Chapter 9
Promising Programs: A Cross-National Exploration of Women in Science, Education to Workforce

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9.1 The Issue

A "program" is an organized effort to improve delivery of a practice or service to a population. In the context of this volume, the central goal of programs is the participation of women (and girls) in a series of planned activities, which taken together, place or keep them on a path toward a science-based degree or career. To be sustained over time, a program must have financial support, consistent leadership, a visibility that attracts participants, exposes them to essential experiences, and facilitates the acquisition of skills and technical (disciplinary, occupational) culture.

Yet a program, however well-conceptualized, is essentially a trial-and-error undertaking that may or may not be research-based and is typically supported by resources provided by sponsors outside the institution offering it. Local context matters. It shapes how the program is executed on behalf of the served population, translating grand plans into on-the-ground delivery of services.

Effective programs are thus a universal vehicle for intervening in the status quo. But sponsors, performers, and the populations they are intended to serve bring different expectations to the programs in which they participate (DePass and Chubin 2009).

Programs to improve outcomes—student learning, career choice, information on opportunities—populate a continuum that spans preschool to the end of precollege

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instruction, higher education at the postsecondary and graduate levels, and the workforce (from entry to retention, promotion, and ascendance to leadership).

As described below, “promising” programs are an empirical subset of all programs. They share key attributes of track record, data on outcomes and impacts, and continued financial support (Chubin and Ward 2009). Nevertheless, their promising status may be idiosyncratic to time and place. So we must look across cultural and political contexts to ask: What translates beyond a particular discipline and the unique conditions that engendered, and then sustained, a program?

We hope to identify patterns in programs that foster meaningful participation in what we call “careers” in science. Our analysis should complement and elaborate on the discipline-specific chapters elsewhere in the volume. In other words, we are slicing the program pie to highlight the characteristics of success in intervention programs designed to increase participation in the chemical sciences, computer science, and mathematics/statistics.

We also pose questions that connect programs to policies on the one hand, and to goal-directed practices on the other. This is because programs have their own “life cycle”—from design to implementation to evaluation to changes in policy/practice (government, institution, department, etc.)—that yields insights into what constitutes success and promise.

Ostensibly, the purpose of program interventions is to demonstrate an alternative social order where the innovations are “mainstreamed,” i.e., funded and recognized as “best practices” in promoting participation, articulating educational opportunity with the fulfillment of career aspiration, and motivating institutional and cultural progress through the resident population.

9.2 Methodology and Empirical Challenges

Many questions may be raised about the origins, design, implementation, evaluation, and outcomes of a program. A fundamental question is: what is the population to be served, and how is this population linked to the intent of the program? The population should be a natural outgrowth of program intent. Ideally, the design and character of the program should cite evidence that supports whatever is planned as a means of advancing the policy or mission of the organization offering it, and should be tailored to accomplish that goal.

However, identifying limitations and strengths as determined by research and evaluation compounds the difficulty of declaring a program to be “promising.” In most cases, data on program outcomes may be lacking. Even if they do exist, no systematic over-time analysis may have been conducted (Brainard and Carlin 1998). Evaluative data beyond anecdotes and testimonials of participants and alumni are needed. Typically, resource constraints force a choice between operating the program or diverting a fraction of funding to its evaluation. Too often the latter is sacrificed, which creates the quandary faced by this chapter and any effort to ascertain third-party evidence on “eye of the beholder” judgments of program effectiveness, quality, or success.

9.2.1 Some Historical Examples

Programs established in the 1980s, such as the UK's Women in Science and Engineering (WISE) 2006 Campaign,[1] indicated that approaches targeting individual women and girls for funding of research or other education interventions had little impact on increasing representation and advancement of women in academic and engineering fields. Scholarly thinking began to reject the "deficit model," which identified women as targets for intervention, and suggested that by transforming the attitudes and behavior of women, they will enjoy greater opportunity, success, and advancement in science careers (Phipps 2008). Simply out, this model characterizes an individual's lack of progress or achievement as her or his shortcomings—from motivation to capability—instead of deficits in the learning environment that are the responsibility of institutions and educators.

In contrast, a review of undergraduate science programs (Fox et al. 2007: 338) concluded that "most successful" programs focused on structural and institutional reforms as well as mentoring and other support activities. Using regression analysis, the authors identified the "most successful" programs by measuring "the difference between the pre- and post-program rates of growth in the percentage of women among bachelor's degree recipients." These programs, particularly their directors, were more focused on structural factors in the environment that created a less equitable environment for women.

Concluding that the directors of the "most successful" programs recognized the necessity to alter the institutional environment in ways that would create a more equitable environment for men and women science undergraduates, Fox et al. (2007) argued that this approach attempts to "adapt" the broader environment to meet the program goals.

9.2.2 Another Approach

Our approach to programs was structured by several dimensions that build on the above findings while honoring themes prominent in this volume:

- Three STEM disciplinary areas—chemical sciences, computing, and mathematics/statistics (v. all STEM)
- Two genres of programs—one targeting women and girls, the other seeking greater participation of all, regardless of gender, in STEM
- Two principal perspectives on program operation and effectiveness—*sponsor* (government, NGO, private foundation or company) or *performer*/funding recipient (university, specific academic department, professional association)
- Two geographic locations—the developed world of the Global North and the developing world of the Global South

[1] www.wisecampaign.org.uk

Data requirements impose other constraints. More data are collected and analyzed for all of science or STEM (science, technology, engineering, and mathematics) than for specific disciplines. US federal agency programs will support a portfolio of projects mainly at institutions of higher education that reflects a decentralized “experimental” approach to educational innovations. Some of these “projects” excel and thrive over time; most end as the grant expires, leaving little or no trace of impact.

This is why promising programs are the focus here. To identify them, we consulted the websites of sponsoring and performing organizations using the search queries “[US or international] programs for women in [science, or specific discipline]” and “data on women in … ” Queries on “evaluations of programs … “yielded almost no literature, supporting our suspicion that few exemplary programs exist (or remain internal or proprietary documents). Sheer longevity does not equate with effectiveness, and data are insufficient to resolve claims. (Even the discipline-specific chapters of this volume hardly emphasize programs, focusing instead on international comparisons of workforces, women’s distribution across academic ranks, and government investments in women relative to other social or science-based spending.)

We lack a sense of magnitude, i.e., how large is the population of program evaluations? While evaluators speak of comparison groups and controlled treatments (Chubin et al. 2010), basic data-collection on participants and outcomes over short periods are elusive. Therefore, we turned to a decade-old US example that offers a template for empirically characterizing “promising programs.”

