2024 Summer Strategic Initiative:
Proposed Improvements to the College of Engineering Graduate Program and Curriculum

Kenny Mineart, Chemical Engineering
Ben Wheatley, Mechanical Engineering

August 2024

Overview

The College of Engineering (CoE) Graduate Program at Bucknell has existed for years as a small endeavor with relatively few students, largely maintained by a small number of passionate faculty. In April 2021, Bucknell received the results of an external review of the university-wide graduate program, which can be summarized with the following excerpt:

> *…it is time that Bucknell invests a small amount of resources to make graduate programs visible and take pride in their contribution to the institution.*

We believe that the graduate program should receive more direction, support, and attention from faculty, staff, and administrators[1]. To that end, this summer initiative aims to identify and propose **short-term changes that are actionable within the College of Engineering and will improve the graduate program and the experience of students and faculty alike**.

Our proposed initiative goals, which remain unchanged, are to…
1. explore and recommend a new graduate curriculum;
2. establish clearer expectations of graduate students for the duration of their studies;
3. investigate mechanisms to improve faculty engagement in the graduate program;
4. explore opportunities to create a distinctive identity for the graduate program;
5. improve the sense of community among CoE graduate students.

To accomplish these goals, we did the following:
- Developed actionable changes to the graduate program based on our experiences on the graduate committee and advising graduate students
- Developed a new common graduate curriculum for the CoE
- Collected survey data at two time points and at two levels of detail - initial faculty perspectives and feedback on proposed changes
  - Our second survey, where individuals commented on our proposed changes, was completed by 26 faculty. The full results of this survey can be viewed here.
- Hosted a focus group discussion among faculty in the CoE, which influenced the proposed changes and survey questions. Notes from this session can be viewed here.
- Conducted a brief review of other graduate programs at smaller colleges and universities and current best practices for graduate student mentorship among institutions of all sizes

The theme of our proposed changes is that our MS program further emphasizes the role of the thesis in the degree program. We believe this emphasis leverages our advantages as a small institution with one-on-one opportunities between MS students and faculty and de-emphasizes our greatest weakness in a lack of robust graduate coursework offerings.

---

[1]Recognizing that budgets are tight and the value of the graduate program has been debated for quite awhile, we proposed that the program be supported to a greater extent for a fixed period of time (e.g. 5 years), after which the program should be subject to a detailed review. At that point the program can either continue to receive support (in the same or a different manner) or be terminated, whichever is of greater value to Bucknell. This perspective is not the official purpose of this report, however.

Summary of Proposed Changes

We propose that the following changes be made over the course of the next 1-2 years to improve the CoE's Graduate Program. These changes are in line with our vision of a distinctive thesis-focused MS program and enhance the sense of community that graduate students feel in the CoE.

- replace ENGR 695 with a Research Design and Methods course
- implement 0.25-credit Research Communication course
- incorporate an individual development plan (IDP) into graduate curriculum
- implement clearer expectations for students in the CoE Graduate Program

We propose that these changes be among the primary tasks of the CoE Graduate Committee during the 2024-2025 academic year.

Curricular Changes

Before summarizing our proposed changes, it is important to clarify the current common graduate curriculum (across all departments):
- Eight (8) course credits required for graduation
- One credit for Advanced Topics in Engineering Mathematics (ENGR 695) taken in the first semester (or whenever first offered)
- One thesis credit (home department 699) taken in the final semester
- All other courses must be 600 level, or 600 level equivalents
    - Transfer credits from other institutions must be approved by grad office, with a maximum of two (2) transfer credits

We are suggesting two curricular changes be considered for the College Graduate Program. The first change is a new 1.0-credit course **ENGR 6XX: Research Design and Methods** taken by all graduate students during their first semester of study[2]. This course would focus on research methods, with topics such as conducting a literature review, formulating good research questions, design of experiments, the creation of an Individual Development Plan, and an introduction to statistical handling of data. The second change is the introduction of a new 0.25-credit **ENGR 6XX: Research Communication** course that graduate students would take every semester during their studies at Bucknell. The course would carve out dedicated time for students to work on writing their thesis proposal, thesis, and manuscripts, as well as practice presentations for committee meetings and conferences. It would bring all of the College's graduate students together once per week and offer a space for peer feedback on the aforementioned scholarship products. This research communication course may require additional teaching load, however. Initial conversations with the Provost's office regarding these changes were positive, and it appears there are no logistical issues with the 0.25 credit research communication course at the University level.

