“Diversity and Engineering, Past, Present, and Future: Perspectives on Change, Progress, and Challenge”

Amy Bix, Iowa State University
• 19thC little formal education 1800s – trained in field, machine shop, military.
• women in engineering stood out due to rarity (even more than in science).

USMA cadets 1941
• Technical traditions tied engineering to masculinity – romanticized heroes – “real-life engineers and their hair-raising adventures.”

• “boys’ toys” steer to engineering; link hands-on tinkering to masculinity;
• Classroom, profession constructed on assumption engineering for men. Up to or beyond WWII, single-sex education (RPI, Georgia Tech, Caltech - ridicule idea of women engineers).

• 1892 Elmina Wilson
  C.E. Iowa State;
  1894 master’s;
  1902 asst prof.

• 1893 Bertha Lamme
  M.E. Ohio State – Westinghouse
- Cornell 20 women engineering degrees by 1938 (others – Kate Gleason – family tool company Rochester – first woman elected full membership ASME 1914)
- As women, not typical engineers; as engineers, not typical women.
- Outsiders invading a man’s world.

Three Co-eds Invade Engineering Courses And Compete With Men at Cornell University

STAND WELL IN THEIR STUDIES

All Plan to Enter Business on Graduation

ITHACA—If it weren’t for Jeanette Knowles, Jane Morse and Barbara Mart, there would be an even 850 students enrolled in the famous college of engineering at Cornell University. These three young women, the greatest number of women students ever enrolled in engineering here as one-time, seek to find a place for themselves in the fields of structural and mechanical engineering. All three are considered good students, fully capable of mastering the heavy studies which are the lot of the engineering student.

Jeanette Knowles, a junior in mechanical engineering, operates a compression testing machine in the “Mech Lab.”
DURING the awful years of the war it became necessary for the patriotic woman of this country to don her manful's trousers and boots and stride forth to fill his place in industry as best she could. And she liked it. She enjoyed the newfound freedom of being able to kick up her heels, stick a cigarette in her mouth and walk into a barber-shop, saying, "A hair-cut, please, and make it snappy." For it was a chance to defy convention and laugh at grandmothers. And when the war was over, she refused to be displaced. Her freedom was not to be relinquished. And she had her way (witness any barber-shop) and continued to hold down her position as mechanic, street-car conductor, bookkeeper, bank president, senator, and whatnot. But certain fields were not open to her without years of preparation. She could not, at once, become an engineer. And investigating the possibilities, she found that first that awful snag, the Calculus, must be overcome. She found that Descriptive Geometry must be mastered; that Analytical Geometry, Mechanics, Strength of Materials, and Hydraulics stood between her and such absorbing subjects as Bridge Design, Heat Engines and Statically Indeterminate Structures. And she hesitated. But not for long.

For in the 1921 a new sound echoed and re-echoed up and down the long halls of Main Engineering. Hurrying students paused to listen to the click-clack of women's heels upon the tiles of man's last retreat at the University. The less bashful, thinking to perform an act of chivalry, hastened to guide the two co-eds to the building they were seeking, for this was Main Engineering. And the would-be Sir Walters were non-plussed—sunk. For in reply to their inquiries the delicious bits of femininity replied, "Main Engineering? Of course! That's where our classes are. We're to be engineers."

Courageous? Of course, all pioneers are courageous. Determined? Yes! For in spite of all the predictions of the sceptics—predictions that allowed the girls from one county in a year at the outside to change their minds and leave the Engineering School to men alone, the Misses Esther Knudsen and Ursulla Quinn have at last reached the zenith of their school life and are soon to be graduated, whereas most of the sceptics have dropped by the wayside. Even the prospect of six weeks in summer camp with the so-called "hard-boiled engineers" failed to deter them.

Prepared? Again, Yes! A comparison of their marks of even the Tau Beta of the college will show just how well prepared the girls are. Not only have they shown their ability in the more theoretical phases of engineering, but in the more practical laboratory courses, in surveying, and in designing, they have displayed a most unusual aptitude.

It will be mighty interesting to follow their careers after graduation. And it is safe to predict that through their efforts, and their success, succeeding classes of engineers will have larger and larger quotas of girl students in the ranks. And Man's sacred domains will be sacred no longer.

By Pat Stenberg

If a girl has what it takes, she can succeed even in a man's world. The proof for this is found when one hears about Jeanne Chandler, a 1941 electrical engineering graduate of this University, being the only woman engineer on the staff of the Public Service Electric and Gas Company in Newark.

