

FINAL ASSESSMENT REPORT

ADVANCE: *Career Advancement for Women through Research-Focused Networks*

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Erin Leahey & David McBee

with research assistance from Annie Sidransky and Jina Lee

Since the beginning of the ADVANCE grant (NSF Award #1500481) period in 2015, the Association for Women in Mathematics successfully implemented its proposed plans. These plans include organizing and hosting a variety of workshops, including Research Conference Collaboration Workshops (RCCWs) designed to build professional collaboration networks between junior and senior women in specific mathematical sub-fields, as well as shorter (typically one day) follow-up workshops held during annual professional associations meetings. During the grant period, AWM hosted and organized 41 workshops. With a nice mix of both senior women (serving as mentors) and junior women, these workshops seek to support junior women in their mathematics careers and to foster collaborative networks among women working in similar areas. Ideally, these collaborative and mentoring ties decrease women's attrition from the male-dominated field of mathematics, and help women thrive in their careers.

Surveying workshop participants soon after each workshop allowed us to provide formative assessments to workshop organizers. Despite an occasional logistical challenge (technology hang-ups, inadequate room size, not enough time for informal conversations), the workshops were very well received. In general, the participants found the time to be productive and appreciated the collaborative relationships that resulted. One participant in the Women in Shape (WiSH) workshop in 2018 wrote, "I really enjoy the workshops and am always amazed how well the work goes. I cannot explain how/why work, productivity and making connections is so much more efficient at these events than at regular scientific events but it is indeed. It is a real pleasure and fun work atmosphere!" A participant in the Women in Commutative Algebra (WICA) workshop in 2019 had similar experiences: "The atmosphere at the workshop was great. It was much easier to talk with people compared to any other conference/workshop I have ever attended before." A Women in Numbers (WIN) participant compared her 2017 experience to other workshops, claiming "Among all the conferences I've attended with a collaborative research component, this one was significantly better. The group size and group member/project leader made a huge difference, and the overall tone of the conference was supportive." Overall, participants were consistently impressed with the workshops, and found them extremely resourceful, especially before the pandemic moved everything online, making mentoring and collaboration more challenging.

Now that the end of the grant period has arrived, we aim to provide a more holistic, summative assessment of the AWM workshops and their longer-term goals. To what extent have the professional networks, collaborative ties, productivity, visibility, promotion prospects, and professional standing of women mathematicians been enhanced by participation in the AWM workshops? To answer these questions, we collect, code, and compile a wide variety of data from multiple sources.

Data & Methods

For this final report, we took a multi-pronged approach that relied on three forms of data: CVs, Google Scholar; and a final survey. We aimed to gather data from all three sources for each of the 1109 women who had participated in at least one workshop during the 2015-2021 grant period.

First, in summer 2019, we aspired to procure a CV for each woman who had participated in a workshop during the grant period (2015-20). After extensive searching of webpages, we were surprised to find that few mathematicians posted a CV. We were able to download 141 CVs directly off the web, but 108 (77%) were outdated or did not contain all relevant fields. We supplemented this approach with a direct, emailed request for participants to upload a recent version of their CV to a cloud space. Through these approaches, we were able to obtain 233 CVs (21% of workshop participants). During fall 2019, we manually entered information in the CVs into an Excel file. This task was challenging as scholars format their CVs in very different ways, and do not report information consistently. But we gathered time-sensitive information about their position (often academic rank: graduate student, postdoc, Assistant/Associate/Full Professor), the number and dollar amount of grants they had received, the number of invited talks, plenary talks, and other talks they had given each year, and the number of workshops or conference panels they had organized each year. We decided not to code the number of articles the women had published and instead relied on a separate source.

Second, in January 2020, we hired a research assistant with excellent programming skills to search Google Scholar and scrape publication data for each woman who participated in one or more AWM workshops between 2015-2020. With participants' names in hand, she used the Python module 'scholarly' (<https://pypi.org/project/scholarly/>) to retrieve author and publication information and the R package 'scholar' (<https://cran.r-project.org/web/packages/scholar/scholar.pdf>) to extract citation information, all from Google Scholar. From these data we were able to obtain information about the number of articles published annually as well as the number of citations those articles had received to date (but because we only know the cumulative - and not annual - number of citations each article received, the citation data cannot be assessed both pre- and post-workshop, so we omit such data for this report). We were able to retrieve Google Scholar Data for one-third (364) of the 1109 participants.

