

Fighting the Leaky Pipeline: Developing Peer Support for Women in the Earth and Environmental Sciences

ELIZABETH A. AGEE

Department of Civil & Environmental Engineering, University of Michigan

YANG LI

Department of Climate and Space Sciences & Engineering, University of Michigan

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ABSTRACT

While recruitment efforts have improved undergraduate representation of women in science and engineering, retention at later academic career stages remains an issue. For earth and environmental sciences, the struggle to retain women comes at a time when the field faces several external challenges. The politicization of science and threats to critical federal funding jeopardize both basic research and outreach programs. Peer networks, once established, provide necessary support structures for retention while remaining insulated from shifting policies and funding structures. This paper provides an overview of the lessons learned from the development of a peer network for graduate women in the earth and environmental sciences at the University of Michigan. The Michigan Earth Science Women's Network (M-ESWN) formed as a local extension of the Earth Science Women's Network (ESWN), an international peer-networking organization committed to providing professional support and development to women in the earth and environmental

sciences. Through a series of organized events, M-ESWN has worked to (1) address core issues which impact the retention of women in STEM, (2) facilitate networking across departments for women in the earth sciences, and (3) develop sustainable support mechanisms for women scientists. While the long-term implications of the program are yet to be seen, the initial success of the M-ESWN workshops may serve as a template for others, helping mitigate the loss of women from STEM fields.

Introduction

Despite numerous efforts to improve representation of women in science and engineering, recent figures from the National Science Foundation show persistent disparities between the representation of women engaged in STEM fields and the general population (National Science Foundation and National Center for Science and Engineering Statistics 2017). Increased undergraduate enrollment in science and engineering has not translated to gender parity at later career stages, a funneling effect commonly referred to as the “leaky pipeline.” The earth sciences, a conglomeration of fields focused on the study of natural systems from inner earth to atmosphere, face the challenge of plugging the leaks while encountering increasingly contentious circumstances where the need for—and even validity of—the field is questioned (Farstad 2017; McCright and Dunlap 2011; Carmichael, Brulle, and Huxster 2017). Emerging evidence supports peer-mentoring networks as an effective mechanism for both the retention of underrepresented groups (Dennehy and Dasgupta 2017; Thomas, Bystydzienski, and Desai 2015; Adams, Steiner, and Wiedinmyer 2015) and group advocacy (Wolf 2017; Van Noorden 2014; Appenzeller and Staff 2017). This work outlines the current issues affecting retention of women in the earth sciences and documents the establishment and outcomes of the Michigan Earth Science Women’s Network (M-ESWN), a peer networking group at the University of Michigan, Ann Arbor.

Identifying the leak: identifying a core audience

Earth science, given its broad scope, often defies traditional academic demarcations, finding homes in departments ranging from natural sciences to engineering. Current demographics of earth science-related fields were examined at both the national and university level to identify current gaps in gender parity within academia. While the statistics provide a general overview of participation, they do not account

