Introducing New Engineering Faculty to Multidisciplinary Research Collaboration

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Abstract

In recent years, a large and rapidly growing body of academic research has involved multidisciplinary collaboration. This trend has been driven by a dramatic rise in funding for multidisciplinary projects and research centers, along with a growing recognition that few truly important unsolved research problems involve only one discipline and faculty members cannot hope to become experts in everything.

When planning a week-long orientation workshop for new engineering and science faculty at North Carolina State University, we felt a responsibility to acquaint the participants with this reality of academic research and to help prepare them to engage in collaborative efforts that go well beyond their familiar academic turf. To this end we organized the workshop participants into bi-disciplinary pairs and gave them about 90 minutes to formulate a research project involving each of their areas of expertise. Most of their project outlines (including some from the most unlikely pairings) were coherent, feasible, exciting, and in the opinion of the workshop leaders, likely to be fundable if they were followed through to completion. Some of the pairs have in fact continued their conversations and several proposals are expected to emerge.

This paper briefly outlines the content of the orientation workshop, describes the structure and operation of the project formulation exercise, summarizes the proposed projects, and recounts the participants' reactions to the exercise.

Introduction: Orienting New Faculty Members

Robert Boice[1] has found that most new faculty members take 4–5 years to become as effective in teaching and productive in research as they are capable of becoming. This result is not surprising considering how little the higher education community does to orient its initiates to the challenges that come with their new jobs. Most new Ph.D.'s who join faculties have only been prepared to work on a research problem someone else has defined. They are expected to figure out for themselves how to plan a course, teach it effectively, assess the learning of their students, define their own research problems, identify and approach potential funding sources, form a research team of graduate students and possibly faculty collaborators, write successful proposals, carry out the research, disseminate the results, balance the competing time demands imposed by teaching, research, and service, and integrate themselves into their campus culture.

Boice[1] also found that about 10% of new faculty members are what he terms "quick starters," who climb the learning curve to full effectiveness and productivity in 1-2 years. At N.C. State, new faculty members participate in a week-long orientation workshop[2] designed to provide guidance in all important aspects of faculty careers, thereby increasing the chances that those capable of being quick starters will in fact do so. The workshop takes place two weeks before the start of the fall semester and includes two days on effective teaching, two days on building and managing a research program, and a half-day on balancing time demands, integrating into the campus faculty culture, and meeting the requirements for promotion and tenure. The workshop was given in Fall 2000 exclusively to College of Engineering participants and in Fall 2001 jointly to participants from the Colleges of Engineering and of Physical and Mathematical Sciences.

The third day of the workshop deals with selecting research proposal topics, identifying and approaching funding sources, writing effective proposals, and managing the internal and external processing procedures required to get them funded. The day includes an exercise in which participants are paired across disciplines and asked to formulate a project that combines their areas of expertise. This exercise constitutes the main topic of this paper.

Bidisciplinary Project Formulation Exercise

At the beginning of Day Three, the participants wrote brief summaries of their research interests and previous proposal writing efforts, and we collected and sorted their responses into plausible pairings across disciplinary lines. For example, a computer science instructor with interests in data mining was paired with a chemical engineer interested in new materials generation via combinatorial synthesis techniques, and an electrical engineer with interests in optical switching was paired with a computer scientist involved with optimal network synthesis. After we ran out of plausible pairings, we matched randomly. One faculty member from computer science joined the workshop late and was paired with the only participant still unpaired, another computer scientist who fortunately worked in a much different research area.