When asked why she chose to pursue a masculine career, Miss Chandler replied that she could not draw the side of a house that looked like the side of a house in freestanding style; so she took a high school course in mechanical engineering. From then on it just seemed natural to her to study engineering at college.

Answers to "Chandler"

"Chandler," the only name to which she answers, says that she has encountered no jealousy or animosity on the part of the men who work with her. In fact, she finds that they are swell and that they could not be nicer.

Some day she wants to be able to take engineering apart and put them together again. As for now, "Chandler" contents herself with her desk work. The present problem on which she is working involves a study of heat reactions and turbines.

Still Feminine

Even though Miss Chandler is embarking on a man's profession, she is very interested in feminine activities. She helps her mother with house-cleaning, and she likes to knit her own sweaters. Some day she intends to get married and manage her own home.

If war comes to this country, "Chandler" is going to apply and ask the government to take her on as an oiler. When and if that day which she answers, says that she has encountered no jealousy or animosity on the part of the men who work with her. In fact, she finds that they are swell and that they could not be nicer.

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Books, Plays, Engineers, Bells

Female Engineers Invade
Chem Labs and Airplanes

Dr. James F. McCormick, whose first book, a biography of the Browning, was recently published, is making plans to continue his writing.

Campus Coeds Go Mannish In Trousers

Individuals after the fashion of Elizabeth Hawes became rags-to-riches realistic last week when Sandra Jean Goldblatt started training to climb in the newest addition to their school's playground: Students pushed and rubbed-rimmed slacks, saw fringes and tassles.

Fire Drill Kicks The Gong Around

When the fire alarm was sounded in the main hall, fourth and fifth grades had a reason to be excited. Four bells rang out distinctly, and many students rushed to the exits. The gymnasium was filled with a sense of excitement and excitement.

Girls Invade AIEE
Meeting, Hear Hale Speak On Airfields

American Institute of Electrical Engineers he meeting that contained a discussion different from previous meetings. Fifty percent of those attending were women — RCA Cadettes and Curtiss-Wright girls were there in a body. In fact only 22 of the 148 students attending were civilians, the others were men of the armed services and women in specialized training.

Art Peluso was in charge of the meeting and introduced the four speakers: Ensign Hale of the U.S. Naval Aviation Corps; Dr. Ewing, head of Electrical Engineering; Miss F. Talman, responsible for the RCA girls; and Mr. Pigeon, who is in charge of the Curtiss-Wright Cadettes.

Ensign Hale was the main speaker of the evening with his talk on the work being done in the Alaskan and Alaskan Airfields. He described the airfields being built in Alaska and told of their importance in the war effort. In regard to the weather up and around Alaska, he said it was a bit better than that he had found here in Indiana.
• WWII manpower shortage - “Rosie the Riveter” - window of opportunity to re-examine assumptions gender & technical expertise;

Women Attending Colleges

AN OPPORTUNITY TO PARTICIPATE IN THE WAR EFFORT BY ENROLLING AS A CURTISS ENGINEERING CADETTE

Women selected as cadettes will be placed in one of seven of America’s finest Engineering Colleges as student employees of the Curtiss-Wright Corporation.

Ten-month course of study in Airplane Engineering will begin on January 29. Tuition, room and board and nominal salary will be paid by Curtiss-Wright.

Upon successful completion of this course they will be given positions in our Engineering Department.

If you are now a Sophomore, Junior or Senior; if you have a desire to study Airplane Engineering, if you will be 18 years of age or over on February 1, 1943, you may be eligible.

Write immediately giving age, school you are now attending, courses of study, Request a personal interview.

ENGINEERING PERSONNEL
CURTISS-WRIGHT CORPORATION AIRPLANE DIVISION
AIRPORT PLANT, BUFFALO, N. Y.

(IF you are now committed in any manner for employment with any company engaged in war work, please do not apply.)
TABLE B

Distribution of Cadettes by Colleges

<table>
<thead>
<tr>
<th>College</th>
<th>Desired</th>
<th>Number Guaranteed</th>
<th>Enrolled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cornell</td>
<td>125</td>
<td>110</td>
<td>115</td>
</tr>
<tr>
<td>Penn State</td>
<td>125</td>
<td>110</td>
<td>107</td>
</tr>
<tr>
<td>Purdue</td>
<td>100</td>
<td>90</td>
<td>98</td>
</tr>
<tr>
<td>Minnesota</td>
<td>100</td>
<td>90</td>
<td>103</td>
</tr>
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<td>Iowa State</td>
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<td>Texas</td>
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<td>90</td>
<td>95</td>
</tr>
<tr>
<td>Rensselaer</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>750</td>
<td>650</td>
<td>719</td>
</tr>
</tbody>
</table>

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**IOWA STATE DAILY STUDENT**

**TRAIN WOMEN HERE**

Lochner stresses recent drop in German morale. American strength must keep Hitler on defense.