Third, during winter 2019-2020, we conducted a final Impact Survey sent to all 1109 women who participated in at least one workshop during the six-year grant period. The evaluation team developed the questionnaire with input from the AWM ADVANCE leadership team. We asked for the women to reflect upon how, if at all, workshop participation was resourceful to them and their careers. Topics included mentoring, productivity, quality of work, collaborations, visibility, and leadership opportunities, job opportunities, strategies for dealing with setbacks, idea generation, and confidence. For each topic, we provided space for open-ended responses to allow respondents to provide greater detail and voice their opinions. Our initial reading of these written responses suggested that, in some cases, scholars at different career stages may have different experiences, e.g. junior and senior scholars may have different needs or goals when it comes to networking. Because of this, we note when survey responses vary by academic rank. About half of survey respondents (N = 147) answered at least one open-ended question, providing some rich qualitative examples that help illustrate the quantitative findings.

Despite AWM support and multiple reminders, only 33% (n=299) of participants responded to the final survey. Although 22 AWM networks are represented in the survey, just over half of respondents (52%) associated themselves with six (WIN/ WINE, WIT, Wimb, WiSCon, WiCA, and WinCompTop). Most survey respondents are new to AWM; 42% of respondents reported their first participation in 2019, and only 20% reported participating in AWM prior to 2015. Similarly, most participants (70%) were of junior rank (graduate students, postdocs, or assistant professors) when they first participated in AWM activities. To approximate the academic rank of respondents when they filled out the Impact Survey, we utilized data from AWM workshop surveys for those 263 respondents who had completed both Impact and Workshop surveys. According to these data, an estimated 61% of respondents were junior rank and 8% of respondents had no academic rank at the time the Impact Survey was distributed because they worked in non-academic sectors.

Because there is little overlap in the subsets of women for whom we have data from CVs, Google Scholar, and the Impact Survey (e.g., we have data from all three sources for only 31 (< 3%) women), we analyze the datasets separately. We analyze grants, invited talks, and conference leadership/organizing using the CV data; scholarly productivity using Google Scholar data; and more subjective assessments of collaboration and career outcomes using the Impact Survey data. From our administrative records, we obtained the year during which each woman first participated in an AWM workshop. We merged this variable onto each dataset, and calculated pre-workshop and post-workshop values on the variables of interest (e.g., rate of productivity). The results we share rely heavily on comparisons before and after workshop participation. Our expectation is that the workshops were beneficial to the participants, allowing them to maintain and often improve their professional networks, productivity, grant funded research, visibility, and professional leadership opportunities. Most of our analyses are univariate, but we also note any differences between early and mid/late career stage women.

In addition to collecting data from CVs, Google Scholar, and the final Impact Survey, we pool data from each workshop's survey, and identify the (n=199) women who participated in two or more workshops during the grant period. This allows us to create a panel dataset and analyze change over time in self-reports of many of the career outcomes of interest to us, including productivity, collaboration, visibility, grant funding, leadership activities, and conference participation.

Results

Relationship building

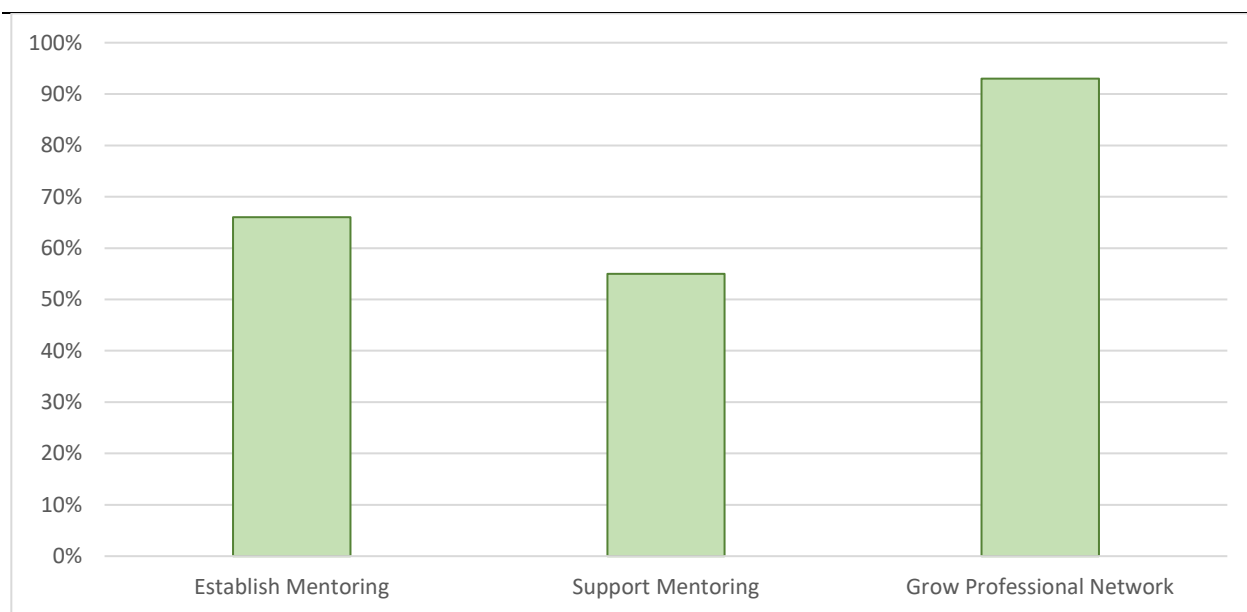
Participating in AWM networks bolstered respondents' professional relationships. Regardless of academic ranks, two-thirds (66%) of Impact Survey respondents agreed that their research network helped them establish mentoring relationships (see Figure 1), and just over half (55%) agreed that those same relationships received ongoing support from their network. One postdoc wrote "My WIMB project leader became a mentor and letter writer for me for my future academic positions. She has also been a wonderful source of wisdom over the years." A non-academic senior researcher stated "I certainly enjoyed becoming mentor for a number of junior mathematicians I met through [AWM area]. I was happy that I was in a position to help them with their careers both by providing advice and writing

