

CHAPTER FIVE · HOLDING INTEREST THROUGH COLLEGE AND COMMUNITY COLLEGE

THE PAST 15 YEARS HAVE SEEN WELCOME CHANGES IN HOW WE APPROACH RETENTION; NO LONGER ARE WE CONCENTRATING ON “FIXING THE GIRLS,” BUT WE ARE NOW EXPLORING WAYS IN WHICH THE SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH (STEM) CULTURE AND CURRICULUM CAN BE ENHANCED TO INCLUDE WOMEN. THE PROGRAMS HERE ARE CONCERNED WITH MEETING THE NEEDS OF WOMEN IN STEM IN WAYS THAT RECOGNIZE HOW THEIR NEEDS DIFFER FROM THOSE OF THEIR MALE COUNTERPARTS. MANY OF THE PROGRAMS IN THIS CHAPTER ARE RESEARCH BASED, WHICH DIVERGES FROM PAST PROJECTS THAT APPEARED TO WORK (PARENTS THOUGHT) BUT DID LITTLE TO ENCOURAGE YOUNG WOMEN TO REMAIN IN STEM MAJORS AND CAREERS.

FOUR OF THE TEN PROJECTS HIGHLIGHTED HERE SEEK TO BURROW INTO SUCCESSFUL ENGINEERING COLLEGES OR DEPARTMENTS AND FIND OUT WHAT HAS HELPED THEM SUCCEED WHERE OTHERS HAVE FAILED. THE PROJECTS DRAW INFORMATION FROM ALL INSTITUTIONAL LEVELS—ADMINISTRATORS, STUDENTS, AND FACULTY—IN ORDER TO DISCOVER THE COMMON FACTORS THAT WILL HELP OTHER INSTITUTIONS MAKE EFFECTIVE AND ACCEPTABLE CHANGES TO INCREASE THE DIVERSITY OF THEIR PROGRAMS.

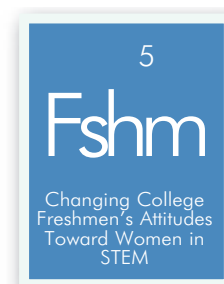
OTHER PROJECTS ARE BASED ON FOUNDATIONAL RESEARCH WELL KNOWN IN FEMINIST SCIENCE STUDIES: THE NEED FOR FAMILY AND PEER SUPPORT AND AN INTEREST IN THE REAL-WORLD APPLICATIONS AND POSITIVE SOCIAL OUTCOMES OF RESEARCH AND SCIENTIFIC FINDINGS. UNFORTUNATELY, WORK WITH WOMEN ATTENDING COMMUNITY COLLEGES HAS LAGGED BEHIND RESEARCH ON WOMEN AT FOUR-YEAR SCHOOLS, DESPITE THE FACT THAT THE COMMUNITY COLLEGE POPULATION CONSTITUTES 26 PERCENT OF ALL STUDENTS SEEKING EDUCATION BEYOND HIGH SCHOOL AND IS 58 PERCENT FEMALE. THIS IS A DIFFICULT POPULATION TO STUDY BECAUSE IT IS MORE HETEROGENEOUS AND HAS LESS SOCIAL OR ATHLETIC INVOLVEMENT WITH THE SCHOOL, AND BECAUSE MANY STUDENTS MUST HOLD FULL-TIME JOBS OR CARE FOR FAMILIES WHILE ATTENDING SCHOOL. BECAUSE A FULL 45 PERCENT OF ALL FIRST-TIME STUDENTS ATTEND A COMMUNITY COLLEGE, THIS PROJECT WILL MAKE AN IMPORTANT CONTRIBUTION TO OUR UNDERSTANDING OF EFFECTIVE STRATEGIES FOR WOMEN TO CONSIDER IN PURSUING A BACHELOR’S DEGREE IN A STEM DISCIPLINE.¹

THE BREADTH AND DEPTH OF THESE PROJECTS WILL EXPAND OUR KNOWLEDGE ABOUT HOW INSTITUTIONS CAN BEST APPROACH STEM RETENTION, AND IT WILL GIVE THEM THE TOOLS TO SUCCEED.

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REFERENCES

1. Levin, J. 2002. *Globalizing the Community College: Strategies for Change in the Twenty-first Century*. New York, Palgrave.