College will train coeds for work in plane engineering. Candidates receive training in engineering schools. Must have two years of college mathematics for eligibility.

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By Janet Emmett

Starting the first week in February, Iowa State will participate in a program designed to train about two thousand engineering students under the direction of the Curtiss-Wright Corporation, one of the largest aeronautical concerns in the country.

This was announced last night by Dean M. D. Hicken, of the Home College.

The plan for the training and employment devotion to aid and aid engineering in warfare is the first of its kind to be introduced.
• 10-month immersion aeronautical eng.

Curtiss-Wright Engineering Cadette Program

General Outline of Program

First Term—22 weeks
Feb. 15—July 15, 1943

Second Term—22 weeks
July 19—Dec. 14, 1943

Subject

Hrs./Wk.

1a. Engineering Mathematics
2

1b. Engineering Mathematics
3

2. Job Terminology & Specifications
2

6. Theory of Flight
3

3. Elements of Aircraft Drawing and Standards
9

7. Aircraft Detail Design
12

4. Elementary Engineering Mechanics
6

8. Mechanics of Aircraft Structures
6

Laboratory
3

5. Properties and Processing of Aircraft Materials
7

9. Aircraft Production Methods
3

Physical Training
2

Physical Training
2

Supervised Study
8

Supervised Study
8

Total Hours Per Week
40

Total Hours Per Week
40

Aircraft Materials and Testing - 6 hours per week for 22 weeks

1. Materials Testing - 48 hours
   a. Tension testing
   b. Compression testing
   c. Shear testing
   d. Bending
   e. Buckling
   f. Torsion
   g. Buckling of columns
   h. Thin web boxes

2. Airplane Parts and Assembly - 48 hours
   a. Spars
   b. Control surfaces and mechanisms
   c. Loading and vibration
   d. Torsion

3. Wind Tunnel - 16 hours
   a. Demonstration

4. Production Engineering in Aircraft Industry - 18 hours
   a. Production methods, equipment, and operations
   b. Production planning
   c. Shop layout
   d. Shop location
Minnesota Cadettes’ first class - prof suddenly burst out laughing - “he had never before faced 25 females wielding slide rules.”
• Patriotic justification
• Culture shock at previously all-male RPI

**THE TIMES RECORD**

**R. P. I. OPENS DOORS TO WOMEN**

**INSTITUTE BREAKS 116 YEAR OLD RULE DUE TO WAR NEED**

*Required as Scientists, Technician, Official Says; Applications Received Next Week.*

War today wiped away another tradition of more than a century's standing.

The oldest college of science and engineering in the country, Rensselaer Polytechnic Institute, which in its 116 years has never admitted women to its degree-granting courses, will open its doors to a limited number.

Livingston W. Houston, secretary-treasurer of R. P. I., said the action was due to the need to train women scientists and technicians to replace men called to war. Despite a large number of applications received during the last several months, decision as to how many might be accepted had necessarily been delayed, he said, until registration this week had revealed how many men students would be enrolled.

Applications from women, who now reaply, will be immediately considered for entrance to classes during next week.
Curtiss-Wright Women Enter Rensselaer To Begin Ten Month Aeronautics Course

Women Invade RPI Campus

Training Prepares Them For Engineering Aides

RPI's student body was increased by 100 last Saturday when the Curtiss-Wright "Cadettes", arrived to begin work at the Institute. The girls' classes started yesterday morning and will continue for 44 weeks, two terms of 22 weeks each. Some of the members of the RPI faculty have been relieved of other duties and will spend their time teaching the cadettes. All of the subjects the girls are taking are entirely new ones in Rensselaer's curriculum and will be taught only to the cadettes. They have been designed with the needs of the Curtiss-Wright Company in mind and were planned by company officials and by Dr. Hemke of the Department of Aeronautical Engineering after many conferences.

Courses

Included in the curricula are courses in Engineering Mechanics, Engineering Math, Materials of Engineering, Elements of Electricity, Machine Drawing and Standards, Stress Analysis, Vibrations, Elementary Aerodynamics, Shop Processes and Practice and Job Terminology and Orientation. After completing their work at the Institute, all of the girls will work as engineering aides in the propeller plants of the company. They will not replace regular engineers but will supplement them. In this way, Curtiss-Wright will try to alleviate the shortage of trained engineers. The idea is a new departure from traditional practice, and the Institute officials are proud that they are able to help by offering the facilities of the school.

