Board 4: Leveraging Undergraduate Curriculum Reform to Impact Graduate Education: a Case Study

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Dr Amos joined the Bioengineering Department at the University of Illinois in 2009 and is currently a Teaching Associate Professor in Bioengineering and an Adjunct Associate Professor in Educational Psychology. She received her B.S. in Chemical Engineering at Texas Tech and Ph.D. in Chemical Engineering from University of South Carolina. She completed a Fulbright Program at Ecole Centrale de Lille in France to benchmark and help create a new hybrid masters program combining medicine and engineering and also has led multiple curricular initiative in Bioengineering and the College of Engineering on several NSF funded projects.

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Dr. Marcia Pool is a Teaching Associate Professor and Director of Undergraduate Programs in the Department of Bioengineering at the University of Illinois at Urbana-Champaign (UIUC). She has been active in improving undergraduate education including developing laboratories to enhance experimental design skills and mentoring and guiding student teams through the capstone design and a translational course following capstone design. In her Director role, she works closely with the departmental leadership to manage the undergraduate program including: developing course offering plan, chairing the undergraduate curriculum committee, reviewing and approving course articulations for study abroad, serving as Chief Advisor, and representing the department at the college level meetings. She is also engaged with college recruiting and outreach; she coordinates three summer experiences for high school students visiting Bioengineering and co-coordinates a weeklong Bioengineering summer camp. She has worked with the Cancer Scholars Program since its inception and has supported events for researcHStart. Most recently, she was selected to be an Education Innovation Fellow (EIF) for the Academy for Excellence in Engineering Education (AE3) at UIUC. At the national level, she served as the Executive Director of the biomedical engineering honor society, Alpha Eta Mu Beta (2011-2017) and is an ABET evaluator (2018-present).

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Dr. Cross is currently an Assistant Professor in the Chemical and Materials Engineering Department at the University Nevada Reno. After completing her PhD in Engineering Education at Virginia Tech in 2015, Dr. Cross worked as a post-doctoral researcher with the Illinois Foundry for Innovation in Engineering Education and in the Department of Bioengineering with the Revolutionizing Engineering Departments (RED) grant at the University of Illinois at Urbana-Champaign. Dr. Cross' scholarship investigated student teams in engineering, faculty communities of practice, and the intersectionality of multiple identity dimensions. Her research interests include diversity and inclusion in STEM, intersectionality, teamwork and communication skills, assessment, and identity construction. Her teaching philosophy focuses on student centered approaches such as culturally relevant pedagogy. Dr. Cross' complimentary professional activities promote inclusive excellence through collaboration.

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Gabriel Burks is a postdoctoral research associate at University of Illinois Urbana-Champaign. He is from Louisiana where he also completed his Baccalaureate Degree in Physics with a minor in Chemistry from Grambling State University. Dr. Burks received his doctoral degree from Drexel Unviersity in Materials Science & Engineering and was also a National Science Foundation GK-12 STEM Fellow for 3 years, in the School District of Philadelphia. Primary research interests are: 1) synthesis and characterization of functional polymeric materials, 2) polymer crystallization phenomena, and 3) pedagogical assessment of conventional and nontraditional STEM spaces.

Leveraging undergraduate curriculum reform to impact graduate education: a case study

Abstract

For more than a decade, American industries have complained that the skills of engineers entering the workforce are not sufficient to meet the challenges of a high-performance workplace [1]. In addition, ABET has recently changed the student outcomes required for engineering graduates to reflect many of the skills lacking in undergraduate training [2]. Additionally, national studies suggest the preparation of US graduate students is too narrowly focused on academic research skills, at the expense of professional skills such as communication, teamwork, mentoring, and leadership [3]. In response to these studies, many departments are trying to radically change their curricula to better suit the changing needs of employers. However, these changes are often made without a full understanding of the program's strengths and weaknesses. To help bridge the academic-employer disconnect, we suggest improving assessments of academic programs to drive evidence-based changes to curricula.

