Chapter 10
Advancing Women in Science: Policies for Progress

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Over the past few decades, policy issues about the participation of women in science, technology, engineering, and mathematics (STEM) fields have been discussed less in terms of human rights and social justice, and increasingly in terms of national development and international competitiveness. In today's ever expanding knowledge-based and innovation-driven global economy, nations must maximize the development and utilization of all of their human resources. Therefore, enhancing opportunities for STEM education and careers for all segments of the population has become a priority on many policy agendas.

Despite variations across countries and disciplines, the advancement, access, and contributions of women—and of other groups that traditionally have been disenfranchised or underrepresented in STEM fields—have become an integral component of policies concerning national progress and international competitiveness. Within this context, we examine the lessons learned and challenges of promising policies that have the potential to improve as well as to increase the participation of women in STEM fields in diverse economic, social, and national contexts. Although specifically focusing on women, such policies also hold promise to serve as a mechanism for enhancing processes of inclusion, social justice, and progress more generally. After briefly discussing conceptual issues that inform our understanding of these policies, we then use selected analytical dimensions to explore the various characteristics that determine the effectiveness, applicability, and promise of these

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policies in broader terms. We draw upon examples from various countries and regions to illustrate the main points highlighted in this examination, inform our analyses, and further enhance our understanding.

10.1 Conceptual Foundation

Our examination of promising policies is based on the premise that *policy is not only reactive but also proactive. Reactive policies* address public problems and those approaches to public problems that seem not to be working well, if at all. *Proactive policies* can be conceptualized as anticipatory insofar as they identify and address issues before they become problems. Moreover, we posit that "policy" itself can be conceptualized in four major ways: as a proposal and/or plan; as a rationale; as an intervention; and as an initiative. As a *proposal/plan*, policy articulates goals and objectives, and then provides guidelines for activities and actions to achieve those goals and objectives. As a *rationale*, policy provides the underlying principles that justify, validate, rationalize, and support a course of action (or inaction). As an *intervention*, policy can be conceptualized as a correction to a policy, program, practice, and/or course of action to avoid outcomes deemed as undesirable (reactive). As an *initiative*, policy is conceptualized as a course of action that enhances the potential for outcomes deemed desirable (proactive).

As a plan, rationale, intervention, and/or initiative, policy does not occur in a vacuum. Policy is developed in a broader context shaped by political, economic, social, and cultural forces. Rather than viewed as static, policy can be more appropriately conceptualized as the product of various interconnected and interdependent dynamic factors and processes at a given point in time. Whenever change(s) occurs in one or more contexts, policy should be re-analyzed in the context of those changes.

Also, we operationalize the concept of "promise" by identifying specific factors or characteristics associated with policies that have been deemed successful in addressing the same set of issues in other contexts. Because "one size does not fit all," a policy that is promising in one context may not necessarily be promising in another. Accordingly, emphasis is placed on various aspects of policy as they relate to one another, thereby providing a means by which to understand, classify, and compare policy goals across countries and over time. Based on such comparisons, we identify a range of policies that show promise both in general and in the context of specific countries and regions.

10.2 Analytical Dimensions

Through lessons learned from considering a range of policies and relevant examples, experiences, and insights from selected countries in different parts of the world, our goal is to enhance understanding and to stimulate and facilitate systematic and analytical thinking about principles and processes for the development, implementation, and evaluation of policies aimed at increasing female STEM access, opportunities, and participation. To that end, representative policies were analyzed to identify commonalities as well as differences relative to various contexts. Based on comprehensive reviews of relevant literatures and policy approaches, six fundamental and interrelated characteristics were selected to serve as the bases for identifying and analyzing challenges and promising policies for progress in increasing women's participation in STEM fields and careers. These characteristics are problem and issue identification; policy statement; relevant data; gender mainstreaming; institutionalization and sustainability; and diffusion (Fig. 10.1).

Note too, that although we focus primarily on policies and policy processes in specific countries at the national and/or regional levels, these analytical dimensions are applicable to different levels of analysis and actors, as well as across institutional settings. Thus, for example, policy issues at local levels and within specific agencies and organizations (and types of agencies and organizations, e.g., universities) can be approached in similar ways relative to questions of horizontal and vertical policy development, integration, and implementation (Fig. 10.2).

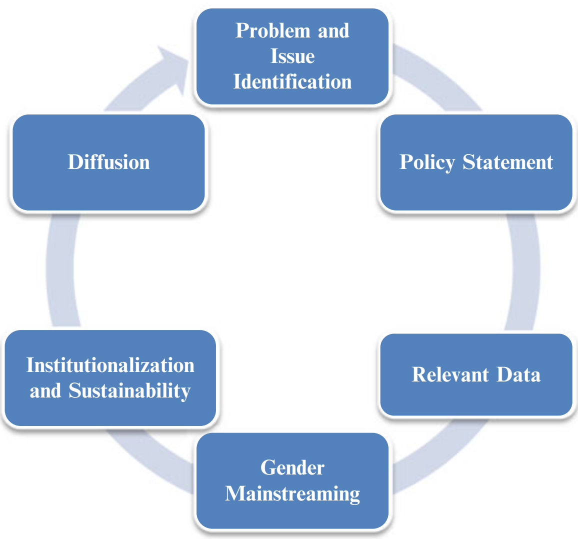

Fig. 10.1 Analytical dimensions

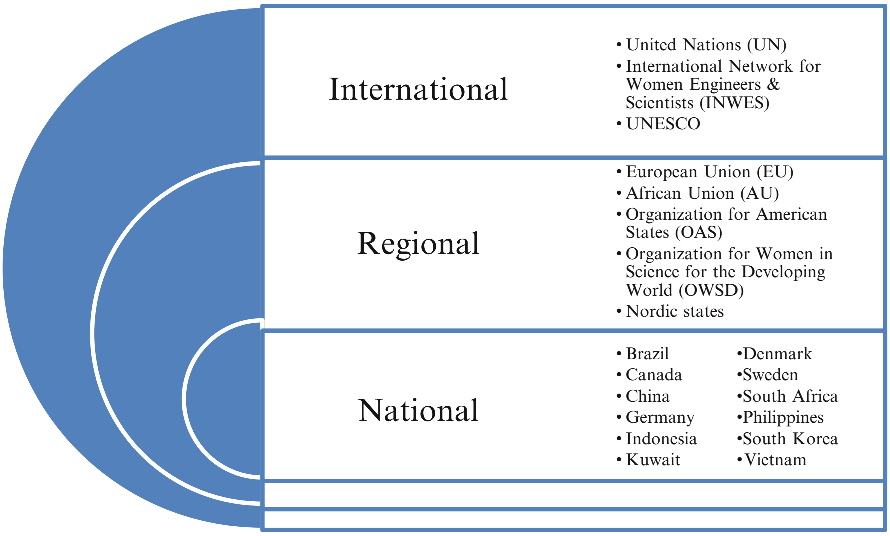

Fig. 10.2 Examples of applications of analytical dimensions

10.3 Problem and Issue Identification

As previously noted, policies can address what does, as well as what does not, work. Moreover, policies can address issues as well as problems; more specifically, all issues are not problems. Consequently, we contend that gender inequalities that depress the participation and contribution of women in STEM are ultimately harmful not only to scientific and technological advancement, but also to economic, national, and social advancement. Internationally, women comprise only a small percentage of the science and technology enterprise, signaling the crucial need for policies that encourage capacity building and bringing the development of knowledge and skills, vision and leadership, and views and aspirations to the science and technology agenda and to overall societal well-being. This situation raises questions not merely of structural adjustment, but also of legitimation and empowerment. Referring to attitudinal and cultural shifts and to access to resources, education, employment opportunities, and participation in decision making, empowerment in particular enhances women's ability to participate fully in knowledge-based activities:

