

ENGAGING MORE WOMEN IN ACADEMIC INNOVATION: FINDINGS AND RECOMMENDATIONS

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Diversity is a key driver of innovation and a critical component of success on a global scale. Countries that deploy strategies to foster greater inclusion of all inventors in the innovation lifecycle will ultimately be best positioned to maximize their gross domestic product and ensure economic prosperity. The U.S. is losing ground because it is not fully engaging a significant portion of the inventive talent pool. According to a 2019 report from the U.S. Patent & Trademark Office, the share of women among all U.S. inventor-patentees is only 12.8%.

In an effort to understand factors that encouraged and discouraged academic women's participation in technology commercialization, a group of Technology Transfer professionals conducted a survey of academic women involved in innovation, invention and/or entrepreneurship. The 168 respondents were from public and private research institutions of varying sizes from all regions of the United States. This paper outlines the key findings from the qualitative and quantitative data around the themes that emerged. It also puts forth a set of recommendations based on the survey feedback, follow-up interviews, and the collective experience of Technology Transfer professionals who work daily with academic innovators. It is our hope that these recommendations will provide valuable insights into concrete actions that can be taken to ensure systemic changes that foster greater engagement of academic women and other under-represented populations in all stages of the innovation lifecycle.

Key words: Innovation, Inclusion, Women, Academia, Engagement

BACKGROUND

Diversity is a key driver of innovation and a critical component of success on a global scale (1). Countries that deploy strategies to foster greater inclusion of all inventors in the innovation lifecycle will ultimately

be best positioned to maximize their gross domestic product (GDP) and ensure economic prosperity. The Equality of Opportunity Project analyzed the lives of over a million inventors in the U.S. and found that innovation in the U.S. would quadruple if women,

Accepted: January 1, 2022.

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people of color, and people from low-income families invented at the same rate of groups who are not held back by discrimination and structural barriers (2). The U.S is losing ground because it is not fully engaging a significant portion of the inventive talent pool.

The 2019 U.S. Patent and Trademark Office (USPTO) Progress and Potential findings reported the women inventor rate (WIR) (that is, the share of women among all US inventor-patentees) grew from 12.1% in 2016 to 12.8% by 2019 (3). While this was an improvement, it is a far cry from parity considering that women make up nearly half the workforce (4).

A recent report by the Institute for Women's Policy Research (IWPR) (5) notes that in 2019 only 21.9% of patents had at least one woman inventor. This is up only slightly from 2016 and at the current rate of progress, women will not reach parity in patenting during the 21st century.

According to AUTM's (the Technology Transfer professional association) 2020 survey data (6), participating U.S. universities and research institutions expended over \$83 billion on research, received 27,112 invention disclosures, and filed 17,738 new U.S. patent applications. It is the role of Technology Transfer professionals associated with these institutions to manage the complex process of shepherding those ideas from the lab to the marketplace — from evaluating and protecting discoveries to commercializing the inventions through new and existing companies.

Recognizing the lack of women participating in the process, a group of senior technology transfer professionals came together at the 2013 AUTM annual meeting to discuss what they could do address the disparity. Collectively, these professionals had hundreds of years of experience working with university innovators, companies of all sizes, and entrepreneurs starting new ventures. Because of the pivotal role that they and their colleagues in the Technology Transfer profession serve in technology commercialization, they recognized they were uniquely positioned to identify and implement actions that could be taken to foster greater inclusion in the process. The group coalesced as the AUTM Women Inventors Committee and is now known as the AUTM Women Inventors

Special Interest Group (WISIG).

Since 2013, numerous entities around the world have recognized this gender disparity and research has been conducted that substantiates and quantifies the initial observations of the WISIG. The USPTO (7), the World Intellectual Property Organization (WIPO) (8) and the Institute For Women's Policy Research (IWPR) (5) have quantified the lack of representation of women in the patenting process. Research done at Osage University Partners (OUP) has quantified the lack of women founders in university-based startup companies and found that, of the more than 6,000 university startups in the OUP database, only 11% had a female founder or co-founder (9). Crunchbase has quantified the lack of venture capital funding invested in women-led startups and shows it actually declined in 2020 to 2.3% (10).

Awareness of the lack of inclusiveness in invention and entrepreneurship is now at an all-time high and significantly more attention is being given to identify and implement approaches to address the problem. Recognizing the changing landscape and wanting to be intentional without being duplicative of existing resources, the WISIG decided in the Spring of 2020 to conduct customer discovery to help guide their future efforts. The goal of the customer discovery was to understand factors that encouraged and discouraged academic women's participation in technology commercialization at their respective institutions. Additionally, they wanted to better understand the barriers that impede female participation so they could engage with the Technology Transfer community and other synergistic groups to further address and reduce those barriers.

Methodology

The WISIG formed a task force to develop the methodology for a survey of female academics who had participated in some level of innovation, invention, or entrepreneurship. The task force members were experienced Technology Transfer professionals giving them a unique ability to identify and reach out to women who fit this demographic. The members of the task force compiled a list of names they knew personally and augmented that by engaging AUTM members who served as Directors of Technology Transfer Offices (TTOs). The task force recognized

that a request coming from within the innovators' own institution would be most likely to garner a response.

Female innovators from public and private research institutions of varying sizes from all regions of the United States were invited to complete the survey. The goal was to achieve representation from various levels of professorship and from different races and ethnicities. Developing a list that identified these variables proved challenging primarily because of lack of access to this data. It was decided to make this information an optional question on the survey and hope for diverse representation among respondents. A goal of fifty responses was established as realistic and sufficient to provide meaningful results.

The task force crafted a questionnaire that consisted of multiple-choice questions, ranking questions, and open-response questions. The survey also captured demographics with the intent of learning how respondent's experiences varied based on their academic position and/or ethnicity and race.

The survey was launched the first week in November 2020 and participants were given a November 20th deadline to respond. The survey exceeded expectations generating 168 responses. The task force evaluated responses to identify key takeaways and common themes.