letters of recommendation.” Some mentoring relationships have extended into tenure-track positions. In the words of a full professor: “For me, it has been a great mentoring experience. The women in the group are mostly assistant professors. We have been meeting most weeks for about two years.” It is important to understand that mentoring relationships take time to develop. As one participant noted, “My participation was just twelve months ago. I have not had time to develop longer-term mentoring relationships.”

Networking

It is no surprise then that 93% of respondents to the Impact Survey thought their AWM network helped them grow their professional network by making new contacts. This was especially true for junior scholars. In the words of one graduate student, “I joined a research group of mathematicians at different stages of their career, and this helped me a lot.” Another graduate student voiced similar experiences: “I definitely got to know many new professors, postdocs and students during [workshop] in a very accessible and welcoming way. And the ones I already knew, I got to know better. Both are valuable for my professional network.” An associate professor voiced similar appreciation: “I’ve found most value in the opportunities to work with new people and make connections with both junior and senior members of my community. (I hired a post-doc on the strength of her participation in one of my groups.)” A full professor wrote, “Through the [name] research network I continue collaboration with an early-stage researcher. We are joined in our group by two established researchers.” The networks of senior scholars were already large, but participation helped them get to know the next generation of mathematicians and to deepen existing connections.

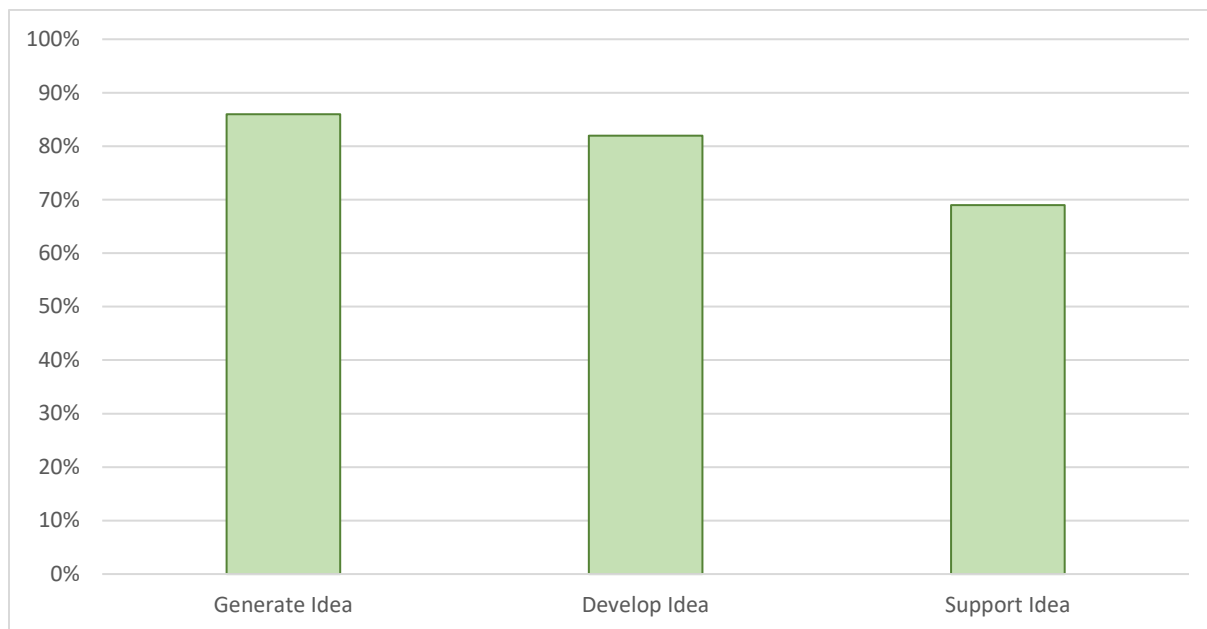
Figure 1. AWM Network Impact on Relationship building (results from Impact Survey, n=299)



