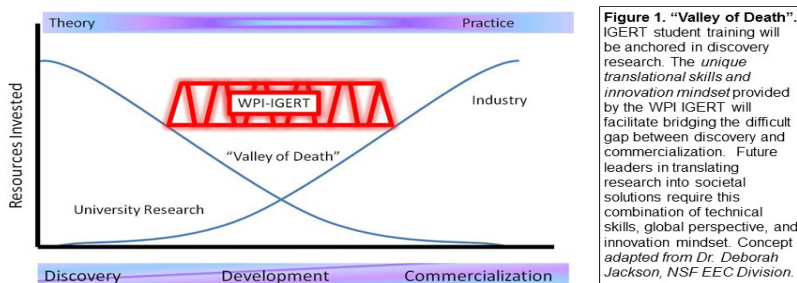


# ENTREPRENEURIAL MINDSET IN STEM EDUCATION: STUDENT SUCCESS

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## Abstract

Worcester Polytechnic Institute (WPI) is engaged in an NSF-funded training program, *IGERT: Training Innovative Leaders in Biofabrication*, which seeks to incorporate innovation and entrepreneurship into the curriculum of PhD students in Biomedical Engineering, Chemical Engineering, Biology & Biotechnology, and related fields. We are training 25 PhD students, over a period of 5 years, through a partnership between faculty from Engineering, Arts & Sciences, and the Foisie School of Business. Our students are taught to develop an innovative mindset from the day they start their PhD project. A biology PhD student who was one of our earliest participants had this to say about the IGERT, "Finding the innovation in your work will give you a reason to come to lab in the morning. It will give you motivation to solve a problem or answer a specific question. Although it may not be readily apparent, there are innovations in all research." By fostering an entrepreneurial mindset in our students, we provide unique translational skills that enable our students to move past the "valley of death" phase, where inventions or ideas from the academic space fail to make it into the marketplace (Figure 1).



Some of the specific methods by which we foster the entrepreneurial mindset include interdisciplinary research projects, modules for teaching innovation, professional development seminars and training sessions, international research experiences, and access to pitch competitions.

## Introduction

Career paths in science, technology, engineering, and mathematics (STEM) disciplines are increasingly entrepreneurial. However, STEM curricula at colleges and universities do not regularly include an entrepreneurial component. Furthermore, it is likely that the engineering and science students of today are preparing for jobs that do not currently exist. Having a firm grounding in entrepreneurship with an emphasis on innovation and invention may be the best way for science students to prepare for the 21st century workforce.



In 2012, an interdisciplinary group of faculty at Worcester Polytechnic Institute (WPI) came together to begin a PhD training program, *IGERT: Training Innovative Leaders in Biofabrication*. In order to better prepare engineers to be tomorrow's leaders in academia and industry, the goal of the IGERT (Integrative Graduate Education & Research Traineeship) is to create an integrated PhD training program that will produce a diverse cadre of future innovators able to translate basic research to solutions for societal (health) problems which will improve our quality of life.

WPI has a strong history of applying technical knowledge to solve important, real-world problems. We are building upon that reputation, embodied by our founding motto of "Lehr und Kunst" ("theory and practice"), and introducing integrated IGERT modules focused on development of professional skills (communication, ethics, mentoring, teaching), translational skills (automation, technology transfer), and an innovation mindset - all in the context of the IGERT trainees' research projects.

The specific objectives of the training program are to: 1) engage students in needs-driven, use-inspired research projects that have the potential to help society, 2) provide technical knowledge and translational skills, 3) foster an innovation mindset, and 4) encourage a global perspective. To meet these objectives, we have designed a unique and exciting program with a focus on biofabrication, which combines interdisciplinary research with translation/innovation modules and industrial/international internships integrated into the research projects. With a well-educated workforce and strong innovative leadership, the US will retain its competitive advantage in this important field.

In this paper, we highlight student success stories, focusing on the development of an innovative mindset, as well as the

creation of hands-on experiences for the students with global partners.

### **Supplementary Coursework in Entrepreneurial Mindset**

In order to supplement the IGERT training, all students are required to take a four course sequence, either in their first and second years or their second and third years. The staggering of the time frame for allows the courses to be taught every other year, while also maintaining the course sequence for students entering the program in different academic years. The first two courses are offered through the Foisie School of Business and provide students with an introduction to many topics essential to entrepreneurship. IGERT trainees benefit from being mixed with non-IGERT students in these courses.

The last two courses are co-taught by business and engineering faculty members. These courses are designed to provide IGERT trainees with an entrepreneurial mindset. Students focus on how their dissertation research can create value. Topics include opportunity identification, understanding customer needs, legal issues in the startup world, forming venture teams, and risk assessment. After discussion, students are asked to apply these topics to their dissertation research. For example, one assignment requires students to give a value proposition for their research, which requires understanding many of the topics covered in the course. In addition to the faculty members, all students are required to provide feedback on each value proposition, encouraging peer-to-peer learning. These courses have been extremely valuable to IGERT students, and we will continue to offer the collaborative courses between engineering and business after the IGERT program officially ends.

## International Experiences

We are going through an unprecedented era of globalization, which presents both new opportunities for collaboration as well as new challenges due to increasing competition. Future scientists and engineers need to learn how to function in this new paradigm. The global leadership of a nation closely relates to its technological and industrial leadership. The goal of the international component is to provide IGERT trainees with a firsthand perspective on research and translation in a global context so that they are uniquely positioned to become successful leaders in an increasingly international market. To encourage a global perspective in the trainees, the specific objectives are:

1. To provide students with an in-depth research experience with international experts in their field of research, which will initiate alliances for continuing collaboration and developing new knowledge.
2. For students to observe and acquire experiential knowledge of culture-specific drivers of technology, innovation, and policies that govern technological development in a foreign country, to better assess how to maintain our technological leadership.

