

Engineering @ Sweet Briar College: A Global Perspective in a Liberal Arts Context

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Abstract – Sweet Briar College, a liberal arts women’s college, is in the process of implementing a new engineering program—only the second of its kind. Building on a strong foundation in the sciences and liberal arts, the Engineering Program at Sweet Briar seeks to address the aims of graduating broad-minded engineers with a global perspective and developing technical skills and confidence in non-SMET graduates by: integrating engineering into liberal arts courses; holding forums on integrating engineering and the liberal arts; offering introductory engineering courses that are open to all students and satisfy general education requirements; offering an experimental measurements course for liberal arts majors; and offering two thematic integrated experience courses, one with a regional perspective and one with a global perspective, that involve multidisciplinary teams of faculty and students developing and implementing solutions to real-world design problems—both courses satisfy general education requirements and are open to all students.

Keywords: Integration, Global, Liberal Arts, Sweet Briar, Women

INTRODUCTION

Sweet Briar College is particularly well-positioned to create and develop an innovative engineering program that will serve as a model for integrating engineering in a liberal arts context. With an average class size of twelve, and a student-to-faculty ratio of eight-to-one, Sweet Briar is a prominent four-year liberal arts and sciences college for women as reflected by four top-twenty category listings in *The Princeton Review* [1] including “Best Overall Academic Experience for Undergraduates,” being one of only four colleges ranked in the top twenty percent in every category of the inaugural *National Survey of Student Engagement*, and in the top ten percent in every category in its subsequent survey [2].

Sweet Briar’s exceptional science departments provide an essential foundation upon which Sweet Briar’s new engineering program will build toward success; these programs include Biology, Chemistry, Environmental Studies, Mathematical Sciences, Physics, and Psychology. In addition to the customary department-labeled majors, degrees in biochemistry, molecular biology, computer science, environmental science, and mathematics-physics are offered. Over the past decade, Sweet Briar has instituted extensive curricula modifications and initiated a progressive summer faculty and undergraduate student research program. The impact of these efforts is notable: since 1992, the number of students majoring in the natural sciences at Sweet Briar increased by fifty percent to one-third of 2003’s graduating class. This reality is particularly compelling considering:

- Only approximately 25 to 30% of students entering U.S. colleges intend to major in the natural sciences or engineering [3];
- National attrition rates in U.S. colleges of natural science and engineering majors is greater than 50% [3];

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- Women are often discouraged from pursuing careers in the natural sciences due to bad classroom and laboratory experiences [4,5]; and
- Women are frequently intimidated by careers in the applied sciences [6].

More to the point, Sweet Briar graduates natural science majors at more than twice the national average for liberal arts colleges, despite being a women's college with a clientele that is traditionally predisposed to pursue degrees outside these fields of study. Nationally, about one percent of the U.S. graduates receive degrees in physics or chemistry [3]; at Sweet Briar, five to ten percent do. Combined with its recognized excellence in programs from philosophy, history, and international studies to dance, theater, and music, the established foundation at Sweet Briar is ideal for creating and developing an innovative engineering program integrating engineering and the liberal arts.

ENGINEERING @ SWEET BRIAR: DESIGNING HER WORLD, DESIGNING OUR WORLD

As reflected in the *Accreditation Board for Engineering and Technology's* (ABET's) Engineering Criteria 2000 Course Learning Objectives, engineering education has broadened in scope in recent years [4,7,8]. The revised objectives seek to engender a more diverse and multi-talented workforce capable of critical thinking, the evaluation of the broad societal and global implications of technology, and teamwork and communication skills, as opposed to the traditional objectives that focused almost exclusively on training large numbers of technical specialists. In light of these expanded criteria, Sweet Briar, with its strong liberal arts, sciences, and new business management programs, is especially suited to offer an engineering program that will prepare women for careers in technical and interdisciplinary fields, both of which now demand a much broader perspective and talent-base than in the past.

