AC 2010-2419: DEVELOPING THE NEXT GENERATION OF TECHNOLOGY LEADERS IN CHALLENGING TIMES: THE US NSF-ASEE INDUSTRY RESEARCH FELLOWS PROGRAM

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Developing the Next Generation of Technology Leaders in Challenging Times: the ASEE-NSF Industry Research Fellows Program

Abstract

This paper describes the motivation, steps and description to establish an industry research fellow pilot program for US engineering post docs. The idea was conceived and brought to the attention of the National Science Foundation Engineering Directorate Engineering Education and Research Centers and established August 2009 with US ARRA stimulus funds. The program will sponsor forty (40) one-year fellowships for engineering post-doctoral students in corporate research labs. For the first time, the engineering post-docs in the program are jointly supported by NSF and corporate hosts labs. By providing collaborative research programs to faculty and post-doctoral students, participants can experience real-life industry entrepreneurial experiences for turning inventions into products and services as well as understanding the skills needed to practice the engineering profession.

I. Introduction

Innovation and invention represent the livelihood of companies in a flat world. Companies must innovate or perish. Both advances in technology, and the entrepreneurial culture that is well ingrained in the mindset of successful companies and their research labs, need to find a way into science and engineering higher education systems to help to develop talent that can not only use technology, but also help create it and develop new business opportunities with it.

Universities are usually the preferred venue/place for post doctoral candidates to spend 2 to 3 years further expanding their research interests, experience and networks before formally initiating their careers with a company, university, or self-owned business. Nevertheless, industry can also provide various means to engage faculty and students in innovation and in the transfer of state-of-the-art research results and emerging technology areas into new businesses. By providing collaborative research programs to faculty and post doctoral students, these students can experience real-life industry entrepreneurial programs for turning inventions and innovation into products and services.

Many engineering and technology companies have competitive external research programs that support research and innovation. These programs allow world-class researchers, professors, and their graduate students to tackle some of the most challenging scientific and technical problems today.

II. Corporate labs and open innovation

According to Henry Chesbrough, “Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. [This paradigm] assumes that firms can and should use external ideas as

well as internal ideas, and internal and external paths to market, as they look to advance their technology." [1]

In order to be competitive in a globalized economy, companies recognize that their innovation strategies need to be part of the larger innovation ecosystem and, if they want their work to have significant scientific and business impact, they must lead, listen to and collaborate with participants in this community. To this end, many corporate research labs pursue an "Open Innovation" approach, in which they leverage relationships with universities, government entities, customers and partners to accelerate research results. Key to competitiveness is leveraging the strength of a company's broader innovation network.

Another dimension of open innovation is technology transfer. Corporate research operations create business value through technology transfer. Thus, by working closely with key partners in their business units, they commercialize innovations that result from research. Once a specific technical approach has been demonstrated successfully, there are a number of ways in which companies can derive value from their work. In most cases, innovations become products or solutions for the company, commercialized by existing businesses or instigating the creation of a new business. However, many companies also pursue licensing the intellectual property they have created, spin-out technology into start-up companies, or use their results as input to future research projects.

III. Science and technology agencies' goals

Science and technology government organizations have goals like discovery, learning, research infrastructure and stewardship that provide an integrated strategy to advance the frontiers of knowledge, cultivate a world-class, broadly inclusive science and engineering workforce and expand the scientific literacy of all citizens, build the region/nation's research capability through investments in advanced instrumentation and facilities, and support excellence in science and engineering research and education. In many ways, S&T government agencies' focus areas are aligned with corporate labs' research focus in that both sponsor and engage "where discoveries begin."

Many S&T Government entities' programs not only provide opportunities to discover and develop new technologies, but also provide a vehicle to transfer these technologies for new business creation that stimulate technological innovation and new business creation in the private sector. These programs strengthen the role of small business concerns in meeting national/regional research and development needs, increase the commercial application of supported research results, and foster and encourage participation by socially and economically disadvantaged and women-owned small businesses. For example, by joining forces with a small company, university researchers can spin-off their commercially promising ideas.