Following a workshop session entitled "Research Overview," each pair was given 15 minutes to exchange and discuss their research interest summaries. Subsequently, a "Writing the Research Proposal" session outlined the key elements of idea generation, problem synthesis and statement, selection of methods and materials, and projection of anticipated results and interpretations, after which the pairs were reconvened and asked to brainstorm possible bidisciplinary projects and then to choose one. The project titles and disciplines of the pairs that proposed them are listed below:

1. *Detecting malicious DNS servers* (Computer Science/Statistics)
2. *Distributed computing for particle/nuclear physics problems* (Electrical and Computer Engineering/Physics)
3. *Efficient reconfiguration of wide-Area optical networks* (Computer Science/Operations Research)
4. *Modeling of neutrino distribution in supernovae* (Mechanical and Aerospace Engineering/ Physics)

5. *Priority-based cooperative decentralized networking scheduling for optimizing the communication for a cluster computer*. (Computer Science/Computer Science)
6. *Statistical mixture models for rainfall data* (Marine, Earth, and Atmospheric Sciences/Statistics)
7. *Temporal event recognition for combinatorial catalyst design* (Chemical Engineering/Computer Science)
8. *Water flow in porous media of very low permeability: bridging the micro- to meso-scale* (Marine, Earth and Atmospheric Sciences/Physics)

The initial idea generation was begun late in the morning and the discussion continued through most of the 45-minute lunch period. Over dessert, the pairs were asked to summarize the status of their project outlines on a single transparency. Did they converge on a topic? If so, what was it and how far did they get in planning their project? If not, what were the stumbling blocks and how might they try to achieve a better outcome in a subsequent attempt? Immediately after lunch, each pair was asked to briefly share its summary by either showing their transparency or reading a jointly written statement. Most pairs went beyond simple summaries to recount alternative ideas they had considered, where their conversation had gone well or flagged, and how they might proceed to turn their sketch into a full-blown proposal.

Several college research administrators were present during the exercise. After each of the pair summaries, they suggested agencies that might be interested in the given topics or related ones, in some cases identifying senior engineering faculty members doing related work. These commentaries provided excellent illustrations of the benefits of seeking advice from senior faculty and administrators when beginning research projects.

After the presentations, we applauded the participants for coming up with such promising ideas in only 90 minutes of conversation with collaborators from ostensibly unrelated areas whom they had just met, and we asked them to imagine what they might accomplish in a full day with someone in a field closely related to theirs.

Among the questions appearing on the 2001 workshop evaluation form was one asking for comments on this exercise. All of their comments but one were essentially variations on the following two:

- This session was great. My partner and I developed a research proposal that I feel could be successful. Also, it was fascinating to learn about someone's research from another discipline.
- It was a very interesting exercise. It helped me understand how easy it can be to iron out a fairly decent idea in approximately one hour! I was quite concerned at first; however, my partner and I are going to try and pursue our idea further.

The only complaint came from one of the two paired computer scientists, who wished that he had been able to work with someone in a different department.

Suggestions to Workshop Facilitators

When the idea of including a bi-disciplinary project formulation exercise in the workshop was first proposed by one of the authors (DFO), we had no idea what to expect. We could readily imagine most of the pairs floundering for 90 minutes, getting increasingly frustrated, and having little or nothing to show for their efforts, and we were relieved when the exercise exceeded our best hopes the first time we did it and delighted when it went even better the second time. In both instances, the opening dialogues about research interests (during which we did a lot of eavesdropping) were comfortable and informative, and all pairs maintained a continuing conversation throughout the rest of the day, often having to be interrupted so we could move to the next topic on the agenda. Progression through the traditional team growth sequence of "forming, storming, norming and performing" was often evident in their interactions, and most of the teams felt that they had come up with a feasible topic and promising project outline. We are confident that we achieved our goals of making the participants aware of the benefits of research collaboration and increasing their confidence in their ability to undertake it. Some of the pairs continued their dialogues after the workshop was over and we anticipate several proposals emerging from their efforts.

An important question is how proactive the facilitators should be in matching the interests of the participants when forming pairs. One extreme would be to collect the interests ahead of time, match them as closely as possible, and help the pairs formed in this manner to identify feasible project topics, and the other extreme is to completely randomize the pairings. There are points to be made for both extremes. The more successful pairs are, the more likely they will be to actually undertake collaborative research after the workshop, and having logical interdisciplinary connections within a pair increases the chances of success. At the same time, maintaining the appearance of random selection reinforces the point that the potential for successful collaboration exists between *any* two fields if the collaborators are sufficiently creative.

