



Cal's First Industrial Engineer?



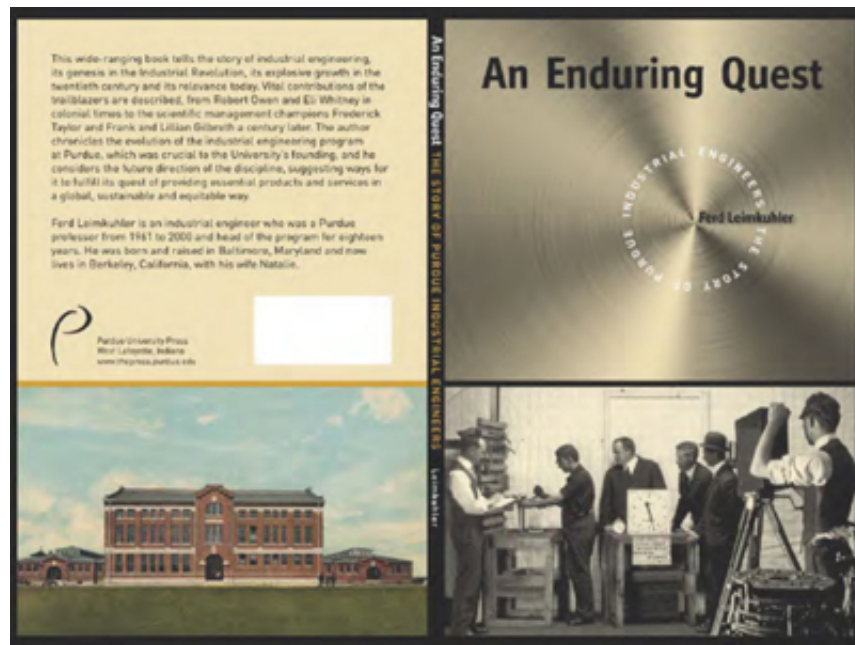
"The Ingenuity and Courage of Lillian Gilbreth." Gilbreth can be seen as one of Cal's first industrial engineers (before there was an IEOR department), and was the first woman to speak at Cal graduation in 1900. While Gilbreth is most often remembered as the mother from the book Cheaper By the Dozen, Leimkuhler argues that Gilbreth should also be remembered for her ingenuity as an engineer and efforts to help more women get into the workplace.

Below we publish Leimkuhler's talk in full, after which we ask a few follow-up questions for Leimkuhler from the Berkeley IEOR department.

The Ingenuity and Courage of Lillian Gilbreth

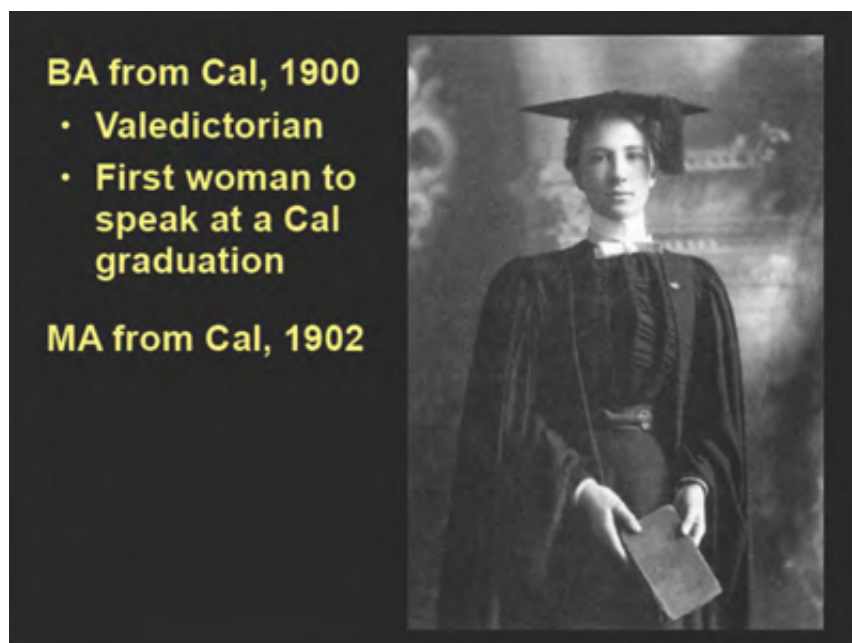
By Ferdinand Leimkuhler, Professor Emeritus, Purdue University

I met Lillian Gilbreth 55 years ago when I joined the Purdue faculty. She had retired in 1928 and returned often to lecture. When I retired from Purdue in 2000 and wrote a history of industrial engineering, (slide 2) I learned more about her. She grew up in Oakland on the estate of her grandfather, Frederick Delger, the richest man in Oakland. His estate was between Telegraph and San Pablo Avenues and between the two BART stations downtown near City Hall.



