



Executive Summary

In May 2008, a two-day workshop was held in Arlington, Virginia with the goal of defining the progress of interdisciplinary research and graduate education and their impacts on academic institutions. The workshop was sponsored by the National Science Foundation (NSF) Directorate of Education and Human Resources, Division of Graduate Education, Integrative Graduate Education and Research Traineeship (IGERT) Program.



Organization and Purpose

The workshop was convened because of the growing acknowledgment of the importance of discoveries and outcomes of interdisciplinary, cutting-edge science and technology for economic and societal growth and vitality. Recognizing the many impacts of interdisciplinary research can catalyze a change in the landscape of U.S. universities to value and increase interdisciplinary graduate education.

Framing options for the future of support for interdisciplinary research and education requires an understanding of the current institutional landscape and the challenges of, opportunities for, and impacts of the transformations stimulated by interdisciplinary research at universities. To ensure a broad view, the perspectives of both institutional leadership and the faculty leading interdisciplinary change projects

such as IGERT were sought. The meeting engaged 101 participants who are the principal investigators (PIs) of IGERT projects as well as the senior leadership of U.S. universities that had active IGERT projects at the time. See Appendix 1 for a list of participants.

Eight working groups addressed questions focused on four critical impact areas of interdisciplinary institutional change:

- Research,
- Faculty,
- Graduate Education, and
- Academic Institutions.

Each of the working groups, four comprising PIs and co-PIs of active IGERT projects and four comprising leading administrators at IGERT institutions, was asked to consider and summarize central questions on the four impact areas that addressed the following topics:

- Progress and impacts made to date;
- What works and what does not;
- Opportunities and challenges going forward; and,
- Metrics for success of interdisciplinary research and graduate education.

The meeting agenda is presented in Appendix 2 and the specific questions addressed by each working group are summarized in Appendix 3. For the purpose of this meeting, participants used the term “interdisciplinary” to mean research and education that crosses disciplinary lines.

Discussion of the theme of interdisciplinarity for each topic frequently touched upon one or more of the other topics. Therefore, the summaries of the workshop themes in this report present key thoughts, contributions, and recommendations derived from both the working groups who

specifically chose to focus on that topic and from other discussions on that topic that occurred during the two-day workshop. This summary is a synopsis rather than a complete and detailed account of the entire work product that each group developed. The process used to develop this report is described in Appendix 4.



Key Observations and Recommendations

The following are key observations and recommendations resulting from the workshop discussions as presented in the working groups' reports.

RESEARCH

Key Observations

Content and methods used in research are in constant flux both within and between disciplines, and researchers must frequently employ interdisciplinary approaches to respond to emerging research problems. To carry out interdisciplinary research, one must have both disciplinary capability and interdisciplinary conversance. The ability to conduct interdisciplinary research is necessary to maintain U.S. competitiveness in high-value industries and has important economic and societal benefits through inventions and innovations that deliver new products and services

or improve the effectiveness and efficiency of existing processes.

Funding agencies play a key and ongoing role in supporting innovation and must continue support for the advances of core disciplinary research while also supporting research that cuts across disciplines. While federal funding agencies express the need for interdisciplinary approaches to problems, their structures and practices fall short. Some funding agencies have responded by funding multi-investigator, interdisciplinary proposals or problem-based proposals, but there are still concerns about the locus for review and funding of individual investigator-initiated grants.

Recommendations for Advancing Interdisciplinary Research

Universities

- Develop new models of university organizational structures and funding to facilitate interdisciplinary research and build incentives for interdisciplinary faculty collaboration.
 - Organize discussions about research around achieving open-ended scientific discovery and addressing social challenges rather than framing discussions in terms of disciplinary versus interdisciplinary science.
 - Form research teams driven by basic or applied problem-oriented research challenges that serve to reduce the emphasis on whether a given research matter is disciplinary or interdisciplinary.
- Develop short-term, intermediate-term, and long-term measures of success of interdisciplinary research encompassing pedagogy, the structure of academia, and developing a diverse workforce in science and engineering, as well as external effects on industry, society (societal problems), and policymaking.