Idea Generation

Participation in a research network helped participants with their ideas, as summarized in Figure 2. Almost all women who participated in an AWM network reported receiving benefits towards developing and honing their ideas. The majority of survey respondents agree that their networks helped them generate new ideas (86%), develop their ideas further (82%), and receive support for those ideas (69%). Statistical analyses find that scholars' evaluations for these phases of creativity do not differ significantly across academic ranks ($p > 0.10$), but open-ended comments highlight the importance of encouragement (especially for younger scholars) and gaining confidence to explore new areas (for more established scholars). One graduate student wrote "I am still early in my research career. It was very transformative to be part of a group of more experienced people, as we tackled a problem, developed our ideas, and polished them for publication." Another graduate student had a similar experience, stating "Even when [my] ideas were not so good, I was never discouraged." A postdoc wrote "My mentors always encourage me to have an active role while doing research. They always listen my ideas and ask me to explore [them]." Conversely, an associate professor wrote "I think the questions above are directed more at more junior researchers. What I got out of it was an increased profile outside my usual research area. I got to meet young researchers who may turn out to be long-term collaborators. I got the chance to explore a new topic with a group and gain new ideas for future research." A full professor had a similar evaluation: "The main benefit I would say was to be exposed and connected to people from different topics or alternative career choices. I keep following up with some of them."

Figure 2. AWM Network Impact on Idea development (results from Impact Survey, n=299)



Collaboration

As hoped, participation in the research networks and associated workshops helped women grow their research collaborations. Eighty percent of survey respondents agreed that these networks have helped them identify additional collaborators and form productive collaborative relationships. Of the 199 women who attended two or more workshops, 95% engaged in collaborative research (15% for the first time), and over half (52%) actually increased their number of collaborators. Between women's first and last workshop, the number of collaborators increased, on average, by 3 people (see Table 1). Two-thirds of women (86/132) had more women collaborators after the workshops than they did prior to the workshops.

Table 1. Changes in Collaborators

	N	Decrease	No Change	Increase	Net Difference (Increase - Decrease)
# Collaborators	134	21	42	72	+2.75
# Women Collaborators	132	15	29	86	+2.82

N = 199

Productivity

As hoped, these supportive mentoring relationships and engaging collaborative relationships were quite generative. In general, we find that rates of research productivity increased after women joined a research network. When we compare rates of annual productivity¹ before and after first workshop attendance using the Google Scholar data, we find that rates increased for almost 75% (151/205) of the participants! Thus, even though forging new collaborations – including new topics and new relationships – takes time and energy, it appears that it truly paid off for most participants.

Responses to the Impact Survey corroborate this finding. As indicated by Figure 3, most respondents (73%) agreed that participation in their research network helped them publish more research; this was particularly true for younger scholars. One graduate student wrote "It was very transformative to be part of a group of more experienced people, as we tackled a problem, developed our ideas, and polished them for publication" and another thought that participation "helped me publish more." A post-doc agreed: "I believe that working with my [AWM area] team has been increasing my research productivity." But statistical analyses suggest that as academic rank increases, scholars express greater disagreement about the positive impacts of their participation on publishing quantity ($b = -0.12$, $p = 0.02$). This is likely because more senior scholars have other main projects in progress, and their participation is likely more taxing as they teach, mentor, and help younger scholars learn the craft of publishing. For example, one associate professor enjoyed her experience, but wrote that "ultimately

¹ Although during our search in January 2020 we found Google Scholar profiles for 364 participants, many of them are young scholars who only started publishing recently, and/or took their first workshop only recently, resulting in only 205 participants for whom we could collect data on productivity both pre- and post-workshop. Many of the more senior women have published quite a bit before they participated in their first workshop, so it wouldn't be fair to compare levels of productivity before and after workshop participation, especially given that workshops took place (2015-2020) so close to our Google Scholar data scraping effort (in January 2020). Instead, we calculate annual rates of productivity (number of papers published per year).

the [AWM] project(s) I've participated in are distractions from my main research focus." A full professor also found her participation to be distracting, stating "The paper coming out of the [AWM area] workshop... has got[ten] in the way of finishing projects that I regard as more important." But in general, three-quarters of participants saw an improvement in their productivity.