A public–private partnership was formed as a result of a congressionally mandated study, *A Land of Plenty* (CAWMSET 2000). Several authors represented in this volume participated in the effort known as BEST—Building Engineering and Science Talent. In the BEST higher education report, *A Bridge for All* (2004), evaluation criteria were developed based on a review of 120+ university-based STEM programs targeted to undergraduate students. All, however, apply to intervention programs targeted to underrepresented groups—women and persons of color—and to postgraduate and workforce-entry training.

Although the principles may be unique to the United States, its education system and economy, they are a fruitful starting point. The column in Table 9.1 labeled “promising” should particularly draw our attention in assessing any education program such as those highlighted below.

9.3 The State of Play

While the United States has been a beacon to the world on how intervention programs can change the trajectory of participation of all underrepresented groups, especially women (who today constitute more than half of the general US population and almost three out of five undergraduates), it has hardly succeeded in transforming the educational process, workplace settings, and career advancement into a bias-free utopia (National Research Council 2007). Sexism, stereotyping, and cultural biases clutter the road traveled to a career in science (Sandler 2009). For those women who

Table 9.1 Best evaluation criteria for assessing higher education programs/practices

Questions/Criteria	Exemplary actionable now	Promising	Not ready to adapt scale
1. Were expected outcomes defined before program launch	Yes	Soon after	Sort of/vague
2. Are outcome attributable to the program intervention	Far exceeded original expectations	Exceeded original expectations	Failed to meet expectations
3. Does it demonstrates excellence, which quality?—i.e., did it increase the diversity of the target population?	Chief outcome achieved and documented (positive trend)	Chief outcome achieved and documented (no monotronic trend)	Equity at core of program design not an add-on
4. What was the value-add of the experience to the target population?	Related outcomes that move treatment group to next competitive level	Majority (but not most) of individuals of treatment population enhanced	Gains for some individual that can be attributed to treatment
5. Is there evidence of effectiveness with a population different from that originally targeted?	Explicit scale-up strategy w/ evidence	Attempt to implement strategy and evaluate	Confined to a single suit
6. How long has it been in place	Planned and executed	Planned	Serendipitous
7. Were there unexpected consequences	Self-sustaining (10+ years)	Majority soft money (10+ years)	New (<3 years)
8. Were there unexpected consequences	Positive in intensity or extent (and measured)	Identification of possible/probable consequences	Evidence for systematic rather than random effect

Source: BEST Blue Ribbon Panel on Higher Education (2002)

thrive in the workplace, countless others are casualties of structures and practices that pose formidable barriers and thwart the development of talent. The results pervade science and create disciplinary faculties, and workforces generally, that challenge claims to meritocracy and incinerate aspirations of student cohorts who see too few women in professional roles they would like to emulate. And if they entertain such ambitions, they can be dissuaded by stories of the journey that women who have ascended are willing to share.

Data and analysis over 30+ years attest to the recurrent patterns that keep women out, down, or struggling to achieve positions of leadership in science (Etzkowitz et al. 1994; Burrelli 2008). This applies equally (and sadly) to stellar positions in different sectors of the economy, e.g., the chemistry department chair or the corporate chief technology officer. What has been documented, therefore, is a reminder that what a country practices is not necessarily what it preaches (CPST 2008). Furthermore, programs created to alleviate inequities and facilitate transitions have not, in the aggregate, produced the rates and quality of participation by women in science that most in the United States would find acceptable—despite isolate institutional transformations fostered, at least in part, by programs such as NSF ADVANCE (Frehill 2006).

The latest, and arguably the most comprehensive cross-national assessment on gender, science, technology, and innovation, was conducted by Women in Global Science & Technology,[2] or WISAT, in collaboration with the Organization for Women in Science for the Developing World.[3] With funding from the Elsevier Foundation, the 2013 report features a "full gender benchmarking" of opportunities and obstacles faced by women in science in Brazil, the European Union, India, Indonesia, South Africa, South Korea, and the United States.

In a nutshell, the report concluded that in all the countries reviewed, "the knowledge society is failing to include women to an equal extent, and in some cases, their inclusion is negligible".[4] The litany of reasons for women's under-participation are familiar: limited access to education, information, technology, entrepreneurship, and employment; lagging indicators on health, economic, and social status; and numerous barriers, including work and policy environments. A dearth of disaggregated data also obscures discipline and work sector comparisons.

Notably, if one examines the individual country reports, programs are seldom highlighted. Admittedly, the WISAT "big picture" examination was not focused on the granular level, yet some citing of signature national efforts would be expected. Instead, committees and structures–the apparatus of policy—are noted, but not linked to particular interventions.

Other international organizations offer *visibility* as their main support for women in science, but most are of small scale, favor anecdotes (stories with "faces") and fellowships, and do not publicize evaluation of their outcomes. While not featured here, we note the sustaining function of The World Bank,[5] Elsevier,[6] L'Oreal-UNESCO,[7] and USDA Borlaug (Africa—Women in Science) Fellows.[8]

In view of our appraisal, the key question becomes: Can we expect better outcomes either in the developed or the developing world, i.e., in nations with fewer resources but perhaps more resolve? Are there programs sanctioned by policy and validated in practice that afford women the education and training opportunities to excel, contribute, and change the face of their disciplines as well as their country's workforce? Clearly, a more top-down European approach will differ from more decentralized, grass-roots bottom-up approaches.

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[2] www.wisat.org

[3] www.owsdw.org

[4] http://www.wisat.org/programs/national-assessments-on-gender-sti/

[5] http://datatopics.worldbank.org/gender/

[6] www.elsevier.com/connect/story/women-in-science

[7] www.unesco.org/new/en/natural-sciences/priority-areas/gender-and-science/

[8] www.fas.usda.gov/icd/borlaug/westafrica.htm

Ideally, one would seek congruence between context and goal, but politics—national and local—tend to get in the way. Different agendas can blunt the impact of policies and undermine even promising practices. While we seek to learn about promising programs that can be adapted for use in other countries and settings, we wonder how can the United States, which generates abundant claims of program outcomes and impacts, benefit from the lessons elsewhere? Just how culture-bound are these programs?

9.4 An Analysis of Select Programs

To guide the analysis below (based on US experience), we reiterate that the *same* program may be examined from different perspectives. A *federal agency program* presents a national blueprint for intervention through several funded projects. Each *recipient university* awarded funding under a program becomes a data point in serving the target population (e.g., women or girls in X), which is a small fraction of the national constituency. Some will excel, while others lag. We are interested in both, of course, but highlight projects distinguished by positive claims. Taken together, recipient universities are defined—more accurately, created—as part of a *performer community*, usually discipline-bound, that seeks improvement in recruitment and retention practices, as well as degree-completion and entry into relevant workforces.