> Empowerment may be understood as the ability to make strategic life choices in the context where this ability was previously denied. It involves changes in the allocation of roles, resources, and power in various aspects of society. Such changes require not only development planning or a top-down approach, but also active participation of women themselves … . Empowerment takes the form of upgrading skills, increasing employment opportunities, generating income for reinvestment and changing the gender equation. (Etzkowitz et al. 2010: 90)

Yet, in many countries, there traditionally has been little acknowledgment of women's societal or public existence, much less recognition of their critical role and capacity to engage in today's knowledge society and to be major contributors and participants in national development (Prakash et al. 2010; Berkovitch 2002). Indeed, it was not until the latter half of the twentieth century in many countries that women were accorded the right to participate in public institutions as individuals in their own right (Berkovitch 2002). The situation has been such that, especially "in the developed world, periods of shortfall in the supply of scientific personnel have prompted governments to enhance women's participation in the field." However, "given subtle biases and exclusionary practices," supply side approaches have been insufficient. Rather, wider institutional policies are required, such as "recruitment into pivotal positions and to important committees so that women can develop a network of contacts, access inside information about organizational politics, and gain visibility" (Etzkowitz et al. 2010: 87).

Effective policy making involves articulating the relevant problem or issue, specifying its scope and the magnitude of its ramifications (Kingdon 2011). Moreover, one of the most critical components of promising policy development is the clear identification of the relevant or target population(s)—that is, the group(s) or segment(s) of the population that the policy is intended to impact—and in what way(s). The Nordic countries (Finland, Iceland, Denmark, Sweden, and Norway) provide an interesting example in this regard. For the past several decades, the issue of gender balance in academia has been an especially prominent issue on their policy agendas. In these countries, 80% of professors are male, with the greatest imbalance represented in the natural sciences and technology fields. Finland, Norway, and Sweden have been identified as particularly proactive countries since the 1970s and 1980s, followed by Denmark and Iceland, with active policies promoting gender equality in research and related funding (EC 2009; Bergman 2013). In the past, initiatives in the Nordic countries tended to rely on national injunctions and legislative schemes, whereas current efforts are framed as "autonomy reforms" in which higher education and research policy is the responsibility of individual institutions. At the same time, research resources have been increasingly concentrated on large units and elite environments. Accordingly, "it is clear that there is a need for more discussion about and research on why excellence in research initiatives have become an instrument that favors male researchers over their female counterparts, and on what can be done to bring more gender balance to elite environments" (Bergman 2013: 10).

Other examples include special initiatives in Europe more generally. Aimed at increasing the proportion of women in academia, especially in the STEM fields, such initiatives have been on the forefront of the European Union (EU) agenda since the 1990s (EU 2000, 2009). Focusing on gender equality and gender mainstreaming, several EU countries have integrated policies providing funding to institutions based on their gender equity performance. Additionally, several European national research councils have instituted monitoring activities and action plans and policies for promoting gender balance and increasing the number of women researchers (EC 2008a, 2009).

Among Asian countries, South Korea, Japan, and Taiwan have launched support programs targeted to increase the presence and profile of women in STEM. For example, South Korea has relatively well institutionalized policies for encouraging female participation in STEM fields. These policies were developed over time as part of a three-phase general plan: Phase I, 1990–2000; Phase II, 2002–2008; and Phase III, 2009–2013. In particular, STEM policy concerns in South Korea beginning in the early 2000s were triggered by two phenomena—"STEM avoidance" and "brain drain"—which opened the door for policies supporting women in STEM fields (Lee 2009).[1] During Phase I in South Korea, the policy agenda for supporting women in STEM was formulated with an emphasis on gender equality in all national policy making. This emphasis is particularly noteworthy because it marks a turning point in terms of taking a gender perspective into consideration in the policy-making process—i.e., gender mainstreaming, as will be discussed below. During Phase II, the Act for Fostering and Supporting Women in Science and Technology provided both a legal and an institutional basis for policy supports for women in STEM. Phase III was aimed at making adjustments and re-establishing policy provisions and goals.

India provides another example of common issues that arise in discussions of women in STEM. "In India, the female-to-male student ratio in most scientific disciplines has been rising, but women are still grossly underrepresented in major scientific establishments in the public sector, not to speak of the upper echelons of science administration and management" (*The Hindu* 2013). Although India has many women studying and teaching science, the percentage of women actually "doing" science is not all that different from that in the rest of the world—that is, it is quite low (Godbole 2007). Moreover, studies have indicated that organizational practices and workplace discrimination cripple women's career growth. Such systemic failure has a cascading effect and serves as a major disincentive and barrier to female STEM participation (*The Hindu* 2013). Accordingly, special programs, such as those run by the Indian Department of Science and Technology and teacher fellowship programs run jointly by the three national science academies, have been established to address additional constraints faced by women teachers (Godbole 2007). Another example lies in the growing numbers of women in the Arab region of Africa and Southern Asia who are earning STEM degrees, but often cannot pursue STEM-related careers due to constraining social attitudes, as is often the case in developing countries (OWSD 2013). Across countries, even in situations where relevant STEM employment is procured, typical patterns reflect serious gender disparities in career trajectories and outcomes (EC 2004, 2008b).

Another variation on related issues can be found in Eastern and Central Europe and the Baltic states ("Enwise"—i.e., Enlarge "Women In Science" to East—countries). During the Soviet era, policies emphasizing gender equality and stressing the importance of education and access resulted in producing a considerable

[1] In fact, both STEM avoidance and brain drain also have been the catalysts for policy developments focused on female STEM education and workforce participation in other countries (UNESCO 2007).

proportion of highly qualified women scientists in Enwise countries. However, the post-Soviet transition saw the restructuring and decline of research systems which, while affecting both female and male scientists, left the female scientists in more vulnerable situations. Although there are higher proportions of women among researchers in Enwise countries compared to western countries, they are less well represented in the highly skilled STEM workforce. Even when there appears to be an overall gender balance among researchers, women have been squeezed out of better positions and are treated more as a backup human resource (EC 2004).

> Women scientists in every region—both developed and developing nations—face obstacles that limit their work and advancement … . Obviously, this hurts the women, but when we lose their skill, their intelligence, and their energy, the impact is felt in reduced innovation and growth across whole economies and whole cultures. In other words, when women drop out of science, everyone loses. (E.W. Lempinen, in OWSD 2013)

Problem and issue identification clearly is a first step in determining policy direction. It is an especially essential task in light of different legal and cultural contexts and applications across and within countries, which leads to some basic questions that must be considered. For instance, to what extent do policy goals and projections intended to increase the representation of women in STEM fields also include references to their increased presence as decision-makers and evaluators? Such positions are crucial to the overall issue of advancing women in science since they function as social and professional arbiters and community gatekeepers.