CHANGING COLLEGE FRESHMEN'S ATTITUDES TOWARD WOMEN IN STEM

ATTITUDES ABOUT GENDER ROLES ARE WIDELY THOUGHT TO DETER COLLEGE-AGE WOMEN FROM PURSUING STEM COURSES, MAJORS, AND SUBSEQUENT CAREER PATHS. ILLINOIS STATE UNIVERSITY (ISU) AIMS TO CHALLENGE SUCH ATTITUDES THROUGH A “WHOLE COMMUNITY” APPROACH. BY GETTING STUDENTS, THEIR PARENTS, STUDENT ADVISORS, AND FACULTY INVOLVED, ISU SHAPES AWARENESS, ATTITUDES, AND KNOWLEDGE ABOUT GENDER ISSUES IN STEM BEFORE AND DURING STUDENTS’ FRESHMAN YEAR.

Activities take place in three overlapping spheres: families, peers, and university courses and programs.

In the family context, as part of the two-day summer orientation sessions for all incoming freshmen and their parents, ISU hosts an orientation session with students and parents that addresses the importance of STEM education to all students, regardless of career plans. Undergraduate advisors also participate in a workshop.

In the peer context, ISU forms learning communities that nurture freshman women’s interest in STEM. The learning communities are modeled on ISU’s existing Connections program (which provides staff-led out-of-class meetings for freshmen enrolled in a particular class to explore common concerns). Each learning community consists of up to

30 students (men and women), their instructor, a minimum of six STEM professionals on or off campus who serve as role models, and a student leader (a university junior or senior in one of the STEM fields) to help students see the applicability of STEM knowledge in a wide variety of fields and occupations.

Additionally, STEM-related gender issues are addressed in a four-week “topical excursion” (learning module, or collection of learning modules) as part of an existing general education course required of all freshmen. For example, a module on science, technology, and society may incorporate a gender-related subtext, highlighting women scientists as authors, showing women at work in STEM, or raising the issue of gender bias in science research.

The researchers involved in this project have developed and validated an instrument that measures attitudes of college freshmen about science and technology. For more information about the Gokhale–Machina–Brauchle Attitudes Toward Science and Technology instrument, contact Paul Brauchle at pebrauc@ilstu.edu.



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WOMEN AT CENS: A RESEARCH SYSTEM

RESEARCH EXPERIENCES FOR UNDERGRADUATES CAN BE PARTICULARLY EFFECTIVE AT ENGAGING STUDENTS. BUT THERE IS LITTLE RESEARCH TO SHOW WHY SOME SUCCEED WHILE OTHERS FALL SHORT.

At UCLA's Center for Embedded Networked Sensing (CENS), researchers are designing a "model undergraduate research experience" aimed at encouraging women's commitment to science and engineering in the long term. The model will encompass engineering, computer science, and physical science, as women are underrepresented in these disciplines. In creating Research Experiences for Undergraduates, the research team is concentrating on three factors, based on data from comparable efforts around the country:

- A *research environment* in which undergraduate women lead investigations with direct implications for society—for example, the environment or education. This connection between research environments and real-life implications can be an effective recruitment strategy.
- A *research experience* structured so that students can be productive

and successful.

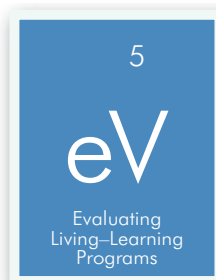
- A *support structure* ensuring that each student integrates into the experience both academically and socially.

Students are being recruited from Mills College and Harvey Mudd College, in partnership with the UCLA Center for Excellence in Engineering and Diversity. The model research experience will be tested and evaluated at CENS.

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EVALUATING LIVING–LEARNING PROGRAMS

WHEN IT COMES TO FOSTERING SUCCESS FOR WOMEN IN STEM MAJORS, LIVING–LEARNING (L/L) PROGRAMS REPRESENT ONE OF THE MOST PROMISING INTERVENTIONS IN HIGHER EDUCATION. BASED IN THE RESIDENCE HALL, L/L PROGRAMS USE MENTORING, SUPPORT, AND COLLABORATION, WHILE BLENDING CURRICULAR AND CO-CURRICULAR ACTIVITIES, TO KEEP STUDENTS ENGAGED AND EXCELLING IN STEM.