In response to national and local studies of employers, our department decided to radically transform the undergraduate curriculum in both content and delivery methods to better meet the need of employers. Our program conducted faculty surveys and interviews, student surveys, and employer surveys to determine key knowledge and skills that are a priority for our program. In addition, we developed a robust assessment system to take baseline data and then collect data during the change process. During this curricular reform, we trained faculty in pedagogical approaches for the classroom and built active-learning classrooms to support the use of more active instruction. While moving the undergraduate program to active-learning, we moved lectures into online content and noticed that the content needed for support of undergraduate classes was often content that may also be needed for graduate curricula, particularly for remediation. Conversations about the graduate program and gaps in knowledge and is driving us to repeat what we have done for our undergraduate program to inform the graduate program of unique educational needs and skills for graduates. Assessment and instructional modules to link across both the undergraduate and graduate programs are being developed. These evidence-driven processes help to facilitate discussion about curricular reform and how curricular modules and assessment spanning across the department can impact the department culture around education across all levels. Here we present a case study of evidence-based multi-level curriculum reform including sharing our needs identification process from industry and department stakeholders as well as assessment tools used to collect student performance data to support multi-level curriculum reform.

Methods

Specifically, the critical challenges that need to be overcome, and are common to engineering departments, are: 1) transform instruction to evidence-based pedagogies; 2) how to transform course content from personal creative expressions to community owned and vertically integrated; 3) how to weave both technical and professional skills throughout the curriculum, including skills defined by the program outcomes; 4) how to create cultures of inclusion that are welcoming to students and faculty of all types; and 5) how to promote and incentivized faculty engagement in the change process and how to sustain change in a large department.

To maintain this common vision, we must create a community across these departmental programs and support feelings of justice within this community. Going beyond prior change efforts, we will maintain cohesion across programs by organizing them around Collaborative Inquiry (CI). CI engages adult learners in cycles of action and reflection to mutually find answers to a common, captivating question. Effective CI requires voluntary participation in small group discussion processes that leverage the diverse experiences of the participants to create and share new knowledge generated through cycles of reflection. These processes change the beliefs and assumptions of its participants, creating the adaptive change needed for instructional change. The captivating questions will flow from our identified challenges. As the group learns together, the central challenges motivating the change will remain centered in dialogue, maintaining buy-in for the necessity of the change effort. We will also engage faculty with experience in curricular change efforts.

Faculty in the department belong to many Communities of Practice (CoP) – undergraduate program faculty, graduate program faculty, undergraduate curriculum committee, graduate curriculum committee, and the faculty as a whole. Based on their participation and belonging to any of these groups, they may engage in processes related to the group's charge but not in other activities. When embarking on curricular reform focused on undergraduate education, graduate program faculty may feel like they aren't included or needed in discussions. By engaging all faculty in discussion and then reflection on these mass discussions in smaller groups, the faculty can reflect on how larger discussions may impact their other communities.

As part of the curriculum reform process, and in order to address the challenges stated above, we engaged all faculty in the need identification process. A first priority was to collect baseline data for the department. Several instruments were created including a climate survey and teaching practices inventory.

Instruments

<u>Climate Survey</u>

The department has developed a climate survey to track how the change effort supports feelings of justice among department faculty, how faculty interact in social network patterns, how faculty perceive their beliefs are changing, and how teaching cultures and practices change over time. We use this survey to measure feelings of justice (outcome, procedural, interpersonal, and informational) and citizenship behaviors among our faculty using standard instruments from organizational change theory [4, 5]. The survey asks questions like, "I relate to people from the Bioengineering Department as if they were close acquaintances/associates" and "Have your views influenced the department?", as well as specific questions related to the project such as questions about career choices, curriculum, and advising. The survey is administered to all faculty, staff, and students twice a year.

<u>Teaching Practices Inventory</u>

All faculty in the department were invited to participate in an interview related to teaching practices inventory, regardless of participation in undergraduate program classes. These results serve as a quantifiable baseline for the teaching practices in the department. Previous research has shown that some teaching practices are more effective than others when teaching science, technology, engineering, and mathematics (STEM) subjects; however, there are very few instances where these teaching practices are measured within university constructs. Along with previous research, there has been a nationwide push for the adoption of research-based teaching practices in STEM classrooms. We conducted a verbal survey interview with engineering faculty, using a modified "Teaching Practices Inventory," to determine the teaching practices that are actively utilized in their respective classrooms [6]. Each faculty received individual feedback and advice related to his or her responses and collective data was used to determine where improvements can be made on a departmental level for a more productive teaching and learning experience.

