The Doctor of Engineering as a New Degree for a New Category of Students: Full-Time, Non-Residential, High-Touch, Research-Focused, Mentored, Professional

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Reinventing the Doctor of Engineering
A New Degree for a New Category of Students

Edward Scheinerman

Johns Hopkins University (JHU) last awarded a Doctor of Engineering (DEng) diploma in 1968. Since that time, the highest degree that the School of Engineering has awarded has been the Doctor of Philosophy (PhD). Now, more than 50 years later, we have relaunched our Doctor of Engineering program—with a complete redesign—to serve a new category of student.

The Students

Our goal in reinventing Johns Hopkins' Doctor of Engineering degree program is to serve students who want the highest, state-of-the-art, mentored, research-based degree available, but who would be poorly served by a traditional PhD program.

Our PhD program is superb for young students fresh out of bachelor's or master's degree programs. Students come to us from around the globe to take advanced courses and to immerse themselves in their mentors' research programs. They can expect to spend five—perhaps six—years on campus and to receive a serviceable stipend (around $30,000 per year) to support their living expenses. While our PhD graduates land jobs in all sectors of the economy, that doctoral program was designed from its inception to raise up a new generation of scholars.

However, there are many professionals who find that their lives are incompatible with the traditional PhD's structure and philosophy. Take, for example, a working engineer in her 40s who is earning a six-figure salary, has a family (spouse, kids, dog, and mortgage) and is eager to advance her knowledge and career. Because we offer online master's education options, she can pop open her laptop and take graduate-level courses in the evening after the house is settled. Once that master's degree is in hand and she finds herself hungry for the depth and research-intensive experience of doctoral education, though, what options does she have? Unfortunately, the online master's model is not an option for doctoral degrees, and the idea of stepping out of her career (and salary!) to move to Baltimore for five or more years to enter studies designed for training scholars is simply unrealistic.

The student described above is far from unique. Many of those enrolled in our online engineering master's programs tell us that they crave more. They are talented, driven, creative, and ready for doctoral studies, though they have no desire to become professors. Instead, they want to advance in their professional careers. How do we meet their needs?

Program Design Philosophy

Our previous Doctor of Engineering degree program was indistinguishable from a PhD program. The fact that that program had been inactive for half a century meant that we were able to start with a blank slate in our quest to reinvent the DEng. We could creatively consider those aspects of the traditional PhD education we wished to preserve, and identify those that we wanted to jettison.

We began with what we consider the heart of doctoral education: mentored, original research. That, we knew we *must* keep. Then we asked ourselves: What can we change? What are our constraints?

Item 1, Residency[1]. We understood that we cannot expect our students to reside near campus. They could be anywhere in the world. If they are nonresident, will they have access to the facilities they need to do their work?

Item 2, Time Commitment. A master's degree can be tackled in the evenings and on weekends. The creativity and depth needed for doctoral studies and research, however, can't be relegated to the sidelines; we need students to be fully committed. And we knew it was imperative to keep the time to degree reasonable.

Item 3, Professional Focus. The PhD degree is the gold standard for becoming an academic, but the mid-career students we want to serve do not aspire to be postdocs and, eventually, assistant professors. Could we design a program meant to enable their ambitions of advancing their knowledge, creativity, and depth in the professional workplace?

Item 4, Financing. Doctoral education is expensive, though not for the student. Typical engineering PhD students are supported through research grants, and by the time one adds up tuition, stipend, health insurance, faculty time, and overhead, the annual cost is in the $100K/year range. Who's going to pay the tab? Not the students we hoped to enroll.

With these goals and constraints in mind, members of our faculty, together with representatives from the Johns Hopkins Applied Physics Laboratory and leaders from local high-tech corporations, set out to create a doctoral program from scratch.

Implementation: Employer Partnerships

The central idea is to instantiate DEng studies and research as a partnership between JHU's School of Engineering and each student's employer. Specifically, we expect the following from the student's employer:

- To provide an onsite co-advisor to be an advocate for the student and a local resource for their work. The co-advisor participates in the assessment of the student's progress.
- To have the students engaged in their Doctor of Engineering work not as an after-hours endeavor, but fully integrated into their "day job".
- To fully fund the cost of the program.

Why would a student's employer do this? Certainly, this is an investment in their employee's technical and professional development, which is, of course, important. But we believe that employers have more incentive to make such an investment if the project that forms the centerpiece of the student's doctoral research is important and of value to their employer.

[1] At Johns Hopkins the residency requirement for PhD students is set at the university level; the School of Engineering cannot waive this.

In traditional PhD programs, students come to the university and are given a project to work on by their advisor. For DEng students, we invert this: The students are required to come to us with the project already defined.

Students applying to the DEng program are expected to present to us an already defined employer-sanctioned project. As part of their application process, they need to find a member of the Engineering School faculty willing to take them on as a student (presumably because of overlapping interest). That faculty member will then serve as the student's primary mentor (advisor).