---

[2]This course is an evolution of a proposed research methods course from the College of Engineering Graduate Program Revision Proposal that was drafted in 2022.

Research Design and Methods Course

The majority of faculty (52%) that responded to our [survey](#) supported the idea of creating a new research methods course for graduate students in the College as a replacement for ENGR 695. An additional 30% of responders would like to see this course as a requirement in addition to ENGR 695. The former option is teaching load neutral, whereas the latter option will require an increase of 1.0 teaching credits per year, which further supports *replacement* of ENGR 695. Comments from the responses that preferred a different course added that they would like this course to be an "intro to being a grad student... much like the RESC/FOUNs." We believe this is likely not a full-semester course but aspects could certainly be incorporated into our vision of the research methods course.

We understand the perspective that removing a mathematics course from the required curriculum for all students may be a detriment to some students whose graduate research requires advanced mathematics. Additionally, the mathematics department has recently chosen to eliminate their graduate program, which raises concerns about graduate math instruction across Bucknell. However, the mathematics department has communicated they will continue offering graduate level mathematics courses for students (courses listed at the 600-level) including:

- MATH 643: Numerical Analysis
- MATH 658: Topics in Operations Research
- MATH 616: Advanced Methods in Mathematical Modeling

Additionally, 300- and 400-level courses in mathematics may also be taken cross-listed at the 600-level. Therefore, we believe that concerns over removing math content from the college of engineering curriculum can be addressed by these courses in the math department. It should also be noted that this graduate course information from math was shared after our college of engineering survey was delivered.

Research Communication Course

The great majority of surveyed faculty (89%) were in support of the new 0.25-credit communication course. Of those that did not think this course should be incorporated, no additional commentary was offered. Of those that thought a different type of 0.25-credit course should be offered, commentary was mostly in-line with the description above. The goals of this research communication course are to provide students with protected time to write and receive peer feedback on their thesis proposal and thesis documents (greater emphasis on the thesis), improve their communication skills, and improve the sense of community among grad students in the college by requiring them to be physically present together in the same room once per week. We propose that this course receive a 0.25 teaching credit load per semester in keeping with other recurring 0.25 credit courses such as departmental seminars.

Greater Clarity of Expectations for MS Students and Advisors

In conjunction with an overall greater emphasis on the thesis for the graduate program, we also envision a set of discrete changes to the program that will help establish clearer expectations of

students throughout their graduate studies and for student thesis advisors. Currently, there is little to no formalized expectations among departments and individual advisors regarding student professional development or pursuit of scholarly outcomes (peer-reviewed publications, conference presentations, etc.). There is a [Policies and Expectations](#) document developed in 2015 that provides a general overview but is not directly integrated into the graduate program in a purposeful fashion. Furthermore, there is little to no documentation associated with forming the thesis committee, procedures regarding the thesis proposal defense, and procedures regarding the thesis defense. Our proposed changes are discussed in the context of improved clarity for students below.

Individual Development Plan
As discussed above, we propose the creation of an Individual Development Plan (IDP) template that students and faculty must complete in collaborative fashion during the first semester (as part of the research communication course). This IDP will include individual skill development, clearly stated research goals and targeted professional experiences (present at a national conference, etc.). We will strongly emphasize the pursuit of a peer-reviewed journal article in this document. This IDP will be reviewed and updated again in the third semester to ensure students are progressing as desired. Currently, students complete a [Graduate Student Review](#) form, which is two pages (one of which is student assessment), and we believe is not comprehensive enough to impart meaningful changes in student development. We have collected IDP templates from multiple Universities and lab groups and will combine and modify these as deemed appropriate for a two-year MS in engineering at Bucknell.

Revision of Committee Meetings and Formal Checkpoints for Student Progress
During the 2022 - 2023 academic year, the graduate committee approved a switch to semesterly committee meetings (in place of yearly committee meetings) in an effort to give students more frequent feedback and direction in their thesis research. This change was not continued into the 2023 - 2024 academic year. The [thesis defense expectations memo](#) is not enforceable and uses vague language in places, and could therefore be improved for clarity, such as specifying expectations on students distributing the written thesis to the committee prior to the defense. An electronic approval process should be in place for both the thesis proposal and thesis defense meetings and documents. We also recommend procedures that confirm a commitment from faculty advisors and/or departments that they will provide the necessary funding to support the proposed research activities (experimental studies, equipment, software, etc.).

