

New Paradigm for Ph.D.-Candidate Curriculum Based on Structured Learning Experiences

The Leonhard Center for the
Enhancement of Engineering Education

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Motivation

There are a number of opportunities and threats to graduate education.

- Graduate students are currently expected to organically become independent researchers without formal training. We believe that incoming students could become more effective researchers more quickly by actively engaging them in structured learning experiences immediately upon arrival.
- Graduate courses are largely taught in a classroom via lecture even though it is well-documented that listening to a lecture is not the best way to learn and does not promote deep learning. A problem-based learning curriculum that also activates collaborative learning is proposed for Ph.D. students both pre- and post-candidacy exam.
- The current graduate curriculum is entirely technical in nature, whereas R&D and academic careers demand additional skills such as teamwork, entrepreneurship, and leadership. Training Ph.D. students in these skills via problem-based learning modules is proposed.
- Essentially all ESM graduate courses are 3 credits. Students could better tailor the curriculum to their needs if the course offerings were more finely discretized.
- As knowledge is gained in an area and problems are solved, new areas of investigation emerge. Student training must keep pace with the ever-changing frontier of knowledge.
- The minimum number of course credits to obtain a Ph.D. degree in ESM is substantial and is seen by prospective students and at least some ESM faculty as a barrier.

Project Goals

1. At the department level, train incoming Ph.D. students to quickly become independent researchers;
2. Provide graduate students with opportunities for structured self-directed learning;
3. Introduce professional skill training into the ESM Ph.D. curriculum;
4. Increase the number of Ph.D. applicants to ESM, and ultimately the number of Ph.D. students in ESM;
5. Position ESM to write proposals for externally funded training grants.

Strategy

1. Create a course for incoming Ph.D. students → methods and tools for Ph.D. level research
2. Develop learning modules for post-qualifying exam Ph.D. students → independent learning of technical skills

New Course: Research Practices in Engineering (3 credits)

Introduce incoming Ph.D. students to research practices with the aim of more quickly transforming them into productive independent researchers. As in research, students working in teams will develop and hone: teamwork skills, oral and written communication abilities, literature review best practices, and how to propose a research topic, etc.

Planned Course Content

1. Graduate studies in ESM; expected course outcomes
2. Diversity, equity and inclusion
3. Teamwork
4. Laboratory safety and procedures
5. Documentation
6. Data management
7. Ethics of conducting research (including SARI)
8. Literature review
9. Oral communication
10. Problem identification and solution
11. Connecting ideas
12. Manuscript preparation

Possible Course Assignments

1. Meet, introduce, and connect ESM professors
2. Write a laboratory standard operating procedure
3. Implement version control on a shared document or code
4. Literature review
5. Oral presentation of a novel research concept
6. Written research proposal

Learning Modules

Modules will be developed in a variety of ESM subject areas (e.g., ultrasonics, neural engineering, fluid-structure interaction, magnetic resonance imaging, bioprinting) including theory, computation, experiments, and nontechnical skills.

Clearly defined objectives, milestones, and outcomes are critical, as is provision of sufficient structure and guidance such that the modules are self-directed, making faculty intervention the exception rather than the rule.

1. Create guidelines for problem-based learning module developers
2. Develop the modules
3. Test and evaluate the modules

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