# Harnessing Internal Resources: Strengthening Engineering Education by Partnering with an Education School

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***Abstract* – In response to the expectation that Engineering programs in the U.S. attract and retain more under-represented students and assess program outcomes, generally, this paper reports on a replicable partnership around assessment and program improvement between the Engineering School and the School of Education at a research university. Under the auspices of a National Science Foundation-funded (NSF) research project, the two Schools, together with nine education doctoral students, engaged nine research questions. The questions focus on student access to and retention in BME specifically and engineering, generally, from high school through the PhD; how well students are prepared for engineering careers or graduate programs; the interdisciplinary nature of BME, and what practices facilitate interdisciplinary work; and the experiences of under-represented students (women and people of color). To accomplish the research, each of the nine education students is engaged in an individual dissertation, focusing on a single question from this larger study. Through monthly meetings, the combined Engineering/Education research team reviews results and discusses implications. The results include benefits for both Schools – real-time applied research experience for the education students and a useful, continuous analysis of data and program improvement strategies for the Engineering program.**

*Index Terms* – collaboration, interdisciplinary, program assessment, retention, under-represented students.

## INTRODUCTION

Two trends in education in the USA are converging on the discipline of engineering. The first is the need to strengthen the number and diversity of students successfully completing STEM degrees. Engineering's participation rates among women and other under-represented groups lag behind most other disciplines [1]. The second is the expectation that institutions of higher education assess, demonstrate and report on outcomes [2]. Engineering needs to be able to identify the difference its programs make in attracting and preparing future researchers and innovators.

While consulting companies abound to assist Engineering Schools, one resource remains under-utilized: Schools of Education. This paper discusses an unusual, but replicable, collaboration between one Engineering School and one School of Education to address the challenge of the education pipeline into and through the field of Biomimetic Microelectronic Engineering (BME) at a USC research university. The paper covers the creation and operation of the partnership, the research plan, a brief summary of results to date, and suggestions for other institutions wishing to create a similar partnership.

## GUIDANCE FROM THE RESEARCH ON ACADEMIC PARTNERSHIPS

True collaboration across academic disciplines, and in particular across disciplines that are unrelated to each other (for example, a science and non-science such as engineering and education) is challenging. An academic discipline is characterized by its unique "(1) body of knowledge, including concepts and beliefs (knowledge of objects), methods for increasing and securing knowledge (knowledge of methods), and values about judging the quality and importance of knowledge (knowledge of values); (2) a social body with effective rules and means for increasing, communicating, and teaching the body of knowledge as a way of self-reproduction" [4]. In other words, not only are our subject areas very different, but the ways in which we discover or test knowledge, and even the ways we interact within a discipline are distinct [5].

What we know about interdisciplinary collaboration comes primarily from the health sciences, and the bulk of that research involves collaboration between researchers and practitioners, rather than researchers across academic disciplines. Our own work with partnerships between universities and community based organizations indicates the need for three critical elements for a collaboration to be successful: (a) a shared understanding of the purpose of the project and each contributor's role; (b) a sense of equity – not that everyone receives the same benefits, but that each gets out of the project in proportion to what they contribute; and (c) frequent and consistent communication about project status [6]. With these elements in mind, the authors, one from a school of education, the other from a school of

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engineering, began a partnership to evaluate the educational impacts of an NSF-funded outreach program in biomedical engineering.

## CREATION AND OPERATION OF THE EVALUATION PARTNERSHIP

Under the auspices of a National Science Foundation (NSF)-funded Engineering Research Center (ERC), a lead faculty member from the BME department invited a lead faculty member from the School of Education (SOE) to direct the assessment of the university-related educational outreach efforts of the ERC. The "science" of the center focuses on the use of nanotechnology to solve specific medical challenges (loss of vision, loss of mobility, and loss of cognitive functions). Part of the center's educational efforts focuses on introducing curricula to support the creation of future researchers and technicians in this emerging, interdisciplinary field. A second part of the program is creating engineering modules to be used at the Bravo Medical Magnet high school in select senior and junior level science courses. This outreach has been occurring for the past 3 years as the grant is in its 3rd year. At the time the partnership started, the ERC was offering four new courses and lab experiences aimed at encouraging undergraduates and master's level students to study BME.

