

Lehigh ADVANCE: Building Community Beyond Academic Departments
Proposal to the National Science Foundation
(Submitted November 2009; revised October 2010 to reflect changes required by NSF)¹

Project Summary

Lehigh University will exploit its commitment to interdisciplinary research and teaching to significantly improve recruitment, retention, career satisfaction, and leadership development of early- to mid-career women faculty in engineering and the natural sciences. The University's plans for cluster hiring and growth in interdisciplinary programs such as Environment, Health, and Information Science and Engineering will provide the opportunity to test model programs and to conduct social science research of the effectiveness of these programs. Lehigh will institutionalize the programs found to be most effective by embedding these programs within implementation of its 2009 Strategic Plan and by developing best practices for interdisciplinary mentoring and evaluation in dialogue with female and male STEM faculty and university leaders.

Lehigh will utilize a comprehensive set of interlocking programs formulated to maximize the impact of interdisciplinarity in creating and maintaining a critical mass of women STEM faculty. These programs include: enhanced search strategies for faculty hiring to substantially strengthen the candidate pools; interdisciplinary mentoring committees; best practices workshops for interdisciplinary mentors and evaluators; workshops and networking for women STEM faculty at Lehigh and regional institutions; leadership and retention interviews; and revised evaluation processes.

Intellectual Merit

Despite national focus on advancing engineering and science through interdisciplinary collaboration and increased participation of women, evidence about the impact of cross-disciplinary structures on the careers of early- and mid-career STEM women faculty is inadequate. Are faculty who choose interdisciplinary paths disadvantaged by the increased effort needed to acquire breadth of knowledge across fields and to establish collaborative connections? How are faculty careers affected by the challenges of obtaining cross-disciplinary funding and the lower number of high impact interdisciplinary journals? As emphasized in the National Academy of Sciences' *Facilitating Interdisciplinary Research* (2005), institutions that encourage such research must be willing to re-evaluate promotion criteria and procedures that have traditionally been disciplinary and departmental. Lehigh ADVANCE will test whether or not interdisciplinary organization can help to create a critical mass and equitable work environments for women STEM faculty if facilitated by vigorous search strategies, proactive evaluation policies, and mentoring and networking programs geared specifically to interdisciplinary research and teaching.

Broader Impacts

Lehigh ADVANCE will model, assess, and disseminate methods for creating, maintaining, and supporting a critical mass of women in engineering and the sciences in an interdisciplinary environment at institutions similar to Lehigh in size and mission. The results of Lehigh's proposed programs and social science study of the gendering of interdisciplinary research will provide evidence for and invite collaboration with other small to mid-sized research universities. These results will be disseminated through symposia, workshops, seminars, website, online toolkits, peer-reviewed journal articles, conference presentations, and networking with peer institutions. Lehigh's regional networks will offer models to other universities and colleges seeking to build intellectual communities beyond the boundaries

¹ All data are from Fall 2009 unless otherwise noted.

of their own campuses. These networks are important for research and teaching collaboration and for attracting young engineers and scientists to academic careers.

Project Description

Interdisciplinary collaboration is becoming the primary means by which scholars in engineering and the natural sciences conduct research for solving significant complex societal problems. Despite the essential focus of agencies such as the NSF and NIH on both interdisciplinarity and increasing the participation of women, we still have inadequate knowledge of the impact of cross-disciplinary structures on the careers of early- and mid-career STEM faculty. In particular, given recognition of gendered workplaces in STEM disciplines, we know little from social science research about whether or not interdisciplinary programs facilitate the career success of STEM women, and whether cross-disciplinary experience at the graduate and postdoctoral levels encourages or discourages women from taking academic paths. Our hypothesis, built upon existing social science findings and Lehigh's recent initiatives, is that interdisciplinary organization, if embedded with proactive evaluation policies and mentoring and networking programs, will help to create a critical mass of women faculty and reduce the professional and social isolation of STEM women.

As a medium-sized private research university with 433 tenure-track faculty, 4,809 undergraduates, and 2,187 graduate students, Lehigh University relies upon interdisciplinary collaboration to develop distinguished programs in education and research. During the past eight years we have invested significantly in clustered faculty hires and infrastructure in areas such as Environmental Science/ Engineering/ Policy (Environmental Initiative), Bioscience/ Bioengineering/ Health Policy (Health Initiative), and Information Science and Engineering. With Lehigh's 2009 Strategic Plan, "Advancing Our Intellectual Footprint," these investments will grow during the next ten to fifteen years with further hires and addition of Energy and Infrastructure to our interdisciplinary programs.

We have the opportunity for institutional transformation by aligning our proposed ADVANCE program for improving recruitment, retention, career satisfaction, and leadership development of early- and mid-career women STEM faculty with the larger goals and directions of the university. Recruiting and retaining women faculty in interdisciplinary structures will be central to implementing Lehigh's Strategic Plan. Transformation will involve analysis of processes, including tenure and promotion, to insure they are sensitive to the issues raised by interdisciplinary collaboration. Techniques and best practices for mentoring, networking, and evaluation will be developed to facilitate the careers of STEM faculty who are pulled in different directions by home departments, centers, and programs. We will model, assess, and disseminate methods for creating, maintaining, and supporting a critical mass of women in engineering and the sciences in an interdisciplinary environment at institutions similar to Lehigh in size and mission.

Research on Gendered Organizations and Interdisciplinary Science

Kanter (1977) first highlighted the numerous effects of being a numerical minority in a work organization. Tokens, as a group, experience a variety of constraining and discriminatory workplace behaviors derived from their visibility including: harassment, isolation, role encapsulation, and restricted access to mentoring. Acker (1990) recognizes in the gendered organizations approach that while numbers do affect organizational inequalities, other factors hold strong influences as well. These occur in concrete ways (occupational segregation, differential access to resources), but also in more abstract ways at the level of meaning. In particular, Acker (1990) notes that women cannot as easily meet organizations' seemingly gender-neutral criteria to the extent that they fall short of the "disembodied universal worker." This concept describes a host of disadvantages that accumulate to women who have "families" and must

accommodate the everyday, and who are subject to gendered meanings (e.g. gender schemas) in their workplaces (Valian, 1998). Converging with Acker (1990), West (1990) analyzes gender and the “labor process,” that is how work is gendered through the ways in which it is conducted, the meanings given to that work (e.g. what counts as “skill”), and the power relations among individuals and groups in the organizational context.

STEM fields are gendered in multiple ways that align with these gendered organization approaches. STEM fields are imbued with deeply gendered meanings. For example, technical expertise, innovation, and rationality tend to be characteristics more easily associated with men than women (Bem, 1974; Cockburn, 1983). When women represent a stark minority in a given context (such as in STEM fields at Lehigh University), these gendered meanings come into play with regard to evaluation and compensation, distribution of resources, and mentoring/networking opportunities (Valian, 1999, Moody, 2009). Furthermore, the organization of work in STEM fields is founded on the unacknowledged construct of the “disembodied universal worker,” which very few women (and not all men) can attain.

Many women in the STEM fields at Lehigh University fall numerically into Kanter’s token category when we examine the gender composition of their home department. Thus, moving those faculty from the token position to a more gender-balanced context should temper many of the effects of tokenism. This is the idea of “critical mass” that Valian describes. While Lehigh University is a smaller university and sometimes cannot achieve the benefits of critical mass for women in the STEM fields easily or quickly through new faculty hires (even as existing faculty retire), we can more quickly employ developing interdisciplinary structures to that end – achieving critical mass.

Achieving critical mass through interdisciplinary initiatives has the potential to reduce tokenism, feelings of professional and social isolation, difficulty finding mentors, and exclusion from informal networks where new ideas are generated, which are all frequently cited as barriers to the early career development and retention of women faculty in STEM fields (Kemelgor & Etzkowitz, 2001). While the integration of female faculty into interdisciplinary collaborative research initiatives may be an effective strategy for addressing these barriers, this strategy may pose risks if university culture (e.g., promotion standards and procedures that have traditionally been situated within disciplines and departments) creates inequity in the evaluation of interdisciplinary scholarship.