In 2004 the National Study of Living–Learning Programs (NSLLP) elicited responses from nearly 24,000 students at 34 universities. More than 1,650 STEM majors participated in the NSLLP, about half of whom were involved in one of 41 L/L programs designed for either single-sex or coeducational settings.

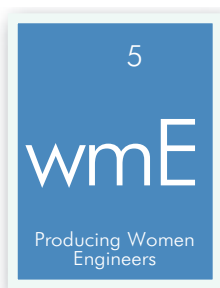
Because most respondents were first-year students—not uncommon for L/L participants—researchers could not yet evaluate L/L programs' lasting effects. This year, researchers at the University of Maryland–College Park (those who led last year's study) are continuing and expanding the NSLLP, in part to probe the long-term effects of L/L participation on women's persistence in college in general, and in STEM disciplines in particular.

The study will employ a number of methods:

- A follow-up survey for participants of the 2004 NSLLP study
- Visits to three to five college campuses that, according to data from the study, offer modestly to high-performing STEM-related L/L options for women
- Expanded data collection from new participating institutions, with the goal of recording continuing trends on women in STEM

Because the study collects data from multiple institutions, it will allow investigators to generalize the results: those campuses interested in developing effective L/L programs for women in STEM will be able to use the study's findings as a blueprint for best models and practices.

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PRODUCING WOMEN ENGINEERS:

A STUDY OF UNDERGRADUATE ENGINEERING PROGRAMS FOR WOMEN

AT PRESENT, WOMEN EARN ONLY 20.1 PERCENT OF THE ENGINEERING BACHELOR'S DEGREES IN THE UNITED STATES. YET SOME ENGINEERING PROGRAMS DO BETTER THAN OTHERS AT ATTRACTING AND RETAINING FEMALE STUDENTS. TO DETERMINE WHAT MAKES THESE PROGRAMS MORE SUCCESSFUL, THE URBAN INSTITUTE IS CONDUCTING A STUDY OF THE 344 SCHOOLS WITH ACCREDITED PROGRAMS ACROSS THE COUNTRY.

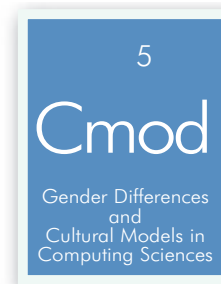
Urban Institute researchers classify each program into one of four “productivity” categories based on enrollment and graduation of women. One goal of the comprehensive study will be to assess the “productivity status” of undergraduate engineering programs across the country.

In particular, the study will examine what approaches, strategies, and interventions lead to a successful program. Researchers will analyze institutional and departmental characteristics to identify patterns both across the nation's programs and within each productivity category. Specific variables include

- Institutional and program selectivity
- Institutional type (Carnegie classification, public or private, minority-serving institution)
- Size of engineering college
- Presence of an engineering graduate program
- Engineering enrollment and number of engineering degrees awarded
- Percentage of engineering faculty that is female
- Percentage of engineering students that is female

Urban Institute researchers will also carry out case studies of six to eight engineering programs rated “highly productive” in graduating women, aiming to analyze the conditions that influence their success. Half of these programs will fit the category “high enrollment and high graduation”; the other half will fit “low enrollment and high graduation.” A comparative analysis should yield an improved understanding of the relationship between enrollment and productivity. Researchers will travel to selected campuses and interview department chairs, top administrators, and engineering faculty, and conduct sex-segregated focus groups of engineering students. Researchers will also collect information on departments' histories and the interventions and strategies they use.

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GENDER DIFFERENCES AND CULTURAL MODELS IN THE COMPUTING SCIENCES

A RESEARCH TEAM AT XAVIER UNIVERSITY OF LOUISIANA IS INVESTIGATING THE UNDERREPRESENTATION OF WOMEN IN THE COMPUTING DISCIPLINES. TEAM MEMBERS HOPE THEIR RESEARCH WILL LEAD TO NEW MODELS OF MORE EQUITABLE AND INVITING COMPUTING EDUCATION.

The researchers are conducting a three-year longitudinal study among 70 male and female undergraduates in computing disciplines at each of 50 institutions of higher education from across the nation: 25 historically black colleges and universities and 25 non-HBCUs. As a baseline, each year at each institution they are also surveying 30 first-year undergraduates not studying a computing discipline.