Slide 2

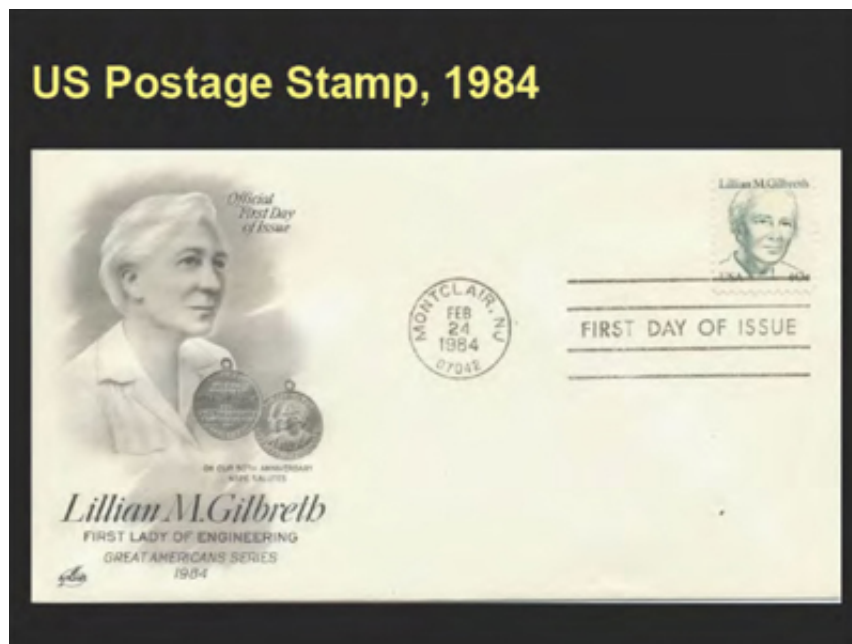
Lillian's parents objected to her going to Cal, but were persuaded by President Wheeler who knew the family socially. When she graduated in 1900, Wheeler made her the class valedictorian and the first woman to speak at a Cal graduation. (slide 3) The major professor for her master's thesis on Ben Jonson was Dean Charles Gayley, the great Shakespeare scholar from Oxford. Here we are, halfway between Gayley Road and Wheeler Hall, talking about Lillian.



Slide 3

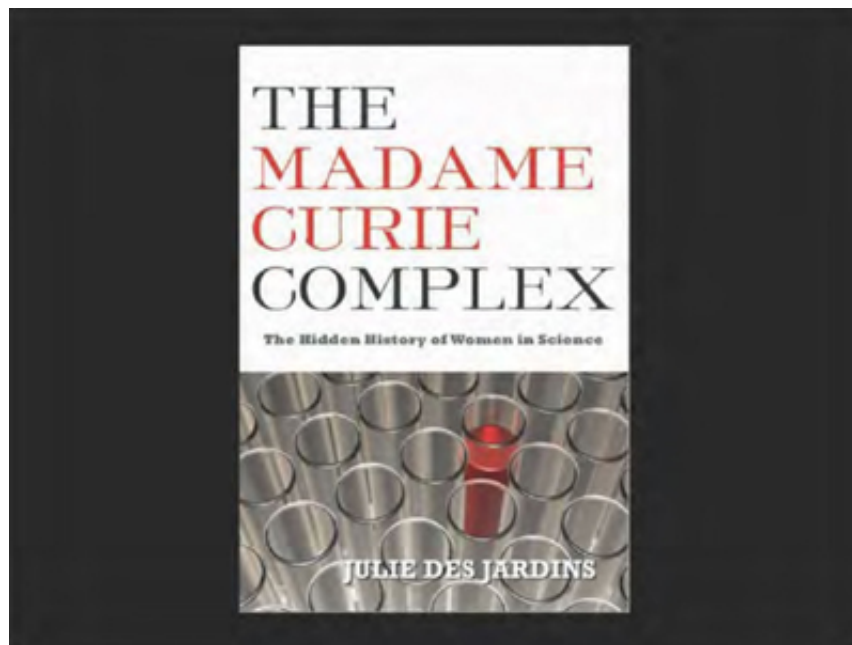
When I moved to Berkeley in 2000, Lillian seemed to be forgotten. She went to Oakland High School with Jack London and Gertrude Stein and, like them, she is on a US postage stamp, (slide 4) but there is no big memorial to her like Jack London

Square, not even a small memorial. In WWII she was America's leading expert on employing women in war work. Her office was in the Brooklyn Navy Yard. However, there is no mention of her at the Rosie-the-Riveter Museum in Richmond.



Slide 4

Professor Julie Des-Jardins, in her recent book on the hidden history of women in science, says Lillian is a prime example of The Madame Curie Complex. (slide 5) Curie had to win two Nobel Prizes to get the recognition she deserved. Being the wife of a creative person and a mother seems to be part of the problem. Lillian's obituary in The New York Times (slide 6) was entitled "Engineer and Mother of Dozen" because she was better known, not as an engineer, but as the mother figure in the movie Cheaper by the Dozen (slide 7) and in its sequel. They are still shown on TV. The books were translated into 53 languages and used to teach English to children around the world.