While Rhoten and Pfirman (2007) recognize that more empirical research is needed to test this hypothesis explicitly, they propose the existence of a gendered preference for interdisciplinary science as well as gendered consequences of this approach. They hypothesize that female scientists are more attracted to interdisciplinarity because it typically involves team-based collaboration and adapting concepts, methods, and results from multiple disciplines to address complex, socially-relevant problems. Thus, Rhoten and Pfirman (2007) warn that while women may be more attracted to interdisciplinarity, there may be a gendering of the costs and benefits of this research. For example, since most interdisciplinary research leads to multi-authored publications, a result may be that the contributions of newer investigators, who are more likely to be women, will be overshadowed by the contributions of well known senior collaborators, who are more likely to be men.

Empirical data suggest that academic research centers (where interdisciplinary research is typically conducted) may provide a more gender equitable context for academic success compared to traditional department settings. Interdisciplinary research centers can take advantage of innovative perspectives on hiring and supporting center members. Centers may provide scientists enhanced research resources such as more opportunities to consult with other scientists, greater access to equipment, and a stronger support system for proposal preparation, all of which may lead to greater research productivity (Corley & Gaughan, 2005). However, other data (Corley, 2005) suggest that some gender differences found in traditional departments still persist in research centers. Female, compared to male, center-affiliated

faculty still report having fewer collaborators, publish fewer articles per year, and are more likely to report feeling discriminated against on the basis of gender. Erin Leahey (2006) raises another concern, proposing that research specialization (repeatedly engaging in research on the same substantive topic usually within a subfield of a discipline) actually aids productivity and visibility.

Evidence currently available from studies of gendered organizations and interdisciplinary science thus suggests both opportunities and cautions in pursuing collaborative strategies to advance the careers of women faculty in STEM fields. While improved search methods and cluster hiring to cross-disciplinary initiatives are important, they are insufficient to achieve critical mass and equitable environments. Institutional transformation also requires mentoring, networking, and review/revision of policy structures to support, retain, and promote women to the senior ranks and leadership.

Institutional Context

Interdisciplinary Initiatives and Gender at Lehigh University since 2001

Since October 2000, Lehigh has targeted growth in critical fields, including the Health and Environmental initiatives and Information Science and Engineering, first with the 2020 Plan, which dedicated approximately \$75 million for academic initiatives. We are now moving forward with implementing our 2009 Strategic Plan, which will provide further growth in these areas. This ADVANCE proposal is connected explicitly to implementation of Lehigh's Strategic Plan. We are planning to develop faculty quality and quantity in concert with the goals of our plan. Our ADVANCE program will work hand-in-hand with the Strategic Plan, together transforming the structure of the university, faculty cultures, and patterns of work. With this interdependence in mind, we are crafting programs that will be sustained into the future.

Lehigh will continue to hire faculty strategically in clusters, with an estimated ten faculty searches each year in interdisciplinary STEM areas. This fall [2009], in addition to thirteen STEM assistant and associate professor positions, we will begin searches for two Presidential Chairs in the Health Initiative: one in Bioscience/Bioengineering and the other in Health Policy and Society. Lehigh has also committed substantial funds to campus infrastructure with the Science, Technology, Environment, Policy, and Society (STEPS) building. This is a 130,000 square foot building scheduled to open in August 2010, which will create a place where engineers, natural and social scientists, and students can work together across disciplinary boundaries.

These initiatives, inspired and developed by faculty and administrators, have already produced substantial change at Lehigh. Since 2001, when the first new faculty hired under the 2020 Plan arrived on campus, Lehigh has appointed 172 assistant professors (all pre-tenure), of whom 41 percent are women. In Fall 2009, assistant professors comprise 22 percent (97 of 433) of all tenure-track faculty, in contrast to 12 percent nine years ago. This faculty renewal, achieved through the 2020 Plan and faculty retirements, presents both the opportunity to create a more diverse faculty and the responsibility to generate the programs, policies, and culture to support the evolving needs of scholars from a variety of backgrounds and with a range of family responsibilities. The overall percentage of women faculty at Lehigh has increased from 20 percent in Fall 2000 to 27 percent this year [2009].

In addition, during the past six years, women have taken leadership positions as Department Chair, Associate Dean, Deputy Provost, Dean, and President. Among STEM faculty, Helen Chan is Chair of Materials Science and Engineering, Sibel Pamukcu serves as Associate Chair of Civil and Environmental Engineering, and Anne Meltzer, former Chair of Earth and Environmental Sciences, is Dean of the College of Arts and Sciences. President Alice Gast, also Professor of Chemical Engineering, since her

appointment in 2006 has stirred enthusiasm across campus for new approaches to fostering faculty and student diversity and gender equity.

Recruiting and retaining women faculty in STEM fields has proved challenging for Lehigh as it has for many research universities. We have initiated a number of policies and programs, discussed below, that have improved faculty retention, yet to achieve the kind of results we want, we think we need to move forward to create and employ truly innovative practices that integrate our interdisciplinary initiatives with efforts for creating a more equitable environment for women and other scholars from underrepresented groups. We see promise for forming a critical mass of women in STEM fields through continued cluster hiring in interdisciplinary fields. The current and potential advantages can be seen by comparing the overall percentages of Lehigh women faculty in the natural sciences (12 percent) and engineering (10 percent) with female participation in the clusters. Women make up approximately 20 percent of the STEM faculty participating in the Environmental Initiative; 28 percent of the STEM faculty in the Health Initiative; and 16 percent in Information Science and Engineering. Participation of women faculty from the social sciences in these initiatives further contributes to the development of critical mass and opportunities for networking. Through these interdisciplinary initiatives, which will grow over the next ten to fifteen years, we see real potential for transforming Lehigh and providing a model for other research institutions approximately our size.

Barriers at Lehigh and Nationally

Historically, Lehigh has experienced significant challenges in recruiting women STEM faculty and retaining them through tenure at the rank of associate professor and promotion to full professor. After some success during the 1990s in increasing the representation of women faculty in engineering and the natural sciences, the lack of programs to support work/life balance and improve department cultures resulted in a wave of resignations. During the three years from 1998 to 2001, Lehigh received resignations from twenty-six faculty, of whom 73 percent were women. All seven of the departing engineering faculty and 60 percent of the departing College of Arts and Sciences faculty were women. This was a wake-up call to administrators and faculty alike. Professor Diane Hyland of Psychology, co-PI on this proposal, conducted follow-up interviews of female faculty who resigned. They indicated that both “pull” factors, such as better teaching, research, and leadership opportunities, and “push” factors, including unsupportive Lehigh department culture, inadequate work/life policies, and lack of professional mentoring, loomed large in their decisions to leave.

Hyland also conducted a quantitative study of the advancement of Lehigh faculty from the associate professor to full professor rank. For faculty hired at the assistant professor rank after 1981, male faculty members in STEM disciplines had a high likelihood, by 2004, of being promoted from associate professor to full professor, most in six years or less. In contrast, female faculty members in these disciplines typically remained at the associate rank for more than nine years or voluntarily left Lehigh while still at the associate rank. The careers of current Lehigh STEM full professors reveal the same gap: male professors achieved promotion after an average of six years in the associate professor rank while female professors spent an average of nine years as associate professor. These very different patterns of professional advancement for women compared to men reflect national trends as reported by Valian (1998) and the Modern Language Association (2009).

The high attrition of Lehigh women STEM faculty in the late 1990s and early 2000s is apparent from looking at the numbers of current associate professors. Of twenty-seven associate professors who have held the rank more than five years, only three are women. Like the male associate professors, these women have served in rank for an average of twenty years and are finding the path to full professor difficult. Progress can be seen among the STEM faculty tenured and promoted in the past five years, as women comprise five of twenty-two (23 percent) of these associate professors. Their numbers will be

joined by additional women engineers and scientists in the next several years. It is thus critical for Lehigh to evaluate policies and create programs to facilitate career and leadership development of associate professors as well as pre-tenure faculty.