The survey also asked the participants if they would be willing to speak with a member of the task force to discuss their experiences in a follow-up interview and sixty-eight of the respondents volunteered. Additional questions were created to delve further into the common themes that were identified in the survey responses. Of the 68 women who originally volunteered, 16 were subsequently interviewed. Follow-up interviews reinforced many of the findings from the original survey and provided expanded insights for the recommendations put forth in this paper.

Demographics of Survey Participants

Survey participants included 166 academic women from across the U.S., and two outside the U.S., from public and private institutions of varying sizes. Respondents had varying levels of experience, ranging from undergraduates new to the process to tenured faculty with decades of innovation and

patenting experience. While the initial plan was to only include faculty, we decided to include all participants to increase the types of experiences and hopefully expand our insights. Since the goal was to understand factors that encouraged and discouraged academic women's participation in technology commercialization, questions were framed around the respondents' experiences at the time of their first invention. The majority were at various levels of professorship (60%) with the remaining being post-doctoral research associates and graduate students (28%) and other (12%). The majority of respondents were Caucasian (73%) followed by Asian (18%), Hispanic/Latina (5%), and Black (2%). As a result of the lack of representation from non-Caucasian and non-Asian respondents, insights on the intersectionality of experiences and race were inconclusive.

Key Findings

The survey contained an open-response question to which 60 respondents shared additional feedback about their experiences. Those responses were analyzed and categorized into one or more of the following themes:

- Training, information, and resources
- Mentors, role models and networking opportunities; people guiding them through the commercialization process
- Interactions with the Technology Transfer Office
- Lack of time and conflicting priorities
- Funding to conduct research and development
- Discrimination and bias

The following are the key findings from the qualitative and quantitative data around the themes that emerged. The quotes notated throughout this document are taken from those responses.

Finding #1 Almost all respondents who participated in technology commercialization efforts were motivated to do so because they wanted to see their research applied in the real world. Other key drivers included compliance with university policies, the search for additional resources for research and development, and potential connections to outside collaborators and industry.

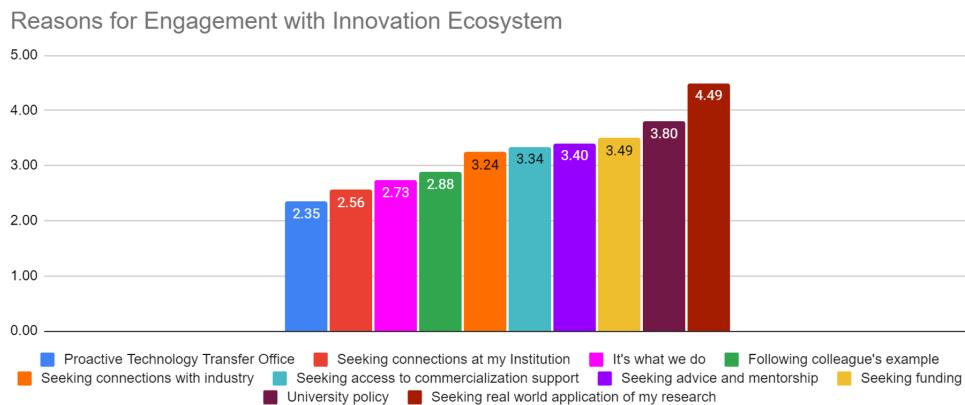


Figure 1. Responses to multiple choice question in survey asking participants why they chose to engage with their innovation ecosystem.”

“Getting a technology out into the world to save lives is really really rewarding.”

A key component to engaging more women in the inventive process is to understand the motivations of women who have elected to participate. The survey explored this by asking participants to score (from 1 (least important) to 5 (most important)) the importance of a prescribed set of eleven reasons as to why they engaged with their university’s innovation ecosystem (by disclosing their invention, taking an entrepreneurship class, etc.) Their responses provide keen insights into developing more effective outreach efforts.

The primary reason respondents engaged was their desire to see their research applied in the real world (Figure 1). This is consistent with research that suggests women are intrinsically more altruistic than their male counterparts (11).

A significant majority rated following university policies obligating them to disclose was an important factor. This correlates with research that demonstrates women have a significantly higher tendency than their male counterparts to follow the rules (12). It is also worth noting that any potentially patentable research discovery generated from federal funding requires disclosure per the terms of the funding

agency.

Over half of the participants indicated they were motivated to participate to explore additional resources for research and development funding. Without funding, it is difficult to conduct the research that generates patentable new discoveries. Funding is also typically a consideration in tenure and promotion for both male and female faculty providing an added incentive to seek it out.

“Initial funding was the biggest gap then and it’s the biggest gap now.”

Respondent comments about difficulties in accessing funding for research and development, patent prosecution, and lack of access to investors were relatively evenly distributed among full professors, assistant professors, post-doctoral associates, and graduate students.

Approximately half of the respondents were motivated to participate to find industry connections and potential outside collaborators.

Less than half of the respondents participated because someone encouraged them or because they were following the advice or example of colleagues. The ranking of importance on this question could be construed in several ways. One could interpret this as simply not an important factor motivating

respondents to participate. Alternatively, it could be interpreted that they didn't have the benefit of a mentor encouraging them. Because many of the open response questions referenced the desire for and importance of mentors, the latter is arguably the more likely interpretation.

Similarly, proactive outreach by the TTO was not seen as a motivating factor. It is unclear if this was not relevant to their decision to engage, if it didn't happen, or if they simply weren't aware of outreach. The question also did not differentiate between outreach by the TTO directly to the female faculty or outreach regarding educational programs being offered to all faculty.

The remaining choices that did not seem important motivators included university culture supporting innovation, and connections to collaborators and expertise within their institution.

It is worth noting that the all-female task force, although well-informed about royalty streams from licensed inventions and the value of equity in start-ups, inadvertently did not include personal monetary benefits as a reason to engage on this survey question. Therefore, we cannot conclude whether the potential for monetary benefits was a motivation for respondents to participate. During the review process, it was a male colleague who brought this to light.

