Federation for African Women Educationalists attributed this to a “lack of self-esteem, poor self-image, and nonassertive behavior among girl students,” according to one study, adding that many male science teachers in Africa hold outmoded views that girls cannot think or work scientifically and that science is too mechanical and technical for girls, thus discouraging female students.
- *Create ICT programs that focus on women’s needs.* Microsoft is now developing a “gender playbook” of IT programs. It will contain a global directory of Microsoft programs for girls and women, along with guidelines for replicating them or creating new ones developed with UN Women. The book will also contain resource material and templates that can be tailored for local use, easing replication.
- *Break the leadership mold.* In a field in which women don’t fit the “standard template” of leadership, there’s great value in creating a class of women STEM leaders. There may be beneficial economic and social consequences for companies that seek the increased participation of women in STEM, since many Web startups, from socializing to shopping, attract more women than men.
- *Encourage team diversity.* According to the National Center for Women and Information Technology, mixed-gender teams have produced information technology patents that are cited 26% to 42% more often than the norm.

Conclusion

The potential solutions to many of the obstacles mentioned above should only be made as part of a comprehensive strategy. Non-systematic approaches to increasing the number of women and girls in STEM will likely fail to produce comprehensive or lasting results. Besides,

ignoring some obstacles facing women in ICT could potentially make other problems worse, or shorten the effectiveness of results.

We recommend that stakeholders investing in girls and STEM examine each of the obstacles affecting the communities to be served.

We also recommend convening thought leaders to discuss the opportunity gap for girls in STEM and ICT, and taking steps to formalize a stakeholders group.

Stakeholders should address each of the obstacles and solutions listed above, and also consider such questions as:

- What sorts of investments are needed?
- What are the social and cultural challenges presented?
- How should a global strategy be implemented and administered?
- How can the effectiveness of such a strategy be gauged?

Likely, there will be no single solution to the problem of enrolling more girls in STEM. Still, coordinated solutions can result in dramatic regional improvements and go a long way toward creating gender-sensitive STEM-focused cultures. A culture that celebrates math, science and technology at all levels of society will naturally increase women and girls' participation. And more public-private partnerships and collaborations between academia, private enterprise, government, and NGOs will help to inspire women to become engaged in STEM.