Panel: Opportunities & Methods to Encourage more Women Toward Research Commercialization

Dr. Adrienne Minerick, Michigan Technological University

Adrienne Minerick received her M.S. and Ph.D. from the University of Notre Dame in 2003 and B.S. from Michigan Technological University in 1998. Adrienne's research interests include electrokinetics, predominantly dielectrophoretic characterizations of cells, and the development of biomedical microdevices. She earned a 2007 NSF CAREER award, has published research in the Proceedings of the National Academy of Science (2006), Lab on a Chip, and had an AIChE Journal cover (2008). She is an active mentor of undergraduate researchers and served as co-PI on an NSF REU site. Research within her Medical micro-Device Engineering Research Laboratory (M.D. – ERL) also inspires the development of Desktop Experiment Modules (DEMos) for use in chemical engineering classrooms or as outreach activities in area schools (see www.mderl.org). Adrienne has been an active member of ASEE's WIED, ChED, and NEE leadership teams since 2003 and during this time has contributed to numerous ASEE conference proceedings articles and educational journal publications.

Babs Carryer, National Collegiate Inventors & Innovators Alliance (NCIIA)

Babs Carryer is director of faculty development and training at the National Collegiate Inventors and Innovators Alliance (NCIIA). Babs is a serial entrepreneur and active in multiple entrepreneurial activities. She blogs about entrepreneurship on New Venturist. Babs taught entrepreneurship at Carnegie Mellon University (CMU) for 15 years, where she maintains an adjunct position. Formerly, Babs was embedded entrepreneur for CMU's Project Olympus and innovation advisor for CMU's Institute for Social Innovation. For seven years at the University of Pittsburgh, Babs taught the Benchtop to Bedside new technology commercialization course. Babs is President of Carryer Consulting and co-founder of LaunchCyte, which has a portfolio of five companies. Babs has a Masters in Public Management (MPM) from Heinz College at CMU and a BA from Mills College in CA.

Ms. Mary Raber, Michigan Technological University

Mary Raber currently serves as Associate Director for the Institute for Leadership and Innovation and Director of the Enterprise Program at Michigan Technological University. She has overseen the implementation and growth of the Enterprise Program at Michigan Tech since its inception in 2000, and is responsible for its overall coordination and development. Her responsibilities include corporate sponsorship development, interdisciplinary program evaluation and assessment, and workshop/course instruction in the areas of teaming and leadership. She is also actively involved in coordination, curriculum development, assessment and instruction in the Pavlis Global Leadership program. She received her BS in Mechanical Engineering from the University of Michigan and an MBA from Wayne State University and is currently working on her PhD at Michigan Technological University. Before joining MTU she held various engineering and management positions during a 15 year career in the automotive industry.

Mrs. Abby Lammons Thompson, Mississippi State University

Abby Thompson is the Entrepreneurship Program Coordinator in the Office of Entrepreneurship and Technology Transfer at Mississippi State University. Through her current role at the University, Thompson works to cultivate a culture of entrepreneurship and innovation among faculty, staff, and students. Thompson assists faculty and student start-up companies with developing strategic business and marketing plans. Thompson manages the MSU Business Incubator and the MSU Entrepreneurship Center. Thompson also manages the Jack Hatcher Engineering Entrepreneurship Certificate program in the Bagley College of Engineering at MSU to enhance business skills in engineering students. Thompson received her Bachelors Degree in Industrial & Systems Engineering and a M.B.A. from Mississippi State University.

Ms. Louise C. Dunlap, DunlapBrowder

Louise C. Dunlap, Biographical Information

As leaders whose work in the 1960s and 1970s helped shape the modern environmental movement, in government service, and as consultants to industry, governments and the public interest, Louise Dunlap and her partner Joe Browder have contributed to strategies that influence the relationship of business, technology and markets to environmental protection and social responsibility. Louise Dunlap, the first woman to be CEO of a major national U.S. environmental organization, joined the firm in 1986.

Louise Dunlap has been instrumental in the development of national strategies and federal policies to make energy efficiency America's most effective response to global climate and energy security challenges. Louise played a key role in lobbying, on behalf of NRDC, for passage of EPACT 2005 with groundbreaking provisions for federal tax incentive programs for energy efficient homes, schools and commercial buildings: programs which will significantly reduce U.S. greenhouse gas emissions, reduce the need for electric power generation, and reduce prices for natural gas. In 2011 and 2012 she helped citizen groups from across the nation organize, through the Citizens Coal Council, a campaign to save the federal Office of Surface Mining Reclamation and Enforcement (OSM) from being illegally merged into a federal coal development agency.