Indeed, we see Doctor of Engineering studies as a form of academic-corporate partnership in which the student serves as the "glue" binding the two sides together. Further, we expect that a collateral benefit will be continued research collaboration even after the student has completed the degree.

The benefits to the student's employer are then:

- High-level training for the employee.
- Collaboration with Johns Hopkins Engineering faculty on a project of direct importance to the employer's line of business.
- Creation of an enduring relationship with Johns Hopkins Engineering.

Beyond the Dissertation

PhD education is designed for future academics. Typically, academics make their impact[2] through scholarly writing: books, conference papers, and refereed journal articles. This is reflected in the final product in a PhD student's studies: They write a book; we call this book a "dissertation." The PhD student then defends the dissertation in a public forum.

Professional engineers may indeed write refereed journal articles, but this is not the ultimate goal of their work. They create computer code, develop simulations, build prototypes, file patent applications, and ultimately bring their technology to customers.

Our Doctor of Engineering program serves professional engineers. Thus, instead of requiring that students present their work in the form of a book, we allow—indeed encourage—alternative ways to demonstrate their research success. The culmination of DEng studies is a portfolio defense. Working with their advisors, DEng students assemble a collection of documents and artifacts to be examined and defended. In addition to an extended abstract giving an overview of accomplishments, the portfolio may contain video, computer simulations, working models, user manuals, invention disclosures, conference/journal papers, and so forth. The portfolio is evaluated by the student's committee and publicly defended.

[2] There are other ways engineering academics have impact including invention disclosures, presentations at meetings, consulting, and so forth. However, scholarly writing reigns supreme, especially for promotion and tenure evaluation.

Beyond Departments

Our PhD programs are based in departments. Students' degrees have their department names attached. One gets a degree in Mechanical Engineering or in Computer Science. Preliminary studies are focused on a particular discipline and degree requirements vary from program to program.

For both philosophical and practical[3] reasons, our Doctor of Engineering program is administered at the School level. Student projects might not fit snugly into one of our pre-defined categories (see *Current Projects* below). DEng research projects are likely be interdisciplinary and student's program committees will include faculty from multiple departments.

The Doctor of Engineering Oversight Committee consists of faculty members from disparate departments. Their responsibilities include evaluating applications, monitoring student progress, and modifying program structure as needed. The Oversight Committee, together with administrative support from the Dean's office, serves as the "home" for the students in the program.

Educational Program: Objectives and Assessment

The Doctor of Engineering degree is designed to be completed in three years. Here is an overview of the process:

Before beginning the program, students are working with their employers to identify a project of importance to their line of business (described above in *Employer Partnerships*) and with an on-site co-advisor. In collaboration with us, they also investigate possible primary advisors (Johns Hopkins Engineering faculty members) who would be natural choices to serve as mentors. Students assemble their applications, which include the project description, various letters of recommendation, and transcripts from their bachelor's and master's programs[4]. Assuming all goes well, they are admitted to the program.

Every student is supervised by a three-person committee: A primary advisor (who is a faculty member in the JHU School of Engineering), a co-advisor (at the student's place of employment), and a third JHU faculty member (who serves on various oral exams and is an extra resource for the student).

There are three overarching education objectives matched with three major assessments. We describe these in detail below. Here is an overview:

Education Objective	*Assessment*
Learn new, advanced material	Preliminary examination
Create a robust research proposal	Research proposal presentation & exam
Execute advanced research	Portfolio defense

[3] By having a single Doctor of Engineering program we avoid having degree requirements that vary from discipline to discipline.

[4] A master's degree in a technical field is required for admission.

Year 1: The program begins in earnest with an in-person meeting (see *Doctor of Engineering Semiannual Conference* in the next section) between the student and their DEng primary advisor. The meeting is formally called a *Diagnostic Interview*. At this meeting, student and advisor review the proposed research program and develop a syllabus of new, graduate-level material for the student to learn during the first semester. The items on the syllabus should be directly relevant to the student's research program. Students learn this material either by taking courses (we have a wide selection of online courses through our Engineering for Professionals program as well as onsite classes if the student resides near campus) or through independent study (directed by the advisor who suggests book chapters and papers to read).

At the beginning of the second semester, the student stands for an oral examination—the *Preliminary Examination*—based on the syllabus developed during the Diagnostic Interview.

During the second semester, the student—who has been working on the research program already—may have preliminary results and can start to refine their proposed research. Working with their advisors, they write a more robust research proposal grounded on the ideas in their application and focused through discussions with their committees.

Year 2: At the beginning of the second year, the student stands for their *Research Proposal Presentation and Examination*. At this examination, the student gives an oral presentation of their proposed research (including preliminary results) and is examined by a panel of faculty to assess their grasp of the material required to execute the research program. The rest of Year 2 is devoted to pursuing the research program.

Year 3: The student continues their research program and assembles a portfolio (described earlier) for the *Portfolio Defense* at the conclusion of their program. The defense is a public examination.

