PLEASE NOTE:
Generally, papers from the *Bulletin for the History of Chemistry* from the last three years are available only to members of the Division of the History of Chemistry of the American Chemical Society and other subscribers. After three years, the Division makes them available to open access.

These papers are being make available to the general public early as part of the 150th Anniversary of the Morrill Act. However, if you would like to read the rest of papers in this issue or others not yet available on open access, consider joining the Division of the History of Chemistry of the American Chemical Society.

CHEMISTRY OF COOKING, CHEMISTRY IN WAR: WOMEN IN NINETEENTH AND TWENTIETH-CENTURY LAND-GRANT SCIENCE AND ENGINEERING (1)

Amy Bix, History Department, Iowa State University, abix@iastate.edu

American higher education has a gendered history, true across the board, but often especially evident in the question of who was allowed to study science and engineering, why, and on what terms. Nineteenth-century women's colleges graduated scores of chemistry, biology and other science majors, but female employment and professional advancement in science-related work remained limited. Before World War II, schools such as Princeton, Caltech and Georgia Tech remained primarily all-male. Many in American society considered it inappropriate or odd for women to pursue science seriously. But at land-grant colleges, female faculty developed pioneering "domestic science" programs, where ideals of intelligent femininity justified teaching women chemistry, as well as physics, nutrition and household-technology. As home economics programs incorporated science into women's territory, they set a precedent that gradually opened other doors at land-grant schools for women to become chemistry students, teachers and researchers. It was also no coincidence that in the late 1800s and early 1900s, land-grant colleges such as Purdue, Iowa State, Cornell, Minnesota and California were among the first in the country to grant engineering degrees to a handful of women. For many years and for many reasons, women were discouraged from pursuing science and engineering in the same ways that men did, a debate that still resonates today.

The position of women in American chemistry, other sciences and engineering advanced slowly during the early twentieth century, but World War II abruptly transformed the situation. The federal government, industry and universities encouraged, even begged, women to enter non-traditional work. The U.S. Office of Education spent millions of dollars running special wartime programs around the country to train women (as well as men) in science and engineering. Land-grant colleges such as Penn State led the way in offering chemistry classes, designed to prepare women for jobs in explosives manufacturing, petroleum production and other essential defense industries. Although many female trainees did not continue full-time careers in science after peace came, the wartime experience ultimately contributed to a long-term transformation. Over the postwar decades, land-grant colleges and other American institutions created and supported new opportunities to help more women than ever pursue education in chemistry, other sciences and engineering. Gradually, change did come, and over the last 150 years, the nation's land-grant college system has played a key role in that evolution of women's place in the world of science and engineering.

Nineteenth Century Education for Women

Both before and after Europe's Scientific Revolution, a small number of women studied and worked in various fields of science, often thanks to supportive fathers, brothers or husbands. Educational reformers advocated offering young women at least some scientific training, especially in fields such as botany and star-gazing, which seemed linked to feminine talents and interests. Both in Europe and America, however, traditional

assumptions about what was and was not appropriate for girls prevailed, favoring an education centered around arts, accomplishments and some areas of basic general knowledge. While applauding the 1826 opening of New York's High School for Females, supporter John Irving said, "I would not wish to be understood as advocating [girls'] attention to any abstract branch of science. Such knowledge is not necessary for them" (2).

Decades before Harvard, Yale, Princeton and many other institutions even considered admitting females, the nineteenth-century establishment of America's women's colleges played a key role in opening up education. In 1837, Mount Holyoke justified women's college education as a vehicle for creating a corps of well-prepared schoolteachers, who would turn into well-prepared mothers, serving to rear new generations of patriotic male citizens. Leaders of women's colleges soon moved toward a broader vision and expanded their curricula to include serious scientific training. Vassar hired noted astronomer Maria Mitchell in the 1860s and required all students to take at least one semester of chemistry, plus botany, zoology, geology and physiology (3).