Results

<u>Climate Survey</u>

In order to facilitate revision of student outcomes and curriculum for the grant project, several surveys went out to students and faculty. The first iteration of surveys covered understanding of the field of bioengineering including career options, and select topic areas and skills relevant to the field of bioengineering. N=73, Faculty 19%, UG 58%, Grad 23%.

Figure 1: Results from career-oriented questions showing faculty, undergraduate, and graduate options on how well the programs prepare them for careers in bioengineering.

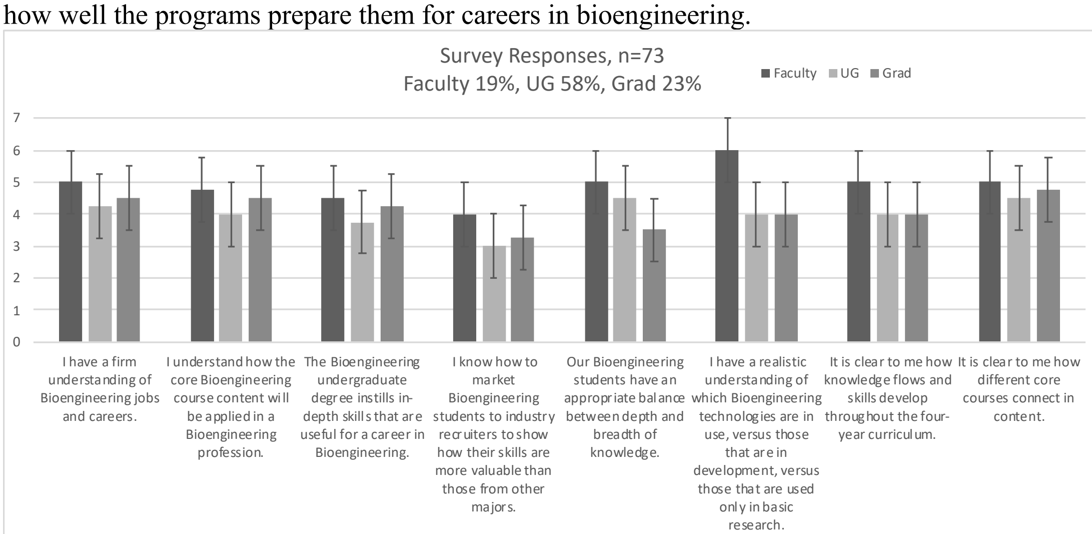
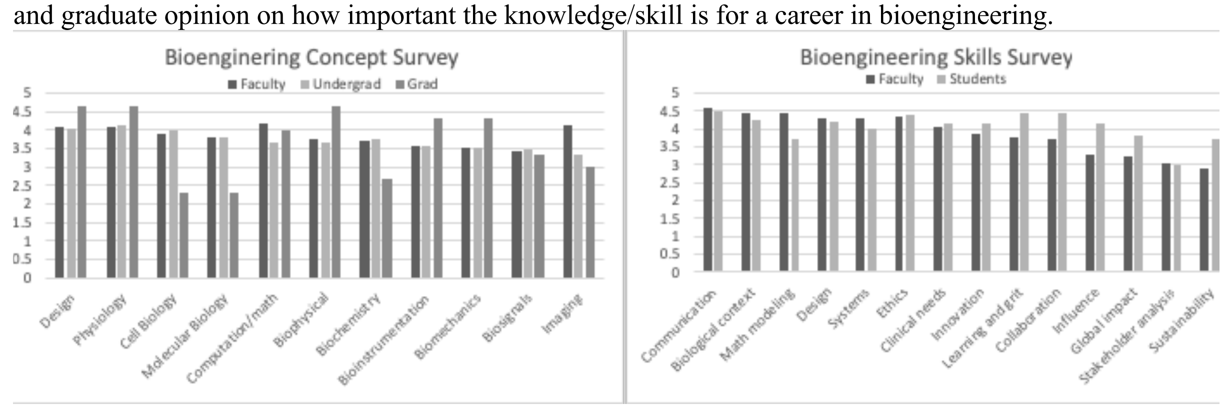


Figure 2: Results from knowledge and skills questions in climate survey showing faculty, undergraduate, and graduate opinion on how important the knowledge/skill is for a career in bioengineering.



All faculty received these data in a faculty meeting presentation and the resulting student outcomes that were formed with these in mind were presented. The survey highlighted a need for more career focused instruction and mentoring as well as a student desire for collaboration and other non-technical concepts like influence and innovation across both undergraduate and graduate students. After the initial survey, all groups are also participating in a new more detailed survey that went out to students, faculty, and employers that aims to parse out more specifics about these topics and skills.