Figure 3. AWM Network Impact on Productivity (results from Impact Survey, n=299)



Heightened productivity is also evident among the subset of women who participated in two or more workshops (n=199). When we examined changes in their publication activity (which they self-reported via a survey after each workshop), we find that 73% of them maintained or increased their rate of article submission to journals (56% maintained, and 23% increased). On average, the women submitted half a paper more per year after participating in the workshops. This is a vast improvement from what we found in the 2017 summative report, where we found little change over time in the number of papers submitted to a journal (mean difference=.06, range=-4 to 3). We see improvement not only in submissions but also in publications. Over three-quarters (78%) of the women increased their annual rate of publication. On average, the women submitted one-third of a paper more per year after participating in the workshops (the mean difference in number of articles published is 0.34). This, too, is a remarkable improvement over what we found in 2017, when the mean difference was zero.

In addition to greater quantity of research, over half (53%) of respondents to the Impact Survey noted that AWM participation improved the quality of their research. Statistical analyses reveal that (unlike research quantity) the benefit of research quality was experienced equally across academic ranks ($p > 0.10$). For example, one post-doc stated "I believe that working with my [AWM area] team has been increasing my research productivity and my publications are stronger." A full professor had similar outcomes, writing "So far, [I have published] five published papers (in very good journals) and I expect more to come, as we keep working."

Grant funding

Analysis of the CV data also reveal that workshop participation helped some women increase their grant activity. Here we analyze the 211 women for whom we have CV data both before and after their first AWM workshop. Twenty-four women with grant-getting experience before the first workshop increased their rate of grant activity afterwards (as indicated by the number, not the dollar amount, of grants they received). Of the 77 women who had no grant experience prior to their first workshop, 14 (18%) later secured their first external grant for research. This is quite impressive, given the lead time needed to develop successful grant proposals.

When we restrict our analysis to the women who attended two or more workshops (n=199), we also see some increased grant activity. Note here that we did not collect data on number of grants, or dollar amount of grants; we only distinguish between having and not ever having funding. Compared to reports after their first workshop, 79% of women were able to maintain their external grant funding and 12% of women were able to secure external grant funding for the first time.

In their response to the Impact Survey, several scholars discussed submitting applications and receiving awards for grants and funding. One participant stated that her project group has “completed a successful AIM SQuaRE (and) are in the midst of a second AIM SQuaRE, and have a NSF grant together. A participant in WINE stated that her group “... has certainly helped me professionally (in terms of senior women supporting my grant and job applications, although I don't know yet whether these were successful).” A participant in WIMB wrote, “I have already organized a mini-symposium with a collaborator from my workshop group, given a talk in a session organized by another group member, obtained external funding for multiple follow-up collaborative visits, and have continued meeting virtually on a regular basis with my group.” A fourth scholar was hopeful about branching out from her collaboration, writing “I think that some members of the group will collaborate on related topics in the future. ... We have several common interests, which could lead to joint international supervision and funding applications.” But one scholar noted that, for her group, “It has been more difficult to talk about grants, fellowships, and money in general, which can sometimes be a sensitive subject.”

Invited Talks

Invited talks are an indication of national and often international visibility. To what extent did workshop participation help women gain such prominence in their field? Analysis of the data we coded from women's CVs reveals that 17 women received their first invitation to give a research talk after participating in an AWM workshop. For example, one woman was invited to give a talk at Princeton University, and others gave their first talks at the International Conference in Mathematical Neuroscience, ICERM, Colorado State University, and USC. Of the women who already had such experience (n=189), half (94) gave more talks per year after workshop participation. When we restrict invited talks to participation in the highly visible plenary sessions at conferences, we also see gains: 28 women gave more plenary talks per year after joining the research network and participating in the associated AWM workshop. It appears that participation in the research networks and associated workshops has helped women mathematicians become known and visible enough in their research

areas to receive a coveted invitation to present their research at a national conference plenary session or another university's colloquium series.