In addition to the shift in workforce skill requirements as demonstrated in the ABET criteria, there has been a nine percent decrease in enrollment of U. S. students in Science and Engineering programs in recent years [3]. Numerous studies have shown that for the U.S. to maintain its lead in technology, it is imperative that more women be recruited into the Science, Math, Engineering, and Technology (SMET) workforce [3,8-12]. Even in non-SMET fields, the *National Academy of Engineering* identifies a critical need for all citizens to achieve a level of technical literacy to facilitate making cognizant personal and civic decisions [13]. The National Science Foundation (NSF) Strategic Plan for Fiscal Years 2003-2008 states, "The U.S. Department of Labor estimates that 60% of new jobs being created in our economy today will require technological literacy while only 22% of young people entering the job market now actually possess these skills [14]." The new Engineering Program at Sweet Briar seeks to both increase the number of qualified women with engineering degrees, and increase the technical literacy of a significant number of non-SMET oriented women who typically have not pursued paths toward technical competence and confidence.

The recently renamed Department of Physics and Engineering at Sweet Briar currently has four faculty members that include a new Director of Engineering. In addition to its plan to develop an ABET accredited degree, the new Engineering Program generated the following Vision, Mission, Set of Program Goals, and List of the Program's Salient Traits through internal discussions with students, faculty, and college administrators, as well as deliberations with regional community and industrial leaders:

Program Vision

Sweet Briar's Engineering Program will be a preeminent blend of engineering and applied science within a liberal arts context of national prominence and international consequence. With emphases on integrated design and hands-on experiences in a global context, and socially conscious team-focused approaches to synthesizing, analyzing, and addressing technical and social challenges, the program will prepare women for leadership roles in our ever-changing world. An exceptional and dedicated faculty will strive alongside students to foment continuous self-improvement through developing critical and creative abilities, effective communication skills, and technical excellence in pursuit of designing her world, designing our world—a sustainable world, a better world.

Program Mission

Our mission at Sweet Briar's Engineering Program is to provide women an unsurpassed, student-centered liberal arts learning atmosphere that emphasizes responsible problem-solving in a global context, design as a distinctive

attribute of engineering, the benefits of hands-on approaches and experiential learning, consequential faculty-student interaction, and the development of graduates who possess the technical knowledge, cognitive skills, ingenuity, and ethical principles needed to excel in their profession, successfully pursue advanced degrees within the U.S. or abroad, and to apply technology to design a better world.

Program Goals

The program goals of Sweet Briar's Engineering Program are to:

- Produce graduates capable of applying currently relevant methods for translating fundamental principles into design applications that are socially relevant and ethically responsible;
- Provide comprehensive technical expertise integrated within a liberal arts context including distinction in the development of written, oral, and visual communication skills in multiple languages;
- Prepare technically adept and adaptive graduates whose endeavors are recognized for their global relevance and social rectitude;
- Provide students a variety of hands-on, team-based integrated experiences in problem solving that prepare graduates for professional practice and the pursuit advanced studies;
- Engender continuous learning and self improvement within the context of the ever-changing contemporary world;
- Offer a comprehensive curriculum that challenges and excites both students and faculty while integrating technology with the liberal arts and providing experiences in industry and abroad.

Learning occurs in many venues—the classroom, the community, the world. Sweet Briar endeavors to create an intense and supportive educational environment that prepares women to be productive, responsible members of a world community. Through an integrated approach combining technology with the liberal arts, the engineering program strives to cultivate leaders who seek to design her world, to design our world—a sustainable world, a better world.

Salient Traits of the Program

Sweet Briar's thriving campus includes a superb faculty and faculty/student ratio, a student-centered learning environment which emphasizes educational excellence, a gorgeous campus entrenched in the verdant hills of Central Virginia, a renown riding program with trails throughout its 3300 acre campus, excellence in the sciences and graduate placement, a vibrant arts program with lauded performances and exhibitions, significant student participation in athletics...the list goes on. In addition to the exceptional characteristics of The College, Sweet Briar's Engineering Program plans to excel in the following areas:

- **Design and Hands-On Engineering Experiences Throughout the Curriculum**
 - Design as a Distinctive Feature of Engineering – Focus From the First Year through Graduation
 - A Minimum of Twelve Lab-Intense, Hands-On Oriented Courses
 - Guaranteed Industrial and/or Research Internships
 - Senior Design Projects Submitted to, and Supervised by, Program Industrial Partners
 - Summer Engineering Projects in the Developing World and Underdeveloped Parts of the U.S.
- **Engineering and Applied Science Integrated in a Liberal Arts Context**
 - Team-Taught 'Integrated Experience' Courses Focusing on Blending Engineering and the Humanities—Social Relevance, Policy Issues, Ethics, etc.
 - Full Participation in the Robust General Education Program at Sweet Briar
 - Socially Conscious Engineering Design Projects in Under-Develop Parts of the U.S. (e.g. Appalachia)
 - Integration of Engineering-Relevant Topics into Non-Engineering Courses
- **A Global Perspective in a Globalized World with a Social Conscience**
 - Full Participation in Sweet Briar's Long-Established Study Abroad Program
 - Socially Conscious Engineering Design Projects in the Developing World (e.g. Guatemala)