Slide 5

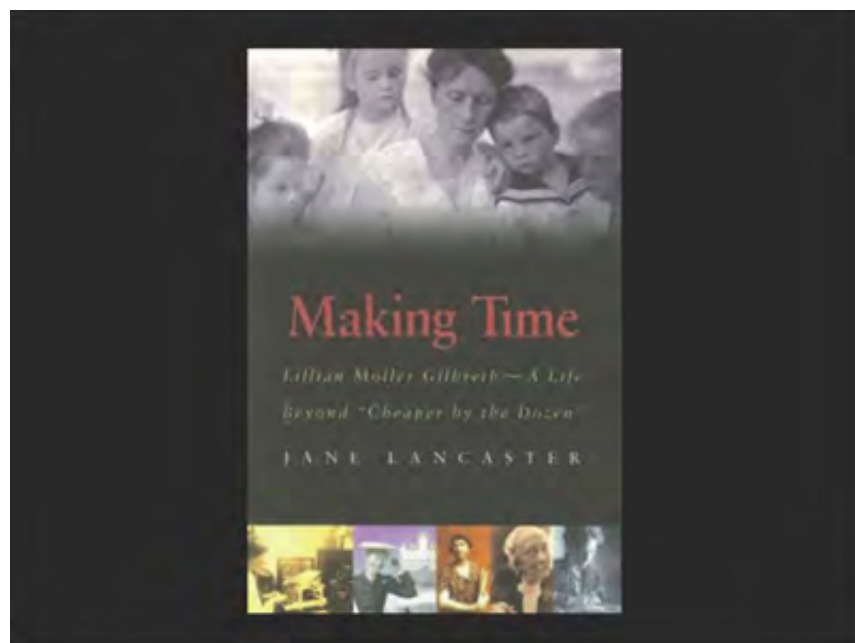


Slide 6



Slide 7

The story is based on the childhood memories of a beloved father who died suddenly when the oldest child was still a teen. Herbert Hoover, who knew the family, said the widow, Lillian, was the bravest woman in America and he hoped the book would make her immortal, but it seemed to have had the opposite effect. Historian Jane Lancaster (slide 8) said *Cheaper by the Dozen* allowed America to forget that Lillian led “one of the most important social changes of the 20th century, namely the movement of married women into the labor force. ... Lillian as engineer and career woman was submerged in the image of Lillian as mother.”



Slide 8

The confusion annoyed Lillian who loved her family and loved her work. She saw no

reason why she shouldn't do both. It was her matter-of-fact, Rosie-the-riveter approach. (slide 9) When asked how to employ women in war work, she said just build separate restrooms, stop trying to make women masculine, and change the jobs and the workplaces to appeal to women.



Slide 9

The Crisis in Engineering

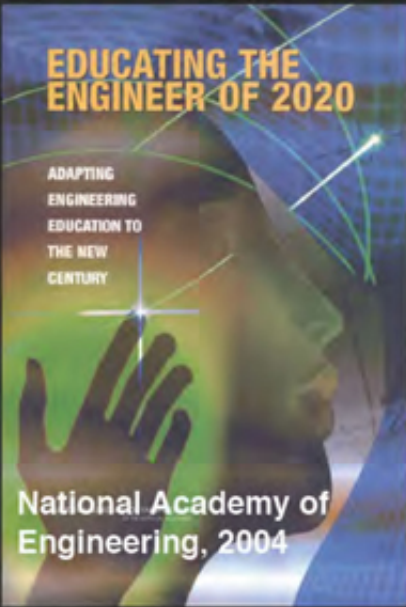
Lillian's career is relevant to the serious national problem that Professor Susan Silbey described recently in the Harvard Business Review. (slide 10) She explained that engineering is a male-dominated profession because its culture tolerates sexism and disregards the human impact of technology. As a result, only about 13% of engineers are women, far less than the 50% it should have as in law and medicine. Also, because its male numbers have plateaued, the engineering profession desperately needs women.



Slide 10

In 2004 MIT President Charles Vest told the Academy of Engineering that the profession needed to redouble its efforts to attract women in order to meet future challenges. (slide 11) The Academy studied different scenarios of science in the 21st century to identify the kind of engineers that will be needed and drew a list of role models. The closing paragraph in the NAE report says: (slide 12)

What attributes will the engineer of 2020 have? He or she will aspire to have the ingenuity of Lillian Gilbreth, the problem-solving capabilities of Gordon Moore, the scientific insight of Albert Einstein, the creativity of Pablo Picasso, the determination of the Wright brothers, the leadership capabilities of Bill Gates, the conscience of Eleanor Roosevelt, the vision of Martin Luther King, and the curiosity and wonder of our grandchildren.



EDUCATING THE ENGINEER OF 2020

ADAPTING ENGINEERING EDUCATION TO THE NEW CENTURY

National Academy of Engineering, 2004

“We must double and redouble our efforts to make engineering schools and the engineering profession attractive and fully engaging to women.”

— MIT President Charles Vest

Slide 11



THE ENGINEER OF 2020

VISIONS OF ENGINEERING IN THE NEW CENTURY

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Slide 12

None earned engineering degrees. The list includes two women who were good friends, Lillian and Eleanor. In addition to computer wizards, Gordon Moore and Bill Gates, and the Wright Brothers, the list includes cultural giants like Albert Einstein, Pablo Picasso, and Martin Luther King. Lillian is included in this august group because of her ingenuity in creating the field of ergonomics and being the first woman elected to the Academy but she did much more than that.

An Amazing Career

Lillian’s amazing career took off when she crossed paths with two geniuses, Frank

Gilbreth and Frederick Taylor. In 1904 she married Frank Gilbreth, a selfeducated inventor of radical ways to build large buildings and an ardent student of human skills of all kinds. (slide 13) Lillian wrote a memoir on Frank's death, called *The Quest*, in which she summarized how they resolved the differences in their backgrounds in two succinct paragraphs. (slide 14)

The new Mrs. Gilbreth was astounded and rather humiliated to learn that there existed a whole body of literature and a field of work about which she knew not even the vocabulary. She was encouraged, however, to find that she was considered to be not only a possible, but a promising pupil, and might enter at once upon a strenuous and diligently directed course of instruction. The bridegroom was also adequately informed as to his limitations and persuaded to enter more thoroughly and seriously into the task of reducing all his methods to writing, which was to become, if that were possible, of literary as well as scientific value. *The One Best Marriage* was to be secured through *The One Best Way*.