We believe that there should be one formal, required touchpoint for each semester, as described below (with proposed changes in **bold**):
1. **First Fall Semester: Complete IDP (collaborative between student and advisor, must be submitted to CoE Graduate Committee)**
2. First Spring Semester - Form thesis committee, write and defend thesis proposal **(requires electronic signatures or approval from thesis committee members)**
3. **Second Fall - Update IDP (collaborative between student and advisor, must be submitted to CoE Graduate Committee)**

4. Second Spring/Summer - Write and defend thesis, along with, associated paperwork

Updated Documentation for Graduate Students
There are a number of documents posted on the College of Engineering Graduate Program Moodle page for students and faculty alike. Many of these documents have not been updated in years, and/or focus solely on the final semester for thesis submission. We will trim, combine, update, and clarify expected timelines and processes in these documents in agreement with the proposed changes and current procedures.

Developing Distinctiveness of the Program

Based on our review of the limited number of Engineering MS programs from institutions that are comparable to Bucknell in their engineering programs (Kettering, Rose Hulman, etc.), we came to the conclusion that having a program focused on research projects (i.e., thesis work) under close collaboration with faculty could be distinctive. Many of our peer institutions only offer course-intensive or course-only MS degrees or other degree programs over 1-2 years. While it is certainly true that many students are seeking short, coursework-oriented degree programs to prepare them for industrial work, this leaves a gap for students (especially international students) who are more interested in thesis work and would prefer the environment of a smaller institution such as Bucknell where they can work more closely with faculty one-on-one. Approximately half of the faculty surveyed agree that having a thesis-focused MS degree program would help to increase our uniqueness compared to peers, while one-third responded that "this is unlikely to make us more distinctive, and we are not distinctive". Financial support for students in our thesis-focused program offers additional distinctiveness. To be clear, our program already contains a moderate research focus with some financial support, however, there is room to amplify both aspects in order to heighten this distinctiveness. The several actionable items outlined above will increase the thesis-focus of our program in the short term. On the other hand, we advise pursuit of additional resources to offer greater financial support of the program in the longer term.

Increased Faculty Engagement

We initially anticipated that getting more departments involved in the CoE Graduate Program - namely, Computer Science and Biomedical Engineering - would provide a straightforward boost in faculty engagement and increase the number of graduate students in the College. However, it was brought to our attention during the Focus Group Lunch that Computer Science faculty members do not feel they would have time to support this and that it does not align with their interpretation of the University mission. While no one from the Biomedical Engineering Department attended the Lunch and there were not any specific comments in this regard to our survey, Biomedical Engineering faculty were involved in discussions surrounding the College of Engineering Graduate Program Revision Proposal from 2022.

During our summer work, we identified that generating a thesis-focused MS program would contribute to our distinctiveness. We also wondered if this would naturally lend itself to greater faculty engagement by increasing student attention to their thesis project and generating a

higher probability of scholarly output. Responses to our survey were mixed in this regard with 48% of faculty reporting that they are already involved in the Graduate Program and intend to continue at their current level in the future, 26% replying that they would likely be more involved, and 18.5% responding that they don't currently engage in the Graduate Program and are unlikely to start based on this change. Two main themes emerged in the comments made by those in the latter category: (1) they feel graduate students need to be paid higher stipends and are unwilling to engage with the Program unless that change occurs and (2) they would be more likely to engage if we had "better quality applicants". These aspects of the program are beyond the scope of our initiative, which seeks to improve the program by taking actionable steps in the near future. However, we feel it is important to share these perspectives - particularly that related to financial support - for longer-term consideration. Additionally, enhancing our distinctiveness and structuring a graduate program towards a particular emphasis of thesis work may improve applicant quality in the future, particularly among students who seek to pursue a PhD, many of which are international.

Improved Sense of Community Among Graduate Students

The proposed research communication course is specifically designed to require students to gather in person once per week for protected time, which we believe will go a long way in establishing a sense of community among students. In the past, there have been efforts at the University and College level to establish a greater sense of community, including luncheons/dinners (which are attended but infrequent) and dedicated graduate student office space (which is not utilized heavily because students typically spend the most amount of time in their labs). We believe that to first build a sense of community, students must spend time together in a physical space on a regular basis. Since our graduate coursework at Bucknell is so limited, there are few opportunities for students to do so. We anticipate that after students have begun to spend more time together, there will be additional efforts and opportunities that could be employed **with direct involvement of the graduate students themselves,** such as regular social events. Prior attempts to generate cohort building ideas and activities in conjunction with students has been difficult due to the scattered nature of the physical spaces that students use.