- A International Relations Concentration in the B.A. in Integrated Engineering & Management
- Foreign Language Minor Attainable by Taking Two Additional Courses
- **A Distinctive Set of Specialization Concentrations: Students Complete Four Electives in Their Chosen Concentration**
 - Bachelor of Science in Engineering Science—Available Concentrations:
 - Physics
 - Materials
 - Environmental Science
 - Computer Science
 - Chemistry
 - Biology
 - Bachelor of Arts in Integrated Engineering & Management—Available Concentrations:
 - International Relations
 - Environmental Studies

It should be noted that the material listed in this document is the intended direction of the program; promotion of the program via emphasis on these items is encouraged. But, the curriculum and details of the program have not yet been presented to, or officially approved by, the faculty or administration of Sweet Briar College. Such approval will be pursued over the course of the spring semester of 2005.

THE PROGRAM

At the core of Sweet Briar's Engineering Program is the design of curricula that address the delineated goals and objectives of the program. In this light, the two flagship degrees offered by the program are a Bachelor of Science (B.S.) degree in Engineering Science—seeking ABET accreditation for all B.S. graduates—and a Bachelor of Arts (B.A.) degree in Integrated Engineering and Management. A novel aspect of the Sweet Briar approach is the development of the engineering courses from a “clean-slate”, based on best practices from existing engineering programs and education coalition findings. Program models upon which the Sweet Briar B.S. curriculum is based include the Engineering Science programs at Smith College [15], the only other women's college in the U.S. offering engineering, Harvey Mudd [16,17], a program that awards an undesignated engineering B.S. rather than a specialized degree that includes a minimum of thirty percent humanities and social sciences, and the University of Michigan's “Curriculum 2000” [18] with goals emphasizing teamwork, communication, computing, dealing with uncertainty, ethics, and environmental awareness. In addition to a solid foundation in physics, chemistry, and mathematics, B.S. students at Sweet Briar take courses in statistics and computer science, must satisfy all of the college's general education requirements, be proficient in a modern (foreign) language (four semesters), and select a science concentration in which they're required to take four additional courses. Building on the strengths of this solid liberal arts and science foundation is a broad-based set of fifteen integrated engineering courses, some of which are described in “The Approach” section of this paper [19].

The B.A. option in Integrated Engineering and Management combines a subset of courses in the Engineering Program with a subset of Sweet Briar's new Business Management program courses. This interdisciplinary degree is an adaptation of models of the Integrated Science and Technology (ISAT) program at James Madison University [20] and more traditional ABET-accredited Engineering Management degrees, such as the one found at the University of Missouri-Rolla [21]. By incorporating strong liberal arts and science foundations into a degree that combines a balanced course-load in engineering and management [22], the Integrated Engineering and Management degree epitomizes the cross-disciplinary approach while addressing emerging workforce needs for technically literate managers and business leaders in the private and public sectors.

The initial course sequences for the Engineering Science and Integrated Engineering and Management curricula are the same. Students at Sweet Briar are not required to declare a major until their fourth semester, thus giving students the opportunity to explore engineering. In addition to a supportive, all-female educational climate, such an approach provides women two years to “test the waters,” helping to eliminate the oft-encountered intimidation factor of having to commit, from the first day, to an engineering curriculum and culture dominated by male students, a

common reality at large institutions, that is generally perceived by female students as unpleasant, uninteresting, and overly challenging [18]. To encourage all women at Sweet Briar to consider exploring technical literacy, even those outside of SMET programs, in addition to developing engineering courses that satisfy general education requirements, an engineering minor has been created [23]. A student combining a minor in engineering with a major in the sciences will increase her career opportunities in technical fields and facilitate her potential acceptance into competitive engineering programs. By combining a minor in engineering with a major in a liberal arts field, a student can achieve a level of technical literacy not traditionally pursued by students in the liberal arts.