With this large nationwide sample, the investigators hope to gain more accurate knowledge regarding gender, ethnicity, and culture in the computing disciplines and better support understanding of the computing disciplines across the fields of psychology, sociology, and education. The comprehensive study features a multidisciplinary, culturally diverse, collaborative team. (Microsoft, Inc., and Apogen Technologies, Inc., are corporate partners.)

The architecture of the project was presented in February 2005 at the Association for Computing Machinery Special Interest Group in Computer

Science Education conference in St. Louis, Missouri (<http://doi.acm.org/10.1145/1047344.1047477>). Members of the research team also described the challenges of conducting a national computing discipline study in October 2005 at the American Society for Engineering Education/Institute of Electrical and Electronics Engineers Frontiers in Education conference in Indianapolis, Indiana (<http://fie.engrng.pitt.edu/fie2005/papers/1297.pdf>).

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ENGINEERING CULTURES THAT PROMOTE DIVERSITY

TO DETERMINE WHAT WORKS BEST IN RECRUITING YOUNG WOMEN TO STEM AT THE UNDERGRADUATE LEVEL—AND KEEPING THEM IN THESE DISCIPLINES—A TEAM OF RESEARCHERS AT VIRGINIA TECH IS CONDUCTING A STUDY OF ENGINEERING DEPARTMENTS AROUND THE COUNTRY. THE STUDY WILL USE QUANTITATIVE AND QUALITATIVE DATA TO EXAMINE DEPARTMENTS WITH FEMALE COMPLETION RATES BOTH ABOVE AND BELOW THE NATIONAL AVERAGE.

A central premise of the study is that the culture of engineering departments and colleges has a substantial impact on the success rates of young women. “Culture” here refers to the attitudes, values, beliefs, and practices of institutional leaders, faculty, and students. “Practices” consist of pedagogy, curricula, and policies both formal and informal.

The team will identify elements of departmental (and institutional) culture for schools with female engineering graduation rates above the national average. Research tools will include a questionnaire and self-assessment guide that address schools’ cultures regarding women in STEM. Using a student questionnaire, the team will predict women’s interest in, and choice of, STEM majors on the basis of individual, environmental, and structural factors. Ultimately the researchers will write case studies of best practices for maintaining a climate friendly to women in engineering fields.

Schools participating in this study will receive two-hour training workshops on getting women involved in engineering fields, and faculty modules, to be available online, containing case studies and other resources:

- A follow-up survey for participants of the 2004 NSLLP study
- Visits to three to five college campuses that, according to data from the study, offer modestly to high-performing STEM-related L/L options for women
- Expanded data collection from new participating institutions, with the goal of recording continuing trends on women in STEM

Because the study collects data from multiple institutions, it will allow

investigators to generalize the results: those campuses interested in developing effective L/L programs for women in STEM will be able to use the study's findings as a blueprint for best models and practices.

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INCLUDING THE SOCIAL STUDIES OF SCIENCE IN SCIENCE COURSES FOR GENDER EQUITY

THE BIOLOGY DEPARTMENT AT VIRGINIA TECH ADDRESSES THE LEAKY PIPELINE IN STEM—THE FALLING AWAY OF WOMEN AND MINORITIES AS THEY PROGRESS THROUGH EDUCATION, TRAINING, AND THE WORKPLACE—BY INCORPORATING THE SOCIAL STUDIES OF SCIENCE INTO ITS BASIC BIOLOGY CURRICULUM. THE CURRICULUM DESIGN TAKES THE POSITION THAT TRADITIONAL SCIENCE COURSES UNCONSCIOUSLY REINFORCE AND TRANSMIT THE EXISTING CULTURES OF SCIENCE AND THAT THESE CULTURES ALIENATE WOMEN AND MINORITIES. REVEALING THE RULES OF SCIENCE MAY PROVIDE A PERSPECTIVE FOR STUDENTS TO RECOGNIZE AND UNDERSTAND BIASES AND DEVELOP STRATEGIES FOR RESISTANCE AND CHANGE.

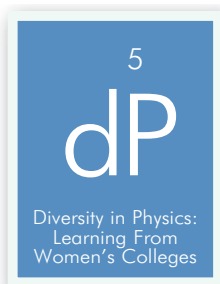


In a transformed cell and molecular biology course, the content included readings on and discussions of history, ethics, and the influence of science on society and vice versa. Typical topics for student presentations were the social impact of the Human Genome Project and genetically modified foods. Tests consisted of short essays and fill-in-the-blank questions instead of multiple-choice options; answers were analyzed for students' demonstrating a broader view of biological epistemology and practice.