Louise provides strategic Washington policy advice to Global Cool Cities Alliance founder and global energy efficiency leader Art Rosenfeld, to the Citizens Coal Council about community and environmental impacts of coal mining, the Foundation for Pennsylvania Watersheds on coal and watershed issues, and to the Abandoned Mine Lands Campaign. She serves on the Board of the Environmental Integrity Project, and has advised The Energy Foundation about buildings energy efficiency. She coordinated Congressional strategy for the community and watershed groups which in 2006 succeeded in re-authorizing the federal Abandoned Mine Lands program, securing at least $1.5 billion for Pennsylvania AML cleanup. Louise continues to work with community leaders fighting against abusive mining practices.

Louise Dunlap created and led one of the most effective campaigns in the history of the environmental movement: the seven-year national citizens' effort to enact federal legislation, the Surface Mine Control and Reclamation Act of 1977, requiring the coal industry to protect valuable farmlands, streams and wetlands and to reclaim all surface mined lands. Louise remains a strategist and advisor for citizens in the coal fields.

The national environmental group she co-founded in 1972 supported publication of the first popular book about the urgent need for energy efficiency and alternative energy to sustain the global economy (Energy for Survival, Wilson Clark, Anchor Press 1974). Louise became an advisor on energy efficiency to the California Energy Commission in 1987, providing CEC with strategic insights about national developments influencing efficiency, fuels and transportation issues. She participated in the earliest California and U.S. alternative fuels and reformulated gasoline efforts, and was central to the development of markets and state and federal regulatory systems for alcohol fuels and fuel additives.

Louise was a principal strategist and lead lobbyist working on behalf of the Chair of the California Energy Commission for enactment of the federal Alternative Motor Fuels Act of 1988, and advised the Chair of the California Air Resources Board and the California Energy Commission regarding automotive fuels and the Clean Air Act of 1990.

Louise Dunlap began working on environmental and energy issues in 1969, as legislative advisor to the President of the National Parks Conservation Association.

In 1971, Louise became Assistant Legislative Director of Friends of the Earth, helping to coordinate FOE's strategy in the first national environmental campaign to raise energy efficiency and climate protection issues: the successful effort to stop federal subsidies for a proposed U.S. commercial fleet of supersonic passenger planes.

From 1976 until 1986, Louise was President of the Environmental Policy Institute and Environmental Policy Center, groups she co-founded in 1972, which under her leadership grew into the national environmental community's largest public-interest environmental lobbying organization in Washington.

Louise Dunlap has been a member of the Board of Visitors of the Duke University Nicholas School of the Environment, was a founding member of Duke's Women's Studies Council, of Senator Jay Rockefeller's

National Alternative Fuels Task Force, and of the Democratic Women's Leadership Forum, chairing the WLF Environment and Energy Task Force. She has also served on the boards of the national League of Conservation Voters, Clean Water Fund, Scenic America, Environmental Policy Center, and National Clean Air Coalition. In 1987, she was honored by citizens from across America, at a ceremony on the National Mall commemorating the 10th anniversary of the federal coal surface mine reclamation law, and was also honored by Friends of the United Nations Environment Programme for her global environmental leadership. In 2008 Louise received the Watershed Hero award from the Pennsylvania AML Campaign. In 1984 Louise was elected an Alternate Delegate from Maryland to the Democratic National Convention.

Louise Dunlap is a 1968 graduate of Duke University, was born in Lancaster, Pennsylvania, and lives with her husband and partner Joe Browder in Fairhaven, Maryland. Publications, Louise Dunlap

"An analysis of the Legislative History of the Surface Mining Control and Reclamation Act of 1975," Twenty-First Annual Rocky Mountain Mineral Law Institute, Matthew Bender, 1976

"Environmental Perspectives on the Effectiveness of SMCRA" (with James S. Lyon), West Virginia Law Review, Spring, 1986

"From Kitchen Tables They Changed the Law," USA Today guest column, August 3, 1987

"Environmental Protection, Competition, and Changes in World Energy Markets" (with Joe Browder), Papers, Volume II, American Mining Congress, April 1988

Panel: Opportunities & Methods to Encourage more Women Toward Research Commercialization

Abstract

Recent reports and analyses have identified that women tend to commercialize research and engage with industry/entrepreneurship at a much lower rate than men. A multitude of programs exist to help researchers transition from an academic laboratory into business ventures around a particular technology. Universities have personnel and support programs to help guide patent applications, form business entities, seek early stage funding, and network with entrepreneurship incubators and programs. This paper seeks to demystify this process such that more women are encouraged to further develop their intellectual capital and pursue commercialization ventures. The information included herein is compiled from panel members, is introductory in nature and utilized as a preliminary, enabling resource.