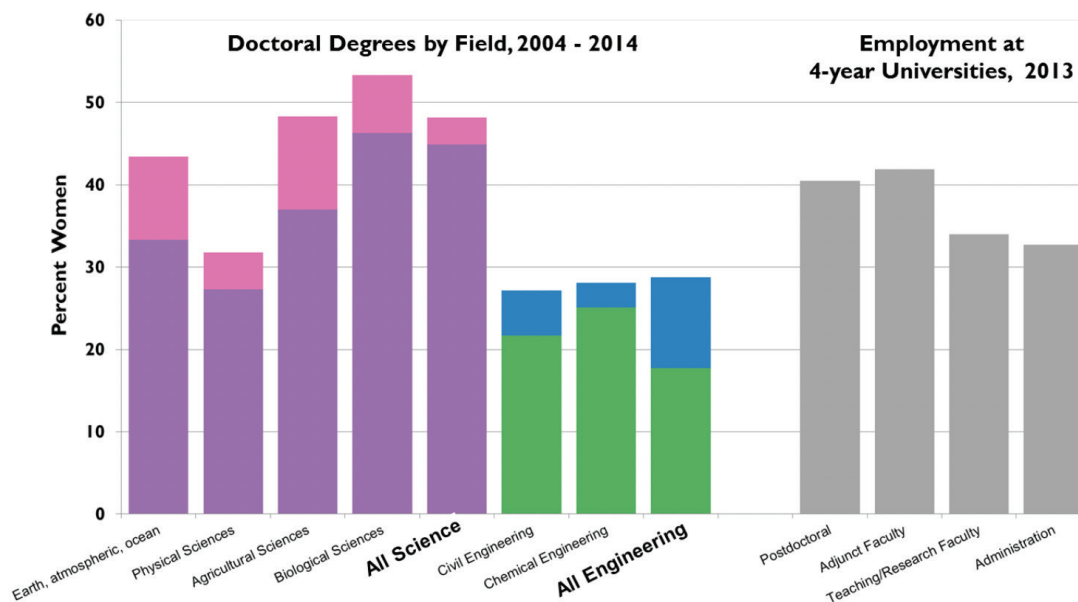


Figure 1. *National doctoral and faculty statistics.* (left) Statistics from the National Science Foundation showing the percentage of women awarded doctoral degrees in science and engineering. Lower bars denote 2004 while the upper bars denote 2014. (right) The percentage of women employed at four-year universities by career level for 2013.

for individuals who identify as earth scientists, but who work within other field designations. Nationally, the percentage of doctoral degrees awarded to women in the earth, atmospheric, and ocean sciences increased from 33.3% to 43.4% between 2004 and 2014. Yet for civil engineering, which routinely engages earth scientists, women received only 27.2% of the doctoral degrees conferred in 2014. At later career stages, field specific statistics were not readily available; but overall, women represent 33.5% of science, engineering, and health university faculty. For positions that rely heavily on federal support (e.g., full, associate, or assistant professors in universities), the percentage decreases to 30.0% (National Science Foundation and National Center for Science and Engineering Statistics 2017).

At the university level, graduate enrollment statistics were examined for University of Michigan departments that contain one or more groups focused on earth science related research (https://secure.rackham.umich.edu/academic_information/program_statistics/doctoral/). Enrollment statistics, mirroring national trends, show stronger gender representation in the science departments compared to engineering

Table 1. Female enrollment statistics for departments focused on earth and environmental research at the University of Michigan.*

Program	Ph.D. Enrollment, 5 Year Avg	Ph.D. Enrollment, 2016	Incomplete Ph.D.s from enrollment period 2001- 2004	Incomplete Ph.D.s from enrollment period 2005- 2009	Mean Attrition
Ecology & Evol. Biology	50%	50%	32%	33%	32.5%
Natural Resources & Env.	55%	63%	25%	29%	27%
Earth & Env. Sciences	46%	48%	30%	37%	33.5%
Chemistry	43%	42%	31%	20%	25.5%
Env. Health Sciences	69%	67%	40%	22%	31%
Climate & Space Sci./Eng.	41%	41%	40%	27%	33.5%
Env. Engineering	60%	69%	18%	35%	26.5%
Civil Engineering	26%	28%	29%	29%	29%
<i>AVERAGE (S&E):</i>	48.8%	51.0%	30.6%	29.0%	29.8%
<i>AVERAGE (SCI):</i>	48.5%	50.8%	29.5%	29.8%	29.6%
<i>AVERAGE (ENG):</i>	42.3%	46.0%	25.9%	31.0%	28.4%
All Graduate Programs	42%	42%	26%	25%	25.5%

* https://secure.rackham.umich.edu/academic_information/program_statistics/doctoral/

departments (Table 1). Attrition rates for the doctoral programs at the University of Michigan range from 20-40%, but are generally lower than national Ph.D. attrition rates for STEM (~41 %) (Council of Graduate Schools 2007). Given the rates of attrition and the decrease in female participation at the faculty level, female graduate students were deemed an appropriate target audience for peer mentorship. The underlying premise is that if peer networks are formed at early career stages, they can mature and provide adequate support mechanisms before women leave the pipeline. At the graduate career stage, individuals can specifically benefit from shared development opportunities, which help align personal and professional interests with an appropriate academic plan. A meeting of peers also provides a low-risk environment in which to develop career skills, voice concerns related to personal performance or institutional practices, and gain valuable insights from others' experiences.

Michigan Earth Science Women's Network

M-ESWN was formed as a local extension of the Earth Science Women's Network (ESWN). ESWN is an international peer-networking organization committed to providing professional support and development to women in the geosciences. Formed in 2002, it has grown to over 3000 members, representing individuals from

all career stages, sectors, and from more than 60 countries (Adams, Steiner, and Wiedinmyer 2015; Hastings, Wiedinmyer, and Kontak 2015). ESWN provides virtual support and mentoring through web forums (<http://www.eswnonline.org>), social media, and an employment listserv, as well as development opportunities at prominent conferences (e.g., the American Geophysical Union Fall Meeting).