At Vassar, charismatic chemistry professor Charles Farrar influenced numerous students, including Ellen Swallow, who particularly appreciated Farrar's emphasis on chemistry's practical applications to ordinary life. Unable to secure a job in industrial chemistry after graduating Vassar in 1870, Swallow managed to become the first woman admitted to MIT, a land-grant school since 1863—though MIT accepted Swallow only as an experiment, without granting her status equal to male students. She finished both a second undergraduate degree at MIT and a master's degree from Vassar in chemistry, and married MIT engineering professor Robert Richards. In 1876, Ellen Swallow Richards helped open MIT's Women's Laboratory, which gave dozens of female students a place to study chemistry, in the years before MIT accepted them as true degree candidates. In 1884, MIT appointed Richards as an instructor in its new sanitary chemistry lab, first in the country, where she specialized in pioneering studies of water pollution and public health, helping shape sewage-treatment standards. Meanwhile, Richards extended her interest in showing women how to benefit by applying chemistry to everyday household life. In 1882, she published *The Chemistry of Cooking and Cleaning: A Manual for Housekeepers*, which emphasized the scientific principles behind good sanitation, effective cleaning and nutritious meals. Richards went on to help establish the discipline known as home economics, domestic science or household engineering. She became the first president of the American Home Economics Association, founded in 1908. (4).

Histories of women in American science, both as students and as faculty members, often center around the significance of elite women's colleges such as Vassar. There is very good reason for such a focus; as Margaret Rossiter and others have documented, those schools cultivated some of the most well-trained female scientists of the late 1800s and early 1900s. But it is important to also remember the broader story, that during some of the same decades that prestigious women's colleges were graduating alumnae in physics, biology, math, and chemistry, the American land-grant college system was created and expanded. Not all land-grant schools were automatically coeducational from the start, and certainly those institutions did not treat female and male students equally. Nonetheless, land-grant colleges provided invaluable access to science education for thousands of young women. With regard to the history of chemistry, the role of the land-grants is particularly important, since their leadership in the field of home economics became the basis for requiring and encouraging female students to take a significant number of science classes and conduct scientific research projects.

Starting from the era during and just after the Civil War, land-grant schools that were coeducational, had to decide how to shape college training for young women, in accordance with the mission of promoting economic and social advance by providing accessible, practical training centered around agriculture and mechanical arts. Trustees at Iowa State College, which admitted women from its start in 1869, declared

> If young men are to be educated to fit them for successful, intelligent, and practical farmers and mechanics, is it not as essential that young women should be educated in a manner that will qualify them to properly understand and discharge their duties as wives of farmers and mechanics? We must teach the girls through our Agricultural College to acquire by practice a thorough knowledge of the art of conducting a well-regulated household, practiced in our Farm House, Boarding Hall, garden, dairy, and kitchen.

First president Adonijah Welch commented,

> If to woman has been entrusted, by virtue of her nature, the care of infancy, training of childhood, and… guardianship of public morals, what wonders for the advancement of society might she not

> accomplish if she were properly taught for these duties?... Among her increased facilities for scientific instruction should stand prominent the study of domestic economy.

Iowa State adopted a "ladies' course of study," and its first official class in domestic economy appeared in 1871, under the title, "Chemistry as Applied to Domestic Economy" (5).

During the late 1800s and early 1900s, home economics became a convenient home for female land-grant students, a gender-appropriate and hence respectable academic base to prepare them for marriage and "scientific home-making," and/or employment as teachers, extension workers, "women's page" reporters or other gender-appropriate jobs (6). Land-grant programs served as a vehicle to propagate the field, as early female graduates secured posts to inaugurate home-economics teaching in other colleges and in secondary schools. The field gained academic credibility with formation of the American Home Economics Association in 1909, building on a decade of annual conferences held in Lake Placid, New York, where influential women and men defined the goals of their new discipline and outlined possible directions for teaching, research and social impact (7).

By 1912 at Iowa State, home economics had grown into its own college division, which expanded rapidly. Majors took a considerable range of science courses; beyond basic requirements in chemistry and physics, female students pursued physiological and nutritional chemistry, food analysis, plus classes on research statistics and writing scientific papers. The school boasted (8),

> Courses in domestic economy have been organized on a thoroughly scientific basis.... Instead of merely empirical work, learning how to make a good bread, a lesson which any good mother ought to be able to teach her own daughter, students in this subject should approach it in as thoroughly a scientific manner as students in any field of applied science ... and should be as well equipped ... as the technically trained agriculturalist or engineer.