Slide 13

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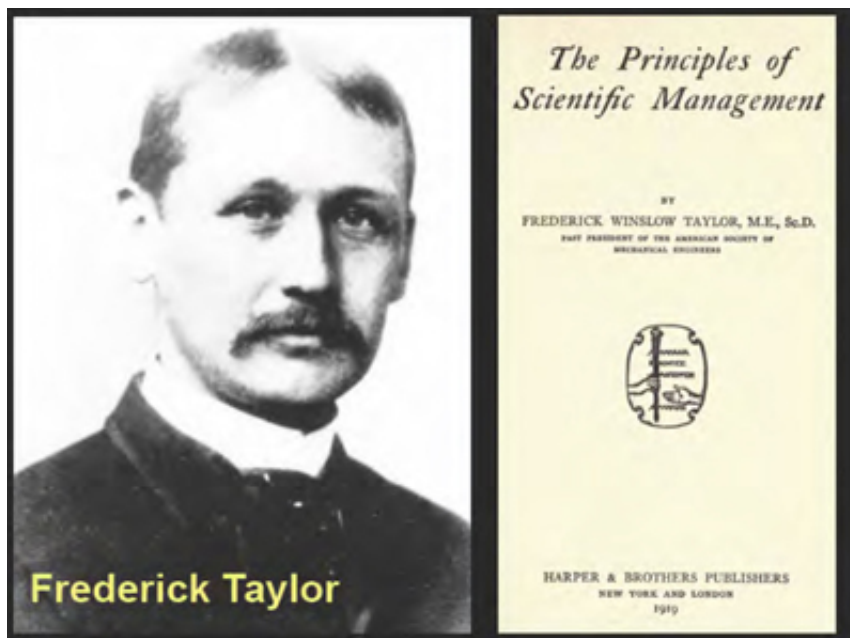
The bridegroom was also adequately informed as to his limitations and persuaded to enter more thoroughly and seriously into the task of reducing all his methods to writing, which was to become, if that were possible, of literary as well as scientific value. The One Best Marriage was to be secured through The One Best Way."

– Lillian Gilbreth, *The Quest of the One Best Way*

Slide 14

Lillian learned engineering by ghost-writing many books and articles on construction, factory and office work, and studies of surgery and dentistry, aging, disabilities and more. She got credit as an author only if she used her initials to hide her gender.

In 1907, the Gilbreths became associates of Frederick Taylor who was world famous for the way he reorganized Bethlehem Steel. (slide 15) He cut the cost of making steel in half by studying every job with a team of scientists and devising a tight management system to apply their recommendations. Harvard, Penn, NYU, Dartmouth, and other schools created new graduate programs based on his theory of scientific management. Taylor taught the capstone course in Harvard's program.



Slide 15

Steel was vital to WWI and world leaders urged their industries to use Taylor's ideas. (slide 16) President Theodore Roosevelt hired him to reorganize America's shipyards and armories. But in 1912, Taylor had a devastating setback when the union at Watertown Arsenal got Congress to ban the use of Taylor's methods in federal facilities.



Slide 16

Anticipating labor hostility, Lillian made the first scholarly study of what she called the Psychology of Management (slide 17) in which she concluded that scientific management should benefit workers and achieve industrial harmony if it is done cooperatively with labor and if ergonomics is used to develop methods and standards. She submitted her study as a PhD thesis in 1911 but Cal wanted a year of residence. She chose to publish it as a book that is still in print one hundred years later.

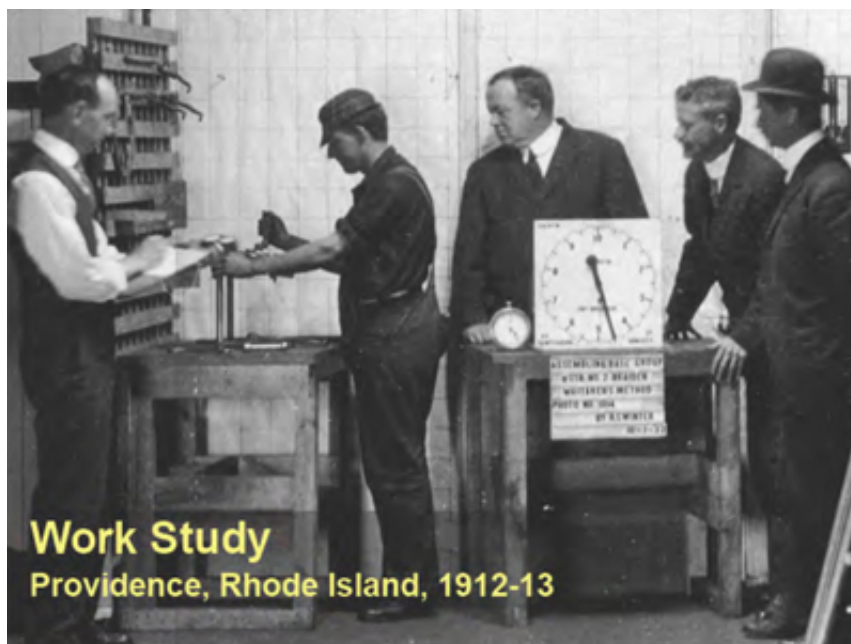
PhD Thesis, 1911

- Withdrawn and published as a book
- Still in print 100 years later



Slide 17

The Gilbreths tested their ideas by reorganizing a large company in Providence R.I. (slide 18) Their labor-friendly approach irritated Taylor, but won clients as far away as Europe. Lenin wrote in the margin of a Gilbreth article that it was “an excellent example of technical progress under capitalism toward socialism.” Also in Providence, Lillian earned a PhD at Brown University in 1915 with a study of the efficiency of the Providence school system.