10.4 Policy Statement

Effective policies focus on actions that are goal oriented, and closely couple policy articulation with policy implementation. In other words, promising policies not only clearly specify goals and objectives, they also provide directives (or guidelines) for implementation. For instance, since the 1990s, the European Commission has supported special initiatives aimed at increasing the proportion of women in academia (EC 2000, 2008a, 2009). The focus has been on gender equality in academia, as well as incorporating gender perspectives in the content of research in the EU and around the world. Again taking an example from the Nordic countries, a primary policy initiative in Sweden was the Identification, Development, Advancement, and Support (IDAS 1999–2007) project for increasing the number of females in academic leadership positions; this initiative was followed by VINNMER (2007–2014) sponsored by the Agency for Innovation Systems to enhance career opportunities for women in strategically important research areas.[2] (VINNMER will be continued by the Mobility for Growth program with the objective of supporting career development for experienced researchers through mobility and international collaborations.) In 2004, the Danish Minister of Science, Technology, and Innovation

[2] See discussion and references for these initiatives in Bergman (2013).

in conjunction with the Minister for Gender Equality established a "think tank" to elicit institutional commitments to recruiting more women to research. Also, Norway's Ministry of Education and Research has provided short-term funding incentives for institutions to appoint qualified women to academic positions in mathematics, the natural sciences, and technology fields in which they are underrepresented. Similarly, in 2013, Iceland began a 4-year initiative, administered by the Minister of Education, Science, and Culture, in which awards are made to institutions showing substantial progress in gender balance. In Finland, all government committees, advisory boards, and other corresponding bodies, including the four national research councils, must have at least 40% women by law. In fact, all Nordic countries have adopted laws and administrative mechanisms for promoting gender equality.

Across countries, women cope with pressures of work, home, and limits on their participation in society. These pressures impact women's status in the workforce in general, and the STEM workforce in particular. Efforts from India have shown that, as steps to empower women in science, new regulations have been established to allow women with young children to work flexible hours and the country's Ministry of Science and Technology has itself invoked related policies for women scientists in all 65 of the institutes that operate under its purview (Bagla 2008). Also, the Indian National Science Academy has earmarked funds for limited research grants for some of its female members. Still, although women earned some 37% of STEM doctorates in India, the glass ceiling for promotions remains intact (Bagla 2008). As in other countries, both developed and developing, "even when obligations at home are solved and the conflict between professional and traditional roles is defeated, women still face gender disparities in terms of job satisfaction, income level, and recognition from colleagues and society at large," regardless of their professional acumen (Zubieta 2006: 192). Note, however, that India's Department of Science and Technology recently has introduced the Women Mobility Scheme for Employed Scientists, aimed at enhancing women's roles and positions in science. The stated objective is to strengthen ongoing gender initiatives and to provide a plan for seamless mobility of employed women professionals in research and development (IDST 2012).

In many instances, policy approaches begin with constitutional statements—as a case in point, the Vietnam constitution proclaims equal rights for female and male citizens and prohibits sex discrimination. Moreover, the Vietnam constitution posits that state employed women "shall enjoy paid prenatal and postnatal leaves during which they shall receive all their wage and allowances as determined by law. The State and society will create all necessary conditions for women to raise their qualifications in all fields and fully play their role in society." This is an example of government policy as a catalyst for institutional initiatives to enhance women's participation in the workforce.

Another case in point is South Korea: during the Phase I policy plan (1990–2000), issues concerning women in STEM were put on the national public agenda. This action was largely due to the efforts of the Association of Korean Women Scientists and Engineers (KWSE), the first organization for women in science and technology in South Korea. KWSE's goals were to increase the number of women in STEM and to protect their rights. KWSE lobbied for the government to adopt affirmative action in employment, promotion, training, scholarship, and policy-making processes (Lee 2009). Initially, despite strong efforts on the part of KWSE, women scientists received little positive response from government officials. However, it is critically important to note that KWSE was successful in bringing issues concerning women in STEM into the public discourse and demanding at least some acknowledgment of these problems. Consequently, during Phase 2 (2002–2008), two basic plans were implemented. The rationales for both plans were strategically framed in terms of national competitiveness and human resource development. The main focus of the First Basic Plan was to remove fundamental barriers for women's entry into STEM fields. The main focus of the Second Basic Plan was policy efficacy, with the goal of supporting and promoting relevant policies and programs. In particular, compared to the First Plan, the Second Plan provided more employment protections for women facing career interruptions due to childbearing and marriage, and sought to improve the overall working environment.

As has been noted, flexible maternity leaves and childcare assistance have been viewed as helping the family life–work balance. In Japan too, equal opportunities are enshrined in law and, at the institutional level, many universities now have responded by providing maternity pay and child care facilities (Bonetta and Clayton 2008). The University of Tokyo, for example, offers fellowships to encourage women scientists to return to work after career breaks. Changes in India have included the launch of a new government fellowship program for women scientists whose careers have been interrupted by their husbands' job transfers or by childbearing, and women have been seizing the opportunity to resume their science careers (Bonetta and Clayton 2008). Typical strategies in some universities and companies have included adopting policies such as recruitment targets, mentoring programs, and women-only awards.

As mentioned, a critical component of the policy statement is the policy goal. However, while promising policies are goal oriented, it is important to recognize that goal achievement can be defined (and assessed) in terms of targets and quotas.

10.4.1 Promising Policies Include Targets and Quotas

Promising policies clearly define goals, establish a plan to meet those goals, and provide metrics to aid in assessing the degree of progress made toward achieving those goals in a specified amount of time. Some related policy discussions of gender equality use notions of "targets" and "quotas" interchangeably. Both targets and quotas are specific objectives that are measurable at multiple points in time. However, there are distinctions between them that have significant ramifications for both policy and practice.[3]

[3] This discussion draws on information from the Australian government's Workplace Gender Equality Agency (WGEA 2013).

10.4.1.1 Targets

Much of the research literature on the efficacy of targets and quotas in addressing gender diversity tends to focus on private sector companies. This literature defines “targets” as voluntary goals set by individual companies for themselves (WGEA 2013). In this context, setting targets is voluntary, which can be a disadvantage insofar as not all organizations will set them, or those that do will set them at levels that are ineffective. By setting their own goals, companies increase “buy-in” from their employees which, in turn, increases the probability of successfully achieving those targets. A company can tailor targets to its organizational structure and the environment in which it operates, and can make whatever adjustments are warranted in real time. In addition, a company can set targets at various organizational levels. Businesses are familiar with the concept of targets, and view them as an effective tool to improve performance in general.

10.4.1.2 Quotas

Quotas are imposed on an organization by an external body that has authority to enforce them—for example, government—with the ability to set and implement penalties for non-compliance. Moreover, individual companies cannot negotiate quotas with the government. Compared to targets, quotas work faster in terms of putting issues (such as gender equality) at the top of an organization’s agenda. However, one problematic aspect of quotas is that organizations, even within the same industry, vary in terms of certain characteristics such as size and structure. Consequently, setting the same quota across firms in a given industry does not impact all firms to the same extent and/or in the same way.

Some countries, such as Denmark, Finland, and Iceland, never employ quotas or earmarks to address gender imbalances. By contrast, Norway and Sweden previously implemented earmarking schemes that proved highly controversial. In fact, in Sweden, earmarking was used primarily to increase the proportions of men in female-dominated academic fields; this policy was discontinued in 2011 (Bergman 2013).

10.4.2 Promising Policies Delineate Benchmarks to Assess Progress

Promising policies not only set goals but also provide guidelines for using established standards or benchmarks defining success to assess progress over time relative to short-, medium-, and long-term goals. Moreover, promising policies address issues of accountability in terms of related policy implementation and evaluation. Several countries have operationalized accountability in terms of integrated policies aimed at increased institutional funding based on performance in gender equity (e.g., Germany, Netherlands, and Ireland).