Student feedback indicates that going beyond memorizing and reciting facts helps students better understand material. For example, one student found that studying genetically modified foods led to an understanding of multinational corporations, governing authorities such as the World Bank, the economies of third world nations, and the lives of their people. Other students began to look at science from a perspective outside of science, asking why an experiment was done, or questioning the political and personal motivations that affect scientists and the relationship between science and social institutions.

A paper on the theory behind the project, titled "Teaching Science with the Social Studies of Science for Gender Equity," by Muriel Lederman, has been published in the *Journal of Women and Minorities in Science and Engineering*. A manuscript on the implementation of the theory, by Jill Sible, Dayna Wilhelm, and Muriel Lederman, "Teaching Cell and Molecular Biology for Gender Equity," has been accepted by *Cell Biology Education*. A chapter, "Biological Diversity," reflecting on the course transformation and its effects, will appear in *Letters from the Future: Linking Students and Teaching with the Diversity of Everyday Life*, by D. L. Brunson and others (Stylus Publishers, Sterling, Va.).

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DIVERSITY IN PHYSICS: LEARNING FROM WOMEN'S COLLEGES

WOMEN'S COLLEGES PRODUCE FEMALE SCIENTISTS AT TWICE THE RATE OF COEDUCATIONAL INSTITUTIONS. COLORADO COLLEGE RESEARCHERS ARE STUDYING THE PEDAGOGY, CURRICULUM, AND CULTURE OF PHYSICS DEPARTMENTS AT SIX WOMEN'S COLLEGES TO DETERMINE WHICH FACTORS LEAD TO THEIR SUCCESS IN RECRUITING AND RETAINING FEMALE PHYSICS MAJORS.

The study concentrates on physics departments because, of all the sciences, physics has the lowest rate of female participation at every professional level. Women earn 22 percent of bachelor's degrees granted in physics, as compared with 40 percent in life sciences; they earn 18 percent of Ph.D.s in physics; and women hold only 10 percent of college faculty positions in physics.

The project builds on a previous NSF-sponsored study that compared the practices of undergraduate physics departments with low proportions of female majors against those with higher proportions. Researchers observed that departments successful at attracting female majors had several traits in common: a female-friendly departmental culture, an emphasis on cooperation rather than competition, and a strong connection with alumni. Researchers hypothesized that physics departments at women's colleges would exhibit similar characteristics.

A research team (consisting of two experienced female physicists, a sociologist, and a newly graduated physics major) visited institutions of diverse profiles, including Wellesley, Bryn Mawr, and Spelman colleges, and a Roman Catholic college. In addition, the team investigated one program in which physics majors took courses at a separate, coeducational institution.

Researchers interviewed female and male faculty, observed classes, and studied curricula to determine how physics instruction was modified for all-female classes. Tapes of interviews, notes on classroom observation, and other information were transcribed and coded using NUD*IST, a qualitative database program that allows cross-referencing among

different categories of information. Researchers also referred to data from the earlier study for comparison.

In addition to confirming the results of the previous study, the researchers found that physics department faculty at women's colleges recruit students into the major by

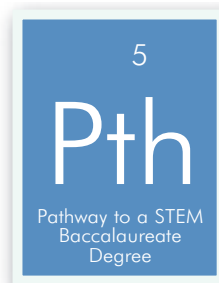
- Providing an attractive curriculum and interactive pedagogy in the introductory class
- Including introductory students in the professional and social activities of the department
- Using astronomy and astrophysics to encourage students to major in physics
- Being more aware of gender issues
- Emphasizing high academic standards and goals
- Fostering a spirit of cooperation
- Building their students' self-confidence

Results are being presented at meetings of the American Association of Physics Teachers and the American Physical Society. They will also be submitted for publication in journals read by physics instructors and made available on a Web site.