In the past several years we have conducted five faculty surveys that provide relevant information on job satisfaction and barriers: the Campus Climate Survey conducted by Rankin & Associates (2006, entire Lehigh community including faculty); two Alfred P. Sloan Awards for Faculty Career Flexibility surveys (2006 and 2008, all tenure-track faculty); the Collaborative on Academic Careers in Higher Education (COACHE) Survey (2007-08, assistant professors); and a survey conducted by Susan Carlson of Iowa State University (2009, associate professors). These surveys, supplemented by exit interviews of departing faculty, have indicated recent improvement in several areas where Lehigh has revised policies and developed programs: increased flexibility through tenure-clock extensions, fully paid Family and Medical Leave policy, research support for new parents, dual-career programs, and the University Mentoring Program for assistant professors. Some details of these initiatives will be given in the next section.

Still, barriers to faculty career advancement and more equitable environments for women remain, barriers that we intend to address through this proposed ADVANCE program:

- Difficulty for new faculty in establishing research collaboration with senior colleagues;
- Difficulty at both the assistant and associate ranks in obtaining effective mentoring for promotion;
- Lack of a critical mass of women in STEM fields to offer collegiality within and across departments;
- Lack of a critical mass of women to assist in recruiting women candidates for faculty positions and to serve as role models and mentors for undergraduates, graduate students, postdoctoral scholars, and early- to mid-career faculty.

These findings at Lehigh are consistent with significant survey results reported in the National Research Council's *Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty* (2009). Surveys of STEM departments and faculty at four-year institutions indicated several important findings in the area of *recruitment*: 1) Women form a lower percentage of job applicants for tenure-track positions than their percentage among PhD recipients in STEM fields. Women were also less likely to accept a job offer (the one gender-related reason they gave was "family-related reasons"). 2) Two-thirds of the departments failed to utilize a full range of strategies for recruiting women, using at most targeted advertising and recruiting at conferences. 3) Departments were most successful in hiring a female candidate when a woman chaired or served on the search committee.

In the areas of *mentoring and retention*, the NRC study revealed that: 1) Female pre-tenure faculty who had mentors had a higher probability of obtaining grants (93 percent) than those without mentors (68 percent). For female associate professors, the pattern was similar but weaker. 2) Women continued to have an important challenge in department culture, particularly engagement with colleagues on the topics of research, salary, and benefits. 3) Women were equally or more successful than men in tenure review but were less likely to stay at the institution long enough to be considered for tenure.

Work/life issues (American Council on Education, 2005; Sullivan, Hollenshead, and Smith, 2004), gender-biased evaluative processes including teaching evaluations (Sandler, Silverberg, and Hall, 1996), organizational politics including resource allocation (Harvard University, 2005), and male-dominated networking and mentoring (The MIT Report, 1999; Didion, Fox, and Jones, 1998) are among the barriers that become embedded and subject to institutional inertia. Indeed, social science research argues that

many of the barriers to women's advancement also involve a cultural component such that "non-conscious gender schema" that "accrue disadvantage to women" (Valian, 1998) devolve into institutional policies and practices that unwittingly limit women's advancement over time and produce women's dissatisfaction with academic employment. Individual and institutional resistance can hinder well-intentioned programs aimed at "fixing the women" (Burack and Franks, 2004).

Recent Faculty Programs and Policy Development at Lehigh

In 2001, Lehigh took its first major step in work/life initiatives with the Family and Medical Leave Policy for Faculty, which provides full pay for full-time and intermittent leaves for a period of twelve weeks or its equivalent. Two years later, the University adopted the Domestic Partners Benefits Policy, which extends all benefits, including the FMLA policy, to domestic same-sex and opposite-sex partnerships. In 2006, the faculty and trustees approved an automatic one-year tenure-clock extension for new parents to supplement the previous six-month extensions associated with FMLA leaves.

Lehigh University then received an Alfred P. Sloan Award for Faculty Career Flexibility, one of five awarded in 2006 to research universities. The grant provided funding through June 2009 for several new initiatives and facilitated important progress in changing Lehigh's culture. Under leadership of faculty committees, the initiatives kindled discussion of work/life issues among the Board of Trustees, administration, deans, department chairs, and faculty. The follow-up Sloan survey (2008) indicated extensive dialogue and understanding of Lehigh's work/life policies.

The new initiatives included Lehigh Sloan Research Grants, expanded tenure extension policies, and dual-career programs. We are sustaining the programs with Lehigh funds. The *Lehigh Sloan Research Grants* provide \$6,000 to each pre-tenure Lehigh faculty member who takes an FMLA leave for the care of a newborn or adopted child or other family member. The purpose of the grant is to assist faculty members in maintaining visibility in their department and profession during the leave and the subsequent transition back to full-time status. The grant can be used for child or elder care and housekeeping as well as more traditional research expenses. In addition, pre-tenure faculty can now take one-year *tenure extensions* for parenthood by birth or adoption (including children under six years old at the time of the faculty member's hire), physical disability, primary care of a family member, public or military service, extreme personal hardship, foster care, and an exigency arising out of a family member's active military service. Our several *dual-career initiatives* include the Faculty Dual-Career Assistance Program for faculty partners/spouses to locate positions in the region. For academic faculty and staff positions, we helped to expand the New Jersey Higher Education Recruitment Consortium to include eastern Pennsylvania and Delaware. The Provost and Deans have also implemented guidelines that clarify the procedures and funding for hiring partners/spouses to faculty positions at Lehigh.

Since 2002, Lehigh's administration has also placed significant emphasis on *professional mentoring* of pre-tenure faculty, with programs in each of the four colleges and a university-wide mentoring program. Provost breakfasts with department chairs often focus on faculty mentoring, work/life issues, and retention. The Director of Faculty Development coordinates an annual two-day orientation for new faculty and organizes frequent events on teaching and technology. The Committee on Faculty Mentoring and Work Life Issues sponsors meetings of assistant professors with the university faculty mentors and holds events on faculty career development. We recently overhauled our policy for hiring, mentoring, and evaluating faculty with *formal joint appointments*, who comprise a small subset of faculty working in interdisciplinary initiatives. The new policy includes best practices such as memoranda of understanding (MOU) and special evaluation committees made up of faculty from each participating department/center. These mentoring and evaluation processes provide a basis for developing more broadly effective practices in our ADVANCE program.

The Sloan Award has been crucial in changing Lehigh's culture regarding work/life issues, with greater use of FMLA leaves and tenure extensions. During the academic years 2000-01 to 2004-05, only five Lehigh assistant professors took FMLA leaves for parenthood or care of a family member (one per year, 1.5 percent of the assistant professors per year). From AY 2005-06 to 2008-09, fifteen assistant professors (ten women, five men) took FMLA leaves for these reasons (3.75 per year, 4 percent of the assistant professors per year). Engineering and science faculty took seven of the leaves post 2004-05 on an intermittent basis, whereas this option had not been clarified earlier (and thus was not used). This permitted the assistant professors to keep their labs and research groups in operation during the FMLA leave. For example, the intermittent option allowed a geologist to conduct funded research in the Yukon during part of the semester she was on FMLA leave. An accompanying uptick occurred in use of the tenure extension for parenthood. We also see improvement regarding the dual-career issue. During the years 2006 and 2007, after we began conducting exit interviews on a systematic basis, six of ten departing assistant professors indicated that the dual-career issue played an important role in their decision to leave. Since we instituted the dual-career guidelines, we have hired spouses/partners to tenure-track faculty and staff positions, and no faculty have given that reason for leaving.

At the same time assistant professors acknowledge significant improvements with tenure-clock flexibility, dual-career programs, and the Lehigh Sloan Research Grants, as they gain tenure they feel less support at the associate professor level. For this reason the Committee on Faculty Mentoring and Work Life Issues has conducted a survey and workshops to obtain data for moving forward to improve mentoring toward promotion of associate professors; encourage use of Lehigh's sabbatical policy to promote their research and scholarly programs; improve communications for associate professors about Lehigh's work/life policies and programs; and revise policies on triennial review and promotion to full professor for clarity of process and criteria.