To capture a program, we must slice deeper into nationally aggregated data characterized above and throughout this volume. Complementing global analysis by "calling out" a subset of promising programs illuminates key sponsors and/or performing bodies. Therefore, the program vignettes are a kind of triangulation that connects macro and micro data.

Because few studies track student progress longitudinally, we have selected examples judiciously to illuminate promising programs from different "angles," as it were. Displayed in Table 9.2 are the genres we feature, and (depending on the reader's disposition) the limits of generalizing from them.

Our effort to identify at least one promising program in each disciplinary area featured in this volume was not realized. For the Global North, information on programs emanating from the American Statistical Association and the Association for Women in Mathematics was so scarce that no assessment could be conducted.

Table 9.2 Promising programs by type and origin

Discipline	Program	Origin
Chemical sciences	COACh	Global North
Computing sciences	BPC-A/NCWIT	Global North
Mathematics/statistics	See below	
All STEM	ADVANCE/Wisconsin	Global North
	OWSD	Global South

Instead, we gleaned details on efforts that represent inputs, but not outcomes. This void demonstrates how, even in developed regions with long professional histories of organization and operation, putting programs on a firm empirical foundation has not occurred. This does not reflect well on either sponsors or performers.

Like many professional societies, the ASA has a committee on women and administers various awards, especially the Gertrude Cox Scholarship.[9] Yet as recently as 2012, laments about the invisibility of women in the association's conferences and other activities are well-documented.[10] Women comprise 30% of the membership, but the "big tent" is not consciously as gender-inclusive as it could be.

As the AWARDS Project[11] found in 2010 for six professional societies (including ASA) that host competitions for gender-neutral awards, committee composition influences awardee selection and nominations of women limit the pool of eligible (even if self-nominations are encouraged). Evidence of systematic bias in one aspect of professional life can have significant ripple effects on prospective recruits.

The Association for Women in Mathematics (AWM) was founded in 1971 and today has more than 3,000 members (women and men) from the United States and around the world. Often working in concert with the workforce-oriented century-old American Mathematical Society[12] and the undergraduate-focused Mathematical Association of America,[13] AWM plays a plethora of roles, providing educational resources, forums, travel grants, prizes, mentoring, and advocacy for girls and women in mathematics.

For example, for more than twenty years AWM has organized and sponsored Sonia Kovalevsky Days (SK Days[14]) held at colleges and universities throughout the country. SK Days consist of a program of workshops, talks, and problem-solving competitions for female high school and middle school students and their teachers, both women and men. Searching the website for evaluative or outcome data on any AWM program yields no information.

For the other entries in Table 9.2, we offer vignettes with evidence of programs showing promise through longevity and the measurement of performance.

9.4.1 COACh: Committee on the Advancement of Women Chemists

COACh was founded in 1997 at the University of Oregon to design and implement career development programs for women and minorities in STEM fields. Over 10,000 faculty, graduate students, undergraduates, and researchers have participated in

[9] http://www.amstat.org/committees/commdetails.cfm?txtComm=CCSAWD01

[10] http://magazine.amstat.org/blog/2012/07/01/statviewguide/

[11] http://www.amstat.org/committees/cowis/pdfs/AWARDSBackground.pdf

[12] http://www.ams.org/about-us/about-us

[13] http://www.maa.org/about-maa/maa-history

[14] https://sites.google.com/site/awmmath/programs/kovalevsky-days

COACh career-building programs conducted at professional meetings, universities, and laboratories in all 50 US states.

COACh International (iCOACh) works on projects around the globe to build scientific and engineering leadership capacity in scientific areas of global need and in countries where the need is the greatest. The projects are research-focused and aimed at catalyzing and sustaining scientific collaborations and networks across international and cultural boundaries, with women as leaders and active participants. Events have been held at academic institutions and federal laboratories in Africa, South America, Asia, and Europe.

Over 6,000 women faculty, graduate students, and postdoctoral associates have attended COACh workshops. Participating women include chemists, physicists, mathematicians, biologists, computer scientists, geologists, medical faculty and students, materials scientists, and engineers of all types.

Among the most prominent impacts[15] are:

- Over 70% of postdoctoral attendees have landed academic positions.
- 38% reported taking administrative posts after attending the Leadership Workshop. Eighty-six percent of these credited COACh with either the decision to take the position or in helping them be more effective leaders.
- 90% of attendees have mentored their students and other colleagues in skills learned in the COACh workshops.
- 90% said that the COACh skills helped them in addressing issues of committee assignments, developing supportive networks and improving departmental climate.
- Over 80% said that the workshops helped with issues of work-family balance.

Evaluation of the quality of these programs via surveys on the short- and long-term impacts (2–6 years after attending a workshop) reveals that COACh activities impart a range of skills vital for participants' careers while lessening stress (Greene et al. 2010). Today, COACh provides avenues for networking and mentoring of scientists and engineers at all levels to assist them in their research, teaching, and career advancement.

9.4.2 NSF Broadening Participation in Computing/NCWIT

The US NSF launched the Broadening Participation in Computing Alliances (BPC-A) in 2006. By 2010, 11 of the 12 original multi-institutional Alliances were serving the full range of underrepresented groups in computing (Chubin and Johnson 2010). This program sought nothing less than to change the face of computing. The Alliances represent returns on an NSF investment in terms of collective impact on computing nationally—human resources, practices in and out of the classroom, and institutional change.

[15] http://coach.uoregon.edu/coach/index.php?id=3

Girls and women at all stages of education and career advancement comprise the target population for one of these projects, which functions as a national clearinghouse for information and resources relevant to women in computing education, enrichment, and professional development.

9.4.2.1 NCWIT: The National Center for Women in Technology

The National Center for Women & Information Technology is a nonprofit community of more than 500 prominent corporations, academic institutions, government agencies, and nonprofits working to increase women's participation in technology and computing. NCWIT helps organizations recruit, retain, and advance women from K-12 and higher education through industry and entrepreneurial careers by providing community, evidence, and action.[16] NCWIT is the only national organization actively researching women and IT innovation, including women as IT patent holders, women's contribution to open source, women as authors of computing research papers, women starting IT companies, and women as technical conference speakers.

While NCWIT resources span K-12 to workforce, the most compelling hands-on tools have been produced within the past 5 years under the following titles[17]:

- How to Create and Sustain a Women in Computing Group on Your Campus (2013)
- Top ten Ways to Be a Male Advocate for Technical Women (2012)
- How Can Encouragement Increase Persistence in Computing? Encouragement Is Effective in Work Settings (Case Study 2) (2011)
- Strategic Planning for Recruiting Women into Undergraduate Computing: High Yield in the Short Term (2010)
- Women in IT: The Facts (2009)

NCWIT's age/grade-specific resources—scorecards, workbooks, tipsheets, recruitment strategies, entrepreneurship in IT, etc.—is a treasure trove of "how to" tools for a community in dire need of diversifying to tap the contributions of women. As a hub, NCWIT's record of performance is changing the face of the US computing workforce.