THE APPROACH

To address the specific aims of graduating broad-minded engineers with a global perspective and developing technical skills and confidence in non-SMET graduates, the Engineering Program at Sweet Briar is pursuing the following:

- Integration of engineering into liberal arts courses;
- Holding forums to receive broad input on the integration of engineering and the liberal arts;
- Having the introductory engineering courses satisfy general education requirements and be open to all Sweet Briar students;
- Offering a basic experimental measurements course for liberal arts majors; and
- Offering two thematic integrated experience courses, one with a regional perspective and one with a global perspective, that involve multidisciplinary teams of faculty and students developing and implementing solutions to real-world design problems—these courses satisfy general education requirements and are open to all Sweet Briar students.

Engineering in Liberal Arts Courses

The initial attempt at integrating engineering and the liberal arts at Sweet Briar was incorporated into a National Science Foundation (NSF) grant [24] that included a curriculum development budget item for summer stipends to engage non-engineering faculty in the creation of courses and/or course modules that tie into the engineering curriculum, and also to support the development of novel approaches to facilitate course integration. Two prominent examples of this aspect of the program are a course proposed by Dr. Lynn Laufenberg in the Department of History focusing on engineering, history, and society in the west from antiquity to the Renaissance, and a course proposed by Dr. Matthew Calarco in the Department of Philosophy combining engineering ethics and the philosophy of technology. The development of these two courses, along with others, will take place during the summer of 2005 with input from both liberal arts and engineering/science faculty at Sweet Briar and beyond. Both courses will be implemented in the 2005-2006 academic year.

Integration Forums

The first forum on integrating engineering and the liberal arts at Sweet Briar was an honors colloquium wherein the Engineering Program's new director, Kurt C. Schulz, presented, "Integration of Engineering and the Liberal Arts at Sweet Briar and Beyond [25]," to students, faculty, and administrators at Sweet Briar College. During half of the session, Dr. Schulz first defined engineering, the liberal arts, and integration, then overviewed the engineering program and plans for integrating the program with the liberal arts; the second half was devoted to an open exchange of ideas. Items from course credit hours and post-graduation student opportunities, to nomenclature and design project possibilities, were discussed. All represented groups offered ideas and comments, including the president and dean of the college. The integration items presented in this paper are partially a result of interchanges that took place at this first colloquium.

In the spring of 2005, two distinguished integration experts, Dr. Thomas Hughes, an author of books on technology and society who holds a B.S. in mechanical engineering, a Ph.D. in history, and currently lectures at the Massachusetts Institute of Technology (MIT) [26]; and Dr. Rosalind Williams, Dean of Students at MIT and Director of its Science, Technology, and Society Program [27], will participate in a forum on the integration of engineering, science, and the liberal arts at Sweet Briar and beyond. The forum will be open to all and include Dr. Schulz, representatives from the Sweet Briar faculty in the sciences and the liberal arts, and Sweet Briar

administrative representatives. As an incipient program that is flexible and striving for innovation and excellence, the Engineering Program at Sweet Briar is strategically positioned to absorb and quickly seek implementation, minimally on a trial basis, the ideas and possible approaches to integration that will be generated and discussed at such a forum

Introductory Engineering Courses

Two 3-credit courses comprise the foundations of the Engineering Program at Sweet Briar; these two courses are ENGR 110—Designing Our World: An Introduction to Engineering Design [28], and ENGR 120—Analyzing Our World: Foundations of Engineering Analysis [29]. The first course, ENGR 110, emphasizes The Design Process—the process by which engineers approach problem solving. Via active participation in two major hands-on team projects, in which mechanisms are designed, built, and contended, students apply underlying scientific principles, examine how devices work, prepare project plans and written reports, analyze and present data, and conduct economic analyses. Underlying themes include teamwork, communication, optimization, trade-offs, and decision-making. By satisfying Sweet Briar general education requirements in quantitative reasoning skills and written communication skills, and being designed as an engaging and enjoyable learning experience open to all students, this course is well positioned to expose non-SMET students to fundamental engineering concepts while simultaneously laying the requisite foundation of key skill development in communications, multidisciplinary teamwork, and the quintessential aspect of engineering education—The Design Process. In the fall of 2004, prior to the new Engineering Program being promoted off-campus, twelve students enrolled in the ENGR 110 course. Of the twelve, four are considering pursuing undergraduate degrees in engineering, three are pursuing majors in other SMET fields, and the remaining include a modern languages major, a psychology major, a studio art/creative writing major, and an international affairs major. Diversity in year is similarly broad, including two juniors, two seniors, and three sophomores.