A knowledgeable workforce and capacity building are essential elements in engaging and sustaining research programs, so a fundamental element of many (if not all) S&T programs provides for building capacity in these areas through undergraduate, graduate and post-doctoral programs. Many nations understand that by building the technical capacity of its workforce, they pave the way for economic development. Technically competent citizens are needed - those who

can both develop solutions to engineering and infrastructures challenges, and also invent new products and processes and create small business startups.

Given the challenges that the world faces today, there is an urgent need to transform the economy with science and technology. There is a vital need to put scientists to work looking for the next great discovery, creating jobs in cutting-edge technologies and making smart investments that will help businesses in every community succeed in a global economy. And what better way to leverage what the industrial sector is investing in, than by developing the next generation of technological discoveries that will ensure every nation on the planet capitalizes on science and technology for economic development.

More than ever, there is a need to prioritize investments in science and engineering grand challenges, such as those listed in the US National Academy Report, like energy independence, civil infrastructure, climate change and credible economic models for successful recovery of economies.[2]

IV. Promoting industrial experiences to engineering post docs

In March 2009, Hewlett Packard - with the support of several other corporate research labs - approached the US National Science Foundation (NSF) with the idea of establishing an Industrial Research Innovation Post Doc Fellowship Program**.** This program would allow top science and engineering post docs to work on industrial research and development and partner with industrial scientists in developing the next generation of engineering and IT-related technologies, increase opportunities for tech transfer into new businesses opportunities, advance their careers and finally, enhance the possibility of creating innovations in the engineering and science curricula. This initiative was seen as particularly relevant to the contemporaneous economic situation, enhancing participants' likelihood of obtaining a job and/or creating new jobs through new business creation while the US and global economies recovered. The program would also provide opportunities for future engineering professors to acquire real-life engineering experience and impact the engineering/science curriculum.

V. The pilot

The idea presented in March to the Engineering Directorate (Engineering Education and Research Centers Division) was very well received. In May 2009, NSF asked ASEE to submit a proposal to support a number of engineering post docs in corporate research labs for one year. Since 1893, ASEE has provided intellectual leadership and accomplished professional support for educational activities that advance the United States' science and engineering enterprise. This history of both dynamic collaborations with other science and engineering organizations and innovative, society-based programs, has established ASEE as an integral contributor to collective efforts to build the nation's human capital in science and engineering. With its 48+ years of experience administering student and faculty fellowship programs, over 20 years of experience managing postdoctoral fellowship programs, and its industrial relationships, ASEE was uniquely positioned to manage such a program.

Thus, in early September 2009, NSF awarded ASEE funds to establish the Corporate Research Postdoctoral Fellowship Program (https://aseensfip.asee.org) to encourage the involvement of creative and highly-trained engineers in areas of great interest and relevance to the nation as we face current economic challenges. This program provides recent engineering PhD recipients the opportunity to conduct post-doctoral research in a corporate setting. Up to 40 positions are anticipated. Each research fellow will receive a stipend of at least $75,000 plus health insurance benefits, of which the host company would provide a minimum of $27,500 and other non-cash support.

A. Corporate labs benefits and endorsement

Many corporate research laboratories are proud to offer opportunities to a large pool of qualified post-doctoral candidates through this proposed program. It is clear that this program will offer a significant benefit to companies, providing the chance to advance critical scientific, engineering and IT research at a faster pace, during a time when hiring full-time researchers is a challenge. Faster research outcomes are likely lead to increased opportunities to transfer technology to businesses and/or spin-out companies and more opportunities for growth. This program would also allow corporate labs to identify top technical talent who may be recruited for full-time positions after their industrial research fellowship position is finished.

Since the very beginning, several corporate laboratories found this idea attractive, expressing support and interest in the program to NSF, and their willingness to host post docs students in their research laboratories.