Introduction

This paper and corresponding panel was organized based on the premise that, while data shows women engage in technology transfer at a lower rate than men, direct discussion of this issue will encourage and empower more women to commercialize their research. This effort brings together individuals with experience at all stages of the technology transfer and commercialization process to talk about:

a) The current disparities in technology transfer by gender
b) Existing programs which strive to correct the disparity
c) The process of moving research from the lab to commercialization
d) Resources that are available to fund and guide the technology transfer process

Panelists include Babs Carryer, Director of Faculty Development and Training at NCIIA, a national organization focused on university entrepreneurship; Abby Thompson, a Research Associate at Mississippi State University's technology transfer office; Adrienne Minerick, a chemical engineering professor at Michigan Technological University; Mary Raber, Director of student enterprise programs at Michigan Technological University; and Louise Dunlap, a political entrepreneur in public policy. Each panelists provides unique perspectives on approaches, pathways, and challenges associated with commercializing university technologies. The paper includes a brief review on the disparities in technology transfer by gender, followed by responses from each of the panelists in the three later categories above. The goal of this paper is to archive the wisdom from this session for future reference.

Disparities in technology transfer by gender

Gender gaps have been noted in the technology transfer arena [1]. Stephan concludes that, "women are less likely to disclose than are men, less likely to patent, and less likely to engage in entrepreneurial activity, such as starting a company or serving on a scientific advisory board," although rigorous quantification of the bias was left for future studies [1]. In the medical school research community, women were as likely as men to report inventions although women disclosed fewer inventions [2]. Haeussler hypothesized that women will engage less in

commercialization and after analyzing data determined that male scientists were 8% more likely than women to patent an idea and men were 4% more likely to found a company compared to females. A difference was not found between consulting rates [3], which to many suggests that networks do not differ greatly between the genders [4]. Babson's Global Entrepreneurship Monitor Reports on Women and Entrepreneurship surmises that women have less tolerance for risk[5]. Babson's 2011 US report on entrepreneurship found that young men had "higher perceptions about opportunities, confidence in capabilities, affiliations with entrepreneurs and risk–taking propensity" compared with young females[6]. Researching women entrepreneurs and their challenges in getting funded, venture capitalist, Cindy Padnos, found that gender and other factors affects the decision of who invests in who: "Called homophily, this tendency refers to the selection of people based on characteristics such as gender…Homophily permeates all levels of equity investment."[7] She concludes that men invest in men, leaving women to find women investors who will listen to, and invest in, their story. Since women investors are fewer than men this adds to the gap.

Studies from the Kauffman Foundation have found that "Despite recent gains, women still lag behind men on key measures of startup activity."[8] Kauffman cited that 5.65% of women faculty obtain patents on their research, as opposed to 13% of men faculty and, furthermore, that only 6.5% of women faculty are Science Advisory Board member of high-tech firms, compared with 93.5% of men faculty[8].

Differences in women engaging in technology transfer have been attributed to fewer opportunities at earlier career stages [4]. Also, the hierarchical academic structure is thought to contribute to lower commercial engagement by women[9]. Another theory is related to accumulative advantage, which suggests, "increasing returns to success are driven by peer evaluations based on reputation" and individual university cultures can influence behaviors greatly [10]. Stephan and El-Ganainy broke these attributes into 'factors affecting supply' of women entrepreneurs and 'factors affecting demand.' The supply aspect of the study identified gender differences in attitudes toward risk, competition, selling the science, type of research, and geographic location, while the demand aspect identified venture capital preferences and gender discounting [1]. It was noted that many commercialization opportunities arise from personalized invitations from others, but the work was unable to discern whether fewer women were asked or whether fewer women took advantage of such opportunities. Murray and Graham had documented women who were invited to, but later excluded from the process [4]. Jha and Welch examined collaborative relationships and found that women-women partnerships tended to be stronger and more prevalent than men-women partnerships[9b] in collaborative science. Extension of this concept to programs to increase technology transfer and commercialization has occurred as discussed in the 'existing programs striving to correct gender disparities' section.

Attributes of those who engage in technology transfer

Irrespective of gender differences, technology transfer is an activity within which few academic researchers engage. Hence, there is much to be learned from literature studying attributes for those who do engage in some form of technology transfer from patenting to consulting to full commercialization. As an indicator of the importance placed on commercialization, prior to 1980, fewer than 20 universities had technology transfer offices; such offices now exist on

almost all research campuses [11]. Academics have largely valued publications over patents [10, 12] though this varies by fields, and patents and patent searching behaviors need further study [13]. Other work found that productivity in patenting was not related to commercialization success; instead, faculty need entrepreneurial spirit [14]. University and commercial science is now viewed as largely connected [15].