Factors mentioned in the open response questions that were a deterrent to participation in innovation

“Time is the biggest issue holding me back. This is especially true as I try to combine this with getting tenure and having/raising kids (oh, and now a pandemic).”

included time constraints and conflicting priorities. Responsibilities such as teaching, administration, publications, and the need to successfully attain grant funding to get tenure and promotion take priority over commercialization activities. These constraints exist for male and female academics but are more pronounced for women because of their typically larger proportion of time spent on household responsibilities. Assistant professors (44%) and postdoctoral associates and graduate students collectively (38%) represented the majority of comments related to time, motivation, and conflicting priorities.

Finding #2- Approximately two-thirds of respondents were aware of technology commercialization training programs at their institution, and three-quarters of those who were aware participated. Slightly fewer were aware of entrepreneurship training at their institution, however, considerably fewer (only approximately half) of those aware did participate. Respondents who participated in both types of training programs considered the training to be helpful.

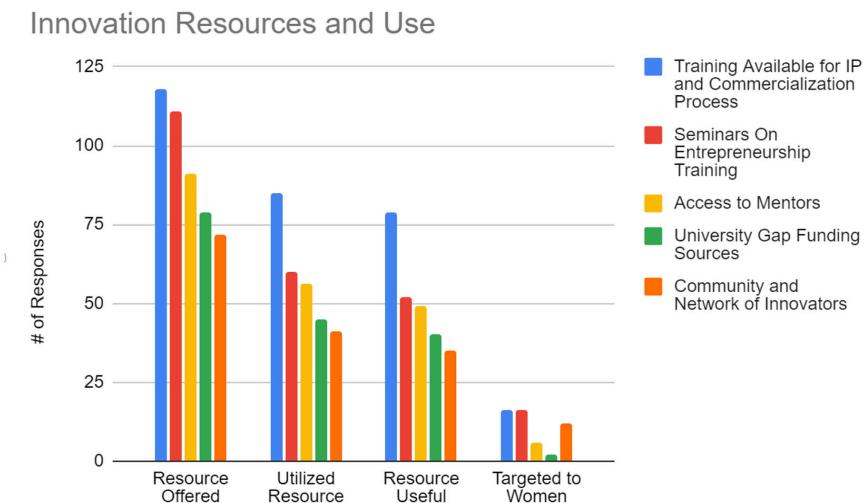


Figure 2. Survey results depicting the knowledge and use of resources typically offered by commercialization offices at institutions.

"I think learning about the commercialization process as a graduate student demystified it for me early on and enabled me to file additional IP, acquire more licenses, and found a company later."

"The various trainings that I have attended have been invaluable, but again, I think that somehow these need to "reach" more faculty, grad students, and postdocs, particularly women who might not see themselves as entrepreneurs or innovators."

Collectively, the most frequently referenced topic in the open response questions was the need for training on commercialization, intellectual property, and entrepreneurship related topics. These comments were cited most often by those early in their academic career at the assistant professor level (26%), followed by postdoctoral associates and graduate students, collectively, at (42%).

Specifically, a key barrier to respondents' participation in innovation was their lack of knowledge of intellectual property and the commercialization process. Associate professors and staff scientists made the most comments related to Intellectual Property Policies (33% from each for a total of 66%), followed by assistant professors and post-doctoral associates at 17% each.

It is important to note that all survey respondents had been involved with innovation, invention, or entrepreneurship within their respective institutions. It is reasonable to assume therefore, that they are more aware than other female faculty of the technology commercialization and entrepreneurship training programs available to them and have a greater incentive to participate (Figure 2). Therefore, it was no surprise to the task force that that 70% (118) of respondents were aware of training on technology commercialization and that 50% (85) participated in that training. Similarly, 66% (111) were aware of entrepreneurial training however, only 36% (60) participated in that training.

It is interesting that fewer respondents were aware of or participated in entrepreneurial training

programs. This could be due to the lack of entrepreneurial training programs being offered by their institutions, the lack of awareness of such training programs, or the unconscious biases held by women wherein they don't typically self-associate as entrepreneurs and therefore disregard these programs as training not intended for them. Women tend to be more risk averse than their male colleagues and entrepreneurial activities are seen as a high-risk activity (18).

Another possible explanation is that women were participating in technology commercialization activities at their institution for the altruistic motivation of seeing their research applied to help people. Conversely, among academics, participating in entrepreneurial endeavors has historically been seen as "going to the dark side" or "selling your soul" (19).

"I think building a dedicated career stream for basic science academics to venture into the innovation and commercialization space would be great."

Those who had received some level of training believed it was very helpful and frequently credited it for much of their success. The NSF I-Corps training was referenced multiple times and was considered extremely beneficial as were several programs targeted specifically at women in innovation (20).

Finding #3 - Academics look to their tech transfer offices for training on technology commercialization.

"I don't really know a lot about what resources are available or how to access them"

"My institution doesn't advertise these programs very well if they exist."

"Even if resources are available, they are hard to find. Also, even if you find them, it is hard to attend them as a full-time faculty."

Again, since the participants surveyed had all been involved with innovation, invention, or entrepreneurship within their respective institutions, it is reasonable to assume they would have a much greater awareness than most female faculty of their TTO and the training programs and resources offered. For this reason, it is not surprising that the majority of respondents would look to the TTO to provide that training.

However, there were numerous comments made from respondents who were not aware of training programs at their institution (if they existed), or how to find resources to help them through the process demonstrating a need for better outreach and potentially more resources.

Finding #4 - The majority of respondents felt they had a reasonably good understanding of the commercialization process.

More than half (57.8%) of the survey respondents indicated that they had a good understanding of the commercialization process because of access to resources and training provided by their institution. This is in direct contrast to findings from the 2021 Gender and Racial Diversity in Invention & Patenting report (5) by the Institute for Women's Policy Research which stated:

- Women reported not understanding what constituted an invention.
- Women reported a lack knowledge about where to go for information on patenting.
- Women said they were often confused about the basics of the patenting process.