The ENGR 120—Analyzing Our World: Foundations of Engineering Analysis course lays the analytical foundation for studying and practicing engineering in the modern world. This course meets the requirements for three Sweet Briar general education areas: knowledge of scientific theory, quantitative reasoning skills, and oral communication skills. The essence of this course focuses on the development of quantitative reasoning skills from arithmetic analysis and analyzing data to problem solving and the application of logical reasoning. The course is oral intensive as it routinely involves, and requires, students to not only develop quantitative solutions, but to present and defend their logic to the instructor and the class—orally. As per the organization of the course into two cooperative-learning sessions, interactive methods, focusing on oral interchange, will be employed fostering close interaction and forcing students to establish and defend the credibility of their work. Engineering Graphics is the primary method of communicating ideas and designs among engineers and between engineers and machinists—although valuable for non-SMET students, it's essential that engineering students learn this subject early in the curriculum and that they are comfortable with Computer Aided Design (CAD) tools. In addition to CAD, the process by which engineers approach and solve problems is covered along with the use of other essential tools of today's engineers—programming in Excel and Matlab. The analytical skills acquired in this course will be used throughout the engineering curriculum at SBC and are requisite skills for any engineering graduates entering the workforce in the coming years. Students will not only be learning how to communicate technical information, but will be applying scientific theory throughout the course. This course is open to all students, but requires mathematical proficiency at the pre-calculus level and will be taught for the first time in the Spring of 2005.

A Basic Experimental Measurement Course for Liberal Arts Majors

Based on the Integrated Teaching and Learning model developed at the University of Colorado-Boulder [30,31], the Sweet Briar Engineering Program seeks to develop a single integrated multidisciplinary engineering lab space where all levels of engineering and non-engineering students will interact. Such an approach will provide a unique learning atmosphere wherein a large swath of students, who are typically compartmentalized on modern higher-education campuses, will be working side-by-side with innumerable opportunities to learn from each other. By adapting the ITL approach focusing on team-oriented, hands-on learning in the development of five engineering laboratory-oriented courses—four fundamental courses for engineering majors and one broad-based course for non-SMET majors—and implementing mobile National Instruments Educational Laboratory Virtual Instrumentation Suite (NI ELVIS/LabVIEW) workstation systems throughout the laboratory for data collection, simulation, pre-lab

exercises, and virtual experimentation on-site and via the internet—both engineering and non-engineering majors will be exposed to, and have ready access to, cutting-edge instrumentation technology and each other.

The ENGR 101—Basic Measurements for Liberal Arts Majors course will be a 1-credit laboratory-oriented course for non-SMET majors, open to all Sweet Briar students, which will count toward the college-wide general education requirement for understanding the world through scientific experimentation. The NI ELVIS/LabVIEW systems will be used for data acquisition and pre-lab preparation using virtual instruments. This course will take advantage of the experimental set-ups and virtual instruments made available through the development of the other four laboratory courses in the engineering curriculum. To address the general technology anxiety often present in non-SMET majors, this course will use an inquiry-based approach to enable students to acquire the knowledge and skills applicable to the design-build process [32]. As a single broad-based course for non-SMET majors, this course will focus on basic measurements using open-ended experimental modules to encourage learning by discovery. ‘Inquiry’ is a team-based, active-learning approach in which students learn by doing—students stay alert, are engaged more, and learn more [30]. This course is scheduled to be taught for the first time in the Fall of 2006.

Thematic Integrated Engineering Courses

Although offering a laboratory course for liberal arts majors is atypical and will provide non-SMET majors a unique opportunity to gain confidence and proficiency in working with modern technical tools and methods, the truly pioneering aspect of the new Engineering Program at Sweet Briar will most likely be the development and implementation of two thematic integrated experience courses, one with a regional perspective and one with a global perspective, that will involve multidisciplinary teams of faculty and students developing and implementing solutions to real-world design problems—these courses will satisfy general education requirements and be open to all Sweet Briar students. In essence, the idea is to identify a real-world social need that is potentially capable of being addressed through engineering design and implementation—a specific problem (different each time the such a course is taught) for which a team of multidisciplinary faculty and students can devise and implement a solution. Prior to teaching such a course in a given term, a problem will have to be identified and a faculty team assembled—ideally a team composed of individual faculty members with expertise relevant to the specific problem(s) that will be addressed in the course. The administration at Sweet Briar is “on-board” with the plan to develop such courses and has agreed to provide partial funding for the implementation phase each year—additional requisite funding, especially for travel abroad and supplies, will have to be raised by the faculty, and students, involved.