Goethner et. al. determined that the attitudes and perceived control of the process by academic scientists determined entrepreneurial intentions. Both economic and physiological perceptions influenced the transition from intentions to behavior in academic entrepreneurship [16]. Grandi and Grimaldi identified that Business Ideas (BI) Market Attractiveness and BI Articulation were two key factors influencing performance in academic spin-off companies. Market attractiveness was primarily positive if the academic entrepreneur interacted heavily with non-academic partners or agents (i.e. expanding knowledge & experience) while articulation was primarily positive if the academic founders had more experience or assembled a diverse, experienced team [17]. Two key statements made in the paper relate directly to the target audience of this panel and paper, "Academic would-be entrepreneurs should be aware of the importance of keeping their eyes open to the outside, of monitoring market trends and requirements, and of communicating with external actors. These factors are important for academics, some of whom show the tendency to interact only with other scholars and colleagues, and run the risk of becoming isolated and not realizing the potential applications of the technologies that they develop" [17].

Existing programs striving to correct gender disparities

As a means to counter the gender disparities in technology transfer and commercialization, a number of national programs have been developed. The Ohio State University sponsored a 'Reach for Commercialization: A Workshop for Women Faculty and PostDocs in STEM' in late September 2012 as part of their ADVANCE grant from NSF. *Entrepreneur* magazine featured their first annual entrepreneurial women to watch in 2013 [18]. Support groups and visibility for women entrepreneurs is increasing including a wide variety of online articles and educational resources. Four women start a business for every five men, which has been increasing [19]. Nonprofit organizations also exist including the Michigan Association for Female Entrepreneurs (MAFE) [20]. One of the many organizations that focus on women in technology is the National Center for Women & Information Technology (NCWIT)[21], led by Lucy Sanders. Among other research, support and services, NCWIT offers a series of interviews with female entrepreneurs called "Entrepreneurial Heroes" which feature women founders of high-tech businesses[22]. Another organization is The Anita Borg Institute for Women and Technology, which was founded in 1997 by renowned computer scientist Anita Borg, PhD[23].

Internationally, surveys and programs exist in the Middle East [24], United Kingdom [25] and in Europe [26]. In the Middle East, disparities in information and commercialization technology were identified as the greatest barrier to entrepreneurial engagement and so programs to address this are underway [24]. Empowering women via this mechanism was also discussed [24]. The European Commission sponsors a European network of mentors for women entrepreneurs [26].

Panelists are familiar with the following programs and suggest the following:

Panelist #1 (Babs Carryer): I am a university adjunct professor, having taught entrepreneurship at Carnegie Mellon University (as an adjunct in four schools and departments) for 15 years and at University of Pittsburgh for seven years (teaching a class to researchers called "From Benchtop to Bedside, what every scientist needs to know). I have been involved in entrepreneurial initiatives and centers at both universities and blog regularly about entrepreneurship at NewVenturist[27]. At CMU, we have worked hard to increase women in technology and women entrepreneurs. Carnegie Mellon has achieved a five-fold increase of women entering in its prestigious School of Computer Science program, from 7% to 38% over a five-year period. CMU owes much of its success in encouraging women entrepreneurs among both its faculty and student populations from creating, growing and supporting a robust entrepreneurial ecosystem, including Project Olympus, the Institute for Social Innovation and the Don Jones Center for Entrepreneurship[28].

At the National Collegiate Inventors and Innovators Alliance (NCIIA)[21], where I am currently, we do not focus specifically on training or mentoring women entrepreneurs. However, our student E-Team grant and training program plus other programs, such as Student Ambassador, have attracted many young women seeking to learn more about innovation and entrepreneurship (I&E) and how to apply it to their lives and others. Our idea is that if we inform them about I&E and demystify the processes of new technology commercialization while they are students, open to learning and new approaches, then prejudices of gender are less likely to surface later. Another NCIIA program is Epicenter (Engineering Pathways to Innovation), an NSF-funded national initiative at Stanford University in partnership with the NCIIA to unleash the innovative and entrepreneurial potential of engineering students across the US. We focus on undergraduate engineering students and by focusing on I&E as it relates to engineering programs, we engage with many young women entrepreneurs who are passionate about commercializing their inventions and helping people through innovation and entrepreneurship.