An increase in women's visibility and prominence is also evident when we analyze survey responses from the women who participated in two or more workshops during the grant period. All but two women were invited to present their research at some point between the workshops, though the type of talk varies. We also find that the number of invitations has increased on average. Table 2 shows the more than half of women received *more* invitations to give talks at department colloquia, conference sessions, and even plenary sessions.

Table 2. Changes in Speaking Invitations

	N	Fewer Invitations	No Change	More Invitations	Difference (More – Fewer)
Plenary Session	81	10	29	42 (52%)	0.53
Colloquium	143	16	42	85 (59%)	0.76
	123	17	42	64 (52%)	0.53

(Percentages may not sum to 100% due to rounding error or missing data.)

Involvement in professional organizations

Although not as prestigious as invited talks (and typically considered service work), helping to organize sessions at conferences is also an indicator of visibility, as scholars are typically invited to do such work based on their research expertise. In this realm, too, we see some gains. Of the 211 women for whom we could glean this information from CVs, almost one-third (66) had increased their rate of conference session organizing after participating in their first AWM workshop.

Enhanced opportunities for engaging with professional organizations is also evident from the sub-sample (n=199) of women who participated in two or more workshops. Almost all (92%) of women helped organize sessions for their professional organization(s), some (23%) for the first time. Most (86%) were able to maintain their leadership position in professional organizations, and 12% were able to obtain a leadership position, likely for the first time in their career. This, too, is a vast improvement over what we reported in 2017, when most women (94%) saw no change in leadership roles between their first and last AWM workshops. Examples of leadership position include:

- President, Association of Women in Mathematics
- AWM executive committee
- Chair of AMS committee
- MAA committee on Minority Participation
- 2nd vice president, IEEE Inform Theory Society
- President, Women in Math Chapter at SJU
- Steering Committee and Secretary for Society of Computational Geometry
- Editor in Chief, Journal of Combinatorial Theory, Series A
- Steering committee of European Women in Math
- Statistical Society of Canada, Section of Education, President Elect

IAS AMIAS Board of Trustees
Elected member of the Executive Committee of Mathematical Council of the Americas
AMS Associate Secretary
AMS Notices Editorial Board
Chair of WIN steering committee
Board of trustees of Swiss mathematical society

For many scholars, participating in AWM networks and workshops bolstered their professional involvement. In reference to her AWM workshop, one scholar wrote "This was one of the first big events I've helped organize and it taught me a lot." Another claimed it facilitated her promotion, writing "For WIN, I organized several conferences and led project groups at others. I obtained funding. I worked on several long-term collaborations in areas that were new to me. All of these activities helped me when I was applying to be a full professor, or finding topics to give talks about." One scholar effectively repurposed her workshop contacts to support her professional involvement, writing "The WiSDM at ICERM was just one-week long, but I maintain contact with some people afterward for organizing symposiums and special issues." This was echoed by a scholar who saw "several women" who "moved to leadership positions. I see many of the younger women who have been involved in the WIM series step up and organize mini symposium at JMM, Society of Math Biology, and SIAM meetings."

Visibility

In addition to (or perhaps because of) invited talks and session organizing efforts, many women reported that their visibility in the field was boosted by participation in the AWM workshops. Regardless of rank, three-quarters of respondents to the Impact Survey noted that participation increased their visibility in their field (20% did not perceive a change). One graduate student clearly gained professional visibility, writing: "I had the opportunity to work closely with a faculty member, which, fortunately, is actively organizing different events from mini-symposia to summer schools. I participated in many of these events, and as a result of them, I may say the community knows my name and my work." A non-academic wrote "I think that working with this group of women has given me higher visibility in my field, and people outside of my field recognize me more as a researcher for having participated in group research." The gains were less notable for some senior scholars; for example, one full professor wrote, "I was already visible, I think. Also, I publish regularly." At the end of this report, we discuss how the workshops enhanced women's visibility in the field more generally.

Job offers

Connections, mentorship, increased productivity, and heightened visibility helped many younger participants get jobs. One graduate student wrote "The work relationships developed during that workshop were so strong that we are still working together. I am sure they will improve my probability of getting a postdoc position in the future." Another graduate student wrote "I plan to ask my group leader for a letter of recommendation for my career move from graduate student to postdoc." Two postdocs had similar positive experiences. One wrote "The [named] research network has immensely

furthered my career, and I have no doubt that it helped me get the tenure-track job that I'll be starting this fall." The other contributed "My collaboration has included getting to know leaders in our field much better, which has definitely been beneficial to me this past year on the job market." One Assistant Professor agreed that "participation has improved my CV, and helped me get a tenure-track job." However, more established scholars – who are generally less mobile – were less likely to benefit from workshop participation in this way. For example, one associate professor wrote "While I really believe in the roles of the research networks, I struggle some with the huge time commitment that they are. I skipped the most recent meeting of my research network to give more time to developing my research program."