Community Building and the Doctor of Engineering Semiannual Conference

Residential educational programs benefit from serendipitous "hallway conversations" that lead to new insights as well as to strong personal/professional relationships. Replicating that in a nonresidential program presents us with a challenge. Certainly, students and their JHU Engineering advisors will be in frequent contact through phone and video-chat, but we also want to foster student-student relationships.

To that end, we ask that our students come to campus in January and June for a semi-annual Doctor of Engineering Conference. The various oral examinations (described in the previous section) are all done in-person. The *Research Proposal* and *Portfolio Defense* examinations both include public presentations, and we expect students to attend each other's presentations.

To date, eight students have taken their *Preliminary Examinations* and—we are pleased to report—all have passed. We hope this wonderful trend continues!

We also built personal and professional networking opportunities into our new program. These connections are nicely forged through group discussions during meals. We also have professional development components in the conference program. Our first cohort is small (with only 14 students thus far), so the conference is a one-day event. As we grow, we expect the conference to grow as well.

Professional and personal development give the semiannual conference an added dimension. The first two such gatherings included the following events:

- An exercise in improvisational theatre[5] to help enhance students' communication skills
- A presentation by a science historian on the development of the technology industry in California in the 1950s and 60s, focusing on both organizational philosophy and architectural design.

Breaking the Mold: Comparison to Other Doctor of Engineering Programs

In the United States, schools of engineering that offer doctoral education typically award the Doctor of Philosophy degree. There are, however, a handful of other institutions that offer the Doctor of Engineering degree. Typically, these have requirements that echo that of the PhD, but some have a more industrial or practical bent. Some examples:

At Columbia[6] (bulletin.engineering.columbia.edu/doctoral-degrees-engscd-and-phd), the DEng requirements are nearly identical to that of the PhD. Such is also the case at UC Berkeley (see engineering.berkeley.edu/academics/graduate-programs/graduate-guide, section 5), where the requirements for the PhD and DEng degrees are the same, though the DEng degree has a greater focus on environmental and economic impacts.

At George Washington University, the DEng program is tightly focused on engineering management (see emse.offcampus.gwu.edu/doctoral-degrees/doctor-of-engineering/) .

To the best of our knowledge, there are no other programs structured like ours.

Intellectual Property and Sensitive Research

The mission of the university is the creation and open exchange of knowledge. All DEng research portfolios are publicly defended. This can create tension for students whose project involves sensitive data that might be either proprietary or classified. In addition, the cornerstone of the project must involve adding value for the student's employer's line of business, and we fully appreciate that the employer will want to secure the intellectual property (IP) rights.

Fortunately, we have experience with all of this.

The data issue can be resolved by using alternative data sets. A company may be unwilling to reveal sensitive sales data. In such a case, the methods the student develops (which, to be doctorate worthy, should be more broadly applicable than to a single dataset) can be

[5] See, for example, the work of the Alan Alda Center for Communicating Science: https://www.aldacenter.org/.
[6] At Columbia, the Doctor of Engineering degree is designated EngScD.

demonstrated on publicly available alternatives (such as home sales or Twitter messages or Lending Club transactions).

Schools of engineering often engage in collaborative projects with corporations. Before any collaboration begins, the parties agree to how IP will be handled. Likewise, we will develop a Memorandum of Understanding with each DEng employer so all terms are mutually agreeable before the studies begin.

Current Projects

Our Doctor of Engineering program has just begun. Here is a sampling of some of the projects our students are pursuing:

- Geospatial semantic three-dimensional reconstruction
- Analytics and machine learning to secure the Internet of Things
- Social influence and winning in the gray zone: Social media—the newest disruption technology
- Combustion of metal fuels
- Machine learning for human-machine teaming
- Wireless security through anomaly detection
- Integrated zero-net-mass-flux oscillating jet cooling
- Environmental localization, mapping, and guidance for visual prosthesis users
- Unsupervised learning and analytical fusion for infectious disease surveillance

Conclusion

We have just completed the first year of our Doctor of Engineering program, and are pleased with the results so far. A few of the hurdles we have encountered and cleared include:

- Helping faculty in the School of Engineering understand the nature and requirements of our program, and overcoming a bit of skepticism for a dramatic new approach to doctoral education. Fortunately, "early adopter" faculty members who have taken on DEng students tell us that they have been delighted by these highly intelligent and motivated students.
- Working through a few iterations of the admissions process, so that prospective advisors and members of the Doctor of Engineering Oversight Committee have the information needed to make good decisions.
- Developing the financial model to ensure that faculty mentors are actively engaged with DEng students and have the resources they need to engage in collaborative research with the students and their sponsors.

We have developed a full-time, non-residential, high-touch, research-focused, mentored doctoral engineering program for working professionals. With no advertising (we only launched a website: engineering.jhu.edu/deng), we are receiving a great deal of interest from prospective students who are hungry for what we have to offer.