The SOE faculty member assembled nine graduate students enrolled in the EdD (professional doctorate) who were interested in working together through the program's "thematic dissertation" process. Much like a typical research team, the thematic group works together on a broad research area, with each student taking an individual research question from that common topic and developing their own dissertation. Each doctoral student works full time at either a college or K-12 school in the area, and attends the doctoral program part-time. The benefit of this "thematic dissertation" model for the students is that it provides structure for the research process, and reduces the isolation doctoral students often encounter as they write their dissertation. As a result, 85% of the EdD students in this SOE program graduate within four years, compared to 50% nationally [3].

### *Procedures of the Team*

The inter-disciplinary team for this assessment consists of the two faculty and the doctoral students noted above as well as the pre-college and undergraduate outreach coordinators, the academic advisors for BME undergraduate and graduate students and the project's administrative coordinator. The entire team meets monthly to review progress and trouble shoot issues such as access to participants or the development of a specific interview protocol. As results become available, the lead student investigator presents the findings to the team for discussion. In addition, the SOE faculty member and doctoral students meet bi-weekly to discuss questions related to the research literature or methodology, or dissertations, generally.

Two of the doctoral students were selected to be the coordinators of the group, with each being paid a stipend by the NSF grant. One works 20 hours per week and is the lead for facilitating communication and the sharing of materials between the two lead faculty and the student research team. This student is expected to graduate at the end of the 2007 calendar year. The other works 10 hours per week assisting all the researchers in securing participants and coordinating focus groups. This student is expected to graduate in 2008 and so will replace the graduating coordinator, thus the coordination for the project has a succession plan.

Data collection is coordinated such that the group accesses a given student or faculty member via interview or focus group only once, to prevent participants from being solicited too frequently. Therefore, interview and focus group protocols and surveys are designed by the group to incorporate each study's questions. The doctoral students divide up facilitating the interviews and focus groups so that each gets experience, working with their colleagues and the SOE faculty member, gathering the data.

Once findings become available, and after they have been reviewed with the entire research team, the BME lead faculty member coordinates a meeting with the relevant BME and/or Engineering faculty and/or staff to discuss the results and develop strategies for program improvement based on the findings.

## THE RESEARCH PLAN

The partnership focuses on evaluating the outcomes of that educational effort by (a) looking at the now 7 newly designed courses, and comparing their educational outcomes with regard to retention in engineering, with the bio-medical engineering program, generally, at USC; and (b) tracking former participants of the High School project, who are now in college, to see if they pursued any STEM fields while in college. The long-term assessment goal is to determine if the BMES ERC is able to attract and retain an increasing number of diverse and under represented students in the science and engineering related areas of study. The evaluation study has three topic areas, with multiple studies under each, for a total of nine studies. With each of these issues, the doctoral researchers will be disaggregating data to explore patterns by sex and race.

The study is divided into three themes with various methodologies under each theme: 1) Access/Pipeline, 2) Retention, and 3) Graduation/Career Plans.

### *Theme 1: Access/Pipeline*

- **Study 1—**Phone interviews with the 27 students who graduated from the Medical Magnet high school, who are now in college (Class of 2004-2007). [College students under 18 years of age are excluded from the study and High School graduates will be contacted at least 6 months from their High School graduation date].
- **Study 2**—Demographic comparisons of enrollment using an equity index [4] of women and under-represented groups in the ERC, BME and Engineering school generally, benchmarked against overall undergraduate enrollment at the University, and against national enrollment in Engineering programs.

- **Study 3**— Phone interviews with 35 students who have taken BMES-ERC courses, analyze course taking patterns, admission patterns, demographic patterns, career goals.

*Theme 2: Retention*

- **Study 4**—Phone interviews with (a) students who have taken 2+ BMES-ERC courses (N = 22); (b) students who have taken 1 BMES-ERC course (N = 13); and (c) students who enrolled in one BMES-ERC course and dropped after the add/drop week without completing the course (N =5 '06-'07 academic year). Review University course evaluation data. Compare students' experiences in BMES-ERC courses versus other BME/Engineering courses and suggestions for improving the program.
- **Study 5**-- Interviews with faculty throughout Engineering and the ERC (N = 12) about attracting and retaining under-represented students.
- **Study 6** – Interviews with faculty throughout Engineering and the ERC (N = 12) about doing interdisciplinary research and teaching – barriers and facilitators.