Some promising policies encompass specific national gender equality structures in active support of policy goals. For example, in South Korea, the 5-year Basic Plan not only set mid- and long-term goals for supporting women in STEM fields, but also facilitated the evaluation of supporting programs by delineating factors for monitoring and indicating their achievement. In 2004, the First Basic Plan for Fostering and Supporting Women in Science and Technology was initially built around five institutes—four regional and one national. The Institute for Supporting Women in Science and Technology monitors the outcomes of policy programs, such as the recruitment target system (RTS) and promotion target system (PTS), and reports results to the National Science and Technology Council (NSTC). Indeed, the RTS has been lauded as a systemic mechanism that facilitates the attainment of policy goals.

In many cases, policy strategies focus on the local institutional level in order to infuse gender equity throughout an organization; this is a type of bottom-up approach. Some institutions adopt strategies such as mentoring initiatives and/or special incentive funding for recruitment and retention of women in fields in which they are underrepresented. Thus, some institutions, including the Norwegian University of Science and Technology, have used start-up funding to support female appointees in highly male-dominated departments (Bergman 2013). Even when such initiatives are open to both genders, women are much more likely than men to participate in them.

At the national level, influential policies promoting gender balance in research have been found in various organizational entities, most notably national research councils. Examples include the Austrian Science Fund; Academy of Finland; German Research Foundation; Science Foundation in Ireland; Netherlands Research Council; Norwegian Research Council; Swedish Research Council; Swiss National Science Foundation; and the UK Research Councils. Also, the efficacy of such policies is enhanced by bottom-up engagement of the scientific community itself, such as the funding mechanisms put forth by the Czech Republic Contact Center on Women and Science (EC 2009). Moreover, regardless of level of analysis, policies to promote women in research typically are coupled with monitoring activities and action (Bergman 2013; EC 2009).

10.5 Relevant Data

Evidence is crucial to effecting promising policies in terms of plan, rationale, intervention, and initiative. Data that are accurate, credible, reliable and valid both drive and inform promising policies. This point underscores the criticality of the systematic collection over time of data that are relevant to and inform the specification of the policy issue or problem. Such data are used to enhance understanding of the impact of a given or proposed policy on various stakeholders and policy actors from governmental and nongovernmental organizations, institutions, and disciplinary and cross-disciplinary groups. In addition, these data provide a basis for benchmarking and evaluation insofar as they facilitate the ability to identify and assess appropriate indicators of policy efficacy at various points in time.

Data collection efforts, such as the administration of censuses and surveys, are fundamental to the policy process. For example, China's first large-scale time-use survey in 2008 has been used by policy makers to better delineate and address trends that limit female access to employment and mobility. Another example comes from the Act for Fostering and Supporting Woman in Science and Technology in South Korea which mandates that the Institute for Supporting Women in Science and Technology conduct an annual survey on the status of women scientists and engineers; survey responses contribute to a statistical database used for policy evaluation and development. Still another example is the data-driven strategy of the European Union (EU) for enhancing women's participation in science. Every 3 years since 2003, the EU publishes *She Figures*, a publication that consists of human resource statistics and indicators on gender equality in science and in the research and technological development sector. *She Figures* has been praised as a model for collecting, organizing, and disseminating data and information to inform decisions concerning policy design, development, implementation, and assessment.

Note especially that it is crucial to collect and employ appropriate data—that is, data that are collected, categorized, aggregated, and disaggregated in ways congruent with policy statements. For policies aimed at increasing the participation of women in STEM careers, it is essential that data are disaggregated not only by gender, but also by race, ethnicity, field, and other relevant sociocultural, political, and economic categories (Huyer and Westholm 2007). This stipulation applies to data collected in countries in the "developed" world as well as those in the "developing" world. It is important to be aware that collecting relevant data on women—especially in some nations in the developing world—can be challenging for at least two reasons: (1) because women often are not even registered in any citizenship database and (2) there is little acknowledgment of their contributions and/or ability to participate in a meaningful way in STEM (or other) development efforts (Prakash et al. 2010). Policies that (directly or indirectly) combat socio-structural and cultural barriers to the broader societal participation of women have yet to be embraced universally, although some countervailing trends and efforts have been identified (Drori et al. 2002; Berkovitch 2002; UNESCO 2004, 2007). Also, the types of data and measures that are used in policy planning and evaluation can themselves be limiting or problematic if they do not actually capture or reflect the intended goal and related factors identified in the policy problem or issue.

Valid metrics and expanded relevant data collection are crucial for the effective planning, implementation, monitoring, and evaluation of policy initiatives. Reliable data are essential to determine development strategies based on policies seeking to promote gender equity and eliminate STEM gender disparities. Thus, noting that "the presence of certain equality measures is linked with the rates of participation of women in science" (EC 2008a: 8), the European Commission has gone a long way in developing metrics to assess gender equality and participation in STEM education and the STEM workforce, and to assess the impact of specific policy efforts (EC 2008a, 2012). Along with efforts by other researchers and organizations, these activities have served as lessons and provided direction for related data collection around the world.

Although the systematic collection of credible, reliable, and valid data is time consuming, labor intensive, and expensive—the return on this investment is more than worth the time, labor, and cost in terms of the contributions that such data make to the entire policy process: refining the implementation, enriching the assessment, and expanding understanding of the impact of policies on various stakeholders. In sum, these data enable us to identify what is working well, what is not working well, and why.

10.6 Gender Mainstreaming

Despite some efforts to remove gender disparities, women remain underrepresented in STEM in educational attainment, careers, research and development, and decision-making positions (UNESCO 2003, 2004). As a result, a more comprehensive approach—gender mainstreaming—has been introduced across levels of analysis to address related problems and issues. Gender mainstreaming refers to the treatment of gender and gender perspectives as integral to the design, implementation, monitoring, and evaluation of policies and programs in all political, economic, and social spheres (UN 1997). Achieving gender equity necessitates a comprehensive strategy for assessing the ramifications and implications of policies and programs for men as well as for women.

In particular, an objective of gender mainstreaming in scientific research has been the inclusion of women at all levels of seniority in the STEM job market, emphasizing an expanded capacity for full participation in knowledge production and research (EC 2009). With the Beijing Declaration of the Fourth World Conference on Women in 1995 paving the way for the institutionalization of policies for advancing gender equality, gender mainstreaming, especially in regard to STEM education and workforce issues, has been an explicit item on the global policy agenda for the past several years and has influenced national level policy in turn. For example, in 2000 the Indonesian government directed all government agencies to integrate gender mainstreaming in their planning, formulation, implementation, monitoring, and evaluation of policies and development programs.[4] Initial gender mainstreaming strategies were also adopted in South Korea by the Dae-Jung Kim administration (1998–2002). Efforts to take gender equity perspectives into national policies were initiated with the establishment of the Ministry of Gender Equality and implementation of legislation such as the Framework Act on Women's Development, which emphasized the formulation of the policy strategies for promoting women. Furthermore, this trend toward gender mainstreaming helped to create a more favorable environment conducive to advocating policies for

[4] Republic of Indonesia (2000).

advancing, expanding, enhancing, and institutionalizing the participation of women in science and technology.