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PATHWAY TO A STEM BACCALAUREATE DEGREE

MORE THAN 5 MILLION STUDENTS PURSUE CREDIT COURSES AT APPROXIMATELY 1,100 PUBLIC TWO-YEAR COLLEGES IN THE UNITED STATES. KNOWN FOR THEIR OPEN-ACCESS PHILOSOPHY, FLEXIBLE SCHEDULES, AND RELATIVELY LOW COSTS, THESE INSTITUTIONS ARE THE SCHOOLS OF CHOICE AMONG AMERICA'S MINORITIES, WHO REPRESENT ABOUT 30 PERCENT OF COMMUNITY COLLEGE ENROLLMENTS NATIONWIDE. FIFTY-EIGHT PERCENT OF COMMUNITY COLLEGE STUDENTS ARE WOMEN. THIS PROJECT SEEKS TO GIVE STUDENTS ENROLLED IN COMMUNITY COLLEGES THE TOOLS TO SUCCEED ACADEMICALLY IN THEIR PRE-STEM PREPARATION AS WELL AS IN THE TRANSFER PROCESS TO FOUR-YEAR COLLEGES OR UNIVERSITIES.



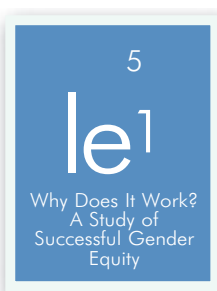
Three products are under development at Iowa State University:

- An instructional video series about the transition from two- to four-year colleges
- The Transfer Student Guide, which will contain research, recommendations, students' reflections, a time line, and a transfer checklist
- A Web site (<http://www.pathway2stemdegree.org/>) through which these two products and other educational resources will be disseminated to students in two-year colleges, educators in both two-year and four-year institutions, academic counselors and advisors, transfer-center coordinators, personnel in business and industry, researchers, policymakers, and the public

The instructional video series, titled *STEM Pathway: Community College to University*, will consist of four half-hour videos and accompanying manuals.

To make these products, the research team will travel to community colleges across the country and interview faculty, program coordinators, and students. The Transfer Student Guide, intended primarily for students who aspire to transfer to four-year institutions, will be made available in Spanish as well as English for the benefit of Spanish-speaking parents.

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WHY DOES IT WORK? A STUDY OF SUCCESSFUL GENDER EQUITY IN INDUSTRIAL ENGINEERING AT THE UNIVERSITY OF OKLAHOMA

AS OF FALL 2001, 58 PERCENT OF THE UNDERGRADUATE MAJORS IN THE SCHOOL OF INDUSTRIAL ENGINEERING AT THE UNIVERSITY OF OKLAHOMA WERE WOMEN, A PROPORTION STRIKINGLY HIGHER THAN BOTH THE NATIONWIDE PROPORTION IN INDUSTRIAL ENGINEERING AND THE PROPORTION IN OTHER STEM DEGREE PROGRAMS AT THE UNIVERSITY. FURTHERMORE, THE PROPORTION MORE THAN DOUBLED IN THE SPACE OF FIVE YEARS, HAVING INCREASED STEADILY FROM 27 PERCENT IN 1996. THIS PHENOMENON WAS ESPECIALLY PUZZLING BECAUSE THE INDUSTRIAL ENGINEERING PROGRAM DID NOT SET OUT SPECIFICALLY TO ACCOMPLISH GENDER PARITY AMONG ITS UNDERGRADUATE MAJORS.

A multidisciplinary team of researchers investigated this phenomenon using an ethnographic research methodology, including interviews with students and faculty in the Industrial Engineering department, in other STEM departments, and at other institutions. Additional data included student academic transcripts, historical documents, and other artifacts. The team will also interview representatives from local industries that tend to employ interns and graduates of the program and will continue to disseminate its findings in a wide range of conference presentations and published articles.

To date, analysis points to four key findings:

- Industrial engineering majors seem to have a better-developed sense of professional identity than students in other majors and describe industrial engineering in ways that jibe with what the literature suggests attracts women.
- The industrial engineering student-faculty ratio is small and faculty members have taken advantage of this situation to nurture social networks. Furthermore, the department has a large number of faculty members whom the students perceive as caring about them.

- The department at University of Oklahoma does have a high proportion of women faculty, but this alone does not account for the gender parity at the undergraduate level. Other departments and fields show disparity between the proportion of women faculty and proportion of women students. In contrast to these other departments and fields, however, women faculty in industrial engineering at University of Oklahoma are highly visible to students before and after the students declare IE as a major, and female students in particular see these women as having characteristics that they value.
- The department has fostered strong ties among students. This sense of community seems to be especially important to the female majors. In addition, many of the women majors have been visible leaders in the department and in the college.

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