Female faculty and graduate students published research connected to broader soc ial and academic themes. Studies of kitchen efficiency connected to scientific-management principles; nutrition research tied into emerging studies of vitamins, while sanitation work linked up with public health and the germ theory of medicine (9).

Domestic science professors at land-grant colleges modeled their philosophy and teaching after (and in cooperation with) science and engineering programs. At the same time, home economics was defined by and for women, explicitly addressing females' presumed sphere of interest, domestic life. In that fashion, these programs created an alternate vision of gendered knowledge, asserting a link between scientific mastery and femininity—at least in the kitchen.

While home economics departments encouraged women to assert interest in science and technology, it is easy to dismiss their existence as a gender-stereotyped trap, a strategy to glorify home-making and conservative gender roles in an era when many women were agitating for the vote, for better professional opportunities and other political, economic, social and political rights. At least in some instances, home economics did seem to serve as an excuse to pigeonhole women with scientific interests and channel them away from men's areas of traditional science and engineering. When ambitious chemistry student Isabel Bevier was considering her options for graduate study in 1889, advisers distinctly told her that "the place for women in chemistry was in work with foods" (10). But home economics provided reassuring gender messages, helping justify coeducation in an era when many experts and parents alike still questioned the wisdom of sending daughters off to college.

Home-economics courses undoubtedly thrived in part because women's knowledge of domestic science didn't threaten men's leadership of pure science and engineering training. Yet on balance, home-economics programs served to subvert the notion of women's scientific ignorance and technical incompetence. Through courses, textbooks, research, extension service and public remarks, faculty women constructed a powerful alternate image of women as scientifically knowledgeable, with an intelligent theoretical understanding applied to practical skills. In decades when female science graduates faced severe difficulties locating rewarding jobs in industry and government, home-economics majors trained in science enjoyed valuable opportunities, including employment with corporations such as General Foods and General Mills, major newspapers and magazines and other businesses.

In part because of the link to home economics, significant numbers of female students at land-grant schools took chemistry, often multiple classes. Photographs at the University of Wisconsin, Iowa State College, and other land-grant schools of the early twentieth-century showed men and women working side by side at laboratory benches. In 1907-08, the

University of Wisconsin made it compulsory for home-economics majors to take at least one chemistry class in each semester of their freshman, sophomore and junior years (11). Chemistry classes served as prerequisites for a wide range of other courses, including food selection and preparation, nutrition and dietetics, textiles, home sanitation, child development and household management. Wisconsin encouraged female students with a concentration in hospital administration to take physiological chemistry and pharmacology; those focusing on applied bacteriology took advanced classes in the chemistry of water analysis (12). As the curriculum in home economics expanded, so did the emphasis on chemistry, especially for those women who conducted original research to earn their master's degrees and doctorates.

The requirement for female home-economics majors to take chemistry and other classes created a precedent for women in the laboratory, which helped a small but number of women secure places as students, faculty and staff in land-grant chemistry departments. Iowa State, for instance, hired Nellie Naylor in 1908 as an Assistant in Chemistry, to set up lab preparations and experimental demonstrations. She remained at Iowa State for 45 years as the second woman on its chemistry faculty, promoted to associate professor after she completed her chemistry doctorate at Columbia. For more than twenty years, Naylor headed the program of chemistry instruction for all first-year women studying home economics (13).