9.4.3 NSF ADVANCE

Perhaps the most promising gender-conscious science and engineering faculty-focused program in the United States is NSF ADVANCE. Established in 1995, the goal of ADVANCE is to increase diversity in the science, technology, and engineering workforce by increasing representation and advancement of women in academic

[16] https://www.ncwit.org/ncwit-fact-sheet

[17] http://www.ncwit.org/resources

and engineering careers. Initially, NSF pursued this goal by funding professional development awards to women and underrepresented minority scientists, but these efforts to fund individual women faculty had little impact on improving the representation of women in the academy.

Later, NSF implemented ADVANCE to specifically address gender inequities (Meyerson and Tompkins 2007) perpetuated by institutionalized structures and practices. Indeed, ADVANCE became synonymous with "institutional transformation," enhancing the climate for advancement through policy, changing attitudes, and increasing the percentage of women who are hired and promoted within the institution. The goal is to change the academic environment and not just those who populate it. The result would include increased participation and advancement of women (NSF 2001; Sturm 2006).

9.4.3.1 University of Wisconsin-Madison ADVANCE

Awarded as part of NSF's first cohort in 2001, the ADVANCE Institutional Transformation grant at the University of Wisconsin was named "Women in Science and Engineering Leadership Institute (WISELI)" and implemented to address institutional "climate." These included an examination of university policies, including a review of resource allocation to women and men faculty, increased emphasis placed on hiring women faculty, a workshop to train faculty to perform more thorough and fair evaluations of applicants, and workshops for department chairs designed to: (1) increase awareness of the experiences of faculty from underrepresented groups, (2) empower them to believe they could change the environment, and (3) inform them about perceptions of their faculty members (through a web-based survey). Participation in all of the workshops was voluntary.

Baseline data were collected prior to the ADVANCE interventions. In 2002, 26 women science faculty participated in in-depth interviews to assess their experiences and perceptions of the climate on campus. Findings of these interviews were used to develop a survey that was administered to all faculty at the institution. The 24-item survey assessed the climate of the department and institution for various groups (women and faculty of color) and for individual respondents. The survey was administered in the spring 2003 and generated at 59% response rate among science faculty. ADVANCE interventions followed and the university faculty were re-surveyed. Eleven "climate indicators" assessed individual faculty perceptions of how respected they felt by their colleagues, students, staff, and chairs; how included, valued, recognized, or isolated they felt; and whether they believed they "fit" in their departments (Sheridan et al. 2007).

Women faculty felt that the departmental "climate" was more negative than their male counterparts. They reported feeling less respected, excluded from informal networks and departmental decision-making, and perceived less fit with their departments. In contrast, men faculty and department chairs assessed the quality of the departmental climate for women as much more positive than did women faculty. The majority of the faculty and chairs perceived the experiences and climate as more positive for women faculty and lacked awareness of the negative institutional climate for women.

A 2006 survey of faculty (post-intervention) revealed modest change in perceptions. Women faculty were significantly more likely to say that department climate had improved than declined in the last 3 years. They also were no more likely to report the departmental climate as good than they were in the 2003 survey. Findings revealed that men faculty and chairs had not significantly changed their perceptions about the climate for women. They still perceived the institutional environment as "good" and lacked awareness of women's perceptions of fit in the department. For women faculty whose department chairs or hiring committee chairs had attended a WISELI workshop, findings indicated more positive perceptions of these women faculty, though not significantly so (Pribbenow et al. 2007). Participation in workshop interventions by chairs and senior faculty may have had an impact on the quality of experiences of women faculty with whom they interact.

Overall, Sheridan et al. (2007) concluded that the climate for women at the University of Wisconsin "improved slightly" between 2003 and 2006. There was, however, a decline among majority men in perceptions about the quality of the environment for women. These findings were not convincing that WISELI interventions had a positive impact on perceptions of climate among women and majority faculty at the University of Wisconsin. The authors also speculated that while there was a general openness to explore these issues, participation in some WISELI activities might have created backlash among faculty who see these activities as benefiting only women.

9.4.4 OWSD (TWAS) Postgraduate Training Fellowship Program

The Organization for Women in Science (TWOWS 1995) for the Developing World (OWSD, noted above), was created in 1989, consists of over 4,000 members, and works with its sister organization of TWAS (the academy of sciences for the developing world) to promote women's access to science and technology (TWOWS 1995). The OWSD Postgraduate Training Fellowship Program was established in 1998, and has been funded by the Swedish International Development Agency's Department for Research Cooperation (SIDA/SAREC) for young women scientists under the age of 40 to secure postgraduate training in centers of research excellence in the Global South. The Program seeks primarily to:

- Increase training and research opportunities for young women scientists living and working in countries in the Global South.
- Facilitate development of scientific and technological knowledge production in the Global South through training and exchange programs between scientists in the Global North and South.

Table 9.3 OWSD postgraduate fellowship training program: applications and awards

Applications (1998–2007/2008)	
Africa region	1,517 (83.5%)
Asia and Pacific region	288 (15.8%)
Arab region	12 (0.7%)
Awards (1998–2007/2008)	
Africa region	213 (81.6%)
Asia and Pacific region	45 (17.2%)
Arab region	3 (1.2%)
Awards by country	
Nigeria	16.8%
Sudan	8.6%
Bangladesh	7.9%
Kenya	7.2%
Cameroon	6.2%
Myanmar	4.8%
Tanzania and Uganda	4.5% (combined)

Over 80% of applications and awarded fellowships go to nationals from the Africa region. Nigeria, which has a strong educational system and is the most highly populated country in the region, dominates with over 25% of applications and almost 17% of awards (see Table 9.3). Disciplines favored in applications and awards are the biological sciences (cellular and molecular biology and systems biology) and agricultural sciences, followed by chemical sciences, and to a significantly lesser extent mathematical sciences and physics.

Despite a 50% attrition rate (of 261 awards accepted) due to award cancellations and departures from the program by applicants, since 1998 the OWSD Postgraduate Fellowship Training Program has demonstrated excellence as a model for training institutions in the Global South. Since 1998, 75 junior women scientists (<40 years old) have completed their Ph.D.'s in these training centers. In 2010, there were approximately 45 fellows undergoing training. While the Africa region is disproportionately represented, there is a significant gap in the Latin America and the Caribbean regions, where social and economic disparities within country and region are prevalent.