Panelist #2 (Abby Thompson): We do not have any programs specifically focusing on female entrepreneurship at the faculty level. However, we are focusing on correcting this disparity at the student level. We believe starting at the student level will help correct the disparity in years to come. Beginning in the 2013-2014 academic year, we will be offering scholarships to female entrepreneurs. Like many colleges, we already offer scholarships for females entering technical fields. We would like to take that a step further and begin encouraging our females to not only choose a technical field but to also think innovative and entrepreneurially. We are also nurturing our female students and faculty to be entrepreneurial by providing business plan competitions where they can take their idea from conception to implementation. Our college of engineering will launch a new program this spring called Think Big[29]. The Think Big Program focuses on driving innovation in engineering encouraging students and faculty members to solve some of the world's biggest problems. The Entrepreneurship Center will partner with the college of engineering to provide training to the inventors on how to write business plans and develop investor pitches.

Panelist #3 (Adrienne Minerick): I'm an Associate Professor and was specifically recruited into a program targeting women for technology entrepreneurship. The parent program is called

ACTiVATE [30] and it was licensed by INFORUM Michigan [31]. There are four of us from Michigan Technological University partially sponsored by the MTEC SmartZone [32], which is a local business accelerator. We are geographically distant from where the ACTiVATE classes were being held and so additional funds from the university and the SmartZone were obtained to cover flights to Detroit. The course has guided us through concept presentations, resources, market analysis, primary research, value proposition & market entry, profiling customers, pricing and sales forecasting, feasibility assessment, and many others [30]. The process is overwhelming and I'm thankful it is a structured process with clear milestones and deliverables. Without this, it would fall in priority behind all the other demands on my time and I wouldn't have made as much progress. More recently, our National Science Foundation research earned us the opportunity to participate in an NSF I-Corps program [33]. Our team is comprised of my postdoc is the Entrepreneurial Lead, my colleague from ACTiVATE is the Mentor, and I am the Principle Investigator (PI). The program is an intensive program that uses I-Corps team interactions with potential customers to help guide the development of a viable business model. The structure is to develop hypothesis about customers and the market and then test those in a process similar to the scientific method to determine if the hypothesis was valid. I'd highly recommend this uncomfortable, yet learning-intensive program to anyone considering commercialization of their research.

Panelist #4 (Mary Raber): At Michigan Tech, we offer students an opportunity to participate in the Enterprise Program, an experiential learning program that promotes and strengthens students' knowledge of, and comfort-level with, entrepreneurial initiatives and business operations. Participation on an Enterprise team offers an alternative to the traditional two-semester senior capstone design experience that better meets the needs of both students and industry. Initially funded through an NSF Action Agenda grant, the Enterprise program[34] offers teams of students from varied disciplines the opportunity to work for several years in a business-like setting to solve real-world problems supplied by industry. This alternative capstone design program has converted the traditional classroom into a multi-year, interdisciplinary, experiential learning environment and has transformed the role of instructor from one who imparts knowledge to that of advisor and mentor who guides students as they discover and apply knowledge. The program is now institutionalized and self-sustaining at Michigan Tech. Each year, it attracts growing numbers of engineering and other STEM-discipline students to the university, retains them, and successfully prepares them for leadership and other professional careers upon graduation. Enterprise was recently featured in NAE's publication titled *Infusing Real World Experiences into Engineering Education*[35].

The Enterprise Program's organizational model consists of multiple Enterprise teams (currently 27 with membership ranging from 10 to 80 students on each team) formed around selected technology thrusts (e.g., aerospace, wireless, hybrid vehicle, human health). Most team projects are supported by industry financing, although other financing mechanisms are also in place, such as research funding. Teams typically have multiple projects ongoing at any given time and project work can and often does carry over from year to year. Each Enterprise team has one or more faculty advisors who guide and mentor the team and grade the performance of team members. Teams are run like small companies and teams select student leaders to serve as CEO, VPs (operations, finance, marketing), and project leaders.

The process from research lab to commercialization

Academics interested in technology transfer have so many routes to commercialization available to them that the process can be quite complex. One can simply file a disclosure and a patent and wait for it to be marketed by their tech transfer office or be noticed by a company waiting to license it. Alternatively, the academic researcher can commit to developing the technology to the point it is nearly complete for licensing (most attractive to businesses) or jump into manufacturing the product. The later sometimes requires academic leave or a move to a full-time entrepreneur. The further along the process that a technology progresses, the more financially valuable it becomes. Business climates have changed such that larger companies frequently do not buy ideas and then complete their own development. Instead they wait until a technology has proven itself valuable and then purchase or license the rights or the company.

