Interdisciplinary Research: A Student's Perspective

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Commentary

Interdisciplinary Research: A Student's Perspective

by Eric N. Brown

Academic research is adopting a new methodology of addressing scientific questions. Increasingly research is done as part of large centers and interdisciplinary groups, an approach that provides new ways of addressing and motivating the development of ideas. In some cases it proves to be the only means to resolve a problem that no single discipline is able to solve. But it also creates a new environment in which graduate students study and perform their thesis research. This paper addresses one graduate student's experience of working with an interdisciplinary research group in the field of self-healing polymer composites.

Interdisciplinarity versus Multidisciplinarity

Historically, choice of institution for graduate studies has revolved around a search for the single faculty member or department that offers the best opportunity in the student's area of interest. The skill sets and relationships developed during the period of study are expected to direct the student's future career. Students would expect to form an intimate working relationship with their mentor, focusing on a well, but narrowly, defined problem. As successful as this specialized, disciplinary approach to research has been and as essential as it will continue to be to the university structure, it is not adequate to address many larger questions that are of interest. Thus this practiced model is now giving way to interdisciplinary research and multi-investigator projects.

Interdisciplinary teaching and research are already strong and important aspects of the intellectual environment at leading academic institutions, as can be seen by their many centers, institutes, and interdisciplinary programs. Often students obtain cross-disciplinary education through informal one-on-one interaction with faculty, choice of elective classes, and minor areas of study. Steven Richardson (*1*) suggested that we recognize the 1990s "as a decade of integration. By that I mean loosely that higher education is moving through a period of connections—among disciplines, between the university's various student, faculty and staff constituencies." This transition is being driven by the prospective gains in insight and understanding of research areas from the integration of concepts and methodologies of different disciplines. Potential gains are especially evident when an impasse occurs due to the constraints of one's own discipline.

The terms interdisciplinarity and multidisciplinarity are often used interchangeably to refer to researchers from different disciplines or backgrounds coming together to collaborate on a common goal (*2*). However, when strictly defined these two terms take on dramatically different meanings (*3*), with profound implications for the potential of a research endeavor. *Interdisciplinarity* is the emergence of insight and understanding of a set question through the integration of different concepts, methods, and theoretical frameworks assembled from a wide cross-section of disciplines to generate novel concepts and synthesize new theories. In practice, many proposed interdisciplinary efforts ultimately work at the multidisciplinary level. In *multidisciplinarity*, while a group of researchers from different disciplines cooperates by working together on a set problem towards a common goal, they continue to do so using theories and methods from their own discipline, with occasional use of output from each other's work. They remain within the boundaries of their own disciplines in regard to both their working practices and results. True interdisciplinary research renews the individual disciplines by introducing new questions, ideas, and methods.

Joining an Interdisciplinary Research Group

My personal search for an area of graduate studies led to my working in the nascent field of autonomic materials. This search—which originated as a search for a single advisor—focused on finding intellectual and financial support on a promising project involving mechanics of materials. I was excited by the prospect of starting into the fledgling research area of self-healing polymers. The environment an interdisciplinary group would foster also intrigued me. Rather than working on a specialized project with a single professor, I have been working closely with four faculty members with dramatically different expertise and have had the opportunity to encompass multiple areas of the project. Through interdisciplinary research we have been able to demonstrate significant autonomic healing (*4*). Continuing optimization of the self-healing system has yielded greater than 90% healing efficiency (*5*).

The breadth of education provided by an interdisciplinary project has far exceeded my expectations. To ensure true interdisciplinarity, the self-healing materials group has continued to work closely within and across the student and faculty constituencies. In addition to work performed under the direct tutelage of Nancy Sottos, my thesis advisor who is in the Theoretical and Applied Mechanics Department, I have had the opportunity to become involved in issues such as materials processing and polymer chemistry. My research and personal level of growth have benefited greatly from the influx of ideas and support from these faculty and departments. As Pelikan (*6*) suggests, "the difference between bad scholarship and good scholarship is the result of what a student learns in graduate school, but the difference between good scholarship and great scholarship is, as often as not, the general preparation of the scholar in fields other than the field of specialization." The addition to the educational experience, however, spans beyond direct impact on research. Success of interdisciplinary research depends upon the fundamental competencies of the individual disciplines. As such, students involved in interdisciplinary projects require a level of knowledge and rigor

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of their chosen discipline equal to their peers, while having the additional stimulus for the evolution of their scholarship from the ingress of concepts and methods of other fields.

Working in an Interdisciplinary Group

When an interdisciplinary group of the type I work with is brought together, the members do not necessarily have a common technical vocabulary or perspective for addressing the chosen question (*7*). In fact, there are many obstacles and cultural differences that prevent cross-fertilization of ideas. These include dissimilar concepts, different methods of analysis, contrary expectations, and dissimilar criteria for value judgments. For example, when considering issues of polymerization as applied to self-healing materials, a chemist may focus on issues of polymer molecular weight and percent yield while a mechanician will focus on fracture and adhesive properties. These differences of culture can foster personal and communication skills in the students. We have had the fortunate opportunity to work in the Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign, which was founded on the premise of enabling interdisciplinary research. Students and faculty from a cross-section of departments are collocated to encourage cross-disciplinary interaction.

Perhaps the most significant challenge facing a student working on collaborative research while preparing a dissertation is amassing a clearly defined body of personal contributions. In the model of one student, one professor, the student demonstrates contribution to the entire body of work, while acknowledging the role of his or her advisor. To fully harness the potential of interdisciplinarity, however, students must learn to work with each other, sharing knowledge and ideas. Often the initial idea of one student is realized by a second. In these cases each student must demonstrate value added to the end result or conclude that either the conception or the realization alone is the critical development. In some research projects, students work secluded from the group while professors interact at an interdisciplinary level. While this makes for a clear distinction of the student's body of work, it prevents the project from fully realizing the potential of interdisciplinarity through continued close interaction within and across the students and faculty constituencies. More importantly from the educational standpoint, it deprives the student of the many wonderful opportunities provided by involvement with an interdisciplinary research group.

Advantages of Interdisciplinary Research

Successful interdisciplinary research holds great potential in situations where difficult questions are to be solved and individual disciplines are not adequately equipped to address all facets of the problem domain. Novel results can be attained by individuals coming together from across the disciplines and working as a team. To achieve this requires participants to be open to new ideas and ways of communicating with each other. It also requires learning about the way another discipline works. Students would be well advised to take classes offered by their peer disciplines as well as their own. As with all opportunities available to students in our leading institutions of higher learning, the benefits of being in an interdisciplinary research environment are very real and very rewarding but require active participation of the student to be fully realized.

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Editor's Note: Research results on self-healing polymers from the interdisciplinary group discussed in this article are described in the report from *Nature* on page 10 and illustrated on the cover of this issue.