Funding Agencies

- Reduce the boundaries between disciplines at each of the funding agencies to encourage cooperation on review and funding. Foster interdisciplinary research at the individual research grant level in addition to the larger interdisciplinary grants.
- Collaborate among funding agencies and other constituency groups such as industry or states, and learn from each other's experience.
- Maintain a balance of funding between disciplinary and interdisciplinary research, emphasizing scientific problems as the major determinant in the types of funding programs in the portfolio.
- Increase the numbers of grants supporting interdisciplinary research and training clusters and centers in order to enhance the total investment in interdisciplinary research.
- Ensure the inclusion of more reviewers who are receptive to and conversant with interdisciplinary research. Multiple disciplinary reviews are not the same as review by colleagues who are experienced in interdisciplinary collaborations.

Key Observations

The principal driver of interdisciplinary research is the faculty, as faculty members are in a position to identify new research opportunities. Faculty hiring practices are changing rapidly as the nature of research changes. To address the ongoing changes in the nature of inquiry, institutions continue to develop a range of hiring strategies, including cluster hires with a variety of models and hires with appointments shared between or among university units.

While the excitement of addressing significant new research problems as well as the advantages of

collaborative research are intrinsic incentives, successful collaboration depends upon faculty recognition and appreciation of each other's contributions to the research. However, successful interdisciplinary collaborations in both research and education can be difficult and time-consuming in many current university structures. Too often faculty lack institutional incentives and may even have disincentives for interdisciplinary research and education. Faculty may not be able to find funding for an interdisciplinary research grant or may not be rewarded by obtaining promotion or tenure for participation in

research and education that crosses university units.



Recommendations for Advancing Interdisciplinarity and Engaging Faculty

University Policies and Procedures

- Develop mechanisms for faculty with traditional disciplinary expertise to learn and embrace new interdisciplinary approaches and collaborations.
 - Establish incentives and remove disincentives for faculty to perform interdisciplinary research and teaching.
 - Address the incompatibility between traditional hierarchical administrative structures and new interdisciplinary cross-cutting programs.
 - Develop paths to reduce the potential tension between disciplinary and interdisciplinary interests when hiring faculty.
 - Reward successful interdisciplinary initiatives.
 - Provide mentoring and training of both junior and senior faculty in the skills needed to succeed in interdisciplinary research, including effective communication and teamwork.
- Develop new and agreed-upon models for evaluating faculty contributions to interdisciplinary work.
 - Establish policies regarding distribution of interdisciplinary grant overhead funds and credit for multi-authored publications, patents, and grants.
 - Define a mechanism for faculty to explicitly identify, communicate, and obtain credit for their individual contributions within multi-investigator interdisciplinary projects and publications.
- In order to facilitate the development of a broader more interdisciplinary view by faculty research collaborators, consider separating the research/graduate teaching functions from the academic unit-driven undergraduate teaching mission.
- Collect data and evaluate successful models of institutions that have demonstrated success with interdisciplinary initiatives.
- Develop ways to ensure benefit for multiple academic departments by using each other's courses, avoiding duplication of effort, and at the same time acknowledging the value of what their cognate colleagues bring to the table.

Recommendations for Advancing Interdisciplinarity and Engaging Faculty – Continued

Faculty Hiring, Appointments, and Assignments

- For both prospective faculty and for current faculty engaging in interdisciplinary endeavors, provide absolute clarity and transparency in the following areas:
 - Policies for tenure, promotion, and raises;
 - Faculty workload assignments when shared across departments or other units to foster interdisciplinarity; and
 - Valuation of work, which must be explicit and include both traditional measures and nontraditional measures that capture interdisciplinary breadth.

GRADUATE EDUCATION

Key Observations

There is a current and future need for scientifically trained professionals who can solve more complex problems, apply techniques from one field to another, communicate with others across disciplines, take risks, and be creative. It has been observed that students attracted to interdisciplinary graduate education appear to be more independent and more likely to “think outside the box” than others. On the



other hand, it has also been observed that interdisciplinary graduate training enables students to tackle more complex research problems, to be more creative, and to take greater risks.