*Theme 3: Graduation/Career Plans*

- **Study 7**—Survey of undergraduate program graduates who have taken BMES-ERC courses (N =38 '06; N=39 '07) about their experience in the BMES-ERC program before graduation (3 weeks prior to graduation) and one year after graduation.
- **Study 8**- Interview employers (N=16) based on the graduation survey to determine if students with a degree from BME are academically prepared.
- **Study 9**- Survey of graduate program graduates who have taken BMES-ERC courses (N =28 '07) about their experience in the BMES-ERC program before graduation (3 weeks prior to graduation) and one year after graduation.

*Assessing the Collaboration, itself*

Although not part of the NSF assessment, the study team noted the need to periodically assess how the collaboration was working. The SOE faculty lead created an open-ended survey using Survey Monkey and administered it at the one-year anniversary to the faculty, staff and education doctoral students who were working on the collaborative. Individuals were asked to indicate their level of contact with the "other group" in the collaborative (i.e.., if one were from the ERC, they were asked about contact with the SOE), the activities that had been most helpful to them, and suggestions for improvement.

## RESULTS

The collaboration is on-going, expected to run for the remainder of the ERC, which is anticipated to be funded through 2013, therefore results are based on the first year of the collaboration. In this section, results are provided that summarize briefly the studies conducted so far and the progress of the collaboration, itself.

*Study results*

- **Study 1: High School alumni.** As we have not yet been able to contact the comparison group, findings are limited to a discussion of the
- **Study 2: Demographic Study**. The equity index, benchmarking enrollments of women and under-represented students in the ERC and BME program against enrollment in Engineering and the University revealed the following:
  - ERC has 24% more females at the undergraduate and 15% more females at the graduate level compared to Engineering as a whole.
  - ERC has 6% more Asians at the undergraduate and 14% more Asians at the graduate level compared to Engineering as a whole.
  - At the undergraduate and graduate level ERC lacks the number of Black, Hispanic, and Native American students who participate in an ERC course in comparison to Engineering.
  - At the undergraduate and graduate level ERC has a lower percentage of students who are non-resident aliens.
- **Study 3**— Preliminary survey and interview data confirm the literature about engineering career choice: the majority of students chose engineering because of family influence; they either have an engineer in the family, or in the case of the first generation college students, chose engineering because the family saw it as a legitimate, status-bearing career path that could bring future economic stability for the individual and ultimately the family. Few mentioned being exposed to any outreach efforts.

*Theme 2: Retention*

- **Study 4**- Preliminary interview data indicates no significant differences in the undergraduate characteristics or experiences of students who stop out versus those who persist in the neuroengineering specialization. A majority of the students was unfamiliar with the BMES-ERC and the courses that were tied to its educational component. The BMES-ERC courses are technical elective courses for BME students. Therefore, the students took ERC courses based on the number of technical course units needed to complete their degree. Students who dropped an ERC course during add/drop week dropped for a variety of reasons: added the course late and felt behind, wanted a lighter course load, or after attending the class, discovered that the discipline did not meet their interests.
- **Study 5**-- The dominant theme expressed by faculty about increasing the diversity of students in the program was that they were interested but did not know how to make it happen. They pointed to several key school-wide diversity programs, and to the one faculty member in the ERC tasked with increasing student diversity as

positive efforts, but did not talk about having any personal responsibility for the effort, nor did they mention any structural barriers

- **Study 6** – Interviews with faculty throughout Engineering and the ERC (N = 12) about doing interdisciplinary research and teaching – barriers and facilitators.