One of the unexpected outcomes of the OWSD Postgraduate Training Fellowship Program is that the majority of fellowship graduates fail to return to their countries of origin because the specialized training they receive makes it difficult for them to find suitable employment in their fields. The failure of graduates to return to their countries of origin is largely due to the unstable economic and political climates, which are conducive neither to advanced scientific research nor lucrative job opportunities. In addition, there is the prospect of dealing with inequalities of gender, class, and ethnicity in the labor market and patriarchal institutional culture of the scientific community (Huyer 2010: 18).

Drawing on data for the dominant Africa region, however, there is evidence of positive outcomes. Based on third-party evaluation and continuous monitoring of publication productivity, skills acquisition, and involvement in professional networking by the OWSD, Huyer (2010) found that 90% of fellowship graduates had published or were in the process of producing one or more peer-reviewed articles, and 66% of graduates had maintained professional relationships with their supervisors through research collaborations. Another outcome is that the majority of graduates are now working in university research institutes in the Global South, even though they may not be residing in their countries of origin. Thus, the program has generated some amount of South to South exchange, stemming to some extent the problem of "brain drain" to the North.

9.5 The "Life Cycle" of Programs: Policy and Practice

The data presented on the four programs above give hope … and pause. The BEST template set a high standard. While gender-focused programs in the United States have flourished, few have manifested the rigor of interventions that produce desired outcomes. This does not mean they have failed to occur, only that producers have not shared results in a public way. Data that are accessible, however, tend to suffer from a preponderance of self-reports, no comparison group, and short time-series. The upshot is that, even in the relatively resource-rich Global North, rhetoric about gender equality outpaces reality.

Within the ambitious and well-financed ADVANCE Program, some projects (like Wisconsin's) fared better than others in fostering or sustaining institutional transformation. COACh illustrates how pockets of success occur amidst the global landscape. "Successful" programs are clearly relative to time and place. What works for a targeted population in one site may or may not take root, may not transfer to other populations and sites, and may not be sustainable for reasons unrelated to the effectiveness of the interventions.

Similarly, the lesson of the OWSD Fellowship Training Program is a lack of uniformity in supporting individuals while exacerbating imbalances between host and "feeder" countries. And as NCWIT illustrates, broadening participation in computing must change not just practice but consciousness about how organizational structures unwittingly deter girls and women from aspiring to or persisting in a science-based career.

In short, context matters and may overwhelm the good intentions and arduous efforts to change culture, practices, and minds. From our modest examination, one key generalization is that participants may report positively on the experiences afforded by a program, but we know little empirically about the impact on career development and especially women's ascendance to leadership positions. For example, we might "start with data that permit pre-post comparisons of women deans correlated with women's share of undergraduate enrollments in those disciplines, and move to microqualitative data that begin to explain what is perceived and how participants act on those perceptions" (Chubin 2013).

9.5.1 Program Practice

If a program has a "life course"—a sequence of events that extend from its planning to its demise or transformation due to changes in organization, personnel, or support—then comparing even promising programs raises inevitable questions: What is the journey from conception to institutionalization and beyond for the "successful" or "effective" intervention program? Does it work especially for women, for students in a particular age range, or for our three focal disciplines of interest? Is there anything typical or universal that can be identified as essential, indeed indispensable?

Based on our survey of several ongoing programs around the world, and a more detailed analysis of four promising but disparate programs, we conclude the following:

- Multiple interventions are a kind of organizational strategy, but the more dispersed the resources and focus, the less we can tell about the impact of S&E career production. Funding constraints dictate scope and limit evaluation to *either* educational preparation or subsequent stage(s) of the career.
- Length of operation indicates sustained commitment by a sponsor or performer, but does not guarantee accountability for outcomes. On what are sponsors basing their funding decisions?
- Outcome evidence is scarce, either because it is not produced or not shared publicly. In this era of evaluation and continued improvement, this seems indefensible but common.
- Generalizing is a risky undertaking. Based on available evidence, the likelihood that similar programs and populations in different cultural contexts would benefit from adapting what the program-in-question has learned is premature.

Arguably, any intervention program geared to increasing the number and improving the experience of science participants, especially those known to be underrepresented by discipline or sector, may be better than none. The effort, however, does not assure the outcome. And some of that is due entirely to factors beyond the program's control in the larger sociopolitical environment.

9.5.2 The Link to Public Policy

A truism of public policy is that without enforcement a policy is no more than words on a page. The saga of applying Title IX in the United States to the participation of women in science, both in the educational and employment domains, is a reminder of the gap between governmental intention and action for change (Redden 2007). Shifting to other political systems, populations, and opportunity structures underscores how culture can promote or inhibit what even a national government seeks to accomplish in educating its citizens and preparing them for the workforce.

From a policy perspective, what makes a program "promising"? We have explored that question in this chapter from the two angles of sponsor and performer. With policy as an "enabler," research would be welcome on:

- How to leverage resources from one sponsor to build and sustain support for the program after initial funding has dissipated. Building a consortium of partners is one approach, with funding provided to bridge the education-to-workforce gap, matching skills to needs, supply to demand, in ways that capitalize on all who are trained and credentialed.
- Utilizing comparative climate data to inform policies that foster changes in organizational practices. Knowledge alone will not suffice; providing incentives for "doing the right thing" by all participants is needed.
- Identifying and funding organizations with gender-sensitive infrastructures to disseminate resources to those lacking training in populations they have seldom educated in their disciplines. Critical masses of, e.g., women and foreign-born students, will both attract and help retain them to degree completion.
- Finally, encouraging "experiments" built on programs that have a track record of propelling women into the science workforce. New programs can emulate design specifications regarding scale, target, trajectory, and time frame from intervention to first workplace entry. Evaluating and publishing outcomes will heighten accountability.

9.6 Conclusions

This chapter has asked: How do we learn what works in so-called STEM programs targeted to girls and women? Further, it has searched for and presented only evaluation data on programs that have operated for many years. Whether in the Global North or Global South, programs can be categorized by discipline, nationality, geography within a country, and the familiar intersections of gender, race, ethnicity, and social-economic status. Source information will limit what is known and explanations for observed trends. There is an indisputable data gap created by a lack of longitudinal, standard-measure, periodic information collected, analyzed, and shared across national, disciplinary, and institutional boundaries. This has created a decided "knowledge gap." We draw conclusions, and act on some of them in the presence of little valid and reliable, systematically evaluated data. Such is the inescapable reality of educational interventions.

Disappointments aside, in our effort to move systematically from program context to description to inference, we have begun to assemble a research agenda. One goal should be a catalogue of key characteristics manifested on the education pathway en route to the workforce that *both* facilitate and impede transitions for individuals and structural change for organizations. Only with a better grasp of these characteristics and their cross-cultural variations can the scholarship in this volume inform stakeholders in government, nonprofit organizations, and the media.