The first all-woman class ever to occupy the study halls of Rensselaer Polytechnic Institute begin a year's intensive training. They number 100 students, all employees of Curtiss-Wright Corp.
• war-training women’s presence reflected positively on growing number pursuing full engineering degree.
They'll Help Play 'Taps' for Japs

No knitting or other sissy stuff for these five girls—they're doing their bit for national defense in a manly way. The only female students in the College of Engineering, they are pictured being schooled by Dean W. R. Woolrich.

From left to right, the girls are Orissa Stevens of Houston; Anna Tally, Kellens; Mickie Jo Carleton, Austin; Anna Perry Wood, Austin; and Margaret Ann Magee, Waco.
• Purdue – 1944, over 30 women in engineering; 1945, 75 women. “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.”

• GI Bill limits postwar women’s enrollment – reassertion conservative gender roles.

• 1949 entire U.S.: 763 women enrolled in engineering; 1957: 1,783 women (still less than 1% of total in engineering)
• Penn St. Dean Eric Walker: lack “basic capabilities”- “The most evident ambition of many women is to get married and raise a family… [so] few companies are willing to risk $10,000 on a beautiful blonde engineer, no matter how good she may be at math.”
• Georgia Tech ridicule idea women engineers
• 1952 legal test case
• 1952 divided board admits women to GA Tech under limited conditions;
• All-male Caltech 1960s: “Full-blooded American young men cannot be expected to live four years apart from girls.”
• “Millikan’s monastery”; “eunuchs of science”
• **Undergrad campaign:** “*would feel much more at ease and willing to work if he were not frustrated by the lack of a full, rich social life. The presence of women would be a great civilizing factor. Presently, the Caltech male loafs around in sloppy clothes, unshaved. This would change for the better if an occasional female walked by…. So let’s go coed.*”

• “*Some faculty voiced the opinion that too much savoring of social intercourse may be antithetical to success as a research scientist or engineer. [After all,] most of the Caltech faculty spend relatively little time with their wives.*”
GIRLS COMING TO TECH!

Board of Trustees Vote Coeds For 1970

The Board of Trustees has now approved girls, in principle, President Lee A. DuBridge announced Monday the approval of a proposal to admit women to the undergraduate school, for fall 1970 at the earliest.

At a Board of Trustees meeting last weekend, a proposal voted by the faculty last year was finally approved, effective pending a definitive plan for its administration and implementation, according to Dr. DuBridge. He estimated that not more than five per cent of the incoming freshman class would be female, a number about equal to the percentage of coeds in the M.I.T. undergraduate school.

Not More Than 5%

The women will be enrolled both as freshmen and as upper-class transfers, on the same academic qualifications that apply to male students. There are still fairly few women interested in pursuing a course of study in science and engineering. Dr. DuBridge stated, but many are extremely able and will easily compete with the men.

"The action of our trustees will open up opportunities to women of exceptional ability who can profit by a Caltech educational experience, and will encourage more women to seek careers in science and engineering. "We feel that in this action Caltech is responding to a national trend toward coeducation at the college level," the educator continued. "Over the past year 18 American colleges that formerly were all male and 25 that formerly were all female have become coeducational."

Increasing Rate

This trend is due to the fact that women are playing an increasingly important role in business, and industry. Dr. DuBridge pointed out, adding that broader educational opportunities should be made available to them so that they may better fit themselves for this role in what has become a coeducational society.

"The presence of women graduate students on campus since 1923," he noted, "has confirmed the expectation that women can add much to the intellectual life of Caltech. Forty-five of the 703 graduate students enrolled this year are women."

Action Unanimous

"The unanimous action of the trustees follows the recommendations of both the faculty and student body for Caltech to break from its tradition of being a monastic type of Institution and to become coeducational," Dr. DuBridge said. "A recent Princeton University study shows that more than 80 per cent of the high school men who rank in the upper two-fifths scholastically feel that coeducation increases the attractiveness of a college."

Coeds are sure to get a very warm welcome at Caltech. But will there be enough to go around? Don't fight boys!
• **MIT pre-1940s**: 65 women maximum any one time, out of 5000 students.

• “There’s such a shortage of engineers, one wonders if we are justified taking positions away from male students for females.”

• “Except for the rare individual woman, [MIT] is an unsuitable place.”

• **Medical director**: “[Any] girls competing against high-grade intellects [of MIT men would] suffer a severe blow to their pride.”