Work Study
Providence, Rhode Island, 1912-13

Through all of this, the Gilbreth family grew steadily. They moved to Montclair N.J. in 1919, just before the birth of their 12th and last child. (slide 19) In Montclair, the Gilbreths taught a summer school for university professors and engineers. After Frank's sudden death in 1924, Lillian used the school to replace the clients who did not

want a woman consultant in their factories. She and her students made major innovations in retail sales at Macys and Sears, in office work for IBM, in health care products for Johnson and Johnson, and in the design of kitchens and appliances for General Electric. She became famous for her design of the efficient kitchen. (slide 20)



Slide 19



Slide 20

Politics and Industrial Engineering

In 1928, Lillian had a major role in the election and administration of her friend Herbert Hoover. (slide 21) Later, she blamed the Great Depression on corporate greed and on the engineering profession. In a speech, she said: "The worker, not the

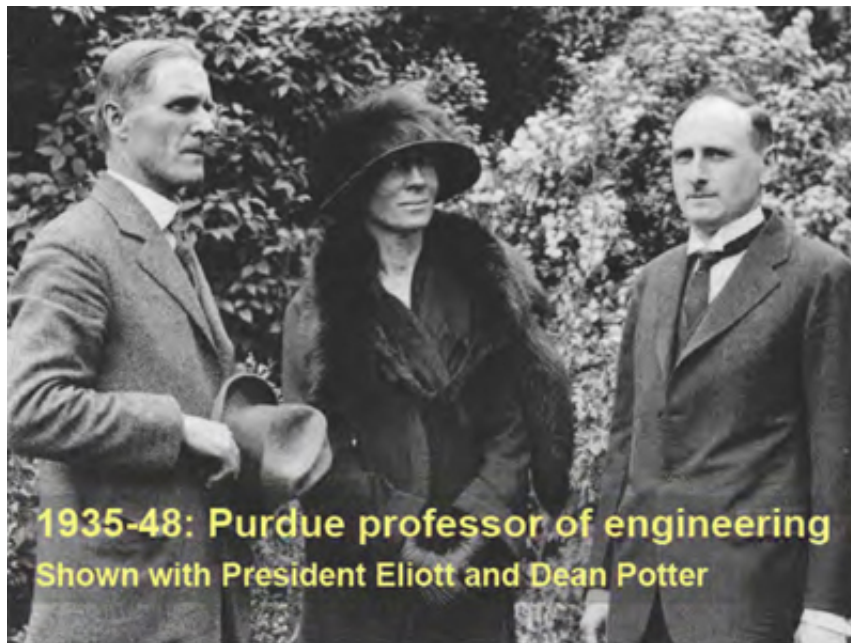
machine, has to be the main concern. A shift from materialism to humanitarianism is imperative.” Lillian eventually worked for five U.S. presidents: Hoover, Roosevelt, Eisenhower, Kennedy and Johnson.



Slide 21

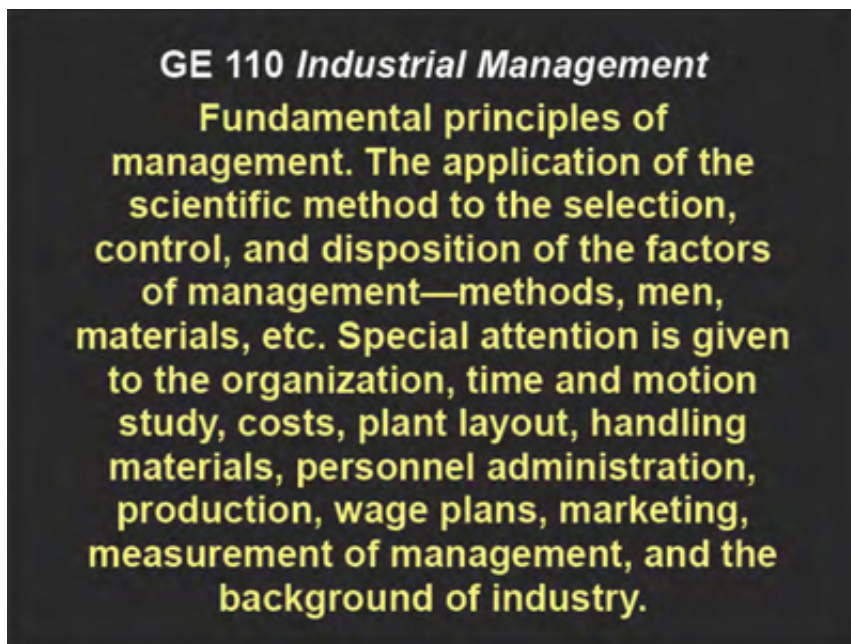
In 1935 she joined the Purdue faculty to develop a program in engineering management for her close friend Dean A. A. Potter. (slide 22) She and Frank had lectured there often. Her undergraduate course became the most popular course on campus. It was described in the catalog this way. (slide 23)

GE 110 *Industrial Management*. Fundamental principles of management. The application of the scientific method to the selection, control, and disposition of the factors of management – methods, men, material, etc. Special attention is given to the organization, time and motion study, cost, plant layout, handling materials, personnel administration, production, wage plans, marketing, measurement of management, and background of industry.