A possible explanation for the difference in these findings is that the criteria for participating in the WISIG survey was to be an academic woman with some level of involvement in innovation, invention, or entrepreneurship. Therefore, with involvement comes knowledge of the process. Additionally, since, 60% of participants were at various levels of professorship, the majority of respondents were well-established in their career path, making it more likely that they had above average participation in the commercialization process and thus above average understanding of it.

From our follow-up discussions, many women reported an initial inability to find the knowledge and support they needed and therefore had to self-educate

at the start of their innovation journey. This finding reinforced our earlier assumption that experience resulted in expanded knowledge of the process and emphasizes the importance of early exposure and experience for female innovators.

Finding #5 - Fewer than 10% of respondents were aware of any training, mentoring programs, or other resources specifically targeted at assisting women in the commercialization process.

"Looking back, our advisor/partner at the university Innovations office is a woman supporting our all-woman entrepreneur team. I think our shared gender, and her confidence in our ability to try a LOT of new things, has been central to our moving forward with trademarking, launching our business, getting good industry advice, etc."

Fewer than 10% of respondents were aware of training programs or resources geared specifically for assisting female academics with technology commercialization related activities. Programs and resources designed for women foster greater participation by providing a more welcoming and inclusive environment and are not hampered by the gender specific socio-dynamics that typically take place in gender-mixed environments. Examples include men typically leading a group while women typically assume the role of note taker or secretary.

The most frequently cited topics that would be helpful with respondent's innovation endeavors were related to training and mentoring, with a few comments that specifically referenced gender specific training. Numerous comments were made about the desire for a female mentor.

Finding #6 - Mentorship was referenced repeatedly in the open-response questions as something respondents wished they had access to and felt would be helpful in engaging in commercialization activities.

Mentorship was the second most frequently referenced topic in the open-response questions. The majority of assistant professors, post-doctoral

“The availability of mentors I believe was the most meaningful thing (colleges, institutes, and start-ups) have done to help.”

“A member of our faculty was my mentor and that example was key.”

“It was helpful to have a woman as a mentor or in the meeting as often, I am the only woman with older white males except the assistant.”

decide which of these patents that do get issued will be maintained by paying the maintenance fees throughout the life of the patent.

Comments made by survey respondents about their TTOs were evenly split as to the helpfulness of the TTO staff. Approximately half of the comments were made about the “exceptional” assistance respondents received from the TTO staff. Many stated that without the TTO’s assistance they would not have been able to navigate the process. It is worth noting that respondents who commented positively about the assistance they received from the TTO frequently mentioned that person was a woman.

“I would never have taken any of these steps without their (TTO) help. The person assigned was amazing. It did make a difference that she is a woman.”

The other half of the comments made indicated they felt their TTO was less than helpful, and some went so far as to say they felt the TTO “undermined” their efforts. Specific comments were made about the lack of diversity in the TTO and the office’s proclivity to work with established faculty who tended to be Caucasian males rather than ensuring that all inventors are included and heard regardless of their position. Other comments stated that frequent turnover at their TTO was frustrating and created more work bringing their new TTO officer up to speed.

“When disclosures are filed, the TTO considers male-filed disclosures more seriously than mine.”

Comments related to concerns about discrimination, gender bias, racial bias, or combinations thereof during their innovation and patenting process were mostly from assistant professors (29%), and then distributed evenly among all other academic levels.

Most Frequently Cited Barriers to Participation

Barriers to participation were referenced throughout the survey responses and during the follow-up interviews. The following are the most frequently cited barriers to participation from the qualitative and quantitative data.

associates, and graduate students mentioned mentorship (53%) followed by full professors (23%). Respondents expressed significant interest in mentors and role models with a subset of respondents specifically interested in those of the same gender and ethnicity. Those respondents who had been fortunate enough to have a mentor reported that their mentor was invaluable in encouraging them and helping them in their innovation journey and often credited that mentor as a key to their ability to succeed.

There were numerous references made about the lack of representation of women in the innovation ecosystem not only as mentors but as the people performing the training, and those tasked with assisting faculty through the invention disclosure and patenting process.

Finding #7 - Experiences with their Technology Transfer Offices were mixed. Some viewed the TTO as very helpful, while others felt a lack of assistance, or in a few cases, discriminated against.

The TTO is the designated office within an institution tasked with reviewing invention disclosures submitted by researchers. The staff of the TTO have finite budgets and are tasked with making decisions about which invention disclosures to submit for patenting. Based on AUTM statistics, historically approximately 50-60% of invention disclosures submitted at academic institutions are put forward for patenting. When a patent application is rejected or claims are denied, the TTO staff further decides whether or not to continue to pursue the patent or fight for those claims. Additionally, the TTO staff

Funding

Funding is a challenge for both male and female academics, however, it appears particularly daunting for women. An analysis of National Institutes of Health funding over a ten-year period found female applicants across all grant types apply for fewer grants, ask for less money, and received an average of \$40,000 less on first time research awards compared to their male counterparts (13). It also found that female submission rates were significantly lower at the entry-level faculty rank. Women's average academic rank also emerged as a critical issue in unequal access to grant funding.

Across all SBIR/STTR programs which provide federal funding for early stage, high-risk research and development, the proportion of Phase I applications and awards to women-owned small businesses has remained consistent from 2011 to 2018, hovering between 13 – 15% (14). Awards were consistent with the number of proposals submitted by women-owned small businesses. Further analysis needs to be done to understand why women apply for such a small percentage of these awards.

Total venture funding invested into women-led startups has actually declined from 2.8% in 2019 to 2.3% in 2020 (10). This is despite the fact that the number of women-owned firms has grown at five times the national average, with 1,072 new women-owned firms starting every day (15). The dominance of men (95%) in the venture capital industry and the findings that male entrepreneurs are 60% more likely to be awarded venture funding than female entrepreneurs make funding for female entrepreneurs a major challenge (16).