Exposure to interdisciplinary study as undergraduates is the best preparation for interdisciplinary study at the graduate level. Because many complex problems are interdisciplinary in nature, graduate students must acquire a broader knowledge base

Recommendations for Future Interdisciplinary Graduate Education

- Ensure that undergraduates are prepared to do research and have sufficient depth and breadth in a discipline to undertake interdisciplinary research when they are graduate students.
- Develop mechanisms to support, recognize, and reward teamwork in graduate education and in thesis topic research.
- Develop specific outcome goals for skill development in the broad topic of professional skills and match training to these goals.
- Recognize the unique stresses on graduate students in interdisciplinary programs and provide support and mentoring.
- Make funding mechanisms that are typically tied to departments more portable and guarantee multi-year support, but also ensure a mix of experiences, including teaching experience, for those aiming for careers in academia.
- Provide credentialing through dual degree programs, certificates, minors, concentrations, designated emphases, or other means so as to recognize a graduate student’s interdisciplinary training and potentially aid in communicating both disciplinary depth and interdisciplinary breadth to potential employers.
- Utilize and build on successful collaborations from the past and use these as models for transformative interdisciplinary graduate training.

and different skills in approaching complex interdisciplinary problems. Yet, departmental resource allocation may limit their ability to work across units. Furthermore, graduate students are strongly affected by the complexity and breadth of the research they pursue as well as the number of faculty from areas outside their own with whom they interact. Therefore, students need both training in and exposure to interdisciplinary research and education. The maximal amount of interdisciplinary graduate education within an institution is determined by the amount of interdisciplinary research at the institution. However, interdisciplinary research does not ensure interdisciplinary graduate education.

There are many examples of universities that have found ways to make graduate education more flexible and to provide both disciplinary

depth and interdisciplinary breadth, ranging from cross-campus programs to individualized interdisciplinary doctoral programs.

ACADEMIC INSTITUTIONS

Key Observations

University administrations can make a real difference as supporters of faculty to lead and administer visionary interdisciplinary research and educational programs and collaborations. Maximal success of interdisciplinary research requires institutional recognition of its importance through the investment of resources and provision of incentives and rewards to faculty and departments. The central administration of an institution can facilitate interdisciplinary research by the types of new faculty positions created and by the resources provided to new faculty in interdisciplinary areas of research.

Supra-departmental structures such as centers and institutes can play an important role in supporting interdisciplinary research and education and are ideal for housing expensive core facilities to be shared by faculty of various disciplines, but they can also create tension with discipline-based faculty and departments. Some of this tension revolves around graduate education and the participation of graduate students in research in these supra-departmental structures.

The value of interdisciplinary collaborations and their output have been accepted internationally and models are being developed and instituted abroad to exploit these benefits.

Recommendations for Supporting Interdisciplinarity in Academic Institutions

- Be strategic in planning for investment in interdisciplinary research and education based on institutional strengths, size, and type.
- Move away from rigid hierarchical structures to more dynamic and flexible structures in which faculty have some fluidity of movement between or across disciplinary homes.
 - Provide physical space and shared facilities that bring people together to support collaborative work.
 - Take advantage of new interdisciplinary funding opportunities offered by federal funding agencies.
- Clarify expectations for new and current faculty doing interdisciplinary research and education, and include all parties in the contract.
- Add new elements in promotion and tenure guidelines to include recognition and reward for contributions to interdisciplinary research and education.
- Continue to base interdisciplinary graduate education solidly in disciplinary programs while allowing mechanisms for new programs to evolve.
- Extend support for interdisciplinary research and education into undergraduate education.
- Forge links between majority and minority institutions in order to take advantage of the attraction of interdisciplinary research to broaden participation in science and engineering.
- Examine international models for interdisciplinary research and education and consider adapting/adopting successful models.