Panelist #1 (Babs Carryer): At CMU, I developed a commercialization roadmap to help faculty walk the path towards commercialization. In my role as embedded entrepreneur, I spent time with faculty projects, working with them for a period of time as long as two years in some cases to clarify their role, the commercialization strategy, the product, customers, competitive landscape, and business model. I found that if I helped the faculty researcher understand the importance of the market and customer that they would let that inform their research. I also found that setting expectations that researchers cannot lob their invention disclosure over the tech transfer fence and think that the technology would successfully make its way into the market – they must be involved and champion their invention to an innovation to commercialization. Researchers want their inventions to end in the market because they want to help people. I taught them that meant their own involvement to develop the technology from the lab to the marketplace.

As a professor, I interacted with students who would develop projects in my classes and then use independent studies (or graduation) to push them to the next level until it was clear that a business opportunity existed for their technology. My experience has taught me that it is essential that universities have friendly and collaborative tech transfer offices, such as exists at CMU, and they initiate programs such as Project Olympus to support would-be entrepreneurs among their faculty and students.

At the NCIIA, we work with researchers on educational programs around the commercialization process in a program called Research to Innovation (R2I). We currently work with the Center for Sustainable Materials Chemistry at Oregon State University and University of Oregon on a program designed to expose research students (PhD and post-docs) to the commercialization process. I see this area as a huge growth opportunity as the need for understanding the commercialization process within academia increases.

Panelist #2 (Abby Thompson): We work extremely close with all of our inventors when trying to decide the correct path to take once they submit a disclosure. For some scientist, the path is obvious, but for others it is not. Therefore, we try to help each inventor see the pros and cons to all of their options. We hold regular informational sessions for all new faculty on the services our office provides. We also try to visit each new faculty so they are aware of our office and our familiar with our faces. A few changes on our campus have helped our faculty members become

more aware of technology transfer and more willing to work with us. For example, the promotion and tenure form was recently changed to include patents and start-up companies. Therefore, faculty are more motivated to think about commercialization. Additionally, our University recently merged our Entrepreneurship Center with our Technology Commercialization Office, to become the Office of Entrepreneurship and Technology Transfer. Since that merger, we have become more entrepreneurial and have seen more faculty start-up companies than in years past.

Panelist #3 (Adrienne Minerick): In addition to the ACTiVATE course, my university's technology transfer office has been particularly helpful. My group widely published the idea with which I am currently focused for commercialization; the work was critical to earning me promotion and tenure and so I do not regret publishing. Working with our technology transfer office however has taught me the misconceptions I had about this process. The fundamental science is usually not the patentable part and so publishing this part of the work should be done. The key aspect that must be patented is the part that makes the technology realizable into a commercial product. Thus, NSF has focused funds to extend fundamental science to the next stage of discovery to help with this process. This is a good thing because, in my own experience, it is difficult to get additional research funding from NSF for continuing research. It gets reviews along the lines of being 'incremental' and "no longer novel." My institutions technology transfer office has been extremely helpful in supporting the process and paperwork to form a limited liability company (LLC) and involving me in training and off-campus laboratory spaces/resources, which are necessary for many small business grants. I'm still very early in this process and am unfamiliar with the entire path to commercialization. The NSF I-Corps program is quickly helping me identify the intellectual contributions that are of commercial interest. The program has also facilitated contact with a number of patent attorneys, one of which voluntarily took on a mentorship role.

Panelist #4 (Mary Raber): The Enterprise environment is one in which innovation can thrive. Within the program, students are afforded a variety of opportunities to develop their entrepreneurial interests, including elective coursework in Technology Commercialization and participation in an annual Invention Disclosure Competition. Enterprise students make up only 14% of Michigan Tech's undergraduate student body, but they account for over 30% of the university's undergraduate invention disclosures. All Enterprise students sign invention disclosure agreements, which provide team members with financial incentives if products are patented and commercialized. Three Enterprise teams are currently commercializing their products and looking at new business options.

Resources that are available to fund the technology transfer process

Individual states and geographical regions have business incubators as well as competitions to fund entrepreneurs. Funding sources can include angel investors, investors, state grants, loans, and federal grants. An institution's technology transfer office or entrepreneurship center can help substantially in navigating such programs.

Panelists give the following advice in this area:

Panelist #1 (Babs Carryer): Pennsylvania has been very active in promoting economic development through its Ben Franklin Technology Development programs. In Pittsburgh, we have numerous incubators and accelerators, such as Idea Foundry, AlphaLab, Innovation Works and the Pittsburgh Life Sciences Greenhouse. CMU's and Pitt's tech transfer offices have close relationships with all of these organizations. We also have regional individual angel investors and our most well-known angel group, BlueTree Allied Angels, which was founded and is run by a woman, Catherine Mott. A small venture fund was started recently called Pittsburgh Equity Partners, and they invest in companies that are coming out of some of our incubator and accelerator programs. I have found that it is very important that universities form bridges to the community around entrepreneurship to lower the risk of failure for entrepreneurial ventures.