In connection with her home-economics-related teaching, Naylor published a 1933 textbook and lab manual, *Introductory Chemistry With Household Applications,* adopted at numerous other land-grant and other colleges. The book started with fundamental chemistry of atomic structure, characteristics of gases, liquids and solids, properties of solutions and types of reactions, then applied such principles to topics such as the chemistry of yeast and other leavening agents; the chemical principles of antiseptics, disinfectants and preservatives; water hardness and softening agents; properties of different textile fibers and cleaning methods; and the metallurgy of different cookware. Naylor wrote, "A chemistry teacher, before a class of home economics students, needs to bridge the gap between familiar home-like problems which have held the attention of the girls in their own field and the scientific facts which she is intending to disclose to them." Naylor's textbook linked study of saturated and supersaturated solutions to the students' experience with candy-making in their foods-laboratory course, and explained colloid chemistry with references to mayonnaise and jellies. Naylor said she believed that women were as much interested in chemistry as men were, especially when seeing its connections to life in general. She wrote, "A girl can learn to analyze a baking powder as easily as to analyze an ore, and one can appeal to her interest in a baking powder" (14).

In addition to teaching chemistry to home-economics majors, Naylor also served as a counselor for those freshman women who opted to pursue degrees in pure chemistry and a mentor to Iowa State's female graduate students in chemistry. Meanwhile, Naylor published numerous articles in the *Journal of the American Chemical Society*, specializing in the amylase of wheat, rye and other cereal grains. Her research collaborators included a growing number of master's and doctoral students, both male and female, both in chemistry and in the food and nutrition department (15).

Just as land-grant colleges allowed women to gradually insinuate themselves into chemistry and other science departments, they also allowed a handful of female students to enter an even more traditionally masculine field, engineering. It was no accident that the state land-grant schools provided America's first female engineering graduates, at a time when Caltech, Georgia Tech, RPI and other technical schools remained all-male. Just six years after the University of California, Berkeley, opened, Elizabeth Bragg Cumming earned the first woman's civil engineering degree there, in 1876, writing a thesis on a technical issue in surveying (16). In the 1890s, Iowa State College granted civil engineering degrees to sisters Elmina and Alda Wilson. After Elmina earned her engineering master's degree from Iowa State, the school hired her to head its drafting room, then promoted her; as assistant professor of civil engineering, she helped plan a new campus water system (17). Bertha Lamme completed an 1893 mechanical engineering degree at Ohio State, then designed motors at Westinghouse (18).

During the early twentieth century, simply being a woman studying engineering was still unusual enough to get your picture on the front page of campus papers. Media coverage at Cornell, Iowa State and elsewhere treated each woman engineer individually, as if each case were unique—which it was. Under the cute headline, "Beauty Meets Resistance," the *Penn State Engineer* noted in 1934 that Olga Smith had become the first female enrolled in electrical engineering. But slowly, the number of female engineering students at land-grant schools such

as Illinois, Ohio State, Penn State and Purdue began to add up, one or two at a time.

At Cornell alone by 1938, more than twenty women had received engineering degrees. Nora Stanton Blatch earned a civil engineering honors degree in 1905, then worked for construction companies and the water-supply board in New York City. Cornell graduate Olive Dennis established a thirty-year career as an engineer and designer at the B&O railroad. Female engineering students such as Blatch and Dennis remained a curiosity. Remarking on the intriguing rarity, a 1920s campus paper ran the headline, "Three Coeds Invade Engineering Courses and Compete With Men at Cornell University: Stand Well in Their Studies." Alongside a photo of mechanical-engineering junior Jeannette Knowles working on a compression-testing machine, the article noted that the three represented "the greatest number of women students ever enrolled here at one time," attending classes alongside over eight hundred men (19).

Administrators didn't encourage women to enroll in engineering; just the opposite. Gladys Tapman had to cite Cornell's promise of instruction in any subject regardless of sex, before the dean accepted her into civil engineering. Cornell's handful of female engineering students, nicknamed "Sibley Sue" and "Slide Rule Sadie," became the target of jokes. Isolation made their experience hard. One said (20):

> A girl has to want … pretty badly to go through with the course in spite of the unconscious brutality of … [male] classmates …. She must be ready to be misunderstood, as … many … will conclude that she took engineering … to catch a husband. She must do alone lab reports and other work men do in groups—because men who are willing to face the scorn of their peers and … work with her are more interested in flirting than in computations. She must be prepared for a lonely academic career; she cannot approach her classmates to exchange notes without appearing bold ….