Although a number of countries and organizations previously had policies focused on female recruitment,[5] explicitly engaging the language and institutionalizing the approach of gender mainstreaming have become a strategy for integrating gender equity considerations in the standard operating procedures and activities of governments and other organizations. One example can be taken from the Nordic countries where objectives have shifted to emphasize "a gender equality perspective in all decision making in academia and in policy development in general" (Bergman 2013: 9). It also is noteworthy that countries with the largest underrepresentation of women in research in Europe—Austria, Germany, Switzerland, the Netherlands, and Belgium—now are adopting proactive policy approaches at national and institutional levels (Bergman 2013).

Mainstreaming female participation in all aspects of careers in STEM fields requires continuous and systematic monitoring over time. Although monitoring is a critical determinant of policy impact, its effectiveness depends on implementation parameters and goals. The role of South Korea's Institute for Supporting Women in Science and Technology, which was responsible for monitoring the outcomes of policy programs, is a case in point. In 2012, the Institute's "reorganization" abolished all regional institutes, which thereby reduced its main responsibilities from policy planning and development to training and education only. Moreover, this reorganization limited the role of monitoring to the small national institute, thus raising concerns about the overall policy process, implementation, and effectiveness.

Promoting gender equity in public and private research spheres necessitates systematic monitoring of women's participation in STEM careers not only in terms of quantity (e.g., numbers), but also in terms of quality (e.g., status as indicated by presence in decision-making positions). The lack of consistent and appropriate data disaggregated by field on gender distributions and statuses in science and, in some countries, a general dearth of research on women in STEM have been identified as a hindrance to gender mainstreaming in some areas, such as the Enwise countries (EC 2004).

10.7 Institutionalization and Sustainability

Institutionalization and sustainability are key attributes of promising policies. In this case, "institutionalization" refers to the degree to which a policy (program and/or practice) is integrated into the standard operating procedures of an organization. The concept "sustainability" refers to continuation of a policy over time. Institutionalization can be conceptualized as one indicator of sustainability—the greater the extent to which a policy is integrated into the standard operational

[5] These were typically individual-oriented approaches.

procedures of an organization, the greater the likelihood that the policy will be sustainable. Sustainability cannot be precisely defined; rather, sustainability is context specific. However, across contexts, sustainability has become an important criterion in the decision to accept or reject a given policy, practice, or program.

Regardless of the level of application, promising policies share the following characteristics:

- Statements that explicitly link gender mainstreaming to social and economic development
- Direct and indirect support for implementation
- Demonstrable relevant and practical commitment

Thus, for example, rather than a general statement about the importance of educating all citizens for the national good, promising policies for gender mainstreaming clearly and unequivocally delineate women as a specific policy category, and assert that women must be educated—especially in STEM—to enhance national growth and international competitiveness. In addition, as promising policies, they include directives for action. Accordingly, in the context of advancing women in STEM, institutionalization can be defined as the extent to which gender mainstreaming policies are coupled with national policies for development; that is, the degree to which gender mainstreaming policies are integral components of national policy—rather than peripheral add-ons. In this same context, sustainability can be operationally defined as the extent to which policies, programs, and practices are likely to persist over time.

Policies that show promise for effecting change are sustainable insofar as they can be maintained and supported over time in terms of goals, implementation and outcome. Measures for enhancing the participation of women in science might include improvements in the following areas:

- Science education and access at all levels
- Recruitment and retention initiatives
- Antidiscrimination legislation

Sustainable policies—especially in the context of development—meet the needs of the present without compromising the ability of future generations to meet their own needs (UN 1987). Gender mainstreaming policies that focus on improving education for all, as well as enhancing women's participation in STEM, are strategies for more sustainable development (Cohen 2006). This point is consistent with the conceptualization of sustainability in higher education in the UN Decade of Education for Sustainable Development (UN DESD).

Both effective and promising policies are sufficiently flexible to adjust to economic, legal, social, and political changes in the policy environment. Consequently, these policies require action that cuts across government, institutional, and disciplinary contexts. In STEM fields in particular, successful policies depend on both top-down and bottom-up strategies to address barriers to women's full participation. It is important to note that these barriers include—but are not limited to—"neutral" policies and practices that differentially impact women. Examples can be found in the regional contexts of the Nordic states and the European Union, and in the national context of South Korea. For example, since the 1980s, the Finnish government has worked with universities to ensure the implementation of gender equality legislation and, since 2010, has formally approved the idea of integrating gender equality issues in academic and STEM policy overall. In South Korea, the 2002 Act for Fostering and Supporting Women in Science and Technology provided both a legal and an institutional basis for policies that support women in STEM (Lee 2009). However, in the absence of the institutional commitments, sustainability can be compromised. Supporting programs can be unexpectedly abolished or reduced. Even with ostensibly supportive policies, implementation can be diverted and programs abolished or merged, resulting in weakened effects of affirmative action, as was the case for South Korea's RTS and PTS. Sustainability and institutionalization are synergistic; both are necessary for policy to fulfill its promise.

To address issues of gender mainstreaming, the Philippines' Department of Science and Technology established a women's association to provide funding for research and training. Similarly, India's Department of Science and Technology has supported gender initiatives within its budget commitments over time, positing objectives of encouraging and empowering women and of gaining gender parity in the science sector (IDST 2012). For example, in 2009, the Department initiated the Consolidation of University Research for Innovation and Excellence in Women Universities (CURIE) program to enhance the research infrastructure in these institutions. Also, special scholarships were established to motivate women to make contributions to national development through technology research, development, and adaptation. Other plans have included schemes for providing opportunities for women of 35–50 years of age in STEM fields who had breaks in their careers for pursuing research; special efforts were made to identify and encourage women in small cities and remote areas. Thus far, approximately 30% of the women awarded fellowships have been employed in universities and national laboratories, and have been acclaimed as a significant addition to the country's STEM workforce (IDST 2012).

10.8 Diffusion

Policies and policy approaches also can provide general models for goals and actions framed as plans, rationales, interventions, and initiatives. With both developed and developing countries asserting the need for STEM expertise, policies cannot be viewed as applicable only at the national level (cf. Blättel-Mink 2009). Promising policies are those with rationales, principles, and processes that can be adapted and applied on different levels across organizations and in various contexts. From this perspective, our understanding of policy can be enhanced through analyses of relational processes and interactions at and across different levels of an organization.

Certainly, women in STEM can benefit from a range of targeted policy efforts, such as gender mainstreaming in line with well-established conventions and directives (e.g., the Convention on the Elimination of all Discrimination Against Women); frameworks governing women's workplace rights; and systematic data collection on women and their experiences in STEM, work, and family life (OWSD 2013). The international context is strategically significant for regional and national governments and organizations operating as policy actors and sources of policy ideas, policy agenda setting, and policy formulation, implementation, and evaluation. Indeed, the international context can provide leverage for and lend credibility to policies being proposed in individual or groups of countries. Frequently, initiatives begun by some component of the United Nations are adopted by individual member states and/or consortia of countries (McNeely 1995). Similarly, regional organizations also serve as sources of policy ideas and models for individual members. For example, as a condition of membership in the EU, a country must agree to participate in and adopt certain policies, programs, and platforms. Also, local, national, and regional level policies and issues can inform and drive policies in other countries and regions around the world (Drori et al. 2002).