After contemplating the alternatives, we have decided that the optimal course of action is to continue to match participants in disciplines that are complementary but not obviously so (as, for example, matching a chemist and a chemical engineer would be). Good combinations in our experience are computer scientists or experts in statistical analysis matched with experimentalists in any discipline, and experts in applied mathematics matched with non-mathematicians interested in modeling physical, chemical, or biological processes and systems.

Another question concerns the time that should be devoted to the exercise. We believe that 90 minutes constitutes a minimum for meaningful results to be achieved, but there might be value in allowing more time for the participants to flesh out their ideas to a greater extent. One approach would be to carry out the exercise in two stages, so that the participants could do some exploring, writing, and polishing as "homework" after the opening exploratory session and then report on their results in the second session.

The enthusiastic responses of the participants and the quality of their work suggest the power of this exercise both to interest new faculty members in collaborative research and to convince them that it is something well within their power to do. We intend to continue the exercise in future offerings of the orientation workshop, and we recommend it for any faculty development workshops or learning communities that deal with research project planning and proposal generation.

Suggestions to New Faculty Members

Research collaborations offer several benefits to new faculty members. The right collaborator can supply critically important knowledge and skills that the new faculty member might be lacking, and working with a successful experienced researcher can take years off the usual research learning curve. Multidisciplinary collaborations in particular expand the list of research topics that can be addressed, opening the door to funding possibilities that are not available to single-discipline projects.

If you are a new engineering faculty member, this paper should make it clear that coming up with ideas for multidisciplinary collaboration is not a terribly difficult task, nor does it require unusual creativity. Participating in a workshop exercise like the one described in the paper makes the task much easier, but most new faculty members do not have such opportunities, which simply means that you will have to be proactive and create them for yourself. Here are several suggestions for going about it.

1. Brainstorm (either individually or with a faculty mentor) a list of disciplines that might have a remote chance of complementing your research area. Use your imagination—besides other engineering disciplines, think about physical and biological sciences, mathematics and statistics, computer science, and (if your research involves human behavior in any way) the social sciences and humanities. For each discipline you come up with, write one or more possible project topics. Then prioritize the combined list of topics in decreasing order of your interest in working on them.
2. Ask one or more experienced researchers in your department to comment on the potential feasibility and fundability of your projects. Unless you have a strong feeling to the contrary, eliminate the ones that they regard as unsuitable by either criterion.
3. For each of your top two or three topics, list the knowledge and skills you would look for in a collaborator. Focus on skills that complement yours. For example, if you are a theoretician, consider finding a skilled experimentalist and consider the converse if you are an experimentalist; if your project involves collecting data of any sort and you don't have a strong background in statistical design and analysis, consider finding someone who does; and if you are thinking about educational research of some sort, consider collaborating with someone in education, educational or cognitive psychology, or sociology. (We could go on, but you get the idea.)
4. Find potential collaborators with the qualifications you identified. Ask your colleagues if they know anyone who fits. Call the head of the department in question and ask who works in the areas you have identified, or check the university catalog to see who teaches courses (especially graduate courses) in those areas.
5. Call the identified potential collaborator on your highest priority project and arrange a meeting to explore possibilities. If he or she is not interested for any reason, ask if a colleague might be. If you strike out, go on to the next project.

6. When you meet with a potential collaborator, describe your idea as positively and enthusiastically as possible. When you find someone interested in pursuing the idea with you, take it from there.

It is probably be a good idea to pursue only one of your projects at a time, but don't throw out your list. At the very least, this exercise will broaden your thinking about your research area and will introduce you to faculty colleagues who might be useful or interesting to know. There is no telling what else it might lead to.

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References

1. Boice, R. *The New Faculty Member*. (1992). San Francisco: Jossey-Bass.

2. Brent, R.; Felder, R. M.; Rajala, S. A.; Gilligan, J. G.; Lee, G. (2001). "New Faculty 101: An Orientation to the Profession," *2001 Frontiers in Education Conference Proceedings.* Washington, DC: ASEE/IEEE.

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