**1935-48: Purdue professor of engineering
Shown with President Elliott and Dean Potter**

Slide 22

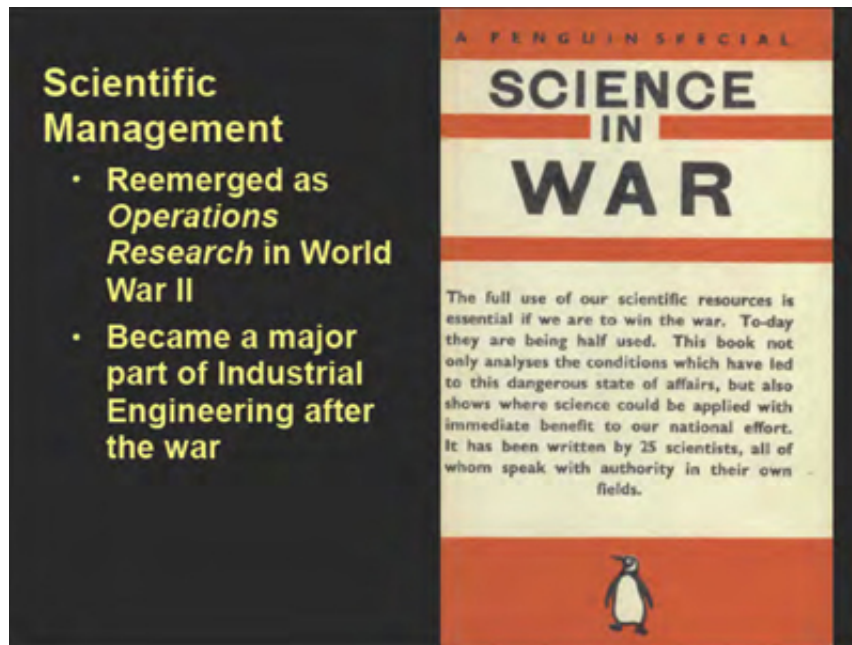


Slide 23

Lillian's first PhD student wrote her thesis on the design of industrial kitchens. Another, thesis on hospital engineering, was used to start the first degree program in it at Georgia Tech. When she retired in 1948, the Purdue program was very large and was divided into two separate schools of industrial management and industrial engineering.

Scientific management re-emerged in WWII. (slide 24) Under the code names operations research and management science, it mobilized scientists to work on large logistic problems like the Atlantic convoys and air defense. After the war, operations research, ergonomics, and the design of production and service systems were

combined in the new field of industrial engineering. The Gilbreth Medal is the highest award given by the Institute of Industrial and Systems Engineers.



Slide 24

The Toyota Production System

Lillian made a huge impact on society by influencing the way automobiles are made. It began in the 1920s when Japanese engineers came to America to study scientific management. Two were Takuo Godo and Tsuneo Ono. (slide 25) Godo founded the Japan Management Association (JMA) to promote scientific management. Lillian conferred with him when she visited Japan in 1929 to represent Hoover at an engineering congress. After WWII, JMA led the U.S. backed effort to revive Japanese industry.



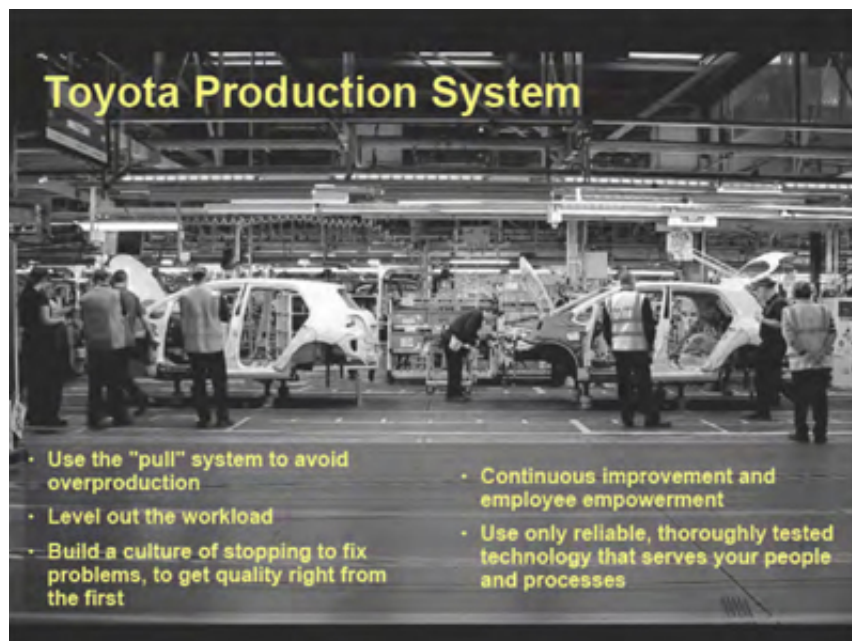
Takuo Godō
Founder, Japan
Management Assn.