National and international networks are critical mechanisms for policy institutionalization and diffusion. While acknowledging differences among countries and regions in regard to gender participation in society more generally and in STEM in particular, international and regional groups act to promote the formulation of STEM development policies encompassing gender considerations. Consequently, both governmental and nongovernmental international organizations play especially significant roles in networking and policy diffusion. For instance, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) has long been committed to promoting equal access to education and to increasing the participation of women in STEM fields and encouraging their access to scientific and decision-making bodies. Thus, for example, while many Latin American countries lack specific policies to promote a more significant incorporation of women in STEM (Zubieta 2006), UNESCO has been consulting with various nongovernmental organizations and member states since 2011 to establish a regional plan including gender relevant science, technology, and innovation policy for Latin America and the Caribbean.

Recognizing that women's talents have been under-recognized and under-utilized in most countries and that they can provide vital contributions to development, UNESCO has promoted the establishment of national committees on gender, science, and technology for assessing and promoting gender mainstreaming in STEM-related policies. While member states ostensibly have signed on to pursue related policies, their capacity to follow through, and their political and institutional will to do so, can vary widely. However, the fact that related issues are incorporated in the policy dialogue is critical to the policy process and to opening doors for policy diffusion.

The International Labor Organization (ILO) also promotes gender equity in numerous resolutions and conventions. For example, the ILO Policy on Gender Equality and Mainstreaming calls for systematically analyzing and addressing the specific needs of both women and men in all initiatives, and for targeted interventions to enable both women and men to participate in and benefit from development efforts. Such measures are meant to provide guidance to member states. Thus, for example, as have other countries, Jordan has followed ILO recommendations to establish a comprehensive system of relevant sex-disaggregated data collection allowing for directed and flexible responses to labor market concerns and supporting transparency in policy formulation, monitoring, and evaluation has allowed for on-going policy transformation (Goulding 2013: 134). In fact, Jordan has taken female participation seriously in terms of development and rights and has led its region in the adoption of UN, UNESCO, and ILO informed policies for gender sensitive employment services and targets for women. Jordan's policy agenda also has reflected gendered social protections, including childcare assistance and maternity insurance, which arguably are helping to overcome cultural and economic barriers to women's labor market participation (Goulding 2013).

In many countries, international organization priorities in policy formulation can be highly influential in terms of their effects on national legislation promoting gender equality and antidiscrimination. However, while their activities are necessary to facilitate a more gender sensitive policy environment, they may not be sufficient to guarantee that countries adopt and implement effective policies. Thus, we find situations in which, for example, the Iranian government barred women from careers in nuclear physics and electrical engineering; Chinese institutions expected women to obtain higher entry grades for science courses than their male counterparts; and women in developed countries obtain more than half of all university degrees but their share of qualifications in science and technology is a mere 30% (*The Hindu* 2013). In general, women remain more constrained by unequal access to productive resources and forms of employment discrimination—intentional and/or unintentional, direct and/or indirect. That is,

> … there are many challenges, misconceptions, and obstacles that prevent policy makers from designing effective gender sensitive employment policies and strategies … . Globally, there is a habitual separation of economic and social policies, with gender issues often relegated to under-resourced and under-prioritized social policy. (Goulding 2013: 132)

10.9 Conclusion

Women remain the least integrated into the STEM workforce in countries around the world. Beyond questions of social justice and rights, women's underrepresentation in STEM translates into a significant loss of scientific human capital for development and progress (UNESCO 2007). It is generally recognized that "the difficulties encountered by women, constituting over half of the world's population, in entering, pursuing, and advancing in a career in the sciences and in participating in decision making in science and technology should be addressed urgently" as fundamental issues of national development and progress.[6] Nevertheless, despite recommendations against gender bias especially in the context of promoting development, it is not unusual for females to be disadvantaged at many stages in STEM career pathways. Social and cultural barriers represent some of the greatest impediments to gender equality in the sciences. Indeed,

> In many countries, the problem is not merely to attract women to STEM fields, but, even more to the point, to transform male (and female) attitudes and to remove other societal barriers and constraints to their participation in STEM. Because politics sets the context for policy action, the interests of different stakeholders may not be aligned and may even be antithetical to one another. Consequently, successful policy making often must be treated as a balancing-act. (Leggon and McNeely 2012: 114)

To inform and enhance understanding of what works and what does not work to achieve gender equity in STEM, through systematic analyses of relevant policies, we identified characteristics of policies that are promising in terms of planning, development, implementation, and evaluation. Various conceptualizations of policy as plan, rationale, intervention, and initiative reflect both reactive and proactive policy approaches. Consequently, we conclude that, to develop, nurture, and fully engage the STEM potential of all segments of society, what is needed are changes that will enhance effective policy development and implementation, such as the following (cf. EC 2008b):

- From *inertia to awareness and sincere commitment* to the goal of gender equity
- From *gender imbalance to gender balance* in representation in career and decision-making positions and roles
- From *opacity to transparency* in funding, recruitment, and promotion procedures
- From *inequality to quality* in science, a critical component of which is equality
- From *ignorance to knowledge* based on appropriate (accurate, credible, reliable, and valid) evidence
- From *complacency to urgency* in fulfilling the STEM potential of all segments of society

In sum, women's participation in STEM varies by factors such as discipline, sector, and nation. When allowed the opportunity, girls and women perform at increasingly high levels in STEM fields (EC 2000). Even in countries and fields in which more women are earning advanced STEM degrees, these increases typically are not reflected in the STEM workforce (cf. Blättel-Mink 2009). Despite—or perhaps because of—advances in women's participation and representation in STEM, extreme variations and policy challenges remain. Therefore, enhanced understanding of lessons learned from effective and promising policies designed to advance women in science is critical for success in meeting these challenges.

[6]From UNESCO's Declaration on Science and the Use of Scientific Knowledge (in Cetto 2000: 466).

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Vignette 10.1
A Comprehensive National Approach to Promote Gender Equality in Science: The Case of Norway

Liisa Husu

The Nordic countries—Finland, Denmark, Iceland, Norway, and Sweden—can be characterized as global gender leaders when it comes to overall gender equality in society (WEF 2012). In all five Nordic countries, gender equality promotion in science and in academia more generally has been actively on national policy agendas since the 1980s, especially in Finland, Norway, and Sweden (Bergman 2013). Yet, if the proportion of women among full professors is used as an indicator of gender equality in academia and science, Norway and Sweden do not excel in a European comparison, reflecting the same level as European (EU-27) countries on average. In 2010 in the EU-27 and Sweden 20% and in Norway 21% of all professors were women; Finland and Iceland did slightly better with 24%; and Denmark had clearly lower figures with 15% (EC 2013).

However, the area in which Nordic countries do excel is gender balance in scientific and academic leadership and decision making. For example, while nine out of ten European universities are still led by men, the Nordic universities, nearly all of which are public institutions, clearly show a more gender balanced pattern: 43% of Swedish, 31% of Finnish, and 25% of Norwegian universities had female Rectors (the highest leadership position) in 2010 (EC 2013). When it comes to high level scientific boards and committees, recently monitored by European Women and Science Statistics, Nordic countries again show near gender balanced patterns, with Sweden at 49%, Norway at 46%, and Finland at 45% of women in contrast to the EU-27 country average of 36% in 2010 (EC 2013). Notably this development is not anything new in the Nordic region; the boards have been gender balanced since the early 2000s and even earlier (see EC 2003, 2009). Nordic women have thus reached significant representation among gatekeepers who shape the scientific agenda.