After seeing these results and participating in the undergraduate program changes to program outcomes in the wake of the new ABET outcomes, the graduate programs curriculum committee also underwent a process of forming student outcomes and engaging stakeholders in the formation of the program outcomes. Previously, the graduate programs had no published program outcomes, so the undergraduate program outcomes combined with the survey findings were used to guide the writing of outcomes.

MEng Program Outcomes

1. Ability to apply quantitative skills and engineering principles to propose novel and practical solutions to medical/human health problems
2. Ability to gain basic understanding of business, finances, intellectual property and regulatory matters
3. Understanding of professional and ethical responsibilities
4. Ability to communicate real-world scientific problems with bigger vision and offer solutions, as well as their impact, effectively to a diverse audience and stakeholders, both orally and in writing
5. Demonstrate moderate to high technical mastery in chosen research area, shown by the ability to identify an important scientific problem, formulate a hypothesis, and design experiments to conduct research and data analysis to test the hypothesis. The student should also be able to formulate alternatives.
6. Develop effective leadership skills in order to foster the ability to conduct collaborative research and work with a diverse team

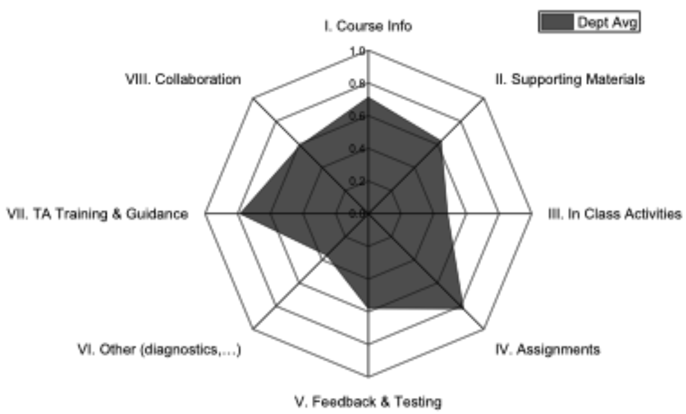
PhD Program Outcomes

1. Ability to apply quantitative skills and engineering principles to propose novel and practical solutions to medical/human health problems.
2. Understanding of professional and ethical responsibilities.
3. Ability to communicate scientific problems and solutions, as well as their impact, effectively to a diverse audience and stakeholders both orally and in writing.
4. Demonstrate depth of technical knowledge in chosen research area, shown by the ability to identify an important scientific problem, formulate a hypothesis and design experiments to conduct independent research and data analysis to test the hypothesis. The student should also be able to formulate alternatives.
5. Develop effective leadership skills in order to foster the ability to conduct collaborative research and work with a diverse team

Teaching Practices Inventory

The TPI was administered by interview and 17 faculty participated in the interviews. Results showed that department faculty have a high average score with an average of 38.7 and a standard deviation of 5.8, compared to the published average from a study of 5 schools of 30.46 ±3.3 [6]. The data underscore the need for training and guidance on in class activities and feedback and testing in evidence-based instructional practices, but a strength in variety of assignments given in class.

Figure 3: Shows average faculty score on each category, highlighting the need for guidance on diagnostic tools and in-class activities, but also highlight a strength in variety of assignments given in class.



After seeing the results of the TPI, we offered a workshop on common evidence-based teaching practices that faculty could try in the classes. Our faculty generally lack the experience to immediately implement the proposed experiences and assessment techniques. To help supplement this, we created a workshop to provide focused pedagogical training as needed, linking best teaching practices to content, offer assistance with and coordinate exercise development, ensuring continuity between curriculum levels, and assure fluid communication and continuity among faculty comprising the department and throughout all levels of the curriculum, which is especially important considering that target skills and content are threaded longitudinally and coordinated throughout curriculum.

Graduate programs have followed up and asked for more help in designing assessments for online learning platforms as well as how to implement some of the evidence-based instructional practices in an online environment, which we are piloting in the coming semester.

Conclusions and Future Work

Graduate programs are often neglected but by involving the entire department in curriculum reform, rather than just the undergraduate curriculum committee, the changes are able to have a bigger impact on the entire department and its culture around education.

Acknowledgement

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