Time Constraints

Time constraints exist for male and female academics but tend to be more pronounced for women. Women spend an average 5.7 hours on daily household and family care work compared to their male counterparts who average 3.6 hours. As a result, they have little time for what is seen as extra-curricular activity including participation in invention and commercialization activities (17). These differences have been exacerbated even further by the COVID-19 pandemic.

Lack of Knowledge

A key barrier to respondents' participation in

innovation was their lack of knowledge of Intellectual Property and the commercialization process. The most frequently referenced topic in the open response questions was the need for training on commercialization, intellectual property, and entrepreneurship related topics. While such training programs continue to increase in popularity, they are often not marketed in a manner that effectively engages female academics or are not offered at a time and place conducive to their participation. Many survey respondents have subsequently garnered that knowledge as a result of their participation in invention and commercialization and therefore have an above average knowledge of such programs.

Discrimination and Gender Bias

Most references to discrimination in the survey open response questions revolved around interactions during the invention disclosure and patenting processes with male scientific colleagues, patent-attorneys, and the TTO staff. Respondents felt there was a very clear propensity for TTOs to work with established faculty who were most frequently Caucasian males. They frequently cited being left out of the discussions about patenting and licensing decisions. Furthermore, if they were the sole inventor, they were often not given the same level of consideration as their male counterparts. Follow-up interviews emphasized this feeling of bias and also a higher level of satisfaction when respondents worked with female TTO staff.

Recommendations

There are many important initiatives geared at the longer-term pipeline challenge of diversity in STEM education and initiatives to assist women already involved in business. There are far fewer initiatives focused on engaging the current STEM educated female workforce, many of whom work in academic institutions, to foster their participation in innovation and entrepreneurship. U.S. innovators tend to be experienced and highly educated and most hold advanced degrees in the fields of science and technology. Focusing efforts to engage STEM-educated women who have an above average ability to contribute to the innovation ecosystem has significant potential for both short-term and long-term impact.

Based on the quantitative and qualitative data

“Training is key. Scientists are not trained in how to protect their work. I was lucky that my institution provided the support for doing it.”

obtained from 168 female academic survey respondents, and the decades of collective Technology Transfer experience of the group, the WISIG recommends to Policy Makers and organizations that support Technology Transfer the following actions to increase the engagement of academic women in all stages of the innovation lifecycle.

1. The technology commercialization pathway is viewed as complex and daunting. There are programs that exist across the country to specifically engage female innovators in the process. Unfortunately, most of these programs are available only in the specific institution where they were created and championed. Identifying the most successful of these programs and creating turnkey templates to scale them on a national level would increase their accessibility and their impact.

Training was the most frequently mentioned topic in all the open response questions and cited as one of the most important things universities can do to assist faculty in their innovation journey. A subset of those responses commented on the male-centric nature of the training they attended and referenced the need for female inclusive training. It is important to develop programs specific to women as they face unique barriers and challenges and do not typically participate in generalized commercialization training at the same rate as their male colleagues. Female specific training has met with resistance at some academic institutions. Male dominated academic administrators understand the need for training on the inventive process but often fail to recognize the gender-specific hurdles facing women in innovation. For example, research has found that venture capitalists prefer pitches by men, even when the same content is delivered by men and women (21). Similarly, investors have been found to ask male investors and female investors different and gender-biased questions. Training on investor presentation techniques is common in entrepreneurial training programs offered to faculty. Female specific

training provides additional knowledge about the biases held by venture capitalists and provides participants with techniques for overcoming those biases to increase their likelihood of garnering funding. Similarly, other gender-specific training topics should focus on recognizing challenges encountered by women innovators and provide techniques for addressing them.

Another reason for apprehension to female specific training are concerns about whether federal laws make it illegal for a training program to discriminate based on gender. These concerns have been overcome at dozens of institutions by ensuring similar training is available for all academics so participants can opt in for the generalized training or for the more female-centric training.

The Institute for Women’s Policy Research conducted research in 2018 identifying 55 programs nationally that had some component of fostering greater engagement of women in innovation (4). They reviewed these programs to identify those that met the following criteria:

- Being actively focused on addressing the gender gap in patenting and/or innovation among U.S. adults
- Being in operation at the time of study
- Having received recognition from others as doing something innovative or exemplary to address the gender gap in patenting and innovation
- Having data on the program’s outcomes or a way to measure or assess its impact (desired, not required)
- Having been in existence for more than a year (desired, not required).

The IWPR then did in-depth analysis of seven programs representing a range of instructional models that met the above referenced criteria. A common theme across these programs was limited funding and the lack of sufficient staffing. Because of these limitations, the programs existed only within the institutions where they were created or within confined geographies and were unable to scale for broader impact. Two of the seven proven successful programs are no longer being offered due to lack of institutional support.

Rather than having individual institutions struggle to identify mechanisms to engage more women

Programs Fostering Greater Engagement of Women in Innovation	Location
Accelerating Women and under-Represented Entrepreneurs (AWARE)	University of Illinois Urbana-Champaign
Bioscience & Entrepreneurship Inclusion Initiative	BioSTL, St. Louis Missouri
*Empowering Women in Technology Startups (Ewits©)	University of Florida
MyStartupXX	University of California San Diego
REACH for Commercialization™	Ohio State University
SBIR/STTR Phase 0 Assistance Program	U.S. Department of Energy
*STEM to Market	Association of Women in Science, Washington DC; Chicago, IL; and the San Francisco Bay Area, CA
<i>*Programs no longer offered.</i>	

in their innovation ecosystem, it would be far more prudent to leverage existing female-centric programs that have a proven track record. This could be done by working with established programs to develop turnkey templates that could be customized and implemented by interested institutions across the country. An alternative approach could be to provide already established programs like those referenced above, with the funding required to enable them to scale on a national level. Both options would provide institutions that are interested in engaging more women in their innovation ecosystem with the knowledge and tools necessary to do so. Allocating seed funding for program implementation would incentivize institutions and increase the dissemination of these impactful programs. Following the example of the NSF Advance program, requiring institutions receiving grants commit to long-term support of the program would ensure program longevity.