Of the Nordic countries, Norway has shown the most comprehensive approach to addressing gender inequalities in science and academia, effectively involving key

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stakeholders, adopting innovative measures, and systematic and long-term backing by political will at the highest levels. Norway is not a member of the European Union but, rather, is an EC-associated country, participating fully in European research activities. The most radical measure allowed by Norwegian legislation was an attempt to earmark academic positions for the underrepresented gender. However, this measure was disallowed by the EFTA Court (the Court of Justice of the European Free Trade Association States) on 24 January 2003 as discriminatory against men (see Lismoen 2013). This EFTA ruling forced Norway to develop other types of measures.

The political will to promote gender equality in universities and research has been notably evidenced by the high-level Committee set up by The Ministry of Education and Research. The Ministry appointed in 2004 the *Committee for Mainstreaming Women in Science*, later changed to the *Committee for Gender Balance in Research*. The Committee has completed three terms. It is a national level Committee with comprehensive expertise in gender issues, supporting gender equality developments and providing recommendations on institutional measures in universities, colleges, and research institutes, engaging in awareness-raising activities and providing advice to various stakeholders in the academic and research sector (Gender Balance in Research 2013).

The committee is funded from the state budget, and the Chair and members are appointed by the Ministry of Education and Research. The funds cover a secretariat and support relevant activities. The committee cooperates closely with the Research Council of Norway and KILDEN, the Norwegian state funded information center on gender. It reports regularly to the Ministry of Education and Research and other relevant entities.

The committee members are representatives of key stakeholders, e.g., universities, research institutes, students, and funding bodies, holding high positions in their institutions and demonstrating personal engagement in their institution's work for gender equality. The appointment principles for members thus take into account not only formal representation but also individual commitment and potential for high institutional impact.

The Committee can be characterized as an active national level think tank and information hub for gender actions in academic and scientific research in Norway. It also has high regional visibility and impact, in the Nordic countries and Europe more broadly, as well as further international presence. Its information portal, *Gender Balance in Research—Norway* (in both Norwegian and English) is primarily a collection of relevant Norwegian resources. The portal was developed by KILDEN Information Centre for Gender Research in Norway, another important national information hub, at the assignment of the Committee.

Inspiration and encouragement through university information and advice are complemented by a substantial monetary incentive. In 2007, Norway's Ministry of Education and Research established a Gender Equality Award of two million Norwegian kroner, presented annually to reward the research community's gender equality efforts. In practice, the Committee has been commissioned by the Ministry to assess the nominees and announce the award.

The establishment of the Gender Equality Award was a concrete and visible ministerial measure to encourage and mobilize institutions to actively engage in gender equality planning, and to give an extra boost to their activities. The award purpose is to increase the proportion of women in academic positions and thereby promote a better gender balance in academia, along with resources that institutions themselves have reserved for gender equality efforts. Universities, colleges, and research institutes are invited to submit their existing action plans and gender equality measures to the Committee. They also must document financial resources set aside for implementation. The Committee assesses the submitted action plans and measures and gives its recommendation to the Ministry for award to one or more institutions.

Institutions that have been granted Gender Equality Awards have included the University of Life Sciences (2012), the Norwegian School of Sport Sciences (2009), the Norwegian School of Economics and Business Administration (2008), and the Norwegian University of Science and Technology (2007), in addition to traditional multi-faculty universities. However, in late 2014, the Ministry decided to discontinue the national award, news which was critically received by many in the Norwegian scientific community (Mesna 2014) The awards increased the accountability and visibility of gender equality promotion in the competing institutions, since detailed evaluations of all candidates are published on the Committee website. Discussions about whether similar awards should be established have been undertaken in at least Sweden and Iceland.

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Vignette 10.2
Women's Advancement in Science and Engineering in South Africa

Cheryl de la Rey

Before the advent of democracy, the South African higher education system enrolled more men than women. Within a decade of 1994, when the first democratic elections took place South Africa, the gender profile in higher education was at a level that many other countries took decades to achieve. By 2000, the number of women in universities exceeded men; women were 53% of university students. There have been changes in university staffing too, although not as rapid compared to student enrolments and graduations. Up until 2005, universities employed more men than women. In 2006 women outnumbered men for the first time, and by 2007, women comprised 51% of all university employees at all levels.

Two provisions in the South African Constitution have been instrumental in improving the status of women. Firstly, a commitment to gender equality eliminated all discriminatory legislation, policies and regulations. Secondly, there is the provision for redress of past discrimination, which is somewhat unique, differentiating South Africa from many other countries. This provision opened up space for equity legislation compared to equality alone. All employers who employ more than 50 staff must comply with employment equity legislation, one of the key legal instruments, which requires each institution to:

– Set targets for race, gender and disability recruitment and retention
– Report annually on progress in meeting these targets
– Provide reasons when targets have not been met

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Given the relatively rapid upward trend in the participation of women, for some time it was assumed that all was on track to achieve full gender equality in higher education within a definite time span. This optimism has since given way to a reality that shows that below the high level of aggregated data, several continuing and persistent gender disparities are discernible.

10.10 Looking into the Data

Although the total number of women enrolling in and graduating from universities has increased to a level which appears to be equivalent to that of men, closer examination of the data reveals that a pattern of decreasing percentages as the level of study moves upward from undergraduate to doctoral levels. When enrolments are examined by field of study, men continue to dominate in science, engineering and technology (SET). In 2010 women comprised only 38% of enrolments in SET disciplines and women were severely underrepresented in engineering, physics and computer science (ASSAf 2011).

While there is no doubt that women have made meaningful inroads into higher education, it is evident that the path to gender equality is not a straightforward matter of a linear, continued progression. Although South Africa showed dramatic increases in enrolments and graduation of women after formal obstacles were removed and equity legislation was introduced, there continues to be underrepresentation of women in certain areas. The key lesson from the South African experience is that the removal of formal discriminatory policies and procedures even when accompanied by redress measures is necessary to advance the status of women, but insufficient to achieve true equality.

10.11 Culture and Society

Although in South Africa there is no overall inequality in the number of girls in schooling, gender biases in teaching practices and in the curriculum militate against equality in science and mathematics, subjects that are necessary for access and success in SET disciplines. Research has identified multiple factors that inhibit women's participation in the SET sector. The biases include pressure to conform to traditional gender roles in schools; science and mathematics curricula skewed in favor of traditional boys' interests; sexual harassment; the masculine image of science; and the lack of positive role models for girls in SET (Moletsane and Reddy 2011).

Some years ago, while conducting a series of interviews with academics, I realized that a critical examination of the concept of career is crucial, if we hope to gain a clearer understanding of the problem of gender bias (De la Rey 2010). Due to childbearing, childrearing, and other family responsibilities most women are not likely to follow the anticipated pattern of uninterrupted service that contributes to career advancement. For women late beginnings and interruptions to the development of the career trajectory are typical. Unlike male scientists, women's careers are affected by the life events of others, typically their husbands and their children. For some disciplines, such as computer and electronic engineering, the fast pace of change makes re-entry difficult (ASSAf 2011).

Scientific careers, in particular, require large, early stage investments of time and energy. By the time careers are being established, many women confront decisions about relationships and family. Even though career goals have assumed more significance in the lives of women as their participation in all sectors of the paid labor force has increased, women's responsibilities in the family and household domain have not diminished concomitantly.