ENGR 230—Integrated Experience: A Regional Perspective will involve socially conscious design projects within the U.S. As an example, consider that a small community in the Appalachians is isolated most of the year due to a river that flows adjacent to it. The children oft miss school and the adults are unable to maintain employment due to their undependability. The community consists of six or eight families that ‘live off the land’ and the state and federal government consider their case to be too small to warrant consideration for investment. Students and faculty at Sweet Briar, via the ENGR 230 course, could seek to address such a situation—not by faculty lecturing on a preconceived solution(s), but by a multidisciplinary group of faculty and students applying the design process to develop and implement a solution to the problem. Ideally, in addition to an engineering faculty member, the multidisciplinary team of faculty would consist of two or more other faculty members with expertise in one or more fields relevant to the Appalachian region: Anthropology, Sociology, Fine Arts, Religion, Business, Education, Literature, Environmental Studies, Government, History, Law, Music, Psychology, Theatre, Dance, Communications, Women Studies, etc. The possibilities are many and varied. By also fulfilling the Sweet Briar general education requirements for “appreciating how class, gender, ethnicity, and ethical and religions values affect world views and decision making,” and oral communication skills, this course will likely have broad student appeal while promoting a truly multidisciplinary approach to problem solving—an invaluable experience for both the enrolled engineering and non-engineering students.

ENGR 330—Integrated Experience: A Global Perspective will involve socially conscious design projects outside of the U.S. As an example, Dr. Schulz wrote a proposal to Engineers Without Borders [33] for addressing the needs for water systems at a boarding school in the Guatemalan Highlands that serves over thirty rural communities. The project involves designing and implementing systems for distributing water throughout the school, generating hot water (temperatures drop into the forties much of the year), and converting human and animal wastes into usable fertilizer. Students and faculty at Sweet Briar, via the ENGR 330 course, could seek to address such a situation in a

parallel manner to that described for the ENGR 230 course, not by faculty lecturing on a preconceived solution(s), but by a multidisciplinary group of faculty and students applying the design process to develop and implement a solution to the problem. Ideally, in addition to an engineering faculty member, the multidisciplinary team of faculty would consist of two or more other faculty members with expertise in fields relevant to Guatemala, Central America, the Maya, etc. As with the ENGR 230 course, the possibilities are many and varied. By also fulfilling the Sweet Briar general education requirements for “becoming acquainted with non-Western cultures to better understand the world,” and written communication skills, this course will also likely have broad student appeal while promoting a truly multidisciplinary and multicultural approach to problem solving—an invaluable experience for both the enrolled engineering and non-engineering students.

CONCLUSIONS

Building on its recognized strengths in the sciences and liberal arts, Sweet Briar College, an established women’s college in central Virginia, recently created an Engineering Program—only the second of its kind in the U.S. Responding to ABET’s emphasis on producing well-rounded graduates capable of excelling in a globalized marketplace, and the nation’s need for technically competent engineers and managers who possess exceptional communication and teamwork skills and who are comfortable operating in multidisciplinary settings, the new program is pursuing excellence through a keen focus on the development of broadly skilled holistic graduates with a global perspective and on developing technical confidence and competence in Sweet Briar’s non-SMET graduates. While addressing the nation’s need for an increase in the number of women in engineering, the new Engineering Program has embarked on a comprehensive approach to integrating engineering and the liberal arts and engendering a global perspective by:

- Integrating engineering topics into liberal arts courses;
- Organizing forums on the integration of engineering and the liberal arts;
- Offering introductory engineering courses that are open to all students and satisfy general education requirements;
- Creating a basic experimental measurements laboratory course for liberal arts majors; and
- Developing two thematic integrated experience courses, one with a regional perspective and one with a global perspective, which involve multidisciplinary teams of faculty and students developing and implementing solutions to real-world design problems.