Promotion

Career progress of participants is also apparent in their rates of promotion. From the CVs we were also able to gather annual information about each woman's academic rank: graduate student, post-doc, assistant, associate and full professor. When we combine this information with year of first workshop attendance, we find that almost one-quarter (57/233) of women were promoted after workshop attendance. Among the 54 women who were assistant professors when they attended their first workshop, 12 were promoted to associate professor at some point after that workshop. From this we can glean that the workshops were likely beneficial, but of course successful tenure cases are years in the making, and one must go up for tenure on a strict timeline. This is not the case for promotion to the next rank, however. So when we find that over one-third (11/32) of associate professors were successfully promoted after attending their first workshop, we feel more certain that the workshop benefit women's networks and careers and contribute to their career progression and success.

Respondents' attitudes regarding the benefit of the AWM network for tenure were mixed, largely because of variation in the quality of publications that resulted. One scholar wrote positively, "I recently got tenure at my institution. The publications that I got from the workshop were very important to that process." Another also described the benefits of participating. She noted, "The WIMM leaders gave gentle pushes towards publications and kept accountability for timelines. This helped me stay focused on the tenure process which requires publication. This specific publication will be used in my next portfolio towards full professorship." However, other scholars described their AWM workshop publications as being of lower quality or being perceived as less-relevant contributions to their field. In the words of one scholar:

I got (several) papers out of WIN(E), but partly because of the short deadline for submission, these papers were not as good as they could have been. (...) Publications in the WIN(E) conference proceedings are not valued as highly as papers in journals. If I'd not been working on WIN(E) papers, I would have had more time to focus on my other research. (...) I am quite optimistic that the WIN(E) projects will end up being time well spent in terms of my long-term research output. WIN(E) has certainly helped me professionally (...) and listing my WIN(E) activities certainly helped with my recent promotion case.

An assistant professor mentioned similar perceptions of quality in her comments: "Writing a [AWM area] paper can take a lot of time, especially if some co-authors aren't putting in their share of the work.

In the end, it generally gets published in a conference proceedings. I was specifically told that my [AWM workshop] papers didn't really "count" towards my tenure case."

Role Fulfillment

Most respondents (79%) thought that participation in their research network increased confidence in their "ability to successfully fulfill the roles and competencies of their profession." Only a handful (3%) thought otherwise. However, regressing role fulfillment on academic rank shows that seniority is associated with lower levels of fulfillment ($b = -0.08^*$). This aligns with our expectations; to achieve their status, senior scholars were more likely able to fulfill their professional roles prior to their AWM involvement, compared to junior scholars. In the words of one postdoc, "working on the project (and subsequent projects) that began at the workshop gave me confidence as a graduate student to continue to pursue research." Another postdoc wrote:

Before the workshop I had given up on the idea that there was a place for me in Mathematics. After my PhD I took a postdoc in [an area] hoping I could still make a place for me in the research world doing mathematics outside of my community [where I] never felt welcomed. The [AWM] workshop changed all that. The work I have started doing there and being heard and recognized for my value was life changing. Being in a room with [eight] other brilliant mathematicians and being treated as an equal has shown me that I might still have value as a mathematician and I don't have to sell myself as a coder anymore just to be able to do what I love in my free time.

The full professors, by contrast, expressed long-standing confidence emanating from years of experience and past accomplishments. In her open-ended response, one full professor wrote "I was already very well established and had participated in [a network] before the AWM support began." Another stated "I have other networks that contribute to my confidence." A third wrote "I felt very positive about [my first AWM] experience and decided to be again one of the leaders. It was another really good experience. I am looking forward to co-organizing. I feel quite confident in organizing and working with a group."

Final reflections

At the end of the survey, we asked respondents to reflect on how AWM ADVANCE activity - beyond their personal participation in it - may have influenced their field or subfield more broadly. Although a few respondents said "it's too soon to tell" or referenced the challenges of the pandemic, most open-ended responses were overwhelmingly positive.

Respondents noted an increase in the sheer number of women in the field. One scholar expressed her enthusiasm as follows, "Absolutely – this has increased the number of women in the field. It has given me ideas of lots of young women researchers to invite for talks, and more senior women to propose as potential hires." Another scholar wrote, "I think the WIN workshops have had a powerful effect on the field of number theory. I have noticed the increase of conferences and special sessions organized by

women and highlighting talks by women from the network.”