Hints of change came at Purdue in the 1930s, where progressive president Edward Elliott supported bold thinking about opportunities for women. Elliott hired respected engineer Lillian Gilbreth to teach industrial management and mentor female students. As another career consultant, Elliott also recruited famed aviator Amelia Earhart. Purdue had recently opened its first residence for women; with Earhart's high-profile appointment, female enrollment jumped fifty percent, and the new dorm overflowed. Both Gilbreth and Earhart encouraged female students to combine marriage with careers in engineering or science. Still, gender crossing in land-grant culture remained limited; as at other schools, few Purdue women chose to enroll in engineering, and among that handful, attrition proved high (21).

It is, of course, impossible to estimate how many land-grant female students before World War II felt interested in science and engineering, only to be sidetracked by self-doubts or steered into more traditionally feminine fields. Women who persisted understood the simple reality that they needed to tolerate the inevitable skepticism, pointed criticism or outright ridicule from some classmates, professors, employers, family and acquaintances.

World War II Encouragement for Women in Science and Engineering

World War II proved a crucial transition. Defense industries complained of crisis manpower shortages, and military leaders feared that the nation lacked enough expert scientists and engineers who could scale up defense production and design new and better weapons. Accordingly, the US Office of Education set up the national "Engineering, Science, and Management War Training" program. Under ESMWT, colleges in every state ran crash courses in math, physics, chemistry and engineering. Those classes aimed to train underutilized workers to fill gaps in essential defense industries and upgrade their skills. Between 1940 and 1945, the ESMWT program taught almost 1.8 *million* students, spread across every state. Enrollment in chemical engineering classes alone topped 52,000 students, and chemistry courses attracted almost 39,000 students. The curriculum included general chemistry, analytical, inorganic, organic, physical chemistry, biochemistry and applications of chemistry to special war problems. Classes in metallurgy and industrial chemistry were in high demand. Other ESMWT chemistry courses included work in pharmaceutical chemistry, photographic chemistry, colloidal and surface chemistry, plus laboratory techniques and glass-blowing (22).

ESMWT chemistry courses were oriented to meet specific and urgent research, development and production needs in the military and defense industries. For example, with production of smokeless powder scheduled to rise to one thousand tons per day, the Army and manufacturers desperately needed inspectors. Few colleges could handle training in explosives, since faculty were not familiar with the details. Accordingly, the Office of Education ran special preparation for organic chemistry professors from thirty-three institutions, who then organized local

courses on powder science. "We never get an opportunity to complete a class," one noted; arsenals and munitions companies "take [pupils] away from us before they finish." Toward war's end, changing priorities called for more courses on plastics, synthetic rubber and petroleum refining. Colleges focused on serving regional businesses; Oklahoma and Penn State set up courses in petroleum methodology to prepare technicians for the oil industry. One such class placed four unemployed women, two former secretaries and one ex-salesclerk in Pennzoil laboratories; two female soda-fountain operators retrained as core analysts.

With the military taking away able-bodied men, employers turned to "Rosie the Riveter" on the shop floor, and also sought to hire female scientific and engineering workers. Wartime pressures justified stretching gender boundaries, at least temporarily. Government, schools and industry urged women to serve their country by taking more science and engineering. Women ultimately accounted for about twenty-five percent of ESMWT students. A number of schools taught three-month courses in chemical quantitative analysis for women, placing many in industrial labs. Fifteen colleges offered "Engineering Fundamentals for Women," to help women qualify for junior engineer posts with the Navy, War Department or civil service.

