What propels women to head university labs, especially when tenure and biological calendars collide? Three SWE members who direct engineering labs offer keen and encouraging insights.

University Labs: Where Women Excel

BY CHARLOTTE THOMAS, SWE CONTRIBUTOR

University engineering research labs and centers encompass a remarkable fusion of elements. Amidst the jumble of equipment, wires, and computers, seasoned faculty members to undergraduate students work on diverse projects in various stages of development.

Heading this medley is the lab or center director, often described as an entrepreneurial CEO, whose list of responsibilities is stunning in its complexity. Starting with feeding the funding pipeline with well-written proposals that procure grants, they mentor and train the next generation of researchers and professors. While keeping abreast of their own research, getting published, and teaching, they must interact with industry to move fundamental research to prototype and products — all this while maintaining lab safety and managing staff and technicians. In some cases, they also determine salaries.

Though funding, research, and teaching are the primary responsibilities of running a lab, according to three SWE members who currently head university labs, idealism, passion, and fostering environments in which others can succeed are also major components. According to Patricia Davies, Ph.D., director of Purdue University's Ray W. Herrick Labs and professor of mechanical engineering, a successful lab director facilitates success in others. Her function is to discern how best to serve the grad students and faculty members in her lab.

Likewise, "working with brilliant, fun, motivated students on their way to change the world" is how Beth Pruitt, Ph.D., describes her position as principal investigator at Stanford University's Microsystems Laboratory and assistant professor of mechanical engineering.

Leading entails "transferring one's vision and knowledge to future generations by creating an environment where ideas progress from theory to prototype," noted SWE Achievement Award recipient (1995) and life member, Manijeh Razeghi, Ph.D., Walter P. Murphy Professor and director of the Center for Quantum Devices in Northwestern University's Department of Electrical Engineering and Computer Science.

Manijeh Razeghi, director of the Center for Quantum Physics at Northwestern University, stands in its midst. She had the unique opportunity to build the center from the ground up. In her words, her goal was "to decrease the gap between research and production, while facing all the technical challenges and stringent requirements in order to ensure a safe and invigorating working environment."

ANDREW CAMPBELL

An array of lab environments

Though these women share similar ideals as directors, each of their labs exemplifies different facets of university research. They run the gamut from a formal university center comprising many faculty members, visiting experts, and graduate students, with annual operating costs in the millions, to individual professors' research labs with several graduate students working on the professors' projects. Speaking of the tremendous differences, Lisa Frehill, Ph.D., execu-

"In order to succeed on a sustainable basis, you must have a vision of future needs in science and technology. Moreover, it is necessary to bring together an environment where these needs can be satisfied, from theory right through to prototype device."

Manijeh Razeghi, Ph.D., Walter P. Murphy Professor and Director, Center for Quantum Physics, Northwestern University

"Between my research and handling the business of the lab, I still get to play, which could be anything from teaching a student how to wire a circuit... to discussing the next step in a research project."

Beth Pruitt, Ph.D., Assistant Professor, Mechanical Engineering and Principal Investigator, Stanford University Microsystems Laboratory

tive director of the Commission on Professionals in Science and Technology, explained, "Individual labs are one level. Research centers are an exponential order of magnitude and make the connection and synergy between academia and industry. Centers take the ideas and move them to actual development."

Dr. Razeghi is at the multimillion-dollar end of the spectrum. Coming from an extensive background as a pioneer in semiconductors and optoelectronic devices, she directs Northwestern University's Center for Quantum Devices, a world-class laboratory that, since its inception in 1992, has garnered more than $50 million and generated 55 patents awarded or pending, 75 significant awards, 450 publications, 12 books, 21 chapters, and 550 conference presentations.

Her accomplishments extend even further. She was asked to design and build the center from the ground up in 1992. Northwestern recruited her from a position as head of the Exploratory Materials Lab at Thomson-CSF in Orsay, France, by offering her an empty space in which to create a facility according to her vision. "The goal was to set up a facility where research and development could be carried out from theory, through growth and characterization of materials to fabrication and testing of devices, and finally back to simulation for the next step," Dr. Razeghi recalled.

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Beth Pruitt, principal investigator, right, says she enjoys "working with brilliant, fun, motivated students."

The center focuses on high-level research in compound semiconductor science and nanotechnology. To achieve this, the researchers combine their experience in solid-state physics; quantum mechanics; electrical, mechanical, and chemical engineering; and materials science.

When Dr. Davies became director of Purdue University's 51-year-old Herrick Labs in 2005, she stepped into the shoes of three male predecessors. She noted that she was selected to head the lab because she would continue its well-established "mode of operation." As she described it, this meant "giving people ownership of the lab so the research is collectively owned." Currently, the lab has slightly more than 70 grad students, a number of visiting international scholars, and undergraduates.

Dr. Davies brought her research background in vibrations and acoustics to the lab. She initially came to Purdue University's mechanical engineering department from the Institute of Sound Research at the University of South Hampton in England. Her experience at Purdue prepared her to contribute to the focus of the lab, which encompasses thermal systems and air quality, noise and vibration control, electromechanical systems, and modeling of human response for machine and systems optimization. Industry sponsors many of the projects, such as applications for smart buildings, environmental noise, and tactile communications interfaces. There is also an emphasis on multidisciplinary projects. Researchers from the School of Mechanical Engineering collaborate with professors from the colleges of science and liberal arts. She observed, "We look for broader ways of attacking problems, and the lab environment allows us to do that."