> *"We are very supportive of the initiative. We have a long tradition of hosting Post Docs and know the great value that it brings to the Post Doc and to us. Any support that the NSF can provide to allow for growth of this mechanism will be, in our opinion, of great benefit to society and industry."* ***Debasis Mitra, Chief Scientist's Office, Vice President Bell Labs, Alcatel-Lucent***

> *"This sounds great. Yes. It would greatly benefit our organizations – and the PhD's involved. It would combine a depth of knowledge (phd) with increased depth of practical perspective. We have a number of such internal programs already. How can we help?"* ***Andrew Chien, Intel Research***

B. Benefits to participants and the economy

In a time when the global economy is facing enormous challenges, creating jobs must be a top priority. Some of these jobs should also produce significant technological and scientific innovation that will allow the economies to recover and begin to create new opportunities for business growth and prosperity. This program's goal would support government efforts to create an atmosphere in which employees may prosper, businesses may thrive and the economy grows.

Post docs will enjoy both near-term and long-term benefits: in the near-term, they will obtain an immediate position at a prestigious industrial research lab, providing them with a stable job and income, as well as critical career development opportunities as they continue to develop their research capacity. In the long-term, participants may be offered full-time positions in participating companies and their research labs, or may find that their networking and

experiences have prepared them to join the faculty at a research university or another company in their area of expertise. Post docs who choose an academic career could bring new curriculum perspectives and approaches to engineering/science education as well as expand the research horizons by bringing new hard problem areas.

Some post docs may embrace opportunities to transfer technology inventions into start-up businesses, and may start their own companies. In sum, these positions will provide key economic stability to participants while preparing them to further develop their careers and contribute to the economy in years to come.

VI. Brief program description

Post doc research fellows must be US citizens, nationals or legal permanent residents, and possess an engineering Ph.D., Sc.D. or other earned doctoral degree recognized in U.S. academic circles as equivalent to the engineering Ph.D. within three years of their date of application. They must devote their full time to the approved research programs and must be in residence at the sponsoring host laboratory during the entire period of their award. No additional monetary aid or other remuneration may be accepted by the research fellow from another appointment, fellowship, part-time teaching, research or other outside work.

Host companies are required to provide a mentor for each research fellow. Each mentor is required to develop a comprehensive work plan and training program for each of the research fellows under their guidance. Work plans must address the research goals and expected outcomes of the proposed research, and address how the research fellows will be provided with on-the-job hard and soft skills training to be prepared for the shifting industry mix in science and innovation.

Semi-annual progress reports will be required of both the research fellow and the corporate mentors. Mentor reports are to be submitted to ASEE and should include a report on the interactions with the research fellows, address their assessment of the progress of the research plan, list the publications and presentations in process, and address how they would propose to continue the working relationship in the future (if applicable).

Research fellows are required to disclose to the host company any inventions made, i.e. conceived or actually redacted to practice, and any other intellectual property created or developed during the period covered by their performance in the program. ASEE, which will obtain any intellectual property rights from the research fellows, will grant these intellectual property (patents and copyrights, including software) developed by the research fellow to the host company. However, the US Federal Government will retain certain intellectual property rights. The host company must allow research fellows to publish their research results promptly in the open literature.

VII. Examples of expected outcomes

Although this may vary from corporation to corporation, engineering post docs can work in a variety of research experiences. Below several scenarios that provide the reader with an idea of what the post doctoral experience could be in a corporate research lab:

Scenario 1: Post doc student X from Mechanical Engineering at Y University obtains a post-doc industrial research fellowship position in the proposed program and is assigned to work with Corporate A Lab. This Lab is working on a new generation of sustainable IT services that deconstruct conventional physical infrastructure and make possible low-carbon improvements across business operations and product life cycles. Corporate A Lab maintains research collaborations with universities, governments and other companies that could allow the post doctoral student to expand her networking and job opportunities not only within Corporate A, but also with other companies or research institutions. In addition, her contributions may lead to the possibility of adopting or adapting solutions and research being explored in other regions and contexts to other scenarios in the US.