References

- [1] The Princeton Review, *Best 357 Colleges*, August 2004, <http://www.princetonreview.com/college/research/rankings/rankings.asp>
- [2] National Survey of Student Engagement, NSSE 2004 Annual Report, *Student Engagement: Pathways to Student Success*, December 2004, <http://www.indiana.edu/~nsse/html/report-2004.shtml>
- [3] National Science Board, *Science and Engineering Indicators—2002*, National Science Foundation, Arlington, VA, 2002.
- [4] Farmer, H.S., J.L. Wardrop, and S.C. Rotella, “Antecedent Factors Differentiating Woman and Men in Science/Nonscience Careers,” *Psychology of Women Quarterly*, 1999, 23:763.
- [5] Conefrey, T., “Gender, Culture, and Authority in a University Life Sciences Laboratory,” *Discourse & Society*, 1997, 8:313.
- [6] Kremer, K., G. Mullins, and R. Roth, “Women in Science and Environmental Education: Need for an Agenda,” *Journal of Environmental Education*, 1991, 22(2):4-6.
- [7] Accreditation Board for Engineering and Technology (ABET), *Criteria for Accrediting Engineering Programs, Program Outcomes and Assessment*, November 2003, <http://www.abet.org/images/Criteria/E001%2004-05%20EAC%20Criteria%2011-20-03.pdf>
- [8] Fromm, E., “The Changing Engineering Educational Paradigm,” *Journal of Engineering Education*, April 2003, 92(2):113-121.

- [9] Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (CAWMSET). *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology*, 2000.
- [10] Gorham, D., P.B. Newberry, and T.A. Bickart, "Engineering Accreditation and *Standards for Technological Literacy*," *Journal of Engineering Education*, January 2003, 92(1):95-99.
- [11] Meier, R. L., M.R. Williams, and M.A. Humphreys, "Refocusing Our Efforts: Assessing Non-Technical Competency Gaps," *Journal of Engineering Education*, July 2000, 377-385.
- [12] Mikic, B., and D. Grasso, "Socially-Relevant Design: The TOYtech Project at Smith College," *Journal of Engineering Education*, July 2002, 91(3):319-326.
- [13] National Academy of Engineering (NAE), "Technically Speaking: Why All Americans Need to Know More About Technology," National Academy Press, Washington, DC, 2002.
- [14] The National Science Foundation, *GPRA Strategic Plan Draft: Fiscal Years 2003-2008*, June 2003, http://www.nsf.gov/od/stratplan_03-08/draft-stratplan-FY2003-2008.pdf
- [15] Smith College, Academics, Academic Programs, Departments and Programs, Engineering, Picker Engineering Program, Courses & Curriculum, December 2004, <http://www.science.smith.edu/departments/Engin/courses.php>
- [16] Bright, A., and J.R. Phillips, "The Harvey Mudd Engineering Clinic Past, Present, Future," *Journal of Engineering Education*, April 1999, 189-194.
- [17] Harvey Mudd College, Academics & Research, Engineering, The Major, December 2004, <http://www.eng.hmc.edu/major.php?sidebar=major>
- [18] Chesler, N.C., and M.A. Chesler, "Gender-Informed Mentoring Strategies for Women Engineering Scholars: On Establishing a Caring Community," *Journal of Engineering Education*, January 2002, 91(9):49-55.
- [19] Sweet Briar College, Academics, Departmental Pages, Engineering, Courses & Curriculum, B.S. Eng. Science, December 2004, http://engineering.sbc.edu/Curriculum_Files/BScienceDegReq.doc
- [20] James Madison University, "Integrated Science and Technology—Informational Anthology," August 2002, 17-30.
- [21] University of Missouri-Rolla, Academics, Undergraduate Areas of Study, Engineering Management, December 2004, <http://www.umsr.edu/index.php?id=317>
- [22] Sweet Briar College, Academics, Departmental Pages, Engineering, Courses & Curriculum, B.A. IEM, December 2004, http://engineering.sbc.edu/Curriculum_Files/BArtDegReq.doc
- [23] Sweet Briar College, Academics, Departmental Pages, Engineering, Courses & Curriculum, The Engineering Minor, December 2004, http://engineering.sbc.edu/Curriculum_Files/MinorReq.doc
- [24] National Science Foundation, "Implementation of a New Engineering Program at Sweet Briar College," NSF Award #0343071, October 2003.
- [25] Schulz, Kurt C., "Integration of Engineering and the Liberal Arts at Sweet Briar and Beyond," *Honors Colloquium*, Sweet Briar College, December 8, 2004.
- [26] Hughes, Thomas, Visiting Professor, Massachusetts Institute of Technology, Program in Science, Technology, and Society, December 2004, http://web.mit.edu/sts/faculty/info/Hughes_Thomas-css.html
- [27] Williams, Rosalind, Dean of Students, Massachusetts Institute of Technology, Director of the Program in Science, Technology, and Society, December 2004, <http://web.mit.edu/sts/sites/rwilliams/>
- [28] Sweet Briar College, Academics, Engineering, Courses and Curriculum, Courses @ SBC, ENGR 110 Course Webpage, http://engineering.sbc.edu/ENGR_Courses/ENGR_110/ENGR_110_Main.htm
- [29] Sweet Briar College, Academics, Engineering, Courses and Curriculum, Courses @ SBC, ENGR 120 Course Webpage, http://engineering.sbc.edu/ENGR_Courses/ENGR_120/ENGR_120_Main.htm
- [30] Carlson, L.E. and J.F. Sullivan, "Hands-On Engineering: Learning by Doing in the Integrated Teaching and Learning Program," *International Journal of Engineering Education*, 1999, 15(1):20-31.
- [31] Argrow, B.M., "Proactive Teaching and Learning in the Aerospace Engineering Curriculum 2000," *Proceedings of the 2002 American Society for Engineering Education Annual Conference and Exposition*, May 2002.
- [32] Louie, B.L., Knight, D.W., and Sullivan, J.F., "Women's Manufacturing Workshop Series that Supports Inclusiveness and Skill Building in Undergraduate Engineering Education," *Proceedings of the 2003 American Society for Engineering Education Annual Conference and Exposition*, May 2003.
- [33] Engineers Without Borders—USA, Projects, Complete List, Guatemala, Xix, December 2004, <http://www.ewb-usa.org/ewb/project/display.do?mode=byCountry&ID=45>