We have just begun the program analysis needed if incorporating "feedback loops" into program design, implementation, evaluation, and refinement is to become a modus operandi of sponsors and program administrators alike. The road from "promising" to institutionalized, sustained, and scalable "exemplary" programs in science education and training is littered with good intentions, charismatic leaders, pragmatic partnerships, and of course, policies misguided, under-funded, and unfulfilled.

Sobered by this knowledge, we envision the global future of the science workforce (one becoming indistinguishable from the global workforce) that advocates through analysis for the aspirations of especially girls and women. To be sure, programs—the unit of analysis featured here—cannot be imposed on institutions; they must be "owned" by them, seen as culturally concordant, strategic, and evolving to advance societal missions. And programs must not favor one group over another or tilt the playing field in ways that compromise competition, devalues performance, or inflates an ascribed characteristic such as gender.

To be sure, we locally and globally can act to change the history of participation in science—and we must! A creative and productive twenty-first century labor resource hangs in the balance.

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Vignette 9.1
We've Only Just Begun: What Worked and What Has Not Worked Well So Far for the Promotion of Women Scientists in Japan

Sanae M.M. Iguchi-Ariga

Japan remains at the bottom of OECD countries, to our deep regret, in regard to the percentage of women researchers. In concert with the Third Basic Plan for Science and Technology (2006–2010), in which numerical targets for female recruiting levels were shown for the first time, the Japanese government initiated multifaceted programs in 2006 to promote women's involvement in the research workforce nationwide, namely funding for institutions to create model programs (taking after the ADVANCE program of the NSF in the United States), re-entry support for women returning to research after taking family leave (special postdoctoral quota), and outreach programs to attract high school girls into science disciplines. More than 90 universities and national institutes have adopted the ADVANCE-like programs to date; Hokkaido University was one of the initial ten universities to do so.

Hokkaido University is a national flagship research university of about 2,000 faculty members with more than 11,000 undergraduate and 6,000 graduate students. The support office for Female Researchers in Hokkaido University (*FResHU*) has been managing various programs to promote representation of women in academic science and technology and to support their careers (including family support), aimed at the near-term goal of reaching 20% overall female faculty by the year 2020. To boost, but not force, appointments of qualified women scientists as faculty members, extra budgets for salaries from university overhead have been offered as incentives to the faculties recruiting women as members. Women were only 7.0% of the faculty when that unique affirmative action program started in 2006, and in 2013, after 7 years, the level had risen to 12.5% by welcoming more than 100 brilliant women researchers. The affirmative action program at Hokkaido University now has been applied to a national project to increase women in science, agriculture, and engineering fields, which show the smallest participation of women both

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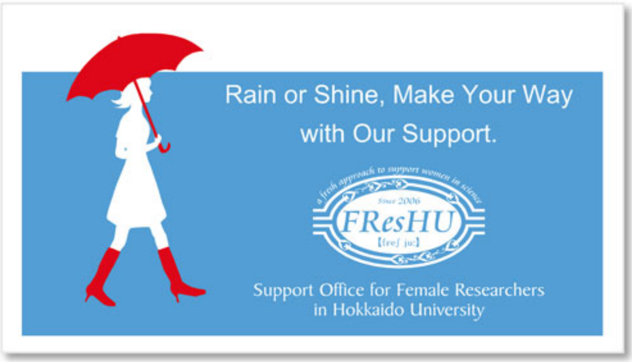
in proportion and absolute numbers. A project has also been implemented at Hokkaido University in which 27 women, including 14 foreigners, have been recruited, increasing diversity in the research and education workforce in 5 years.

Establishing in-campus day-care centers for children and providing human support to laboratories have been successful not only for helping young "mom-scientists" to stay active, but also for improving the institutional climate by showing that women are not "risky" colleagues who would work less critically because of pregnancy and child care.

Another big issue is the two-body or dual career problem. About 10% of male researchers' partners/spouses are also researchers, while more than 50%, even 70–80% in life science fields, of female researchers have researchers as partners/spouses. Support for researcher couples is, therefore, a big concern in the promotion of women in science. Young researchers show a strong tendency to look for positions either in the Tokyo metropolitan area or in the Kyoto-Osaka area, where they might have more possibilities for finding two research posts for "two in science," given a variety of numerous universities and research institutes. Hokkaido University and others located far from the above areas and somewhat isolated from other research institutes should take this issue seriously in regard to securing qualified young researchers. Much related discussion is about fairness in having more opportunities for researcher partners, but the university would also benefit from recruiting suitable pairs of researchers. Of course, evaluation systems must be considered: both partners must be qualified individually and should fulfill faculty needs. Space for laboratories and offices is another concern. Recent developments in information technologies, such as mobile telephones, e-mail, and Skype, can provide some help to remote couples. However, while it might be less problematic as long as it remains a "two-body" problem, the situation becomes far more complicated and serious when they face a "three-body" or "four-body" situation including children or elderly parents. An entire employment system of researchers must be reconsidered in order to maximize the activities of scientists, from junior to senior and regardless of gender, as well as to cope with the declining birth rate which is marked especially among women scientists.

Also, despite programmatic efforts, the percentage of women assuming leadership positions involved in decision-making processes remains disappointingly low, as in the whole of Japan. The promotion of women in science should be far-sighted policy: it requires time and effort to normalize the long and continuous gender imbalance in the research workforce. Promotion activities as well as women's careers should be sustainable. Evaluation of promotion programs and activities, however, often lays too much weight on "numeric values" showing the increase of female researchers. Numbers are, of course, important; we need more women in the research workforce indeed, but we should never overlook working conditions and the quality of the workplace. Female junior faculty and postdoctoral researchers are thus provided various opportunities and training to become empowered and more "visible," such as seminars and workshops on leadership and presentation skills; childcare also is provided as a priority for encouraging and enabling the participation of mom-scientists. Taking pride as a front-runner, the *FResHU* office organizes such efforts and welcomes female researchers, and motivates other universities and institutes as well. In addition, it has formed a network in which women researchers help, inspire, and mentor one another, and networked women function as cores for transdisciplinary research collaboration. Also including "understanding" male colleagues, the network will help women to break through the glass ceiling.

9.7



Vignette 9.2
Initiatives Promoting Women in Science at the French National Center for Scientific Research (CNRS)

Anne Pépin

The National Center for Scientific Research abbreviated as CNRS (from the French *Centre National de la Recherche Scientifique*) is the largest public research organization in France and the largest basic research agency in Europe. CNRS covers all fields of knowledge through its ten Institutes, 33,700 employees—including 25,500 tenured researchers, engineers, technicians, and administrative staff, i.e. civil servants—and 1,000 laboratories located all over the country, and some abroad, most of them joint laboratories with universities or other national research organizations and key industrial partners. Founded in 1939, CNRS plays a central role in the design, funding, execution, and evaluation of research programs at the national level, and is a leader at the international level, boasting 20 Nobel Prizes and 12 Fields Medal Laureates, and ranking first in the world in 2012 in terms of publications (CNRS 2014).