Through work/life programs, new tenure extension policies, dual-career programs, and improved mentoring, Lehigh has increased retention of women faculty in STEM fields during the past five years. Yet recruitment of female faculty remains difficult and women comprise a small minority in engineering, physical sciences, and mathematics. Vigorous efforts for expanding candidate pools and reconfiguring programs/policies to foster success of early- and mid-career faculty in interdisciplinary initiatives are needed to transform Lehigh's work culture, maximize the promise of Lehigh's Strategic Plan, and provide models for other institutions our size.

Strategies: Lehigh ADVANCE through Interdisciplinary Networks and Mentoring

While exploring the promise of interdisciplinarity to attract and retain women in STEM, we must also transform institutional contexts to insure that these engineering and science faculty are not, as a result, disadvantaged in systems of evaluation and reward. Mentors and evaluators must be aware of these aspects of interdisciplinary scholarship: the increased preparation needed to acquire breadth of knowledge across fields, extra efforts required for establishing and maintaining collaborative connections, challenges of obtaining funding for this scholarship, and the lower number of high impact interdisciplinary journals. Risks also exist of increased service, particularly in small and newly emerging clusters. Pre-tenure and mid-career faculty may be called upon and will desire to invest in building the program, benefiting the organization but perhaps at costs to their own productivity. As emphasized in the NAS's *Facilitating Interdisciplinary Research* (2005), institutions that encourage interdisciplinary research must be willing to re-evaluate promotion criteria and procedures that have traditionally been disciplinary and departmental.

By leveraging Lehigh's commitment to interdisciplinary research and teaching, which our 2009 Strategic Plan reaffirms and strengthens, we intend to significantly improve recruitment, retention, career satisfaction, and leadership development of early- to mid-career women faculty in engineering and the

natural sciences. Our plans for cluster hiring and growth in interdisciplinary programs such as the Environmental Initiative, Health Initiative, and Information Science and Engineering will provide both the opportunity to test model programs and to conduct social science research on the effectiveness of these programs. We will assess these interventions formulated to maximize the impact of interdisciplinarity in creating and maintaining a critical mass of women STEM faculty: interdisciplinary mentoring, proximity of offices and labs, revised evaluation processes, workshops for mentors and evaluators, workshops and networking for women STEM faculty, and enhanced search methods to substantially strengthen the candidate pools. Through the strategies discussed below, we will overcome the barriers to women's advancement, forming the critical mass of faculty needed for effective mentoring and network support.

While Lehigh can pursue a few aspects of this proposal without NSF funding, we cannot create the comprehensive program, including social science research, that will assess and disseminate dynamic, intentional efforts to create systematic opportunities for mentoring and networking within the university and with regional institutions. Our goals for this program include:

- Increase the numbers of women faculty in engineering and the natural sciences through improved recruitment and retention.
- Facilitate the advancement of women faculty in STEM fields to tenure, promotion, and leadership positions.
- Advance the careers of women STEM faculty who participate in interdisciplinary initiatives through improved mentoring, networking, and clear and equitable evaluation criteria and procedures.
- Institutionalize this change by embedding the program within Lehigh's Strategic Plan and developing best practices for interdisciplinary mentoring and evaluation in dialogue with female and male STEM faculty and university leaders.

Interdisciplinary Mentoring Committees

Beginning in spring 2011, for new faculty hired to start in fall 2011, all new women STEM faculty will receive a three-person interdisciplinary mentoring committee of senior faculty in fields related to their research and teaching. One mentor will be the chair or full professor of their home department. The other mentors will be faculty in other departments with expertise and research interests that will facilitate networking for the new faculty within Lehigh and in their broader profession. The mentors will immediately help integrate the new faculty member into the research and curriculum of the interdisciplinary initiative. The first step will be to develop a workshop for introducing mentors to current research on gender and interdisciplinarity as well as best practices in mentoring.

The goal of this program is to formalize mentoring processes that we should expect from research/teaching clusters, but which do not always materialize, particularly for women scholars in fields lacking a critical mass of women (Nolan et al. 2008)). While Moody (2009) and Girves et al. (2005) have recommended mentoring programs with multiple mentors, ours will intentionally function as part of interdisciplinary initiatives and within a university culture in which interdisciplinary collaboration is becoming ever more crucial. At hire, the new faculty member will discuss possible mentors with the Deputy Provost for Faculty Affairs and together they will draft an MOU linking the mentors with specific goals. The MOU will also provide flexibility if one or more of the mentors need to be replaced at a later time. With Lehigh resources, and assuming positive outcomes, we aim to expand this program to all new faculty and offer the opportunity to continuing faculty. At an institution our size, with its relatively small departments, female and male faculty are more likely to find collaborators in other departments than in their own. This meshes well with the more general trajectory of academic research and teaching. Interdisciplinary mentoring will become a permanent Lehigh program, underpinning and supporting equitable interdisciplinary work cultures.

ADVANCE Chairs

Each year two tenured Lehigh STEM women faculty will be selected as ADVANCE Chairs to participate as core members of the Lehigh ADVANCE program. The ADVANCE Chairs will bring fresh ideas to the leadership group, participate in the Leadership and Retention Interviews, and help to develop and participate in the workshops, seminar/dinners, and symposia. The one-year positions will be filled through an appropriate nomination and appointment process, and carry the possibility of reappointment for a second year.

Proximity Study

The opening of the STEPS building in August 2010 will present a unique opportunity to study the impact of physical proximity, with resulting day-to-day interactions, on promoting interdisciplinary networks and reducing isolation. The STEPS building will provide office and laboratory facilities for faculty in the Environmental Initiative, bringing together scientists from several STEM departments with social scientists from Journalism and Communication, Political Science, History, and International Relations. In contrast, faculty affiliated with the Health Initiative have offices and laboratories distributed across campus. Similarly, participants in Information Science and Engineering are located in different buildings. Can community be developed among colleagues who do not work in the same building? Can electronic correspondence, seminars, interdisciplinary mentoring, and social networks replace physical proximity? What are the necessary components for fostering interdisciplinary teams? This research will intersect with our studies of interdisciplinary mentoring, evaluation, and networking to examine the significance of physical proximity and other key network elements in creating equitable interdisciplinary communities.

Leadership and Retention Interviews

To assist in developing best practices for mentoring and evaluating women STEM faculty involved in interdisciplinary work and for cultivating leadership, the four co-PIs and two ADVANCE Chairs will conduct in years 1 and 2 standardized individual interviews with Lehigh women STEM faculty of each rank. The interview questions will vary by rank. We will use the information gained to help build our knowledge base on interdisciplinarity and gender to be used for workshops, online toolkits, and publications on women and cross-disciplinary teams. In interviews with *full professors*, we will ask about keys to success and barriers in scholarship and teaching. What were their experiences in disciplinary and interdisciplinary research and teaching? How did they become leaders in their field? What advice would they give to mentors and young faculty to optimize careers in interdisciplinary initiatives? With *associate professors* we will discuss keys to success in tenure, challenges in promotion to full professor, and barriers more generally in academic research and teaching. With *assistant professors* we will explore their early career successes, challenges in achieving promotion and tenure, and barriers in academic research and teaching.

We expect these interviews to last an average of 30 to 60 minutes each. The interview questions will be developed with our evaluators, Jean Russo and Christine Pribbenow, so that the evaluative interviews they conduct with Lehigh women STEM faculty in Years 3-5 will be consistent with the earlier interviews. The project manager and co-PIs will receive information from Drs. Russo and Pribbenow in Years 3-5 that will be helpful in improving the ADVANCE programs and Lehigh culture.

These interviews over the course of five years will allow us to assess the impact of Lehigh's ADVANCE program and changing climate. We intend to continue the retention interviews after the completion of the grant period under supervision of the Deputy Provost for Faculty Affairs. In addition to understanding current best practices from these interviews, we will use insights gleaned from them to evaluate and revise Lehigh policies/programs and follow up specific (perhaps confidential) information to address problems encountered by individual faculty.