It is also vital that universities address the need to clarify who owns student intellectual property (IP). Universities are not consistent in how they treat student-developed IP. At CMU, all students own their own IP unless they are graduate students – usually PhD students – who work in a federally-funded laboratory. This policy has enabled tens of student-led spinout companies annually.

Finally, it is important to recognize the challenges for women in particular in getting new ventures started and growing. Numerous organizations have sprouted in the last 20 years to assist women entrepreneurs. One example is Springboard Enterprises[36], a venture catalyst dedicated to nurturing and funding women-led high-growth businesses. Since January, 2000, Springboard has helped over 517 women-led companies raise $5.6 billion in equity financing, including 10 IPOs, and many high-value merger and acquisitions. 80% of Springboard companies are still in business, and they have created over 10,000 jobs. Another support organization for women entrepreneurs is Astia[37], a not-for-profit global organization founded in 1999 in Silicon Valley to foster women entrepreneurs in high-tech, life sciences and clean tech. Since 2003, they have helped over 250 women-led companies that have raised over $1 billion with 22 exits, including two IPOs.

Panelist #2 (Abby Thompson): In our state there are a number of resources available to fund the technology transfer process. There is a statewide organization whose mission is to drive innovation at a statewide level. They offer convertible notes to qualified start up companies and proof of concept funding for inventors. Two of the three funds managed by this organization require the inventor/start up company to partner with the state's universities to conduct research or proof of concept. These funds have been helpful in the technology transfer process for our University. As a compliment to this funding program, the state has an Angel Fund, which in some cases provides a match to the convertible notes. In addition, our University has an Angel Network, which brings together angel investors on a quarterly basis to see all of the technologies coming out of the University. Groups of investors from these networks judge business plan competitions at our state and university level. These competitions allow our faculty members to win small amounts of funding.

Recently, our University opened a small business incubator. This 10,000 square foot incubator houses 13 start-up companies with the majority coming from within the University. The

incubator provides low cost office space to these companies with business mentoring from the Entrepreneurship Center Advisory Board. Additionally, one new program that is available that we push all of our faculty members to apply for is the NSF I-Corps program. I hope to see other agencies adopt a similar type program. It gives inventors an opportunity to see what type of commercialization potential is out there for the technology by focusing on the customer development process.

Panelist #3 (Adrienne Minerick): My experience in this area is still rather limited. The National Science Foundation funded the basic research behind the technology I'm in the process of commercializing. NSF has worked to develop programs to help bridge technology transfer for commercialization through their Industry & University Cooperative Research Program (I/UCRC)[38]. One program is the NSF Partnerships for Innovation (PFI): Accelerating Innovation Research (AIR), which has Technology Translation and Research Alliance awards. The NSF description states: "The first choice, Technology Translation, encourages the translation of technologically-promising research discoveries made by prior and/or current NSF-funded investigators toward a path of commercialization; while the second choice, Research Alliance, promotes synergistic collaborations between an existing NSF-funded research alliance (including consortia such as Engineering Research Centers, Industry University Cooperative Research Centers, Science and Technology Centers, Nanoscale Science and Engineering Centers, Materials Research Science and Engineering Centers, Centers for Chemical Innovation, and Emerging Frontiers in Research and Innovation grantees) and other public and private entities to motivate the translation and transfer of research discoveries into innovative technologies and commercial reality. Both of these choices are designed to accelerate innovation that results in the creation of new wealth and the building of strong local, regional, and national economies."[39]. I've also been encouraged to pursue other federal support either via a Small Business Technology Transfer (STTR) or Small Business Innovation Research (SBIR) grant via the National Science Foundation or the National Institutes of Health. Information on both programs is available at www.sbir.gov. STTR's most important role is to "bridge the gap between performance of basic science and commercialization of resulting innovations," while SBIR's most important role is to "encourages domestic small businesses to engage in Federal Research/Research and Development that has the potential for commercialization." [40]. The state of Michigan also has training an matching funds offered through Biotech Business Consultants (BBC) [41].

Panelist #4 (Mary Raber): One of the challenges faced in most undergraduate environments is the rather sizable gap that exists between technology developed through coursework and the actual start-up of a new business. Numerous partner organizations are are available to the campus and community that support start-up education, company establishment, growth, and sustainability such as the MTEC Smartzone[42], SmartStart and the MEDC. Michigan Tech has gone one step further and created an independent non-profit corporation, the Michigan Tech Entrepreneurial Support Corporation (MTESC) and a subsidiary for-profit corporation, **Superior Innovations** to serve as proof-of-concepts centers and corporate incubators to enable early stage technologies to be developed into the foundations of viable start-up companies. Superior Innovations helps Enterprise teams that are interested building an external customer base by providing a mechanism for them to transact business outside of Michigan Tech, as a bridging step to spinning off a true business.