Companies desperate for wartime help began recruiting women who had math and science skills, then gave those women customized crash courses to become engineering aides. In one of the most elaborate programs, in 1942, the Curtiss-Wright airplane company began training what they called "Curtiss-Wright Cadettes," giving over 600 women a ten-month immersion in engineering math and mechanics, theory of flight, airplane materials, drafting, job terminology and aircraft production. It was no coincidence that five out of the seven colleges handling Cadette training were land-grants—Cornell, Iowa State, Minnesota, Penn State and Purdue (the other two were RPI and University of Texas). All but RPI already had women enrolled. Granted, only a few prewar women students had earned degrees in engineering, but at least students and faculty were accustomed to seeing women around campus. At these schools, announcement of the Cadette program elicited some joking about the notion of female engineers. But Cadettes could claim to be doing their part for the war effort and on that patriotic ground, they were welcomed. By contrast, at all-male RPI, the arrival of "engineeresses" created a culture shock. Local newspapers carried giant headlines, "RPI Opens Doors to Women: Institute Breaks 116 Year Old Rule Due To War Need," "Curtiss Wright Women … Invade RPI Campus" (23). The Curtiss-Wright story represented a perfect wartime morale-booster; Cadettes proved temptingly photogenic, and *Life* published a special feature (24).

War provided rationalization for training women in science and engineering. While many Cadettes and other women who entered wartime classes did not continue full-time science or engineering careers once peacetime came, others did. More than that, temporary changes had important lasting effects. Before the war, the one or two women enrolled at any one time at schools such as Cornell or Penn State were an anomaly. By 1945, Purdue alone had eighty-eight women majoring in engineering, where a critical mass made life easier; aeronautics major Helen Hoskinson remarked, "Now that lady engineers are not a novelty on this campus, people no longer stare at the sight of a girl clutching a slide rule" (25). Among other land-grant schools, there were fifty female engineering students at Ohio State, forty-eight at the University of Minnesota, thirty-seven at Cornell, thirty-two at Illinois, twenty-seven at Wisconsin and twenty-six at Iowa State. Overall, in November 1945, colleges and universities reported a total of 48,977 men enrolled in engineering courses and 1801 women (at a time when Caltech, Georgia Tech and some other engineering schools still refused to admit women at all). Numbers validated the notion that women could handle technical subjects. It was no coincidence that wartime brought a number of "firsts" for female students in engineering, with more women initiated into student honor societies and joining engineering clubs (26).

Conclusion

Though peacetime American culture brought strong pressures for a return to traditional gender roles, even during the 1950s, women's place in the scientific and engineering world continued to evolve. Women choosing non-traditional fields often still faced serious problems of discrimination in college classrooms, in hiring and promotion, and in professional life. But increasingly, women mobilized, forming groups to provide mentoring, job networking and other forms of mutual support. The Society of Women Engineers (SWE) was incorporated in 1952; female engineering majors at Purdue formed a student section two years later, followed soon by women students at other land-grants such as Iowa State. College SWE chapters undertook a wide range of activities to provide mentoring, networking and other forms of

support; they paired first-year women with "big sisters," hosted talks by industry representatives, organized panel discussions, distributed women's resumes and more (27). Land-grant schools had long contributed to efforts to recognize and support women in science; Iota Sigma Pi, the national honor society for women in chemistry, had been founded in 1902 at Berkeley. The group Graduate Women in Science originated at Cornell in 1921, convened in connection with the American Association for the Advancement of Science. Especially during the 1960s and 1970s, faculty, students and administrators at land-grants and other colleges organized deliberate efforts to encourage more young women to consider studying science and engineering and to help them succeed.

In 2009, women earned just over fifty percent of United States bachelor's degrees in chemistry, up from 2000, when women claimed forty-seven percent of chemistry bachelor's degrees (28). In engineering, physics and other fields and sub-disciplines of science, women remain underrepresented, as undergraduate students, graduate students, postdocs and faculty, for multiple complex reasons. But today, it is virtually impossible to find a land-grant or other campus that does not have multiple programs supporting female students, faculty and researchers in chemistry and other fields of science and engineering. While issues of difficulty and discrimination unquestionably persist for women in science, American education today offers an overall climate of encouragement simply not available to women a few generations before. Especially at land-grant colleges, the history of American higher education tells a dramatic story of change for women seeking degrees in chemistry, in other sciences, and in engineering.

About the Author

Amy Bix is Associate Professor of History at Iowa State University and Ph.D. Program Coordinator in the History of Technology and Science Program. Her most recent book is *Girls Coming to Tech! A History of American Engineering Education for Women* (MIT Press).