Evaluating Tenure and Promotion Criteria and Procedures to Address Interdisciplinary Issues

As part of the current review of the criteria and procedures for promotion to full professor, the Faculty Personnel Committee and Committee on Faculty Mentoring and Work Life Issues are examining the impact of decisions by associate professors to explore cross-disciplinary and innovative teaching and research during the years following tenure. The ADVANCE Team will build on this effort to determine what changes are needed in tenure and promotion criteria and procedures to insure that faculty involved in interdisciplinary research and teaching before tenure are evaluated appropriately.

Best Practices Workshops for Faculty Mentors and Evaluators

In addition to reviewing and revising policies, we will develop best practices workshops for two groups of faculty. 1) In Year 1 and each succeeding year, we will hold workshops for department chairs, center directors, interdisciplinary program directors, college promotion and tenure committees, and senior faculty on best practices in mentoring and evaluating engineers and scientists in interdisciplinary research and teaching, focusing on issues for women and other underrepresented groups. The workshops will build on the literature on mentoring and multiple mentors, but tailor the best practices most specifically to academic careers in interdisciplinary contexts. The literature on team science will provide important insights, yet its attention to gender is limited. Thus we will contribute to this literature both through development of best practices and research focused on the intersection of interdisciplinary science and gender. 2) In Year 4 we will hold a day-long workshop on best practices in interdisciplinary mentoring for department chairs, center directors, interdisciplinary program directors, and senior faculty in the Pennsylvania, New York, Delaware, and New Jersey region, inviting several guest speakers on topics related to gender and team science. We will also utilize our expertise developed through three years of interdisciplinary mentoring, individual interviews, and mentors/evaluators workshops.

Workshops and Networking for Women STEM Faculty

The Lehigh ADVANCE program will build within Lehigh's structure new opportunities for women faculty in engineering and the natural sciences to mentor and network with other women scholars within Lehigh and with neighboring institutions. The Lehigh ADVANCE team will provide institutional support for these groups and will work with the Lehigh administration to continue the programs beyond the NSF grant.

1. During each year of the ADVANCE program and thereafter, we will hold ADVANCE *workshops for Lehigh pre-tenure and mid-career STEM faculty and postdoctoral scholars* involved in interdisciplinary research and teaching, focusing on issues for women and other underrepresented groups. These workshops will be themed on exploration of obstacles to achieving career advancement and strategies for overcoming barriers, including communication and advocacy. Faculty will bring topics to the table and assume leadership of segments of the workshops as their careers advance.
2. Provost Patrick Farrell will organize *leadership development dinner/seminars* for senior Lehigh women in the natural sciences and engineering (associate and full professors, including President Alice Gast and Dean Anne Meltzer) to discuss research and career development issues. We expect this group, too, will set its own agenda in moving forward.
3. The *Lehigh Women's Studies Program* will expand its support for academic and social networking among faculty across disciplines. For example, the Women's Studies research forums currently draw women faculty from across the university in many disciplines even if they do not work on gender-related scholarship. Women's Studies also has social events that include women faculty from around the university, facilitating informal mentoring and advice. With the ADVANCE program, Women's Studies will invite additional external speakers each year to discuss topics of interest to women scholars across many fields, including engineering and the natural sciences.

4. Lehigh's geographical location and size offer the opportunity to serve as a model for other small to mid-sized universities by creating a regional network with surrounding academic institutions. We will start by working with the Lehigh Valley Association of Independent Colleges (LVAIC) to create a "Women in Science and Engineering" group, which will give women STEM faculty in the region the opportunity to review each other's work, invite speakers, and participate in panels on career development in teaching and academic research. We will invite faculty from other colleges and universities in the region as well as scientists and research engineers from local corporations and medical schools (for example, Air Products, St. Luke's Hospital, and Lehigh Valley Hospital).
5. We will build on this regional network to hold Academic Symposia in Years 3 and 5 for women scientists and engineers in the larger region encompassing Pennsylvania, New York, New Jersey, and Delaware. We will focus on Interdisciplinary Research, inviting guest speakers to discuss topics of particular interest to women at various career stages who are building interdisciplinary networks.

Open Access Information Initiative to Facilitate Interdisciplinary Collaboration

A key element of the Lehigh ADVANCE program website will be a dedicated link where faculty and other researchers can conduct searches by keywords, titles, or names to find potential collaborators or intersecting areas of interdisciplinary work. To facilitate spontaneous collaboration, the site may list the expertise, recent research grants, publications, and/or visionary statements of the existing faculty and researchers who are champions of interdisciplinary work and would welcome wholeheartedly the inquiry of new faculty. The faculty list on the site will be updated periodically as more members join the collective. This site will also boast lists of facilities, laboratories, and equipment with contact names, where STEM faculty may inquire about shared use of such resources. We intend to launch this site for Lehigh faculty initially and make it available to regional institutions in later years as we discern the benefits of the site for its participants.

Strategies for Clustered Faculty Hiring

As noted earlier, Lehigh will hire an estimated ten faculty annually to interdisciplinary STEM areas outlined in the Strategic Plan. Through robust searches we intend to match in our hiring, at the minimum, the availability of women PhDs in the relevant fields in engineering and the natural sciences. We will pursue a planned suite of strategies including clustered faculty hiring, broad definition of fields, multi-year hiring plans that permit long-term search strategies, interdisciplinary search committees that include women, networking with target departments and centers for recruiting recent PhDs and postdoctoral scholars, and providing funds to departments for inviting advanced graduate students to give seminars and become familiar with Lehigh.

Statement of Institutional Commitment and Sustainability

Lehigh's administration is fully engaged in the development of this proposal. As PI, Provost Patrick Farrell initiated this project and will chair the Lehigh ADVANCE Leadership Team. President Alice Gast will lend her international stature to mentoring senior STEM women faculty in leadership. Dean Anne Meltzer will also participate in the leadership development/dinner seminars and, with Dean S. David Wu, will provide oversight as a member of the Internal Advisory Committee. Evelyn Lynch, the LVAIC Executive Director, has pledged assistance in creating the regional network Women in Science and Engineering and organizing the academic symposia in Years 3 and 5. Please see their attached letters of commitment.

As noted in the narrative above, we expect to sustain many of our activities beyond the term of the ADVANCE grant period, including the interdisciplinary mentoring committees; retention interviews;

revised evaluation policies; workshops for mentors, evaluators, and women STEM faculty; the regional network Women in Science and Engineering; and strategies for clustered faculty hiring. Our goal of institutional transformation will result from integrating these policies and programs into our interdisciplinary structure.

Dissemination

We will disseminate the outcomes of our strategies and research through a variety of media:

- Workshops, online toolkits, and brochures on best practices in interdisciplinary mentoring and evaluation developed through leadership and retention interviews and research.
- Publication in top-tier peer-reviewed journals of social science research.
- Presentations at interdisciplinary and disciplinary conferences, and workshops and conferences focusing on gender in STEM fields.
- Best practices workshops on interdisciplinary mentoring and evaluation at Lehigh; day-long workshop for regional faculty in Year 4.
- Workshops on career advancement for women STEM faculty, postdoctoral scholars, and advanced graduate students at Lehigh; symposia on topics related to Interdisciplinary Research in Years 3 and 5.
- Lehigh ADVANCE website highlighting: ADVANCE program activities and reports; achievements of Lehigh and regional STEM women; Lehigh online toolkits on interdisciplinary mentoring, evaluation, and searches; open access information to facilitate interdisciplinary collaboration.
- Correspondence and networking with administrators and interested faculty at our peer institutions regarding our ADVANCE program and findings about gender and interdisciplinary collaboration. We will specifically invite individuals from these institutions, as well as colleagues at regional colleges and universities, to our workshop and symposia in Years 3-5.

