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CHANGE OF PLANS

It's time to rethink the research-focused PhD.

If the STEM PhD were a product sold in stores, customers would have long ago called for a redesign. The National Academies, Council of Graduate Schools, and *Nature* have all rightly advocated for reforms to PhD training. They've echoed calls from industry and society for researchers to be more responsive and more quickly generate innovative solutions to pressing problems.

Still, in the United States, most STEM-related doctoral training continues to follow a post-World War II framework for curiosity-driven academic research (see, for example, the development of the atomic bomb). But today's grand challenges in such areas as climate change, energy, and health care require a more directed, use-inspired approach.

For decades, the scientific community has wrestled with the research paradigm. Gradually, support has grown for research focused on pre-identified problems. Yet, little has changed in training students.

The effects of this mismatch are heightened by employment trends. The US is producing more PhD graduates, but fewer are finding academic jobs. According to a recent survey from the National Center for Science and Engineering Statistics, about 90% of engineering PhDs will work outside academia or continue as postdocs; 79% will be tasked with solving problems and creating competitive advantages for their industry employers.

The time for debate is over. We must move forward in a collaborative effort among academic, industrial, and governmental stakeholders to redesign graduate engineering education to center student experience and use-inspired research.

Implementing such broad-scale cultural change is daunting, but some big thinkers are leading the way. In 2021, university, industry, and funding agency leaders joined together at a National Workshop on Industry-University Partnership for Doctoral Education. The result was an engineering change order of sorts, emphasizing the need for graduate training to embrace a problem-solving approach. A collective solution—developed by consortia of universities and private corporations, national labs, defense organizations, and health-care institutes—is required.

One initial effort is Lehigh University's Pasteur Partners PhD (P3) program. Our initiative promotes comprehensive change through four pillars:

- An optional preprogram internship, offering potential research ideas drawn from existing projects at companies;
- Co-advising by a faculty member and an industry researcher;
- Required one-credit courses on skills such as effective communication, teamwork, and independent thinking;
- A one- or two-semester residency to complete part of the dissertation in the industrial environment.

A handful of other universities have taken steps toward reform. For example, the Accelerate to Industry program at North Carolina State University provides graduate students and postdocs with company visits, team practicums, and internships.

But few broad-scale efforts exist, due to various challenges. In our P3 experience, we have faced many. For example, the current academic structure prioritizes research output, such as grants and publications, over training researchers to find realistic, economically viable solutions to real-world problems.

In addition, a natural tension exists between the traditionally open knowledge environment of research universities and companies' interest in protecting intellectual property from competitors.

Stakeholders are also understandably wary about supporting a new program for which ROI will be unknown for years. (Agencies focused on developing a competitive US workforce, such as the National Science Foundation, can help with targeted funding.)

Despite these challenges, early evaluations of P3 suggest success. Industry advisers have acknowledged students' growth in professional, technical, and soft skills. And interns have added staffing capacity needed at companies for previously underresourced projects. Students report benefiting from practical experience, professional connections, a deepened understanding of work in industrial labs, and increased confidence in their career prospects.

These early results are more than encouraging. We believe they represent a viable and replicable set of practices that can revolutionize graduate education in STEM.

Importantly, we must reject the premise that changes to PhD training will undermine its quality. Rather, we believe the universal advantages of a problem-solving mindset will produce better industrial researchers and academicians.

Systemic change will hinge on fundamentally reframing the way PhDs are trained to think about problems, with the support of committed partners in industry and government. To succeed, all stakeholders must share in both the benefits and necessary commitments to create better-trained researchers.

WE ENCOURAGE OUR FELLOW ENGINEERING EDUCATORS TO JOIN WITH US IN REIMAGINING GRADUATE EDUCATION.

We encourage our fellow engineering educators to join with us in reimagining graduate education through P3 consortia or by driving similar innovation at their institutions.

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Learn more about the P3 program at https://go.lehigh.edu/p3.