In July 2001, shortly after two laws promoting gender equality had been passed in France[18] and in an effort to respond to European recommendations on gender equality in research and higher education,[19] CNRS spearheaded national efforts by creating its *Mission pour la place des femmes au CNRS* (MPDF-CNRS), a governance-level operational unit dedicated to the promotion of gender equality and improving the status of women within the organization. A few months later, the French Ministry in charge of research would follow and create its *Mission pour la parité* (renamed *Mission pour la parité et la lutte contre les discriminations* since 2009).

[18] The Law of June 6, 2000, promoting gender parity in political representation, and the Law of May 9, 2001 promoting professional equality between women and men.

[19] Awareness rose at EU level at the end of the 1990s, following the 1995 Beijing UN Conference and the 1997 paper by Wennerås and Wold (1997), leading the European Commission to launch a series of initiatives including the 2000 ETAN report.

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Many actions were initiated over the years by MPDF-CNRS to foster women's advancement in science. Among key initiatives, the Mission has produced a number of qualitative studies on the factors hindering the progression of women in research careers, as well as research and educational tools promoting French women scientists as role models. These tools include, for example, a volume on the role of women in the history of CNRS, traveling exhibitions and DVDs, a mentoring forum for young female Ph.D. students in mathematics in collaboration with the *Femmes et Mathématiques* professional association) and since 2009, MPDF-CNRS yearly publishes a comprehensive, sex-disaggregated statistical booklet recognized by CNRS as a necessary complement to its annual Social Report and a tool for improving its HR management and organizational practices, which serves as a model for the national academic community (CNRS 2013a).

In 2009, CNRS officially committed to the development of a gender action plan in its "Contract of Objectives" with the French State, and a series of national actions have since been put into place, among which tailored awareness-raising and capacity-building trainings on gender equality in research, were developed since 2011 to target all levels of HR and scientific decision-making at CNRS and thus foster systemic change.

As a means to support this commitment, MPDF-CNRS—along with a focused consortium of European institutions—answered and won the first call for proposals on structural change in research institutions launched by the European Commission through its 2010 7th Framework Program Science-in-Society work program—a call strongly inspired from the US National Science Foundation (NSF) ADVANCE Program, which was renewed in the followed three EC FP7-SiS campaigns and will carry on in HORIZON 2020, the next framework program (2014–2020). Project INTEGER (for "INstitutional Transformation for Effecting Gender Equality in Research") was launched in 2011 for a 4-year duration. Coordinated by MPDF-CNRS, it involves two other gender action plan-implementing institutions—Trinity College Dublin, Ireland, and Siauliai University, Lithuania—as well as a German organization, GESIS, in charge of evaluating progress within each institution, and is supported by an international group of expert advisors among which are former ADVANCE officers and grantees (CNRS 2013c; Trinity College Dublin 2013) At CNRS, INTEGER more specifically targets the two CNRS Institutes with the lowest female representation, i.e. physics and mathematics.

MPDF-CNRS has played a leading role at the national level in the development and recognition of gender studies. Recently, it initiated a national inventory of researchers working on gender and/or women, and supported the creation in 2010 of a CNRS pluri-disciplinary thematic network (RTP) on gender studies to explore the integration of the gender dimension in fields outside the humanities and social sciences. In 2012, this successful initiative led the newly created CNRS Mission for Inter-disciplinarity to elect gender as one of CNRS's great interdisciplinary research challenges for the coming years. The Gender Challenge Program (*Défi Genre* CNRS 2013b), co-led by MPDF-CNRS, funds exploratory projects from interdisciplinary research teams developing a gender perspective in different scientific fields, e.g. biology, environmental science, engineering, and computer science.

MPDF-CNRS is also on the Management Committee of a pilot targeted network on gender, science, technology, and environment launched in 2012 and funded by the European Cooperation in Science and Technology (COST, genderSTE 2013), and a member of the Gender and Diversity Task Force (now standing Working Group) created in 2013 within Science Europe, the organization representing research-performing and research-funding organizations in Europe.

A major collaborative effort, the GENDER-NET ERA-NET (GENDER-NET 2014) project, a pioneering FP7-funded networking initiative which is led by MPDF-CNRS, was launched in October 2013 for a 3-year duration. This ERA-NET scheme seeks to coordinate national policies and programs promoting gender equality in research institutions and/or the integration of the gender dimension in research contents. Partners, among which are some of the most advanced national program owners in Europe (from e.g., Norway, Ireland, UK, Spain, Switzerland, France) as well as key North-American players such as the US National Academies and the Canadian Institutes of Health Research, are joining forces for the implementation of strategic joint activities, building on a systematic exchange of information, innovative assessment and knowledge-transfer methods, and the definition of common indicators. GENDER-NET is a pilot transnational policy initiative which will allow for a global vision of the best practices and conditions for success for fostering gender equality in research.

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Vignette 9.3
Building the Mathematics Capacity in the Developing World: The United States Participation in the Volunteer Lecturer Program

Ana Ferreras

The Volunteer Lecturer Program (VLP) in mathematics is organized and sponsored by the International Mathematical Union (IMU) with the goal of building capacity in mathematics and mathematics education in developing countries. Under this program, mathematicians from developed countries deliver intensive short courses in advanced mathematics for degree programs at universities in the developing world. One of the countries from which the program draws volunteers is the United States (US), which has a large pool of mathematicians who have indicated their willingness to participate, essentially pro bono, in the VLP. The program offers 3–4 week mathematics lecture courses on topics at the advanced undergraduate level, with the idea of building capacity and increasing interaction between the US mathematical community and the vast, mostly untapped reservoir of mathematical talent in the developing world. Their participation was managed by the US National Committee for Mathematics (USNC/M) at the National Academy of Sciences, and the program was sponsored by a National Science Foundation grant (DMS-0937225).

9.8 The Experience of the First Woman Lecturer

Dr. Helene Tyler, associate professor at Manhattan College, taught Ordinary Differential Equations in 2009 at the Royal University of Phnom Penh (RUPP) in Phnom Penh, Cambodia. She became the first woman volunteer in the IMU program, and it was the first time that she had lectured in a developing country. Upon her return, Dr. Tyler said, "When I returned to the States and people asked how was it, I responded that I've never worked so hard in my life and I can't wait to do it again!"