References and Notes

1. Presented at the 244th National Meeting of the American Chemical Society, Philadelphia, PA, August 20, 2012, PRES 5.
2. J. Irving, "Address Delivered on the Opening of the New-York High-School for Females, Jan. 1826," *Am. J. Educ.*, **1826**, *1*, 270-278, p 277.
3. M. Rossiter, *Women Scientists in America: Struggles and Strategies to 1940*, Johns Hopkins University Press, Baltimore, 1982. H. L. Horowitz, *Alma Mater: Design and Experience in the Women's Colleges from their Nineteenth-Century Beginnings to the 1930s*, Knopf, New York, 1984.
4. Ref. 3 (Rossiter). M. Ogilvie and J. Harvey, Eds., *The Biographical Dictionary of Women in Science, L-Z*, Routledge, New York, 2000, 1095-1098. E. Durant, "A Lab of Their Own," *Technol. Review*, May/June 2006, http://www.technologyreview.com/article/405825/a-lab-of-their-own/ (accessed Feb. 25, 2014).
5. E. S. Eppright and E. S. Ferguson, *A Century of Home Economics at Iowa State University*, Iowa State University Press, Ames, 1971.
6. A. G. Radke-Moss, *Bright Epoch: Women and Coeducation in the American West*, University of Nebraska Press, Lincoln, 2008, pp 166-167.
7. S. Stage, "Introduction: Home Economics: What's in a Name?" and "Ellen Richards and the Social Significance of the Home Economics Movement" in S. Stage and V. B. Vincenti, Eds., *Rethinking Home Economics: Women and the History of a Profession*, Cornell University Press, Ithaca, 1997. See also M. J. Elias, *Stir It Up: Home Economics in American Culture*, University of Pennsylvania Press, Philadelphia, 2008.
8. *Twenty-Third Annual Report of the Iowa State College of Agriculture and Mechanical Arts …*, Emory English, Des Moines, 1908, 24-25.
9. A. S. Bix, "Equipped For Life: Gendered Technical Training and Consumerism In Home-Economics, 1920-1980," *Technol. Cult.*, **2002**, *43*, 728-754.
10. G. Matthews, *"Just a Housewife:" The Rise and Fall of Domesticity in America*, Oxford University Press, New York, 1987.
11. "Department of Home Economics, 1907-1908," *Bulletin of the University of Wisconsin*, n. 172, General Series, n. 103, (Madison, 1907), p 6.
12. "Home Economics Courses, 1919-1920," *Bulletin of the University of Wisconsin*, n. 984, General Series, n. 768, (Madison, 1919).
13. "Nellie May Naylor," http://www.add.lib.iastate.edu/spcl/exhibits/150/template/naylor.html (accessed Oct. 7, 2013).
14. N. M. Naylor and A. M. LeVesconte, *Introductory Chemistry With Household Applications*, The Century Co., New York, London, 1933.
15. Nellie May Naylor papers, RS 13/6/51, Special Collections Department, Parks Library, Iowa State University.
16. *Women in Transportation: Changing America's History*, (U.S. Department of Transportation, 1998), p 11.
17. R. Weingardt, "Elmina and Alda Wilson," *Leadership and Management in Engineering,* **2010**, *10*, 192-196. E. Wilson, *Modern Conveniences for the Farm Home*, USDA Farmers' Bulletin no 270, U.S. Government Printing Office, Washington, DC, 1906. "Elmina Wilson, Alda Wilson," *The Arrow* (Pi Beta Phi), **1904**, 21, 93. Iowa

State University websites (accessed Oct. 8, 2012): "Alda and Elmina Wilson Papers, 1902-2010," http://www.add.lib.iastate.edu/spcl/arch/rgrp/21-7-24.html; "Marston Water Tower Named American Water Landmark," http://www-archive.ccee.iastate.edu/who-we-are/department-history/marston-water-tower.html.