2. Even though many commercialization resources and training programs exist, there appears to be a lack of general awareness of these programs among female academics. Identifying “best practices” for outreach to these populations and making the outreach methodologies readily available to Technology Transfer Offices and other organizations offering training would ensure greater engagement in their programs.

Even though 66% of respondents were aware of technology commercialization and entrepreneurship training programs, numerous comments were made about the difficulty participants had in finding and accessing the training. This lack of awareness is due in part to how these programs are marketed. Descriptions of the programs often use terminology which is unfamiliar and often times unappealing to faculty, especially female faculty. Therefore, they don't see the training as being directed at them. A number of the survey respondents learned about the training by word of mouth from a colleague or their TTO, not from a written correspondence.

One respondent who was very complimentary of the I-Corps training she received shared that even after having participated in I-Corps and now having founded a company, she reads the correspondence advertising the training programs and workshops and still doesn't participate because she feels like she can't relate to it.

“I'm not sure I felt a lot of the continuing education or opportunities offered have totally thrilled me and I wonder if it is that similar language barrier. They seem very heavy on the business language and light on the social justice responsibility and helping the world which is a strong motivator to me and I suspect other women in academia.”

In addition to the terminology of the outreach, the logistics of when and where these programs are offered often make it difficult for academic women to participate. Challenging logistics (for men and women) include locations off campus, time slots that conflict with other responsibilities, and the length of the programs. Based on comments made, women prefer shorter sessions that are spread out over time rather than lengthy intensive training.

The seven programs identified in the IWPR report referenced earlier that are specifically directed at getting more women engaged in innovation have proven best practices for outreach and logistics. These practices should be researched, documented, and widely distributed to organizations offering related training to increase participation.

Additionally, future surveys would be useful to elucidate the reason behind the lack of participation and to help TTOs to craft outreach and engagement strategies that result in increased participation.

3. There is significant interest in role models and mentors and some specific interest in those of the same gender and ethnicity. We recommend establishing a virtual national mentoring network to assist women in all phases of their innovation journey. Alternatively, identify programs that have incorporated a strong mentorship component and develop methodologies to replicate and/or scale those programs.

Mentors are seen as an extremely important component to the success of individuals in all facets of life, and the same is true for innovation and entrepreneurship. Because of the larger share of household and family responsibilities held by women, they tend to have less time for networking and in turn less exposure and access to mentors. This is further exacerbated by the fact that women are under-represented in innovation and entrepreneurship. Those actively participating are already stretched to find sufficient time to fulfill all their obligations.

Many of the survey respondents credited their mentors as key to their engagement in innovation, and often-times the key to their success. Those who did not have the good fortune of having a mentor frequently referenced how helpful it would have been to have someone guide them through the process.

A number of comments were made about the lack

“The availability of mentors I believe was the most meaningful thing (colleges, institutes, and start-ups) have done to help.”

“People performing training are mostly male.”

of diversity among mentors and instructors in the various training programs. The lack of female role models in innovation tends to reinforce the concept that it is not something for women. It is also more difficult for the male mentors to relate to the many “quiet burdens” that can impede women’s ability to fully participate in the training exercises. However, many women said having a mentor was very important regardless of whether they matched in demographics.

Consideration should be given to establishing a virtual national mentoring network aimed at engaging women in all phases of their innovation journey. Mentoring software platforms exist that enable mentees to identify a mentor on a given topic of interest and easily facilitate that engagement. The platform should have the ability to qualify mentors (both men and women) as knowledgeable on their selected topics and provide them with training on how to be a mentor. Efforts should also be made to engage the USPTO to encourage its 8,000 plus patent examiners and outreach educators to serve as mentors on this national platform. As an incentive, the platform should also offer a credential once that person is approved as a mentor. Having a national platform would also provide mentees with the ability to identify mentors with expertise who might not be readily available within their community.

The platform could also provide resources and training on topics most useful to someone involved in invention, innovation, and entrepreneurship. Once created, the program should be widely publicized using terminology that would motivate women to participate both as mentors and as mentees. Outreach should also be directed at creating awareness throughout the Technology Transfer community.

Alternatively, research should be conducted at institutions with successful mentoring programs focused on innovation and entrepreneurship with special emphasis on engaging underserved

populations. Consideration should then be given to doing one or more of the following:

- Identify best practices and disseminate this information to assist others in developing programs at their institutions.
- Work with one or more of these successful programs to develop a template for replicating their program.
- Work with one or more successful programs to scale them on a national level.

Providing access to mentors will be a key driver to fostering greater participation of women in all phases of the innovation lifecycle. It also has the potential to help institutions increase their retention of female academics who have a greater propensity to leave academia than their male colleagues.

4. Tools, resources, and funding designed specifically to assist female academics are starting to become more readily available. There is currently proposed legislation that will make billions of dollars available to support research and development activities of under-represented populations. Outreach efforts should be increased to garner awareness among female faculty of these opportunities and careful consideration should be given to the approach and the terminology utilized in the outreach.

There were numerous comments made about the terminology used to advertise training programs and in actual training for technology commercialization and entrepreneurship. This terminology affects both the level of participation and the impact of the training. Focusing outreach messages on previously identified motivators for female engagement in innovation will yield greater participation. Delivering training in a manner that helps women understand the connection between their participation in innovation and the ability to ensure their discovery can have societal impact will promote ongoing engagement. Terminology focusing on profits and monetary rewards has historically been an anathema to academics, particularly to female academics.

Rather than relying solely on general faculty communication channels, outreach efforts should identify organizations or groups within the university settings that are focused on the advancement of women. Meeting women where they are and educating them

“The experiences we gained and challenges we encountered implementing this technology GREATLY enhanced my academic research and still do.”

on how their involvement in innovation can help them in countless ways throughout their career will produce better results. Additionally, sharing stories about successful women innovators and the societal impact of their discoveries can provide important role models that enable women to envision themselves in that role.