Project Management

The *Lehigh ADVANCE Leadership Team* will direct the program under leadership of Principal Investigator, Provost Patrick Farrell, to implement programs and work with faculty leaders and trustees to revise university policies. Provost Farrell will also take responsibility for convening the senior leadership development dinner/seminars and supervise faculty hiring. Co-PIs Diane Hyland, Professor of Psychology and Associate Dean for Faculty and Staff of the College of Arts and Sciences, and Jacqueline Krasas, Associate Professor of Sociology and Anthropology and Director of Women's Studies, will conduct the social science research. They will receive research support from a Research Associate. Professor Hyland will also develop the Workshops for Faculty Mentors and Evaluators and Professor Krasas will direct the joint Women's Studies-Lehigh ADVANCE activities. Co-PI Sibel Pamukcu, Professor and Associate Chair of Civil and Environmental Engineering, will collaborate with LVAIC Director Evelyn Lynch to create the regional network Women in Science and Engineering. Co-PI Jeffrey Sands, Professor of Biological Sciences, with Professor Pamukcu will organize the Academic Symposia in Years 3 and 5. Jean Soderlund will serve as Project Director of Lehigh ADVANCE, supervising the staff Project Manager.

The *Lehigh Internal Advisory Committee* will include Dean Anne Meltzer, College of Arts and Sciences, and Dean S. David Wu, P.C. Rossin College of Engineering and Applied Science. We will also invite as members four or five female and male STEM department chairs and senior faculty who participated in focus groups that we held to plan this ADVANCE proposal and the Vice President for Research and Graduate Studies. The committee will meet at least three times per year to assist the Leadership Team with issues that arise, hear reports on progress, and help implement programs/policies within their colleges and the University as a whole. We will also convene an *External Advisory Committee* of national

experts in research and programs on advancing the careers of women STEM faculty. Dr. Jennifer Sheridan, Executive and Research Director of WISELI at the University of Wisconsin-Madison, and Dr. Susan Carlson, Associate Provost for Faculty Advancement and Diversity at Iowa State University, have agreed to serve on our external committee. We would like to recruit several experts on gender and interdisciplinarity such as Dr. Stephanie Pfirman of Barnard College, to join them on the committee. Our plan is to hold an External Advisory Committee meeting each year.

Project Evaluation

Several of the key goals of our proposal will be measured through ADVANCE Institutional Transformation indicators: 1) increasing the numbers of women faculty in engineering and the natural sciences through improved recruitment and retention; and 2) facilitating the advancement of women faculty in STEM fields to tenure, promotion, and leadership positions. We currently collect and report these data internally in order to measure our progress in diversifying the faculty. Regarding allocation of salaries, space, and start-up packages, currently the Deans and Provost monitor the distribution of resources. Compilation and reports of these data on a regular basis to the NSF will provide a systematic method for measuring equity for women STEM faculty.

Goals 3 and 4 of our proposed program will require a more extensive evaluation plan:

- 3) Advance the careers of women STEM faculty who participate in interdisciplinary initiatives through improved mentoring, networking, and clear and equitable evaluation criteria and procedures.
- 4) Institutionalize this change by embedding the program within Lehigh's Strategic Plan and developing best practices for interdisciplinary mentoring and evaluation in dialogue with female and male STEM faculty and university leaders.

Internal Evaluation

Our internal evaluator is Dr. M. Jean Russo, Senior Research Scientist and Scholar, Center for Social Research, who is external to this project but is currently conducting evaluations of two other Lehigh academic programs supported by the National Science Foundation. The aim of this internal evaluation will be to provide the Lehigh ADVANCE Program administrators with timely information regarding the aspects of the program that are successful and to advise them of the less successful aspects of the program so they can be reexamined and modified. The internal evaluator will explore the following evaluation questions. Does ADVANCE have a presence in the University? Are women STEM faculty members aware of the activities supported by the program? Have specific activities supported by ADVANCE affected career satisfaction for women STEM faculty members? Has the ADVANCE team developed workshops and symposia for department chairs, center directors, and senior faculty evaluators to educate them on issues involved in the recruitment and retention of women STEM faculty and the evaluation of interdisciplinary research? Are these workshops perceived as useful to the participants? Do women STEM faculty members perceive that interdisciplinary research is valued by their colleagues and those who evaluate their academic progress? To what extent are the activities of ADVANCE affecting institutional transformation at Lehigh University?

The internal evaluation will involve both quantitative and qualitative methods. To become aware of the activities being supported by Lehigh ADVANCE, the internal evaluator will attend strategy meetings and meet regularly with program administrators. The implementation of the activities will be documented in an annual evaluation report. An annual survey of women STEM faculty members will be conducted starting at the end of the second year of the grant. In year 2, the focus of the survey will be on their awareness of ADVANCE-supported activities and levels of participation in these activities. In years 3 and 5, the survey will focus on career satisfaction, and how ADVANCE activities, such as Interdisciplinary Mentoring Committees, workshops, and opportunities for interaction with other women

faculty, affected their level of satisfaction. In years 4 and 5, additional questions will deal with their perceptions of whether collaboration and interdisciplinary research are supported and valued by their colleagues in their department or program and at the University level. These same questions will be asked in year 1 as a part of the research initiative of the ADVANCE Program (see the “Measures” section of the five-page social science research supplementary document). The progress of this aspect of the program can be monitored by comparing the percentage of women STEM faculty agreeing with statements regarding value placed on interdisciplinary research in year 1 versus years 4 and 5. The internal evaluator will collect feedback from participants at the conclusion of all ADVANCE-supported workshops and symposia. Participants will provide information on what was learned, its perceived usefulness, and how workshops can be improved. In years 3 and 5, a survey will be conducted with department chairs, center directors, and senior faculty who are evaluating women STEM faculty to establish whether they understand the barriers involved in interdisciplinary research and the extent to which they are supportive of it. Finally, the internal evaluator will assist with the collection of ADVANCE IT indicators and help with preparation of the annual report.

All instruments designed for the internal evaluation will be submitted for review to Lehigh’s Institutional Review Board. All the data gathered as a part of the internal evaluation will be analyzed and reported in aggregate to Lehigh ADVANCE Program administrators. In addition to timely informal feedback, the internal evaluator will provide an annual evaluation report that summarizes all evaluation activities and outcomes for the year. This will be submitted to the Lehigh ADVANCE Program administrators and to the external evaluator.

Internal Evaluation Timeline	
Year 1	Document ADVANCE activities and their implementation
Years 1 through 5	Collect feedback on workshops and symposia; assist in collection of NSF ADVANCE Institutional Transformation indicators; preparation of annual evaluation report
Years 2 through 5	Annual survey of women STEM faculty
	Year 2: awareness of and participation in ADVANCE activities
	Years 3 and 5: career satisfaction and role played by ADVANCE activities
	Years 4 and 5: perceived institutional support for interdisciplinary research
Years 3 and 5	Survey of department heads, center directors, faculty evaluators regarding perceptions of interdisciplinary research

External Evaluation

Dr. Christine Pribbenow, Associate Scientist at the Wisconsin Center for Education Research, has agreed to serve as our external evaluator. We will communicate with Dr. Pribbenow informally during the initial years of the implementation of grant activities (years 1 and 2) by sharing evaluation and annual reports and through email and phone correspondence for consultation. In the beginning of the third year, Pribbenow will visit Lehigh to conduct interviews and focus groups with female faculty and other stakeholders, and with the Lehigh ADVANCE Program administrators and University leaders. This visit will be held in conjunction with the convening of the annual meeting of our External Advisory Committee and one of Lehigh’s events—such as a workshop, seminar, or symposium. This third year evaluation will be formative in nature and will address the following questions: Is Lehigh on track to meeting its goals of the Lehigh ADVANCE grant? Specifically, how many female STEM faculty have been hired? How many have been retained? How many have left? Why? What programs and activities

have been implemented? Have they been effective? What are the barriers to achieving the goals of the grant? What changes or improvements can be made to ensure Lehigh's success?