Beyond the career trajectory itself, we also need to examine the gender implications of the ways in which scientific careers are crafted. Scientific careers are built through building up a reputation. Reputations are not simple translations of research productivity as there is no necessary direct relationship between research productivity and reputational capital. The processes of reputation and career building are affected by feedback mechanisms which ensure that past performance brings fresh rewards that promote even further activity that enhances greater reputation. Although reputation is closely linked to research performance, it is also affected by other factors such as access to networks, mentors, and seniority. Reputations are made through informal networks that involve colleagues, friends, critics, and competitors. It works like a narrative, story-telling process through which the characters of science are created.

The competition inherent in scientific careers (e.g., for grants and promotions) also presents a challenge. For many women engaging directly and actively in competition is experienced as difficult because in doing so they risk a perception of themselves as ambitious; a character trait that is inimical to traditional constructions of femininity.

For the few women who succeed, they discover that they not only have to deal with the challenges of the career itself, but they have to overcome organizational cultures and practices that have been shaped in ways that favor men and masculinity. As long as the obstacles remain, the number of women will remain small.

10.12 The Future

What we learn from South Africa and many other countries is that in order to achieve meaningful gender equality in science and engineering we need a multi-pronged approach, incorporating a portfolio of strategies or interventions that address the many facets of gender bias. These interventions include stereotype reduction via media and communication campaigns, mentorship programs, enhanced access to funding and better gender representation in decision-making committees. What Aisenberg and Harrington (1988) called "the rules of the game" were created by men and privilege masculine traditions and behaviors. By identifying many of the unsaid rules and informal practices, we can begin a process of change to open access to more women.

Human capital development is one of the biggest obstacles to African social and economic development, therefore increasing the participation of women in science and engineering is not optional; it is essential.

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Vignette 10.3
Enabling Policies: Capacity Building in Science and Technology in Brazil

Alice Abreu

Brazil, like many other countries in Latin America, has seen the number of women as university students increase substantially in the last decades (OEI 2004). There are now more women than men enrolled at universities and they are also the majority of those completing their courses. In fact, Brazil is an especially interesting case to consider because women constitute, since early 2000, the majority of M.Sc. and Ph.D. graduates. Moreover, although women are less present in engineering, mathematics, physics, and computer science, their participation in these disciplines is larger than in many developed countries. What are the policies that have enabled this exceptional situation?

The Brazilian system of science and technology (S&T) was established in the last 60 years and, since its beginning, has had a strong focus on capacity building. The creation in 1951 of CNPq (National Council for Scientific and Technological Development) and of CAPES (Coordinating Agency for Training of Higher Education Personnel) was crucial to this process. The former aimed at financing research and supporting individual researchers, and the latter sought to promote and enhance capacity among university teachers. The late 1970s saw the establishment of the first graduate level courses in the country, and CAPES also assumed an important function related to the evaluation and quality control of the postgraduate system.

The Brazilian S&T system grew significantly throughout the 1980s and, in 1985, the Ministry of Science and Technology was created. Today, it sponsors the highest national body for science and technology, the National Council for Science and Technology, an advisory consultative board presided over by the President of Brazil. Also, a related Special Secretary for Policy for Women was created with Ministerial status in 2003, replacing the National Council for the Rights of Women, which

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existed since 1985. The S&T system today is quite strong (Abreu 2010; Cruz and Chaimovich 2010), with the highest investment to gross domestic product ratio in Latin America, a well-funded Ministry of Science Technology and Innovation, and a significant presence on the international scene, ranking 13th worldwide in refereed publications.

Brazil currently has 3,343 graduate programs across scientific areas, of which 1,664 are Ph.D. programs. In 2012 alone, M.Sc. graduates numbered 42,000 and Ph.D. graduates numbered 12,000. Moreover, since 1998, women have represented the majority of M.Sc. graduates and the majority of Ph.D.s since 2004.[7] Available figures show that, in 2008, women accounted for 54% of M.Sc. and 51% of Ph.D. degree attainment.[8] Note that education in federal and state universities in Brazil is free of charges, at both undergraduate and graduate levels. These universities represent approximately 35% of higher education institutions, but incorporate almost the whole research community of Brazil.

The Brazilian capacity building effort has increased and diversified substantially from its starting point in the early 1950s. Between CNPq and CAPES at the federal level and agencies at the state level, several different support mechanisms have been put in place. They have ranged from research funding granted through competitive calls for projects, to a wide range of scholarships and fellowships supporting students and researchers at different points in their careers.

For example, the *Scientific Initiation* scholarships are granted to provide support for undergraduate students to work on projects under the supervision of researchers. The scholarships actually are awarded to the researchers, who then select students to enroll in their projects. Also, masters and doctoral scholarship awards are made through graduate programs; in those programs that have been deemed *centers of excellence*, scholarships are available for all accepted students. Postdoctoral scholarships are granted at the national level. Finally, as a crowning support for the best scientists in the country, CNPq awards Senior Research Fellowships on a highly competitive basis.

The numbers supported by these policy instruments are impressive. Together, CNPq and CAPES granted almost 62,000 scholarships in 2002 and almost 142,000 in 2012, as shown in the table. More impressive, however, is the fact that women have steadily increased their participation. Women were the majority in all award categories in 2012, with the exception of the Senior Researcher Fellowships. (Although still significant, women have never exceeded 35% of fellows at that level over the last 15 years.)

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7 In 2004 only Italy, Portugal, and Brazil had a majority of women as Ph.D. graduates (<InternalRef RefID=”Par130” >CGEE 2010: 43).

8 See Box 1 in Frehill et al. (2015).

Brazil scholarships granted by CNPq and CAPES (2002, 2012)				
	2002		2012	
Categories	Numbers	% Women	Numbers	% Women
CNPq				
Undergraduate (IC)	18,843	54	36,391	56
M.Sc. (GM)	5,602	52	9,865	53
Ph.D. (GD)	5,743	49	9,362	51
Post doc (PD)	88	39	1,548	57
Senior researcher (PQ)	7,765	32	9,940	35
CAPES				
M.Sc. (GM)	13,054	NA	43,591	NA
Ph.D. (GD)	10,180	NA	27,598	NA
Post Doc (PD)	179	NA	3,663	NA
Total	61,454		141,958	

Sources: CNPq/AEI (2.9.3-sexo_GA_paisext_0112) and CAPES (geocapes 4.10), accessed 2 September 2013

It is clear that the last decade has seen a very significant growth of the S&T system in Brazil, and women have profited from it. The system is now complex and robust, with a steady source of funding involving different types of institutions and organizations. Systematic efforts for capacity building have effectively included women, who are now the majority of university students at all levels. This strong presence of women in university enrollments and in scientific research arguably is related to the fact that the public sector offers free education and that governmental agency scholarship programs are based on a transparent decentralized and merit-based system. Women can compete on an equal basis and have been very successful in doing so.

However, in regard to scientific careers in both education and research areas, it is important to understand the mechanisms of advancement, which keep women as a minority at the higher levels. It is true that the massive entry of women into university and graduate programs is recent, and a few more years are required to determine how this generation of women will fare. The Full Professors of today typically would have had at a minimum 15–20 years of career progression before reaching that position. This would mean looking back to the 1990s, when the participation of women was not as strong as in recent years.

Sex-disaggregated data in S&T databases reveal interesting aspects of the place of women in the Brazilian science and technological system. However, further research is needed to fully understand the social processes that are behind related statistics and to follow the current generation of women scientists to determine whether they will be able to effectively influence the Brazilian scientific structure and to participate fully and occupy the highest positions in the system.

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