To administer personalized support at the institutional level, M-ESWN is structured to provide peer mentoring and professional development to self-identified graduate women in the earth and environmental sciences attending the University of Michigan. A series of workshops and informal discussion groups were designed to recruit and engage students while also addressing core issues impacting retention during and beyond graduate school. While other societies focused on women in STEM are present at the university (e.g., Graduate Society of Women Engineers, Women in Science and Engineering, and Movement of Under-represented Sisters in Engineering and Science), M-ESWN provides targeted support for earth scientists, providing a platform to discuss contemporary issues in the field while forming valuable professional collaborations.

Patching the leak: targeting the issues

Studies over the past two decades have suggested numerous reasons for the departure of women from STEM, but have centered on the following core issues: (1) accumulating cultural and institutional biases (Lerback and Hanson 2017; Dutt et al. 2016; Rosen 2017), (2) work/life balance (Ahuja 2002; Polkowska 2014), (3) motherhood penalties (Preston 2004), (4) lack of role models and mentorship (Drury, Siy, and Cheryan 2011), and (5) poor support structures (St. John, Riggs, and Mogk 2016). Workshop topics were selected to address these key areas and were designed not only to develop professional skills, but also to provide a forum for personal expression (Table 2). Each workshop opened with an icebreaker event to promote engagement and allow participants to introduce themselves. Peers, faculty, university staff, and external professionals facilitated developmental activities as well. Additional discussion sessions were held with female advanced career scientists to discuss contemporary issues facing women and science. The location of events was varied between campuses of the university to distribute travel burdens across groups.

Table 2. Summary of topics covered and associated learning objectives. The numbered focus areas correspond to core issues outlined in the text.

Event	Summary	Focus Areas
<i>Professional Development</i>		
Scientific Communication	<ul style="list-style-type: none"> • Learning objectives: Improve scientific communication skills by crafting short “elevator pitches” which effectively communicate research to general audiences. • Support objectives: Identify biases that impact women communicators and find strategies to overcome them. 	1
Preparing Academic Statements	<ul style="list-style-type: none"> • Learning objectives: Identify components of academic statements; analyze unsuccessful and successful statements; develop personal strategies for writing statements. • Support objectives: Interact with successful female career scientist (facilitator); discuss institutional biases in the application process and ways to combat them. 	1, 4
Work/Life Balance	<ul style="list-style-type: none"> • Learning objectives: Learn strategies for self-care; identify internal and external resources available; assess personal balance and formulate actionable plans for the future. • Support objectives: Share local resources for mental health, family, and sexual harassment/assault support. 	2, 3, 5
Preparing for non-academic career I	<ul style="list-style-type: none"> • Learning objectives: Identify key components of a successful private sector application; practice consulting case interviews. • Support objectives: Extend professional networks beyond academia; discuss parental support mechanism in consulting. 	3, 4
Preparing for non-academic career II*	<ul style="list-style-type: none"> • Learning objectives: Outline non-academic research career tracks; identify skill sets needed for non-academic careers. • Support objectives: Interact with successful female career scientist (facilitator); discuss impact of politics on research funding and national research laboratories. 	1, 4
<i>Discussion Groups</i>		
Lunch Discussion I	<p>General discussion of gender issues in the earth and env. sciences.</p> <ul style="list-style-type: none"> • Support objectives: Interact with successful female career scientist (moderator); allow students to share their personal experiences as women in the earth sciences. 	4, 5
AGU ESWN Reception	<p>Social meet-up at ESWN reception held at the American Geophysical Union Fall Meeting in San Francisco, CA.</p> <ul style="list-style-type: none"> • Support objectives: Showcase external support structures (ESWN); network with fellow female earth scientists 	4
Lunch Discussion II*	<p>General discussion of gender issues in the earth and env. sciences.</p> <ul style="list-style-type: none"> • Support objectives: Interact with successful female career scientist (moderator); allow students to share their personal experiences as women in the earth sciences. 	4, 5