The USPTO currently has five regional offices across the country whose primary role is stakeholder engagement in the patent system. These offices should identify opportunities to work more closely with university TTOs in their region to engage academic women and provide education about intellectual property and the resources available to assist them throughout the process.

5. Even though half of the doctorates (23) in the United States are earned by women and the largest employer (24) of women with doctorates in science, engineering and health is academic institutions, only 34% of all full professors are women (25). To ensure institutions of higher education have strategies in place to discourage discriminatory behavior, Federal funding agencies should require evidence of a documented institutional Diversity and Inclusion Plan as a weighted criteria on all federal grant applications.

Women represent just over half (52.9%) of Assistant Professors and are near parity (46.4%) among Associate Professors, but they accounted for just over a third (34.3%) of Professors in 2018 (25). Key achievements for Tenure and Promotion in academia are funding and publications. Studies show that among early career biomedical researchers, junior faculty women received significantly less start-up support from their institutions than men regardless of degree discipline (26). This, combined with the NIH disparities in funding referenced earlier, puts women at a fiscal disadvantage from the onset of their career limiting their ability to build a research program and enabling them to advance (13).

All federally funded grant applications should

include a weighted criteria based on evidence of a Diversity and Inclusion (D&I) Plan at the applicant's institution. If federally funded institutions are required to show evidence of a plan as a pre-requisite to funding, it will become much more of a priority for those institutions and in turn for their faculty. Metric reporting requirements in the plan will ensure ongoing attention to it. This effort will also serve as a catalyst for conversation around the topics of diversity and inclusion amongst senior administration and faculty.

This type of action-oriented D&I plan can also be done to recruit and retain faculty. For example, The University of Michigan required all applicants applying for Chair and Dean positions to include an outline of how they would ensure their faculty was diverse and inclusive. Making that part of the process had a huge impact on raising awareness and thus fostering greater diversity among their faculty ranks.

6. Technology Transfer Offices are uniquely positioned in the innovation ecosystem to play a pivotal role in augmenting change that can help make technology commercialization and entrepreneurial activities more inclusive. TTO's should:

- a. Commit to tracking and reporting gender metrics on the AUTM survey**
- b. Implement Gender Intelligence training for all TTO staff**
- c. Adapt training programs and outreach to be more inclusive**
- d. Create reward and recognition programs that would be given consideration as part of their institution's faculty tenure and promotion package**
- e. Review standard practices for communicating with faculty and identify mechanisms to ensure greater transparency around the invention disclosure, patenting, and licensing processes for all parties involved**
- f. Work with AUTM to develop a Diversity and Inclusion Pledge that can be adopted by all Technology Transfer Offices**

a. Commit to tracking and reporting gender metrics on the AUTM survey

Data on participation rates by women in innovation are limited. Much of what has been reported used name recognition software. TTOs are uniquely positioned to capture and report this data without

violating the law. AUTM tracks the gender of people submitting invention disclosures and filing patent applications in their annual Licensing Activity Survey. Unfortunately, this is an optional metric to report and the majority of institutions that participate in the survey do not track or report this data consistently. Tracking these metrics is important to monitor progress. To further incentivize offices to track and report this data, AUTM should work with the USPTO and other offices engaged in intellectual property protection to create a recognition program for TTOs that report these metrics. An equivalent recognition program could also be created for industry.

b. Implement Gender Intelligence training for all TTO staff

The role of the TTO was referenced frequently by survey respondents as both a key to success as well as a barrier to their participation. A number of studies have offered explanations for the gender gap in academic patenting and licensing which are outside the control of technology licensing professionals. There is also research that indicates Technology Transfer professionals tend to favor invention disclosures from male faculty (27) members over female faculty inventors (5). In the present survey some respondents shared having similar experiences.

Technology Transfer officers influence which inventions are patented, licensed, and commercialized. Therefore, they play a gatekeeping role to technology commercialization for innovators at their institution. Like all humans, these people subconsciously hold opinions based on upbringing and culture known as implicit or unconscious bias. There are many interesting studies that have addressed this including the Implicit Association Test developed at Harvard that showed academics of both sexes subconsciously associate science with masculine traits (28). While most people reject the notion that they are biased and would not consciously discriminate against anyone, the data from numerous studies suggests that because of our unconscious biases, we do in fact treat men and women differently.

Unfortunately, Unconscious Bias Training alone has been found to be mostly ineffective at changing attitudes and, in many cases, only serves to reinforce those biases (29). However, implementing Gender Intelligence Training at TTOs would help TTO staff

to understand, recognize, and value the differences between men and women and to identify how those differences are manifested in the innovation ecosystem (30). Having the tools to identify negative stereotypes and strategies to positively overcome them would ensure all faculty (men and women) are being given an equal opportunity to engage in innovation, invention, and entrepreneurship.

c. Adapt training programs and outreach to be more inclusive

TTOs are viewed as the primary source of training on technology commercialization. They should evaluate their programs to ensure:

- The outreach message about the training speaks to all faculty
- Outreach is sent to organizations whose members include under-represented populations in innovation
- Those providing the training represent the diversity of the faculty
- The timing and logistics are conducive to participation

There are a number of programs tailored specifically for women that have demonstrated a high degree of success. TTO's with the resources should consider offering female-focused programs.

d. Create reward and recognition programs that would be given consideration as part of their institution's faculty tenure and promotion package. (PTIE recommendations)

Lack of time and conflicting priorities were mentioned frequently by respondents as a barrier to participation in innovation, particularly the need to teach, publish, and get funding. These activities are recognized as primary components of a traditional tenure and promotion package. TTO's are encouraged to become familiar with the recommendations put forth by PTIE for recognizing scholarly impacts in less traditional means such as innovation and entrepreneurship (31). TTO directors are ideally positioned to engage with their administrations in conversations about best practices for inclusively recognizing faculty innovation and entrepreneurial impact through university reward structures.

e. Review standard practices for communicating with faculty and identify mechanisms to ensure greater transparency around the invention disclosure, patenting, and licensing processes for all parties

involved

Respondents frequently referenced 1) the lack of information and education on how the commercialization process works and 2) the lack of transparency about decisions that were made throughout their innovation journey. Making educational tools available for novice inventors to help them understand the process and establish realistic expectations enables more people to engage and have a positive experience. Numerous examples of these tools in the form of short videos, informative websites, guidebooks, and virtual training already exist. These tools need to be made available at every TTO. While only a fraction of inventions become products that make an impact, a positive first experience with a TTO makes it more likely for someone to be a return inventor.