18. M. Ingels, "Petticoats and Slide Rules," (1952) in Margaret Layne, Ed., *Women in Engineering: Pioneers and Trailblazers*, ASCE Publications, Reston, VA, 2009, pp 85-97. J. Meade, "Ahead of Their Time," (1993) in Margaret Layne, Ed., *Women in Engineering: Pioneers and Trailblazers*, ASCE Publications, Reston, VA, 2009, pp 137-140. M. M. Trescott, "Women in the Intellectual Development of Engineering," in G. Kass-Simon and P. Farnes, Eds., *Women of Science: Righting the Record*: Indiana University Press, Bloomington, 1990. M. M. Trescott, *New Images, New Paths: A History of Women in Engineering in the United States, 1850-1980*, T&L Enterprises, Dallas, TX, 1996.
19. M. Ogilvie and J. Harvey, Eds., "Barney, Nora Stanton (Blatch) De Forest," *The Biographical Dictionary of Women in Science*, Routledge, New York, 2000, pp 82-83. "Woman a Civil Engineer: First of Her Sex to Enter the Heretofore Masculine Profession," *Spokane [WA] Spokesman Review*, Aug. 26, 1923. Alumni folder, "Dennis, Olive Wetzel," Cornell University archives. A. Goff, "Women Can Be Engineers," (1946) in Margaret Layne, Ed., *Women in Engineering: Pioneers and Trailblazers*, ASCE Publications, Reston, VA, 2009, pp 155-177. "Three Coeds Invade Engineering Courses and Compete With Men at Cornell University: Stand Well in Their Studies," *Cornell Daily Sun*, 1923, Cornell University archives, #16/3/860.
20. Raymond Howes, "Concerning Sibley Sues," *Cornell Alumni News*, Oct. 13, 1938, p 30.
21. J. Lancaster, *Making Time: Lillian Moller Gilbreth—A Life Beyond "Cheaper by the Dozen,"* Northeastern University Press, Boston, 2006. R. Topping, *A Century and Beyond: The History of Purdue University*, Purdue University Press, Lafayette, IN, 1988. S. Butler, *East to the Dawn: The Life of Amelia Earhart*, DaCapo Press, Cambridge, MA, 2009). R. Boomhower, "The Aviatrix and the University: Amelia Earhart at Purdue University," *Traces of Indiana and Midwestern History*, **1994**, *6(3)*, 36-41. J. Norberg, *Wings of Their Dreams: Purdue in Flight*, Purdue University Press, Lafayette, IN, 2003. E. Zeigler, "Ross Camp," *Purdue Engineer*, Oct. 1940, pp 10, 14. K. Lux, "Following the Civils," *Purdue Engineer*, Nov. 1941, p 42.
22. A. S. Bix, "Engineering National Defense: Technical Education at Land-Grant Institutions during World War II," in A. Marcus, Ed., *Engineering in a Land-Grant Context: The Past, Present, and Future of an Idea*, Purdue Univ. Press, West Lafayette, IN, 2005, pp 105-133.
23. "Curtiss Wright Women Enter Rensselaer to Begin Ten Month Aeronautics Course," *Rensselaer Polytechnic*, Feb. 16, 1943, p 1.
24. "Engineering Cadettes: Girls Train for Aircraft Industry," *Life*, May 10, 1943, pp 45-48.
25. P. Stefen, "Coed Engineer Comes Through Over Comments of ME Faculty," *Purdue Exponent*, July 22, 1943, p 1. "University's 30 Girl Engineers Have Gripe; Male Engineers Scorn Their Big Ambitions," *Purdue Exponent*, Aug. 9, 1944.
26. "Enrollment of Undergraduate Civilian Engineering Students, as of November 5, 1945," *J. Eng. Educ.*, **1946**, *36*, 388-394.
27. A. S. Bix, "From 'Engineeresses' to 'Girl Engineers' to 'Good Engineers:' A History of Women's U.S. Engineering Education," *NWSA Journal*, **2004**, *16*(1), 27-49.
28. National Science Foundation, *Science and Engineering Indicators 2012* (Arlington, VA: 2012): table 2-18; http://www.nsf.gov/statistics/seind12/start.htm (accessed Dec. 10, 2012).