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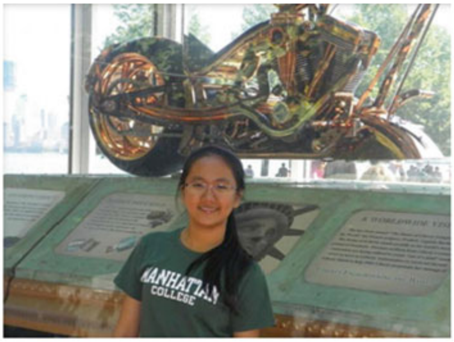
9.9 The First VLP Student in the United States: Following the Mathematics Dream

Dr. Tyler returned to RUPP in 2010 and the highlight of her second visit was meeting Ms. Kimsy Tor, a student who had recently graduated from high school and attained the highest score in the Grade 12 National Exam. While Kimsy excelled at all subjects, her particular talent was mathematics. She audited Dr. Tyler's class where she ranked 8th among the 21 students, all of whom had at least 4 more years of education than she did.

When Dr. Tyler returned to the United States, she contacted the leadership of her institution. Kimsy was admitted to Manhattan College, which provided her with a scholarship to pursue a bachelor's degree in mathematics and a minor in computer science. In 2011, Kimsy became the first VLP student pursuing her studies in the United States. In 2013, she completed her second academic year with an outstanding overall GPA of 3.97/4.0.

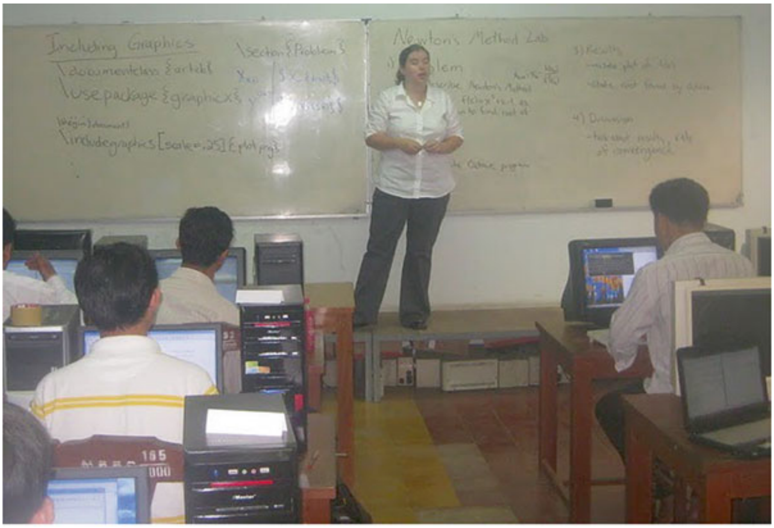


Kimsy Tor wearing a Manhattan College T-shirt

9.10 US Graduate Students Serving as Teaching Assistants in the Developing World

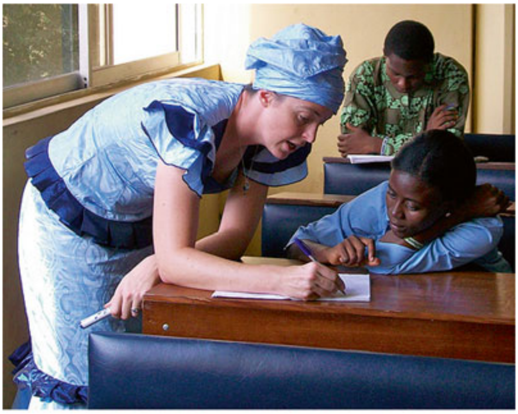
Dr. Angel Pineda, associate professor at California State University, Fullerton, taught Numerical Analysis II at RUPP in 2009 and 2010. Due to the intense volunteers' workload, Dr. Pineda proposed to the USNC/MI that he bring along one of his graduate students to assist him. As a pilot project, Emily Bice became the first US graduate student to serve as a VLP teaching assistant (TA) in 2010. She assisted with grading homework, laboratory assignments, and examinations; was able to give selected lectures; and administered several computer laboratory assignments. She also held office hours, where she assisted students with their homework and theses.

Emily led the development of laboratories using Octave, a free version of MATLAB©, which complemented the material presented during lectures. Dr. Pineda noted that "Emily's work will be extremely useful for future lecturers covering Numerical Analysis, since it is critically important for the developing world to use open-source software such as Octave© and MiKTeX. Having a graduate student helping to teach the course significantly increases the impact of a lecturer and provides a learning opportunity for the student and a mentoring opportunity for the lecturer." Emily stated, "I had a wonderful experience. Dr. Pineda's mentoring was an integral part of my positive experience."



Emily Bice lecturing on Newton's multivariate method

After evaluating the impact of this initiative and building upon its great success, Martha Byrne, a graduate student of Dr. Michale Nakamaye at the University of New Mexico became the second VLP TA. Martha assisted Dr. Nakamaye teaching Symmetry, Calculus, and Functional Analysis at Obafemi Awolowo University in Ile-Ife, Nigeria in 2010. Dr. Nakamaye noted, "Having the chance to share the time with my graduate student Martha was a terrific experience and it helped me greatly." Martha commented, "I love that I got to be a part of the VLP, travel to Nigeria, and had such a wonderful experience there. I'm a better teacher as a result of our time there and getting to collaborate on such a project."



Martha Byrne assisting a student

9.11 Science Diplomacy: VLP Reception at the US Embassy in Cambodia

In 2012, the USNC/M held a reception at the US Ambassador's Residence (William E. Todd) in Phnom Penh to honor VLP's work in Cambodia promoting mathematics. At that time, the VLP has worked with Cambodia for over 6 years. Dr. Tyler gave a welcoming address at the reception, saying that "to say that my time in Cambodia has changed my life, both professionally and personally, may be trite and cliché, but it also is entirely true. I have learned so much from my interactions with the Cambodian mathematics community. The students have been the hardest working and hungriest that I have ever taught, and it is possible that I have learned even more from them. At home, my students have become almost too familiar; I am rarely asked a question that I have not been previously asked. But here my students come to the material with different sets of skills, some even stronger than my students at home. I feel more present during my lectures here than I often do in the United States. I am more sharply focused on how the students react to the material and to how I present it. I am certain that the experience has made me a better teacher, both here and at home."

Dr. Helene Tyler and Ambassador William (Bill) E. Todd

The event was attended by local policy makers, university leaders, VLP alumni, and current students. The purpose of the reception was to increase the visibility of the program and empower local leaders to take ownership in building mathematics capacity in Cambodia. As a result of this reception, RUPP leadership provided space to the Mathematics Department to build the first mathematics laboratory in the country.

The U.S. participation in the VLP is now managed by the IMU. While the NSF grant that supported this effort has ended, the U.S. VLP is now fully funded by the IMU. For more information, see the US VLP website.[20]

[20] www.volunteerlecturerprogram.com