Additionally, we expect that formation of an IDP in conjunction with faculty will further strengthen the relationship between graduate student and advisor, hopefully furthering the sense of belonging of students as researchers and professionals. As graduate students can be overlooked compared to the undergraduate population, we must be purposeful regarding the mentorship that we provide to them. We can also increase visibility of graduate students with physical and electronic flyers throughout the engineering buildings, which we have done in the past.

Tie to College of Engineering Strategic Plan

Improvements to the Graduate Program in the College align with all four of the defined Strategic Plan Values: I) student-first approach (improving the graduate student experience), II) diverse perspectives for engineering success (our graduate students are more ethnically diverse than our undergraduate students), III) transformative teaching and learning (one-on-one time with

faculty is transformative for many graduate students), and IV) collaborative scholarship (the thesis is a collaboration between faculty and student). Regarding specific Goals, there are two that are directly supported by the proposed changes in this document. *Champion Our Distinctive Identity* - This document discusses proposed changes to further develop the distinctive quality of our graduate program. *Foster a Diverse, Inclusive, and Equitable Environment for All* - Many of our graduate students are international, therefore to achieve this goal we must improve the sense of belonging among the graduate students, many of whom have different cultural and linguistic backgrounds than the general Bucknell population. Additionally, graduate students bring further diversity as they are in a different professional stage of their careers from Bucknell undergraduate students and faculty. Improvements to the graduate program can also benefit the *Fortify Existing Connections and Cultivate New Ones* Goal, as graduate students can enhance collaborations through increased scholarly productivity and co-advising. While our proposed changes do not directly address the *Enhance Our Engineering Educational Experience* goal, graduate students do act as teaching assistants and thus play a role in the undergraduate educational experience, especially in upper level courses.

Implementation and Assessment of Proposed Changes

Of the proposed changes, only the 0.25 credit communication course requires resource commitments to implement. The other changes can be implemented with the current College committee structure (Graduate Committee and Curriculum Committee). We plan to take the proposed changes to the Engineering Curriculum Committee for approval and implementation starting in the Fall of 2025 and to directly implement the other proposed non-curricular changes through documentation and procedural updates via the Engineering Graduate Committee. For the 0.25 credit communication course, we will require an additional 0.5 credits in teaching load per year, which can come from any faculty member in any department willing to teach the course. We propose that one or more faculty on the Graduate Committee be the first ones to teach this course, and that perhaps this teaching load could rotate through the committee on a regular basis. Our changes would also require a faculty member and department to commit to teaching the 1.0 credit research course. Since this is a load neutral move and faculty are regularly designing and performing engineering research studies, we believe this course will be easier to staff in the long term than the current graduate level math course. We propose that someone on the Graduate Committee, perhaps in collaboration with the committee, be identified ahead of time to teach the course for the first time.

Assessment of our proposed changes could be completed by the development and implementation of a survey for current and past graduate students in engineering and a separate survey for faculty who have been involved in the graduate program. These surveys could assess perceptions of sense of community among students, distinctiveness, faculty engagement, among others. A retrospective study of the different faculty who have been involved in the graduate program, the number of graduate students, and the number of peer-reviewed publications involving graduate students could also help assess these proposed changes.

Long-Term Perspective on the College of Engineering Graduate Program

In 2021, an [external review](#) of Bucknell's graduate program was conducted. In 2022, the College of Engineering Graduate Committee developed a [response to that review](#) and a [proposed revision](#) to the College's graduate program. Since then the University has made efforts towards various changes to the graduate student experience - increases in graduate stipends, more social events for all graduate students, and sustainable housing for graduate students to name a few - though the College of Engineering Graduate Program is the same. We believe that our proposed actionable changes are a first step towards a more sustainable, vigorous graduate program in the College. However, **an increase in personnel and financial support will be needed to create a thriving and stable graduate program.** A good starting point for a long-term plan is the above linked proposed revision, which could be revisited following the implementation of the proposed changes in this document.