Scenario 2: Post doc student A from University B wins a Post-doc position in Corporate G Lab. This Lab's goal is to develop the next generation of analytical technologies and solutions that will bring personalized experiences to individuals and unprecedented operational efficiencies to the enterprise. He is assigned to work with Corporate G Labs Technology Transfer Office to identify technologies that are ready to be transferred to Corporate G Business Units or to an external partner for new business creation. The student identifies several opportunities, and he begins developing a business plan to commercialize one of them, creating a new technology company in 2010.

Scenario 3: Displaced scientist/technologist M from N company is looking for a position in a world class research lab. Due to current economic conditions, research lab Z does not have open requisitions for full-time positions, but would like to consider him for their post-doc program. The scientist wins an industrial research fellowship and joins the Company H Research Labs. Due to his outstanding contributions in advancing the research agenda, Scientist M is subsequently considered for a full-time research positions at Company H Research Lab and at University K in 2011.

Scenario 4: Post doc student G from University L wins a post doc position. After 2-3 years working in a Research Lab D where she is part of developing and transferring ideas to business, she joins Tech University W, where she reforms the Mechanical Engineering program to address critical skills and competencies related to skills needed for international collaboration and entrepreneurship. She designs a new elective track for students for technology based entrepreneurship.

VIII. Assessing Outcomes

The ASEE-NSF Corporate Research Post Doctoral Fellowship Program opened its website late December 2009. As of March 12, 2010, 47 corporate research labs had posted research project opportunities and hundreds of engineering post docs had uploaded their research interests in the

program website. Over fifty percent of the forty available positions had already been spoken for, 8 post docs already working.

A key element of the program's success and further development and expansion of the program will be tracking the success and outcomes of the program. The program will track research outcomes by fellows (publications, inventions, presentations, etc); tech transfer and new business creation; and stakeholder satisfaction as well as stakeholder satisfaction (research mentors, post docs, experience, placement process, etc). ASEE program officers plan to follow post docs into their next career step and those who end up in an academic career will be asked to assess their experience as to their ability to influence curriculum, enhance student experiences, and develop strategies to enhance graduates' skills and competencies for the workforce; as well as the impact on their research plans.

IX. The future

This program aims to provide engineering post-docs with unique experiences in corporate labs to restore and maintain national innovation by funding a number of positions at corporate R&D labs for top science and engineering post-docs, thus providing a bridge to the workforce for recent PhD graduates and the possible creation of new jobs through new business ventures. The program's outcomes and success will help the stakeholders involved (NSF, ASEE and participating companies) further develop the concept and increase the scope and breadth of the program in future years. The International Federation of Engineering Education Societies (IFEES) has already begun outreach to other regions of the world to share the details of the program and invite them to consider adopting or adapting the model, or enhancing existing local programs.

Discussions have begun with the Kauffman Foundation to provide entrepreneurial capacity building to these 40 post docs and enhance their motivation to start their own technology businesses.

> *"Because engineers affect the world in profound ways, the public—national and global—has a serious stake in the preparation of engineers to design and manage an increasingly technological world. Engineering education that integrates knowledge, skill, and purpose through a consistent focus on preparation for professional practice is aligned with the demands of complex, interactive, and environmentally and socially responsible forms of practice."*[3]
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> ~Sheri D. Shepard, Stanford University

X. Final words

The development of this idea and program has truly been a multi-stakeholder team effort between NSF, ASEE and many corporate colleagues; the full list is impossible to include in this paper. Nevertheless, each participant had the desire to make this program a win-win-win initiative for all: for industry by bringing new ideas and minds with whom to partner, for academia by providing real-life engineering experience for future faculty as well as creating new research opportunities, and for the US by providing a way to develop future technology and

engineering talent and innovations in support of economic development. It is anticipated that a future paper will share the outcomes of this one-of-a-kind program established by NSF in 2009.

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