Our fifth panelist had insights that did not align perfectly with the three topics discussed and so her comments are excerpted here (Louise Dunlap):

Commercializing Insight: Products and Policy: Science and the art of public policy require different talents and training. But when scientists and engineers, or keen observers and organizers of cultural and economic competition, enjoy the kind of insight that turns knowledge into commercial value, understanding how women have commercialized their policy skill may be useful to this review of commercializing engineering achievement.

As recently as 1970, the business of making government decisions, and of influencing how those decisions are made, was dominated by male professionals. Even within the citizen environmental movement, where courage and leadership from women volunteers set the table for important environmental victories throughout America, it was, almost always, male environmental professionals sitting down at that table, with business men and male political leaders, to craft the solutions and decisions that would change business and public policy regarding environmental values.

Here is an instructive example of change in women's participation in the commercialization of policy. Friends of the Earth, a new and at the time very different, aggressively political national environmental organization, was formed in late 1969, and in early 1970 the man who later became my husband became FOE's Conservation Director, in charge of building a staff and strategy to carry out FOE's environmental priorities.

Intrigued by FOE's active approach to Washington politics, I left my job at another national environmental group to join the FOE staff, and soon became director of FOE's campaign to stop the coal industry from abusing people and nature.

Our team grew, when there were problems at FOE we stayed together as another new organization, the Environmental Policy Center, and in addition to my leadership on coal we found ourselves with women directing our campaigns on water quality, offshore oil, and nuclear issues.

At the time, leaders of the older national groups, Sierra Club, Audubon, the various wildlife groups, would have joint strategy discussions in Washington at the Cosmos Club. The Cosmos Club had been since the 19th century, and remains today, Washington's most prestigious club for leaders in science, engineering, environmental management and natural resources.

When we were first invited to join the mainstream environmental groups in a strategy discussion at the Cosmos Club, I and our other women professionals were required to enter the Club's mansion through the back door -- because not only were women barred from membership in the Cosmos Club, but even women guests and members' wives were not allowed to enter the building through the front door. Of course that was the last time our organization, the Environmental Policy Center (now once again Friends of the Earth) participated in one of those gatherings at the boys' club.

The policy world changed quickly. Im 1976, I became the first American CEO of a major national environmental organization. In 1988 the Cosmos Club overturned its prohibition against women members, and the Club's current President, a woman, is the former Editor of the journals Nature and Science. And in the world of commerce, including the business of making and influencing decisions about the ways in which technology enters our economy, women are coming in through the front door, sitting at the table, and often even owning the building.

Commercialization of intellectual products, whether engineering designs or the concepts that will persuade our highly political, competitive and regulated markets to embrace or reject those designs, are post-engineering social decisions. In this brief review there is not an opportunity for a disciplined look at how the intensely competitive and previously mostly-male world of making policy decisions about the role of engineered products in society is now more open to women.

But looking at the entire supply chain, if you will, in seeing how the potential value of patented engineering design doesn't become real value until the potential becomes realized in the politicized marketplace, there may be useful insights into how more women scientists and engineers take the first step toward commercialization if we better understand women's greatly increased participation in those second-step processes that realize potential products.

Conclusions

This manuscript provides an introduction to technology transfer and various aspects of commercialization from patents, commercialization discovery programs, small business formation, grant support, and technology development to venture capitalists, angel investors, and commercialization. As discussed, many reports and analyses have identified that women tend to engage in technology transfer at a much lower rate than men. However, a multitude of programs, many of which now focus directly on women, exist to help researchers transition from an academic laboratory into business ventures around that technology. Not all of these programs follow the same philosophy, although all involve teaching business acumens to technical researchers. This paper strove to explain, via individual panelists responses, information resources, educational training, and support programs to help guide women into the research commercialization arena such that their research gains wider exposure and visible impact. A number of programs directed at students and early career researchers were discussed and links provided such that broader implementation at additional universities can occur. Lastly, the broader perspective of commercializing products and policy was discussed.

Observations that women choose careers with greater tangible impact on people and society have been widely discussed. Thus, the engagement of women in commercialization is a venue through which female researchers can experience the direct impact of their research on people and society. The overarching goal of this paper and panel was to demystify the topic of research commercialization and the entrepreneurship process such that more women are encouraged to further develop their intellectual capital and pursue commercialization ventures.

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