*Theme 3: Graduation/Career Plans*

- **Study 7: Undergraduate Career Plans**. In May, 2006, the team administered the graduation survey to 53 BS BME Seniors. Thirty-eight responded (72% Response Rate). Seventy-one percent had taken at least 1 ERC course.
    1. Students who had taken at least one ERC course planned to work at a higher rate (21%) than students who did not take an ERC course.
    2. 46% of the ERC students who planned to work had been offered and/or accepted a job at the time of the survey.
    3. Overall the BS BME graduates felt that (a) BME should offer BME related coursework during their sophomore year, (b) the BME program is too general to be prepare them for industry; (c) they need assistance applying for jobs and schools, and (c) the BME students applying to medical school wanted more guidance.
- **Study 8**- The employer study will begin in fall 2008.
- **Study 9**- In April 2007, the team administered the graduation survey to 41 BS BME Seniors. Thirty-eight responded (68% Response Rate). 75% of the respondents were seniors in the masters programs and 25% were PhD students. 24% of the MS respondents were part of the designated ERC Medical Device and Diagnostic Engineering (MDDE) program.
    1. Graduate of the MDDE program plan to work at a higher rate (24%) than other masters graduates.
    2. Overall the MS MDDE graduates indicated they would like to see more flexibility in their course work.
    3. Graduates expressed a desire for seeing more faculty with industry experience teaching in the program.

Collaboration results

A preliminary, anonymous survey of the research team, using Surveymonkey.com, resulted in responses from 8 participants, four from the BMES-ERC and four from SOE. The respondents noted two reasons for the collaboration: compliance and curiosity. "Compliance" refers to the desire to respond to NSF's expectations for better assessment of ERC impact, and "curiosity" reflects participants' genuine interest in learning more about both how to do this kind of assessment and how to improve the BME program. There was no difference between the BME and SOE respondents in their perception of goals for the project.

The entire team meets once per month, which 100% of the respondents found to be enough. Indeed, all respondents found the structure and content of the meetings to be "somewhat" to "very" helpful. Elements of the meetings that respondents found helpful included:

- Providing updates about both program innovations and research progress;
- Sharing the timeline for the studies so that the ERC members understand the research agenda;
- Troubleshooting data access problems as ERC members can often help the SOE gain access

Suggestions for improving the collaboration included:

- Providing minutes of the meetings for those unable to attend;
- Providing in writing a brief summary of each research study, the names of the people conducting the study and its status at each meeting;
- Doing more advanced planning around data needs so that efforts maximize our access to participants

## RECOMMENDATIONS

Having a shared vision regarding the purpose of the research collaboration has been key to the success of this partnership so far. The primary strategy behind creating a shared sense of purpose has been communication. Working across two professional schools is physically and intellectually challenging. To get the most out of the partnership, each group needs to make an effort to understand the work of the other – for the educational researchers, this means understanding (albeit at a basic level) the science that is at the heart of the ERC; for the ERC faculty, it means being willing to look at the "intentionality" of their academic programs (how knowledge is sequenced; how experiences are structured) in unfamiliar ways. The partnership, therefore, benefits when its members create a transparent communication and decision-making process. Our partnership has not fully achieved that, but the feedback we received suggests that we are on the right track. Developing the research agenda together, sharing frequent status updates, meeting regularly, and making the effort to share information with those who cannot attend meetings, while seemingly simple steps, go far to insure that the evaluation partnership will be successful.

Access to data can be difficult for an outcomes study like this. Not all programs keep contact information for their alumni, nor do they know all of the employers hiring their graduates, for example. Academic units are rightly protective of student contact information. The SOE researchers needed the ERC faculty to provide legitimacy for their requests for data, and help gain access to student, faculty and alumni. Still, our preliminary samples are smaller than what we would like. Prior to the next round of data collection, we will build into the department's processes some ways to facilitate data collection, such as securing non-University contact information for seniors in the weeks before they graduate. Other groups wanting to engage in similar studies should anticipate having difficulty accessing participant contact information. Possible remedies include working with a campus alumni office, soliciting contact information prior to graduation, and (re-)introducing the assessment project to students at orientation each fall.

Perhaps the greatest asset for a partnership like this is trust. By this we mean that our BME colleagues take a risk in stepping back from controlling the outcomes research, and willingly allow the SOE colleagues to do what they do well – educational outcomes assessment, with the understanding that the process will be respectful and helpful, rather than adversarial. Too often "program evaluation" has come to mean either counting things that do not matter, or "catching people doing things wrong." The SOE colleagues work to demonstrate that neither is their intent. If the two units trust and respect each other, both programs gain – the ERC through practical data and suggestions around program improvement, and the SOE through real-time research opportunities for its doctoral students.

## CONCLUSIONS


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