All IGERT trainees have exposure to a global mindset. We provide travel funds for the trainees to either complete a three-month research experience in an international university and/or attend an international conference in their discipline. Some of the trainees have been able to participate in both of these types of opportunities. In addition, IGERT trainees who have engaged in international research present a seminar to the entire group upon their return to share their experience. Since 2002, five of the first eight eligible IGERT participants have completed 3-5 month internships in China, Italy, Switzerland,

and the UK. The other three students elected to pursue internships in industry.

A major advantage for students who engage in international research experiences is that they are able to grow both academically and personally. For example, a PhD student in Biomedical Engineering spent several months at the University of Bath, England, where she gained technical, professional, and personal skills (Figure 2). She noted that the laboratory in the UK handled safety and energy conservation in a different way than her home lab in the US, which was a new realization for her. In addition to a pending publication, she left the lab with a host of international collaborators, which will benefit her in her professional career well beyond the completion of her PhD.



*Figure 2. A WPI PhD student in Biomedical Engineering talks about her global research experience at the University of Bath in the UK. Seminars allow the students to bring part of the global experience back to their home campuses.*

Although the projects have been positive overall, challenges students faced during their international research projects ultimately lead to great personal growth. One student was engaged in a project at a major research university in China. She had a slow start at becoming integrated into the lab. We later learned that we needed to do more work to prepare both the mentor and student for the project experience, and that our approach to communication needs to be specific for each country. Despite the delay in beginning her project, the skills the student learned in navigating the complexities of an international research experience continue to serve her in a new role as a postdoctoral fellow. This was also a good learning opportunity for the program, as we were made aware of the benefits of advance preparation and clear communication.

Finally, since our faculty are also engaged in multiple types of international collaboration, we also draw on faculty networks and experience to foster a global perspective in the IGERT trainees. For example, one of the faculty received a fellowship through the German Academic Exchange Service (DAAD) to spend time on collaborative research at the Fraunhofer Institute and University of Tübingen. After her return, she gave a presentation to all of the students and faculty in the program, which provided information on both the technical subject, as well as the benefits and opportunities for global partnerships. Another co-PI was a Fulbright Fellow and engaged in collaborative research at the University of Galway in Ireland. All of the IGERT co-PIs are actively pursuing research projects with international partners.

### **Innovation and Pitch Competitions**

From the start of their PhD programs, we encourage all of our students to develop an entrepreneurial mindset. Their research projects provide a natural opportunity for the introduction of entrepreneurship. Based on experience, the best practices and most

fruitful training experiences we have found for engaging students in the entrepreneurial mindset include opportunity recognition, understanding available resources, exposure to startups, engagement with alumni or other outside experts, promotion of interdisciplinarity, and exposure to basic concepts in business and management. Some of this is presented to the students in their coursework and modules within courses. Hands-on experiences and participation in innovation events enhance their learning.

Innovation is a key part of entrepreneurship and involves meeting a need in a novel way, which may include commercialization. The inclusion of commercialization education and training early on in the student's thesis project helps ensure that their research is needs-driven and may make the difference between a widely accepted innovative design and one that never makes it out of the lab.

Pitch competitions have been one avenue to help our students develop and showcase their innovative mindset. Each year, WPI sponsors i3: Investing in Ideas with Impact. This is a campus-wide competition that encourages graduate students to demonstrate their entrepreneurial mindset and provides a chance to refine the presentation skills entrepreneurs need to convince others to invest in their ideas. Competitors consider how their ideas and innovations could become the foundation of new products, new commercially valuable processes, and possibly new companies, and then distill their vision into a three-minute pitch that they can make without the aid of visuals. Each unit (Engineering, Arts & Sciences, and the Foisie School of Business) runs a preliminary competition to select finalists to send to the university-wide annual competition.

Five of seven students from the first two cohorts of IGERT Trainees have been active participants for the past three years and have been winners or finalists. In addition, some

of our PhD students have been successful in external pitch competitions, including Tech Advisor's Network 5 Minute Pitch Contest Poster Presentation, Two Minute Pitch Competition TechSandBox Annual Pitch Fest (finalist), iMATSci Innovation in Materials Science Competition (finalist), which was part of the Materials Research Society's national meeting in 2014. One student has also been part of the NSF funded i-Corps, a program designed to help engineers and scientist discover the impact of their research, with two IGERT co-PIs serving on the team as PI and mentor, respectively. Another PhD student was the co-recipient (with her faculty advisor) of the 2014 Kalenian Award, named for WPI alum Aram Kenian '33. This award honors an inventor based on novelty of their concept, commercial potential, and likelihood of success as a business endeavor. The research projects represented include development of a new cancer biomarker and creation of antibacterial coating for catheters.

Aside from the experience of presenting, students who engage in pitch competitions come into contact with entrepreneurs, investors, and mentors. These interactions can provide valuable insight that helps guide the students in their research, moving them even closer to commercialization of biomedical technologies.

### **Conclusions**

Our unique training program fosters an entrepreneurial mindset in PhD students from the beginning of their studies. We believe that exposure and engagement to innovation and entrepreneurship enhances the PhD experience of scientists and engineers, and better prepares them to be leaders that can respond to society's greatest challenges. All of the techniques we use (e.g., interdisciplinary coursework and modules, international experiences, pitch competitions) can be easily incorporated into existing PhD programs, and will provide career-enhancing opportunities for students.

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