*Joint event

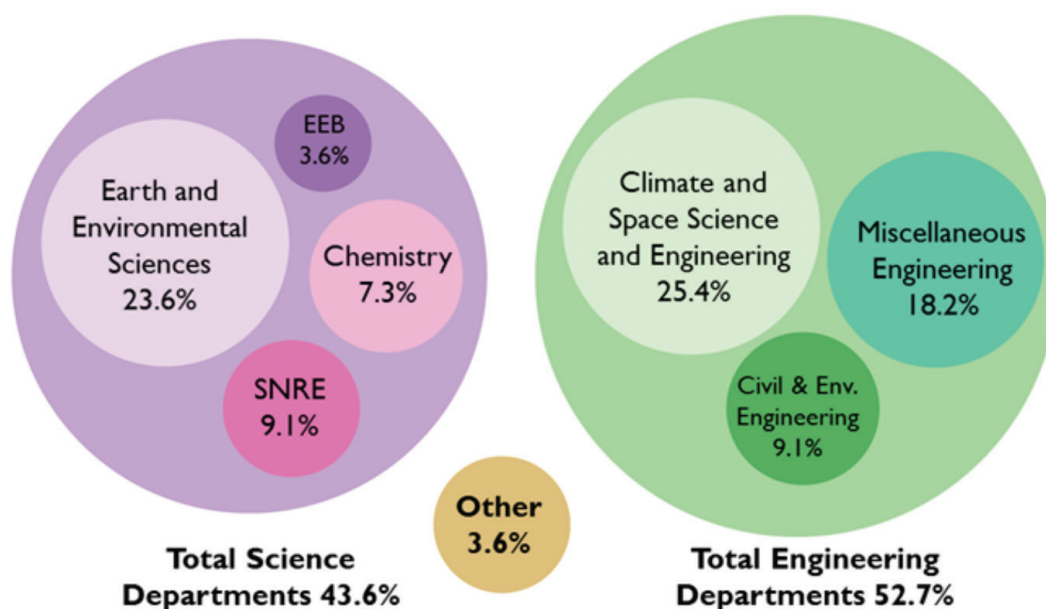


Figure 2. Participation in M-ESWN events by college and department. The departmental breakdown of M-ESWN workshop participation. Numbers account for individuals who attended at least one workshop event and are sorted by graduate program.

Outcomes

The initial success of the workshop series was measured primarily through attendance and network enrollment. Participation was distributed evenly among science and engineering departments, with 55 self-identified earth and environmental scientists participating in at least one workshop event (Figure 2). This number excludes enrollment numbers from a non-academic career preparation workshop, which drew an additional 37 individuals from the general graduate body. The majority of participants were members of other science and engineering societies for women. The accessibility of event locations, as determined by their proximity to students' home departments, and event times were significant factors in the ability for students to participate. The programs represented were directly correlated to the event location (e.g., engineering students participated in events convenient to the engineering campus while science students participated in events centrally located to their campus). Logistical challenges, including advertising across multiple departments and heterogeneous campus policies for student activities, provided additional barriers to outreach.

Experiences and opinions expressed relied on the pool of available participants and willingness of the participants to self-report. Participants echoed the previously reported concerns regarding the involvement of women in the earth sciences. Of the concerns expressed, finding balance between research and personal life was reported most frequently. Alarming, several participants also reported personal experiences with institutional sexism either during or prior to their graduate studies. Through targeted events like the Work/Life Balance session (Table 2), participants were equipped with actionable strategies to ease stress and improve overall mental wellness. To further address the aforementioned concerns, participants were connected with both internal and external agencies and resources. Such resources included free mental health counseling, sexual assault crisis intervention, and family support services. Further outcomes are outlined in Table 2 under the learning and support objectives.

For the non-academic career preparation workshop, M-ESWN collaborated with an international graduate society and a society for graduate women engineers. This collaboration produced more diverse participation, with 30% of the participants being male. Often overlooked in advocacy for women in science is the need for male allies. By inviting this broad participation, awareness was brought to issues affecting equity and social sustainability in science and engineering. After the event, male graduate students expressed interest in (by self-report and through email sign-ups) further supporting female scientists on campus and participating in future M-ESWN workshops. Future development events could directly benefit from targeting a diverse audience to increase STEM allies.

As the network is still young, the long-term implications of participation remain to be seen. The workshop series has been renewed for an additional year, providing an opportunity for deeper development and network growth. As the workshop coordinators are graduate students and act on a volunteer basis, the scope of activities is limited by the demands of an already busy schedule. Faculty and other career scientists play an important role in reducing institutional barriers and facilitating development events. While we tout peer networks as a cost-effective solution, further institutional or external resources could help reduce limitations, expand the reach of the network, and track long-term impacts of participation. For example, these external resources could provide multiple interactive training programs to accommodate audiences with different schedules, and could also provide external funding to support specific early career development events involving networking and hiring.

Conclusions

Peer mentoring networks, implemented at foundational career stages, provide a cost effective mechanism to retain and improve representation of women within academia. M-ESWN, a local extension of the successful ESWN peer network, provides a template for targeting issues directly affecting women, providing participants with actionable strategies, resources, and professional development. The approach is limited by event accessibility and volunteer support, but with further development has the potential for broad appeal across disciplines.

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