In year 4, Pribbenow will consult with the Lehigh ADVANCE Program administrators and internal evaluator about the data gleaned from the interviews of female faculty, particularly recent hires and assistant professors. This external review will be primarily focused on the success of the mentoring program and to be preemptive with issues in tenure and promotion for these faculty. Pribbenow will also review the evaluation data related to workshops/seminars, and department chairs' and center directors' understanding and application of best practices in faculty involved in interdisciplinary research and teaching. This fourth year review will be used to ensure that programmatic activities are aligned with the grant's goals and that they have been effective in ensuring success for faculty at Lehigh.

In year 5, Pribbenow will conduct a final site visit to conduct in-depth interviews with a sample of faculty, department chairs, center directors, and administrators, and with the Lehigh ADVANCE Program administrators. The interviews will focus on issues related to institutional change and sustainability. These data will be reported together with the results from the internal evaluation. In conjunction, the summative report will highlight the NSF indicators, such as hiring, retention and attrition, success and effectiveness of workshops, seminars, symposia, and best practices, lessons learned for creating interdisciplinary communities to advance female faculty, and sustainability of Lehigh ADVANCE programs such as the Interdisciplinary Mentoring Committees, workshops, and the regional group, Women in Science and Engineering.

Timeline of Activities and Evaluation

Strategies and Research	Year 1	Year 2	Year 3	Year 4	Year 5
Interdisc. mentoring comms.					
Proximity study					
Leadership and retention Interviews					
Eval. and revise T&P Policies					
Workshops for Lehigh mentors/evaluators					
Workshop for regional mentors/evaluators					
Workshops/networking for women STEM faculty					
Symposia for regional women STEM faculty					
Website w/open access info					
Clustered hiring strategies					
Gender & interdisciplinarity research					
Evaluation					
Internal evaluator					
External evaluator					
External advisory comm.					

Research Statement

“A Multi-Method Examination of the Gendering of Collaborative and Interdisciplinary Research”

Fox (2001) suggests that women, compared to men, may be more attracted to collaborative research, but may actually engage in less collaborative research due to lower levels of access to networks that foster collaboration. These problems can be exacerbated in smaller and mid-sized universities with relatively small numbers of faculty in a department and persistent underrepresentation of women. One way to build collaborative networks in this type of setting is to pursue interdisciplinary collaboration with colleagues from other departments. However, this strategy may pose risks if the university culture (e.g., promotion policies and procedures) creates inequities in the evaluation of interdisciplinary scholarship. In the Fall of 2007, a workshop, co-chaired by Diana Rhoten and Stephanie Pfirman and sponsored by the NSF ADVANCE program at Columbia, Barnard College, and the Social Science Research Council, brought together panels of scholars from a number of disciplines to assess current knowledge and unresolved questions related to women, minorities, and interdisciplinarity. One major conclusion from this workshop is that there has been inadequate research which examines gender differences in intellectual preferences for and professional consequences of interdisciplinary science. We propose research that will address these questions in the particular organizational context of mid-sized, private, research universities, which may pose a unique set of opportunities and constraints.

Key Questions the Research Will Address

This project will explore the gendering of collaboration and interdisciplinarity by studying research preferences, research activity patterns (which reflect faculty preferences, the norms of academia, patterns of networking and mentoring, and the organizational constraints of their institutions), and career outcomes of women and men. One strand of this empirical research will focus on the gendering of antecedents, research activities, and career consequences of interdisciplinary research. It is often difficult in reviewing earlier findings to disentangle effects of team-based collaboration from effects of interdisciplinarity. Single investigators can pursue unidisciplinary or multidisciplinary research programs, and team-based collaboration can be conducted within a single discipline or can span multiple disciplines. The proposed research will examine these dimensions independently and in interaction. We will explore the antecedents, research activities, and career consequences for female and male scientists who predominantly: work within established disciplinary boundaries; pursue interdisciplinarity by single-handedly integrating the concepts, methods and results from multiple disciplines; engage in team-based research with collaborators working within a single discipline; and engage in interdisciplinary team-based research as a member of a multidisciplinary team. A second strand of this empirical research will explore the gendered organization of work through an ethnographic case study of Lehigh University faculty working in the interdisciplinary clusters as the university implements the ADVANCE interventions. This research will examine academic labor processes and the social organization of work in STEM fields particularly as they relate to the complex interaction of organizational culture and practices and formal policies. The main areas of inquiry will focus on the social organization of work, including the relational and technical/procedural aspects of the work, the meaning of work, and the dynamics of power and inequality as they play out in this particular institutional context.

A rich understanding of the gendering of collaboration and interdisciplinarity will require combined use of survey, interview, observation, and bibliometric methods. Survey methods will examine research preferences and self-reported research activities in faculty representing multiple disciplines and ranks, including comparisons between faculty who do and do not participate in interdisciplinary initiatives. This is an important expansion on research that has solely focused on the self-selected faculty in interdisciplinary centers. Surveys will also be used to examine perceptions of the costs, benefits, and

evaluation of collaborative and interdisciplinary research. Ethnographic interviews and observations of individuals participating in interdisciplinary initiatives will complement the survey research by providing thick description corresponding to the main thematic areas and will allow the researchers to pursue paths of inquiry that were not predetermined, potentially shedding light on some less obvious but equally important phenomena. Data will be gleaned from in-depth interviews conducted with faculty, department chairs, program directors, and deans to shed light on the organization of work in STEM fields. Bibliometric analyses of the research productivity of scholars pursuing different research paths will be used to assess gendering of career outcomes in scientists who vary in the degree of collaboration and interdisciplinarity of their research.

The Theories that Guide the Research

The conceptual model guiding this research is itself interdisciplinary drawing from existing theories and empirical research in sociology, labor relations, women's studies, psychology, and evaluation science.

Gendered Organizations and Labor Process Theory: As indicated in the project proposal, part of the theoretical framework for this research rests on labor process theory and a gendered organizations approach that stems from the early work of Kanter (1977) on tokenism and the work of Braverman (1974) on the social and technical organization of work. According to Acker (1990) "to say that an organization is gendered means that advantage and disadvantage, exploitation and control, action and emotion, meaning and identity, are patterned through and in terms of a distinction between male and female, masculine and feminine" (p. 146). Organizational logic, formerly understood as gender-neutral, is thus undergirded and permeated by gender. Gendering in this sense pertains to everything from divisions of labor (e.g. specialization) and identity to interaction and organizational structures. West (1990) specifically analyzes gender and the "labor process" (Braverman 1974, Thompson 1983), the gendering of work through the ways in which it is conducted, the meanings given to that work (e.g. what counts as "skill"), and the power relations among individuals and groups in the organizational context. Scholarship anchored in these approaches is often conducted using ethnographic methods (Burawoy 1979, Pierce 1996, Smith 1997).

The Science of Team Science: To date, this recently developed field of evaluation research (Stokols, Hall, Taylor, & Moser, 2008) has focused on providing theories, methods, and measures useful to the design, implementation, and evaluation of large-scale, multi-institutional, cross-disciplinary research initiatives, particularly in the area of health. However, the science of team science social-ecologic model (Stokols, Misra, Moser, Hall, & Taylor, 2008) can provide a useful lens for examining antecedents, processes, and outcomes of any type of collaborative research. An important theme in this approach is "readiness for collaboration." For the purpose of the present project three important factors have been found to facilitate or constrain capacity for collaboration: intrapersonal factors, such as individual scientists' unidisciplinary/ interdisciplinary research orientations and their attitudes toward collaboration; interpersonal factors, such as leadership styles of team leaders, mutual respect among team members, and effective communication opportunities; and, organizational/ environmental factors, such as size of work group, spatial proximity, and institutional support for interdisciplinary research.