**“If you have not
read what the
Gilbreths wrote,
you cannot call
yourself an
operations
manager.”**

—Tsuneo Ono,
V.P. Japan Mgmt. Assn., 1993

Slide 25

Tsuneo Ono was vice-president of JMA and in charge of developing its famous production engineering courses, that were based on notes from when he attended the Gilbreth school in 1929. He told a team of visiting American professors in 1993: “If you have not read what the Gilbreths wrote, you cannot call yourself an operations manager.” JMA’s greatest success was to inspire the Toyota System of Production. (slide 26)



- Use the “pull” system to avoid overproduction
- Level out the workload
- Build a culture of stopping to fix problems, to get quality right from the first
- Continuous improvement and employee empowerment
- Use only reliable, thoroughly tested technology that serves your people and processes

Slide 26

The Toyota system focuses on worker teams rather than advanced technology or individual performance. Teams meet after work to find new ways to collectively improve quality. New ideas are rewarded. Quality comes first. The line stops for

defects, unlike automated systems. Teams meet often with top managers. Their families meet socially. All of this is part of the Lillian Gilbreth approach.

The Toyota system was brought to America in 1984 by a company called NUMMI in Fremont CA (slide 27) where both Toyotas and Chevys were made on the same Toyota-style production line for 25 years. It was an experiment to see if Toyota could make cars in America. (slide 28) GM used NUMMI to develop its own Toyota-style global production system that it installed in all of its plants. It took GM 25 years to change its culture. Experts say, if done faster, GM might have avoided the greatest bankruptcy in corporate history.



Slide 27



Slide 28

The NUMMI plant in Fremont now makes Teslas. The plant has a remarkable history. GM opened it in 1962 and closed it in 1982 as “the worst auto plant in history” because of its poor quality, frequent strikes, heavy drug use, and high absenteeism. Yet, thousands of the workers fired by GM in 1982 were hired in 1984 by NUMMI and they became successful team members in the Toyota system. In 1968 Japan made Lillian a member of its Imperial Order of the Precious Crown, (slide 29) for her “outstanding contribution to the guidance and diffusion of scientific management and industrial development.” It is the highest honor Japan gives and is usually reserved for royalty.



Slide 29

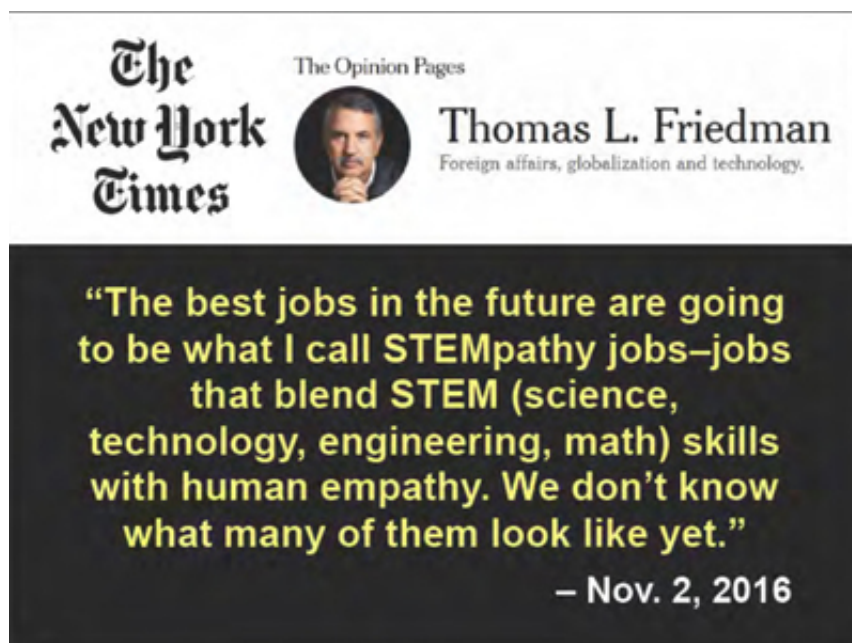
Her Legacy

She won a dozen awards from other foreign countries. In addition to her earned degrees from Cal and Brown, she won honorary degrees from both schools as well as 21 other American schools, including engineering degrees from Michigan and Princeton, and science degrees from Pratt and Wisconsin. In 1966 Lillian became the first woman awarded the Hoover Medal (slide 30) given by U.S. engineering societies to an engineer who demonstrates “great unselfish non-technical service to humanity.”



Slide 30

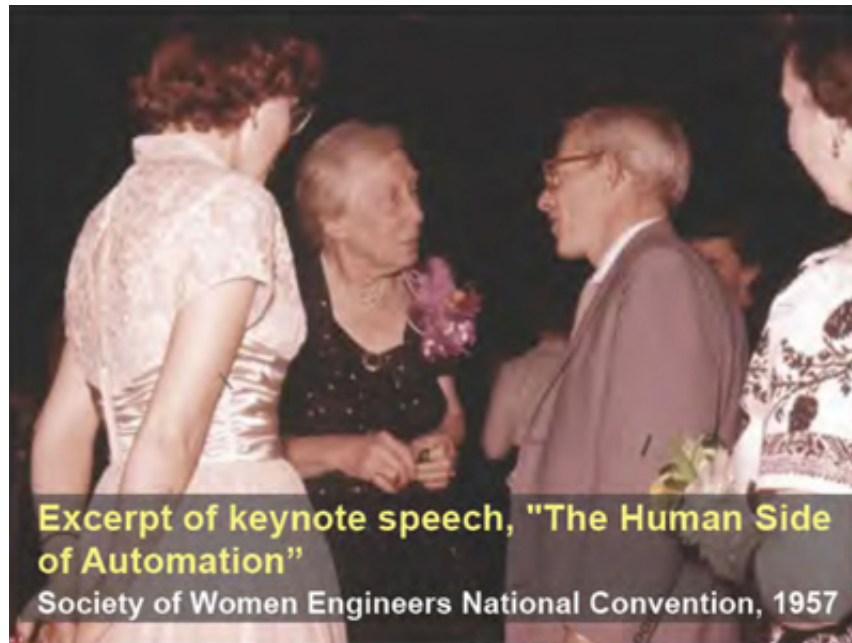
Last week, in an op-ed column in the New York Times on 11/2/16, Thomas Friedman coined the word STEMpathy to sum up in one word the cultural change needed by engineering. (slide 31) "STEMpathy," he says, "is a blend of the STEM skills of science, math, engineering, and management with human empathy." Friedman said the world is yet to see what STEMpathy jobs look like but, obviously, he doesn't seem to know about Lillian Gilbreth, whose life personified his STEMpathy concept.