• “Before 1960, women entered MIT at their own risk. If they succeeded, fine; if they failed - well, no one had expected them to succeed.”
• 1963- McCormick Hall
• 1964 – women’s applications to MIT jumped 50%.

Residence for Women Students at the Massachusetts Institute of Technology
• “You have to walk a mile to find a ladies’ room.” “A conservative Wall Street attitude to women still runs through MIT… [treating women as] incompetent, unnatural intruders.”

• Christina Jansen ‘63 EE: “I was very conscious of having to represent women in each class. If I did anything wrong, said anything stupid, it would be ammunition for all the men who didn’t want us there in the first place.”

• “Discriminatory events were so common that it didn’t occur to us to object. Besides, other engineering schools weren’t accepting women at all, so even though MIT was only accepting 20 a year, I felt MIT was doing us an enormous favor to have us there at all.”
• 1963-73, women at MIT tripled; late 1970s 17% of undergrads, 12% of engineering majors. Female professors as advocates.

• MIT Association of Women Students: numbers ("critical mass")
• “rude jokes, derisive comments about women, being treated as a sex object only, assuming you are less intelligent because female, severe stereotypes into traditional female roles.”

• skewed gender ratio:
  “There is a large emotional burden attached with being a girl here. There is a feeling women have been brought to [Cal]Tech for the express purpose of pleasing the men.”
- Masculine culture of engineering: ads 1950s-1960s;
• 1970 civil rights/equal employment law
• 1950s women less than 1% US engineering students; 2010 18.1%.
• 1951 Georgia Tech zero undergraduate women; 2011 almost 33% women – 24% all engineering majors
• 2011 Georgia Tech graduated nation’s highest # female engineers;
• 1970 Caltech zero undergraduate women; 2011 women 39% undergrad enrollment

• Pre-1963 MIT under 2% female students; 2010 second only to Georgia Tech number female engineering bachelor’s degrees, second only to Olin in percent of engineering degrees awarded to women
• What made the battle so hard? Most dramatic transformation in modern STEM – widening notion of who can/should get involved – creation of today’s advocacy movement to draw K-12 girls, other under-represented groups into STEM.

• 1959
  Webster’s
  Elementary
  Dictionary
• Society of Women Engineers - outreach to K-12 students: “Some day I’ll be an engineer like Aunt Jennifer.”
• North Carolina SWE, 1983
• 1960s on – feminist movement – Title IX; “Free to Be You and Me”; AAUW
• International/national/state/local - Girl Scouts (2 million girls), YWCA TechGyrls;
• Advocacy – 1971 women’s caucus AAAS 1975 NSF Women in Science Program;
• Virtuous cycle: 1966- 2012 women’s STEM undergrad, master’s, doctoral degrees up almost every year. 2012, women just over 50% of all STEM bachelor’s degrees.
• More female faculty/staff/ administrators; more mothers/fathers part of change – support/promote K-12 diversity outreach.
• Re-shaped agenda national disciplinary societies, major STEM institutions. William Wulf, NAE president 1998: “We must celebrate the creativity of engineering to attract more, and more diverse, engineers.”
• NAE website 2001: “Become part of the movement transforming the way engineering is presented to girls.”
• “engineering toys for girls” – books, TV shows, etc.
• **Computer Engineer Barbie 2010** – “a national movement to inspire girls.” “Barbie will broaden what feels accessible – being smart, confident, & tech-savvy, without sacrificing femininity & fun.”

• “You can’t rework a caricature of womanhood with impossibly long legs, pert breasts & glossy hair into some equal-opportunity role model by giving her a laptop, clothes with circuit board motifs and bright PINK glasses.”
“Girls Who Code.” White House Science Fair - Pres. Obama: “We don’t want to just increase the number of students in STEM. We want to make sure everybody is involved. We get the most out of all our nation’s talent, reaching out to boys and girls of all races and backgrounds. Science is for all of us. And we want our classrooms, labs, workplaces & media to reflect that.”
• High-profile corporate support - K-12 diversity outreach comfortable “sell” – non-partisan, non-controversial

• “leaky pipeline” “stereotype threat” “imposter problem” “hostile workplace” “chilly climate” “Silicon Valley bro culture” “Gamergate”

• Issues equity; retaining, promoting female workers;
• 1960s-today, K-12 girls’ STEM advocacy command mainstream support for change, position STEM interests as appropriate, enjoyable, and rewarding for girls.
• Future – broaden culture of STEM diversity outreach, new mechanisms for support; reshaping ideas about nature of STEM itself;
Thank you for letting me talk about a subject I love!

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