Having received her Ph.D. from Stanford University in 2002, Dr. Pruitt balances a full

PURDUE UNIVERSITY/ANDREW HANCOCK

Dr. Davies mentors and trains the next generation at Purdue University's Ray W. Herrick Labs.

"We foster a community of sharing and of helping each other. One of our alums was so positive about this aspect of the labs that he coined the acronym FASTID-C: family, acceptance, sharing, trust, interdependence, diversity - community."

Patricia Davies, Ph.D., Director, Purdue University's Ray W. Herrick Labs, Professor of Mechanical Engineering

schedule of teaching with research in its earlier stages. "It's more exciting to be involved with ideas before they are ready to roll out as products and make money," she explained. She brought five years of Navy experience, plus several years in industry before and during her Ph.D. and a post-doc in Switzerland. Now she works with two post-doctoral students and 12 graduate and three undergraduate students on projects focused on microfabricated devices and bio applications. As a principal investigator, she enjoys the variety of a university lab and the freedom to define what she can do. Her academic career is right where it should be, according to Dr. Frehill, who explained that in the bench sciences and engineering, your career is about leading a lab. "That's how you advance," she said. "Any professor is expected to set up and run that sort of enterprise."

More than technical skills needed

Obviously, superior technical skills are taken for granted, but as these three women demonstrate, running labs demands excellent people skills. Bossing people is not one of them. "It never works," commented Dr. Davies, noting that the success of the lab depends on getting a group of people to work well together. "A picture of me as a great leader is not accurate," she noted.

People skills facilitate one of the main purposes of academic laboratories, which is to mentor and train the next generation of researchers and teachers. Dr. Razeghi started that process by creating a 12-course curriculum in solid-state engineering for the graduate and undergraduate programs at Northwestern. She explained that by starting from zero and teaching the topics herself, "I could select the most passionate and skilled students to join my group."

To her, students are like family. She trains them; teaches them discipline; educates them; and transmits her knowledge, experience, and values to them. Students must write a weekly report, which she reads faithfully, as well as punctually attend weekly meetings. Dr. Razeghi equates discipline with success. One of her doctoral students compared her lab to a steel factory and stated, "She can take iron and mix it with other materials and make it stronger." He was equating making steel to how his professor, Dr. Razeghi, makes students into people of strength and capability who contribute to society. She sees her purpose as ensuring that knowledge is shared and transferred from generation to generation while keeping the most gifted and hardest-working students within the center. "This unique formula guarantees an ongoing world-leading position for the center," she noted.

Dr. Davies also sees the transfer of knowledge as paramount in her job. Sitting with a grad student talking about research is one of the joys of her life, especially when she sees the student's progress. "We start off teaching grad students, and at the end of the project they, hopefully, end up teaching us," she commented. According to Dr. Davies, the proclivity to educate the next generation is not just about producing results but "learning about a system or machine and being able to find out how to measure things, how to analyze and

model them, and use that knowledge to solve problems." To her and the faculty members she works with, "the outcome is understanding how to solve problems."

While student research is serious and hard work, Dr. Pruitt said that between her research and handling the business of the lab, she "still gets to play," which could be anything from teaching a student how to wire a circuit, to taking a class with other faculty members in cell culture, to discussing the next step in a research project and massaging the data to figure out the next experiment. "I get to step in at the most fun parts," she explained. She thoroughly enjoys troubleshooting in the lab culture, which she described as the culture of questions. "Generating new ideas, new programs, and fundraising for those ideas is what enables the students to be able to do the great work they do," she said. ■

A Principal Investigator's Responsibilities to Her Grad Students

Grad students expect a lot from those who are in positions to mentor and guide them to the next steps in their careers. Beth Pruitt, Ph.D., principal investigator at Stanford University's Microsystems Laboratory and assistant professor in mechanical engineering, decided she would write a document telling the grad students in her lab what they could expect from her as a principal investigator. The excerpt below demonstrates the degree of responsibility inherent in heading a lab of any size, as well as the enormous scope of duties involved in leadership:

"**As principal investigator,** my responsibility to the group is to manage research projects and the laboratory and to provide mentoring and career preparation for lab members. You should manage your own time/projects and are ultimately responsible for your Ph.D. research and your goals. As your mentor, I aim to do the following:

- Help you develop the skills necessary to evolve into an experienced, independent, and effective researcher
- Refine your writing abilities with the goal of clear and concise communication through publications, presentations, and grant writing
- Develop your mentorship and team-leading skills through opportunities to supervise and train other students
- Guide you in "asking the right questions," i.e., choosing experiments and controlling variables
- Enable you to develop interpersonal skills for a successful research career, including mentoring, teamwork, and collaboration
- Provide access to world-class facilities and the necessary training to conduct your research
- Give guidance in publishing results in the archival literature to bolster research standing for you and the group
- Provide opportunities to present work in collaborative settings as well as conferences related to your research field"