Slide 31

Lillian said to change engineering don't try to change women but enlarge the profession to let men and women work together, fully and equally, for the benefit of society. A giant step in that direction would be the creation of an umbrella

organization, like the AMA and ABA, with the vision and policies of a house of delegates from all relevant entities.



Slide 32

Below you will find follow up questions for Professor Leimkuhler from Keith McAleer, Communications Specialist for the IEOR department.

Keith McAleer: *Would it be fair to say that Lillian was Cal's first Industrial Engineer?*

Professor Ferd Leimkuhler: That is an interesting question. Certainly, Lillian is ONE OF Cal's first industrial engineers. Lillian Gilbreth was the first Cal graduate to receive a PhD in ergonomics. It was called applied psychology at that time and is now called industrial engineering. She wrote two PhD theses on the topic. The first was on *The Psychology of Management*, for which UCB almost awarded her a PhD in 1912. She wrote a second thesis on *Some Aspects of Eliminating Waste in Teaching* for which Brown University awarded her a PhD in 1915. She lectured on motion and fatigue study at MIT in 1918. She was awarded an honorary master of engineering degree by Michigan in 1928 and a doctor of engineering degree by Princeton in 1953. She was inducted into the National Academy of Engineering in 1966 for her work in ergonomics. Cal awarded her an honorary doctorate in 1933 for her work as an "industrial/organizational psychologist." The Cal Alumni Assn. calls her an outstanding alumna and a psychologist rather than an engineer.

KM: *When you moved to Berkeley in 2000, you were alarmed that Lillian didn't seem to be receiving the recognition she deserved compared to her peers. Since then, have there been any local efforts made to recognize Lillian?*

FL: I got nowhere with Oakland or the Rosie-the-Riveter Museum. There should be support for a memorial. Tim Cook of Apple is an industrial engineer. George Lucas is looking for a place to build a museum of animation. Animation is close to what Lillian and Frank were doing with cameras 100 years ago. In the short run, I would love to see a plaque or such to remind UCB students of Lillian and her accomplishments.

KM: *The workers' union at Watertown Arsenal convinced Congress to ban some of Frederick Taylor's methods in federal facilities. This caused Gilbreth to embark on a study of scientific management which resulted in her seminal work, Psychology of Management, which detracted from Taylor's views as it considered human factors in industry, and not only profit. It has now been more than 100 years since Psychology of Management was first published — which advances in how modern companies treat workers do you think Gilbreth would be proud of, and which practices do you think she would be alarmed still exist?*

FL: Lillian finished writing her thesis about 6 months before the Watertown strike. Perhaps because she was the only woman in the Taylor gang, she was the first to foresee and study the labor problem. Today, I think Lillian would be upset by the continued sexism and lack of women in engineering, as well as the lack of industrial concern for worker welfare. (It's a Bernie Sanders complaint too). She would like what is being done for disabled people and the involvement of women in politics, industry, and science. She was a bit straight-laced and would probably object to modern morality.

KM: *Lillian's story is relevant to the crisis in engineering where even today only 13% of engineers are women. Gilbreth thought companies could attract more women by doing things like having separate bathrooms, for example. What do you think Gilbreth would tell our IEOR students — many of which will go on to start new companies and have considerable influence on many others — to do today to attract (and keep) more women engineers?*

FL: In her biography, *Making Time*, Jane Lancaster says: "Lillian's first reaction on being asked by a panicky Arma (Corporation) executive for advice on how to prepare for women workers is said to have become "something of a byword in the War Manpower Commission." She is reported to have said, "if that's all my job is, I can

finish it with one sentence: ‘Build separate restrooms.’” (See page 311 in *Making Time*.)

The more difficult problem is to change culture. For example, it took 25 years to get the GM culture to accept the Toyota approach. Another example is medicine where it has changed from being almost all male to 50/50. But, the subfield of medical surgery is like engineering. Only 14% of surgeons are women. Women surgeons who are mothers say they need more flexibility in scheduling and better child care support. They improve the practice of surgery in unique ways.

KM *You mention that STEMpathy, an idea embodied by Lillian’s work, represents the culture change that engineering needs. In your view, what needs to happen to make this culture change a reality?*

FL: Friedman’s “STEMpathy” idea is a neat way to describe the cultural change that Lillian advocated. Driver safety and auto efficiency, like environmental sustainability, become important engineering problems. Now, articles on such subjects aren’t published in engineering journals and don’t earn credit towards promotion. Group effort needs better recognition as in science. The separation of engineering into air tight subgroups like ASME and IEEE contributes to the problem.

I believe the most important change needed by the engineering profession is creation of an umbrella agency that would be similar to the AMA and ABA where policies would be set by a house of delegates representing all specialized groups, government entities, and appropriate industrial organizations to both promote the profession and the public good.

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