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Dr. Schulz is an Associate Professor in the recently renamed Department of Physics and Engineering at Sweet Briar College. As Director of the new Engineering Program, Dr. Schulz is actively engaged in developing the innovative new program. His teaching accomplishments include developing multiple engineering laboratories, creating multimedia modules for laboratory experiments, and he is a 5-time recipient of the Outstanding Engineering Professor Award. His research accomplishments include the testing and modeling of advanced composite joints and investigations into novel composite fabrication methods including gamma-radiation curing.

Scott D. Hyman

Dr. Hyman is a Professor of Physics at Sweet Briar College where he previously served as Assistant Dean of Academic Affairs. As the PI on the NSF proposal that funded the creation of the new Engineering Program at Sweet Briar, Dr. Hyman has been active in the program's development. His teaching accomplishments include the incorporation of computer-based demonstrations and "real-time physics" active learning into the physics curriculum, and involving students in his research on neural networks. His research accomplishments include wide-field imaging of the galactic center region, radio continuum imaging, and radio detection of supernovas.

Hank Yochum

Dr. Yochum is an Assistant Professor of Physics at Sweet Briar College where he currently serves as Chair of the Physics and Engineering Department. As a co-PI on the above-mentioned NSF proposal, Dr. Yochum too has been an active participant in the implementation of Sweet Briar's new Engineering Program. His educational accomplishments include training elementary and middle school science teachers and the development of physics workshops promoting the use of hands-on inquiry based physics instruction. His research accomplishments include laser spectroscopy of blue-light induced absorption in crystals and picosecond time-resolved luminescence studies.

Mary Kasarda

Dr. Kasarda is an Associate Professor of Mechanical Engineering at Virginia Tech and spent half of the 2003-2004 academic year as a visiting professor at Sweet Briar College providing guidance and expertise on the initiation of the new Engineering Program. Dr. Kasarda is active in educating women in engineering and focuses on engineering design & economics and dynamic systems in her teaching. Her research accomplishments include an NSF CAREER grant on magnetic bearings for improved process control and studies of magnetic actuators for non-destructive evaluation of rotating machinery for health diagnostics and prognostics.