With regard to transparency, electronic communications make it easy for TTOs to copy all inventors on communications related to their invention disclosure and patent. This creates good will, enables all inventors to share additional data, helps educate junior faculty on the process, and keeps inventors engaged with the TTO so they are inclined to submit future disclosures. Engaging with all parties involved in the research also helps to ensure all inventors are included on the intellectual property, reducing the likelihood of future litigation or patent invalidation.

f. AUTM should adopt a Diversity and Inclusion Pledge for TTOs

There are many versions of Diversity and Inclusion Pledges that exist across various disciplines and communities. They all have in common a goal to raise awareness and augment change toward a more diverse and inclusive environment.

As recognized earlier, Technology Transfer professionals play a gate keeping role in who participates in academic innovation. Developing a pledge which includes a commitment to a set of standards that ensure inclusive innovation would help to raise awareness amongst the Technology Transfer community and provide a common set of practices for ensuring innovation inclusiveness. Because of AUTM's worldwide recognition, this pledge could be impactful around the globe.

7. Federal funding should be allocated to support Technology Transfer Offices and to advance the critically important profession of Technology

Transfer

When the Bayh Dole Act was implemented in 1980, it required universities to proactively protect and work to commercialize federal funded research discoveries. Those responsibilities were assigned with limited guidance and with no allocation of funding to enable universities to perform these functions. The Act was the genesis of the Technology Transfer profession and ultimately led to the creation of our professional association, AUTM. Over the past four decades the profession and the Association have evolved and continue to identify opportunities to improve the complex process of shepherding new ideas from the lab to the marketplace.

According to a 2017 report published by the Biotechnology Innovation Organization, these efforts have significantly impacted the American economy. From 1996 – 2017, Academic Technology Transfer contributed:

- \$1.7 trillion to U.S. gross industrial output
- \$865 Billion to U.S. gross domestic product
- 5.9 million jobs supported
- 480,000+ inventions disclosed
- 117,000+ U.S. patents issued
- 5,000+ startups formed
- 200+ drugs and vaccines developed through public-private partnerships since Bayh-Dole Act enacted in 1980

This impact could be significantly amplified if TTOs were able to better engage the entire inventive pool of their highly educated faculty and students. Many of the TTOs remain significantly underfunded and have limited patent budgets. We recommend that federal funding be allocated to enable these mostly under-resourced Technology Transfer Offices to implement the recommendations outlined in this paper.

Further consideration should be given to provide funding to AUTM to support TTOs in implementing these recommendations. Since AUTM was recently awarded the contract to operate the Federal Laboratory Consortium (FLC), it now has the additional potential to accelerate and transform the outputs of the 300+ federal labs that have historically been awarded similar amounts of research but have had magnitudes less economic impact. AUTM is uniquely positioned to leverage any funding it

receives to magnify the outputs of all federal dollars invested in research and development.

Next Steps

The recommendations put forth are a combination of the survey responses and follow-up interviews from 168 academic women with firsthand experiences in innovation and entrepreneurship and the WISIG members who collectively have hundreds of years of experience in all aspects of Technology Transfer. It is our hope that these recommendations will provide valuable insights into concrete actions that can be taken to ensure systemic changes that foster greater engagement of academic women and other under-represented populations in all stages of the innovation lifecycle. Our next steps will be to engage with the Policy Makers, the Technology Transfer community, and other synergistic organizations interested in refining and implementing the recommendations set forth.

About WISIG

The Women Inventors Special Interest Group (WISIG) coalesced in 2013 as the AUTM Women Inventors Committee and later transitioned to the AUTM WISIG. While the group acknowledged women were not the only under-represented population, they realized as volunteers with demanding careers:

1. They needed to leverage their core competencies and limited resources where they believed they could have the biggest impact;
2. While the data available on women was limited, even less was available on other under-represented groups;
3. Their efforts could ultimately prove beneficial for all under-represented groups; and
4. More focused efforts toward other groups could be developed over time.

Initially, the WISIG formed subcommittees to focus their efforts in three primary areas: *Metrics, Barriers, and Synergistic Organizations*. The *Metrics* subcommittee was tasked with getting a baseline to assess the current state of female participation in technology commercialization. This would enable the WISIG to both better understand the extent of the problem and to be able to measure progress over time. The *Barriers* subcommittee was tasked with

understanding where there were disparities and what the contributing factors were causing those disparities. The *Synergistic Organizations* subcommittee was tasked with identifying other organizations that, because of their role in the innovation lifecycle, were potential collaborators to address the disparities and coalesce around best practices.

Although the membership and the structure of the WISIG have changed over time, the one constant is the passion these volunteers share for their mission to be a catalyst for positive change to increase the participation of women in innovation, invention, and entrepreneurship. Much has been accomplished through their efforts including:

- Working with the leading software platforms used by Technology Transfer offices to incorporate the ability to track gender on invention disclosures.
- Working with the AUTM Licensing Survey committee to add questions addressing gender and encouraging AUTM members to provide this data.
- Development of a tool kit of best practices, tips, strategies, and programs appropriate for Technology Transfer Offices to implement to address greater inclusion in their innovation ecosystems (32).
- Building informal networks of like-minded organizations to share information, cross promote, and collaborate on a number of awareness and advocacy efforts focused on inclusion and diversity. These efforts include but are not limited to webinars, white papers, and panel presentations at conferences and meetings.

As a result of these accomplishments, members of the WISIG are routinely invited to share their knowledge by participating in various working groups and by presenting at meetings and conferences.

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