Social Cognitive Career Theory (SCCT): Lent, Brown, and Hackett (1994; Lent & Brown, 2006) developed an integrative theory to explain academic and occupational interest, choice, performance, and satisfaction. The basic elements of SCCT are: self-efficacy, beliefs about ability to perform specific behaviors; outcome expectations, beliefs about the consequences of actions; goals, desire to engage in an activity or produce an outcome; and perceptions of contextual supports and barriers that will influence goal pursuit and attainment. This model has explained effectively the factors that attract (and retain) students, including women and students attending Historically Black Colleges, to STEM fields such as engineering and computing (Lent et al., 2005; Lent et al., 2008) and differences in male and female

chemists' perceptions of quality of mentoring they received during graduate, postdoctoral and early career training (Nolan, Buckner, Marzabadi, & Kuck, 2008). The elements of SCCT most relevant to this project are goals and perceptions of contextual supports and barriers for interdisciplinary research.

Study 1: Gendering of Research Preferences, Activities and Outcomes

Faculty from mid-sized, private, research extensive universities will complete a survey assessing their research preferences, research activities, self-reported productivity, and perceptions of interdisciplinary research. Bibliometric analyses of their research productivity will also be conducted. Data will be disaggregated for gender, rank, discipline/department, and whether or not affiliated with an interdisciplinary center. If there are sufficient data we will also conduct exploratory analyses for race and age/cohort.

Hypotheses:

- With respect to research preferences, women (compared to men) will have greater preferences for collaboration and for interdisciplinary research.
- With respect to research activities, gender differences in the amount of collaborative research will be smaller in faculty who are affiliated with interdisciplinary centers compared to non-affiliated faculty.
- With respect to collaboration, the correlation between preferences and research activities will be stronger for males than females and for center-affiliated than non-affiliated faculty.
- With respect to interdisciplinary research activities, the largest gender difference will be found for single investigators pursuing sole interdisciplinary research.
- With respect to career outcomes, gender differences in research productivity will be smaller in center-affiliated than non-affiliated faculty.

Participants: Faculty will be recruited from Lehigh and the following institutions (listed with the number of full time tenure track faculty and % women based on Fall 2007 IPEDS data): Case Western Reserve University (554 – 34.1%), Catholic University of America (345 – 36.2%), Rensselaer Polytechnic Institute (398 – 20.9%), Rice University (491 – 25.5%), Southern Methodist University (474 – 25.9%), Tufts University (534 – 38.0%), Tulane University (454 – 30.6%), University of Denver (461 – 40.6%), and University of Rochester (476 – 25.0%). These institutions were selected because they meet the following criteria: Carnegie Doctoral/Research University – Extensive; offer doctoral degrees in engineering as well as the sciences; private; medium-sized faculty; and presence of many interdisciplinary centers and institutes. We will verify that at each institution all tenure track faculty have a departmental appointment. Then for each institution we will review faculty listings on department web pages for all engineering, physical science, and life science departments. Since the primary analyses will involve gender comparisons, all female faculty in these departments, and a male peer of the same rank from that department, will be asked to participate.

Procedures: The survey will be administered online. Each potential faculty participant will be sent an email with a link to the password-protected survey. Reminder emails will be sent at 1-, 2-, and 3-week intervals.

Measures: The survey will include a number of items assessing collaborative and interdisciplinary research preferences and activities. Type of research preferred will be assessed with the 10-item, Research Orientation Scale developed by Hall et al. (2008) that assesses preferences for unidisciplinary, multidisciplinary, and interdisciplinary research. Adapted from Boardman and Corley (2008), we will ask what percentage of research-related work time they would *prefer to spend* and the percentage they *actually spend* on the following: working alone on research that does not include a collaborator; working

with faculty and graduate students in your discipline at your institution; working with faculty and graduate students in other disciplines at your institution; working with faculty and graduate students in your discipline at other institutions; working with faculty and graduate students in other disciplines at other institutions. Adapted from Rhoten (2003), we will ask respondents to classify % of collaborations that are predominantly “close-knowledge creating, involving not only the sharing of ideas and information, but also the collection of data and preparation of papers” and % that are “collegial – primarily information sharing.” We will also ask for the % of collaborators who are female, the % who are individuals the researcher is supervising or mentoring, and the % who are the researcher’s mentors or graduate advisors. We will also ask whether they have co-authored research articles or books with individuals outside their home discipline; published research findings in a journal outside their home discipline; or presented research findings at a conference outside their home discipline; written a research proposal with a colleague from another discipline; obtained a grant with a colleague from another discipline; team-taught a course with someone from another discipline; and mentored a graduate student from another discipline. To assess self-reported productivity, participants will be asked how many books, journal articles, and book chapters have been published and how many grant proposals have been submitted during the last 4 years. The final set of questions will assess faculty perceptions of the value placed on and ease of evaluating interdisciplinary research. For example, they will be asked for level of agreement with the following types of statements: faculty members in my department value collaboration; faculty members in my department value interdisciplinary research; my department chair (dean) values collaboration; my department chair (dean) values interdisciplinary research; interdisciplinary scholarship is more difficult to evaluate than disciplinary scholarship.

Bibliometric Analyses of Gender Similarities and Differences in Research Productivity: As each potential participant is identified, we will search on department and center web pages to code for gender, discipline of PhD, year of PhD, current rank, current department affiliation, and affiliation with interdisciplinary initiatives. Then we will use ISI Web of Knowledge to conduct an author search to create a list of published journal articles. For each faculty member, we will code for number of publications, fields of publications, % single author, % coauthored within discipline with one institution, % coauthored within discipline more than one institution, % more than one discipline within institution, and % more than one discipline more than one institution. Number of published journal articles was selected as the measure of research productivity since it is the primary form of scholarly output in these disciplines at research extensive universities. Prior research (Leahey, 2007) has shown that it is also highly correlated with total productivity counts that include books, book reviews, and contributions to edited volumes.

Study 2: Gender and the Labor Process in Interdisciplinary Clusters

A combination of ethnographic interviews and observations will be used to assess Lehigh faculty experiences in the interdisciplinary clusters. In addition to demographic information and a basic work history, the main areas of inquiry for the interview guide are designed to analyze both the material and social organization of work. For each area, we will develop specific questions to be asked in a semi-structured in-depth interview format. Broadly, interview questions will be ordered around the following themes:

- Career trajectories and decisions about work.
- Key individuals and structures that enable them and/or hinder them.
- Their evaluation of interdisciplinary work, its value to them, to their field, and to the institution.
- Interpersonal relations at work in disciplinary and interdisciplinary contexts.
- Work and family dynamics.
- How power is distributed.

Examples of in-depth interview questions:

- Describe how your discipline views and rewards interdisciplinary work.
- What led you to work in this interdisciplinary cluster?
- What portion of your time is devoted to interdisciplinary work?
- To what extent do you think that participation in a cluster has an impact on teaching, research, networking and/or productivity?
- What are the risks and rewards that accompany participating in a cluster for you? Would you say your experience is typical?
- How does working in the interdisciplinary cluster compare with other academic work experiences for you? For example, is there more or less social support? Intellectual support? Resource support?
- In your view, why do faculty seek out interdisciplinary work?
- What organizational aspects of your research cluster facilitate collaboration, productivity and satisfaction? What are the barriers? What other kinds of organizational policies/practices would be beneficial to you?
- Describe how faculty relate to each other within the cluster. How does this compare with intradepartmental relations?
- Would you say it is easier or more difficult to find balance between work and home life working through an interdisciplinary cluster?

Hypotheses:

- Interdisciplinary work will have a beneficial effect upon feelings of integration or isolation.
- Institutional arrangements can help or hinder the pursuit of interdisciplinary work.
- Interdisciplinary work represents a risk to the scholar.
- Work and family dynamics affect and are affected by interdisciplinary work.
- Power is distributed in more egalitarian ways in interdisciplinary contexts.
- Interdisciplinary work is gendered.

Expected Results

The results of these two studies will give us rich qualitative data about the gendering of interdisciplinarity in the ongoing experiences of faculty at Lehigh and a base of quantitative data on the research preferences, activities, and outcomes of faculty at mid-sized research extensive universities. Our findings will shed light on the complexity of organizational practices and structures within which interdisciplinary work is located. Together the two studies will help us understand how trends toward scholarly interdisciplinary study may enhance or impede the recruitment, retention, and advancement of women faculty in STEM fields.