Beyond sheer representation in the field, there was broad agreement that AWM ADVANCE “improved the visibility of women” mathematicians. As one full professor noted: “I have witnessed more women giving talks. I also witnessed some of the women from the workshop working with a broad coalition of mathematicians to organize a virtual conference for young mathematicians that was very proactive about inclusivity more broadly (women, minorities, LGBTQIA).” One assistant professor noted that her AWM network “has done a phenomenal job of drawing attention to women researchers” and a full professor stated that “it is absolutely clear that the existence of these research networks has greatly increased the visibility of women mathematicians,” for example, there “were more papers published and more talks given by female speakers.”

A younger post-doc shared similar observations:

Recently at the ICERM there was a workshop on [...], a topic which has a large overlap with the research interests of [my AWM] network. I was pleased to notice that a lot of members of [my network] were invited to the workshop and a few of them were speakers. Overall the participant list looked very close to 50-50 split between men and women, and there was an especially strong representation from junior female faculty. Even if the event was not directly connected [to AWM], I feel like the existence of the [AWM] network has influenced and helped creating an expectation for better representation of women at national events, such as these.

An established scholar described how things have changed over time:

Even a generation ago, there were only a handful of women in my field; now there are dozens who are invited to give talks and who publish and shape the community. Many people have commented on how the research conferences have shifted to much more welcoming environments with the introduction of women into the research sphere.

Beyond the presence of more women, respondents noted that women are moving into leadership roles and their influence (especially on younger scholars) is being noted. For example: “I’ve noticed that more women are serving in leadership positions” and “Indeed the number of keynotes delivered by women is notably higher than ~6 years back. Some of the speakers are referred to as a pioneer/influencer in their field”. One mathematician at an undergraduate institution said that “two of my undergraduate researchers have gone on to PhD programs...they have both mentioned the impacts of having female role models.” The AWM ADVANCE research networks have also brought attention to the work of women, especially young women. This is often attributed to collaboration with more senior women in the field. One associate professor wrote: “I have noticed more women “pop up” in my field, largely through the work they do with more established women who then promote their younger collaborators.”

This enthusiasm was tempered by an understanding that room for progress remains. As one respondent noted, “Yes, I have witnessed more women giving invited in talks. However, I would like to see that number to increase in the coming years.” Similarly, another scholar wrote, “I see progress, in terms of more women giving talks etc., but I also see that we have a long way to go.” In contrast to the perceptions expressed above, one scholar was more skeptical, writing, “I am not sure whether more

women are giving invited talks. There are certainly still instances of conferences with few or no women speakers. These conferences prompt pushback.” Finally, one respondent expressed the need for talks to include a wider range of female speakers, “...there are several high-profile women who give invited talks, but there are many more women who are very capable of giving talks who are overlooked.”

At this point it should be patently clear that the AWM networks are transforming the gendered nature of mathematics. Beyond helping women, especially young women, in the field make connections, “feel more comfortable at conferences,” and jumpstart research collaborations, the AWM ADVANCE workshops seem able to foster such field-level outcomes in two ways. First, they “develop an ambient sense of ‘community’” that goes beyond individual mentoring and collaborative relationships. Second, it is normalizing gender balanced programming to such an extent that people are noting and publicly discussing instances of imbalance. For example: “Over the last years people are taking more care of diversity. Having very few female invites speakers at a conference will lead to vocal complaints, for example. Ten years ago I didn't hear anyone say that out loud”. And another mathematician notes that “There are still conferences with all-male speakers or program committees, but now the [my AWM network] steering committee can point this out and direct organizers to [our] network for women speakers.”

Conclusion

It is patently clear that there have been deep and far-reaching returns to the investments that NSF and the Association for Women in Mathematics have made in the research networks. In addition to the individual survey data collected after each workshop, the data collected from women’s CVs, Google Scholar, and a final Impact Survey demonstrate that the research networks, while young, have already influenced many women’s careers for the better. Especially after the initial RCCW workshop, each research network was able to cohere and connect in ways that helped women mathematicians receive guidance and mentorship and general career support, and develop new collaborations. These collaborations are already starting to pay off. Analysis of survey and Google Scholar data reveal that rates of journal submission are up, as are rates of publication. Analysis of survey and CV data reveal that women are progressing through the ranks, getting promoted, securing more research grants and external grant dollars, and becoming more visible in their scholarly communities through deep engagement with (and leadership positions in) professional associations.