Outstanding women in mechanical engineering

Yin Kiong Hoh
Assistant Professor, Natural Sciences and Science Education, National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616, Singapore
E-mail: yinkiong.hoh@nie.edu.sg

Abstract The article aims to sensitise teachers to their perception of engineers and scientists. It also highlights the life and achievements of one outstanding woman mechanical engineer, namely Ilene J. Busch-Vishniac, and summarises the achievements of other outstanding women in mechanical engineering. Teachers can use the examples of these outstanding female engineers as role models to inspire their students.

Keywords women; mechanical engineering; role models

Introduction

The perception that engineers and scientists are intelligent Caucasian men who are socially inept and absent-minded seems to be prevalent among students of all levels, from elementary school to college [1–3]. While the media may, by chance or choice, promote this image, it is unfortunately a realistic one. For example, while women constituted 46.1% of the general workforce of the US in 2000, they represented only 25.4% of the science and engineering workforce [4]. This stereotypical image of engineers and scientists as Caucasian men has, in part, discouraged many women from pursuing any interest they may have in an engineering or science career because they do not want to (and cannot) be the people so often portrayed in the media.

A survey of a group of 150 trainee secondary-school physics teachers was conducted recently in which they were asked to name outstanding female and male engineers or physicists. Most respondents could name only one female but well over 20 male engineers or physicists. Such a finding is in line with studies carried out by Rahm and Charbonneau [1] and McDuffie [5], who reported that a vast majority of trainee teachers perceive engineers and scientists as men. I foresee problems which might ensue if teachers are to carry this stereotype with them into the classrooms.

Fortunately, research has shown that strategies such as presentation of female role models, distribution of career information, examination of sex-equitable materials, and participation in hands-on science investigations are effective in dispelling the stereotypical image of engineers and scientists [6–9]. Research has also pointed to the presence of female role models in engineering and science as the single most important factor in sustaining girls' interests in engineering and science [10].

The present article was, in part, prompted by a 2000 report from the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering and Technology Development [3]. The Commission was established by the US Congress in 1998 to examine how the US could increase its pool of skilled workers capable of competing in the technology-driven economy of the twenty-first century, and also to examine factors contributing to the under-representation of women and other minorities in science, engineering and technology education and employment. This was worthy of attention, as the nation has failed to optimise the use of the talent of its entire population – women formed half the population in 2000 but represented only a quarter of the science and engineering workforce. In 2000, of the bachelor's degrees awarded to women, only 26.3% were in science and 1.7% in engineering [4]. The report cited the lack of exposure to female role models in science and engineering as among the critical factors preventing girls from continuing science and engineering education.

This article aims to sensitise teachers to their perception of engineers and scientists. It also highlights the life and achievements of one outstanding woman mechanical engineer, namely Ilene J. Busch-Vishniac, and summarises in the Appendix the achievements of other outstanding women in mechanical engineering. Teachers can use the examples of these outstanding female engineers as role models to inspire their students.

Ilene J. Busch-Vishniac

Ilene J. Busch-Vishniac was born in Philadelphia, Pennsylvania, on 28 January 1955, to Ruth and Leonard Busch. Her father owned a structural engineering business while her mother was a homemaker. Ilene married Ethan Tecumseh Vishniac on 13 June 1976, and they had two daughters. She established a career focused on the goal of mastering sound – both clarifying sounds that people want to hear and quelling sounds that they do not.

Busch-Vishniac said that her parents had hoped she would become a lawyer. Instead, she entered the University of Rochester as a music major, studying piano at the Eastman School of Music. After one semester she realised that she did not possess the talent and the drive she thought she needed to become a successful performer. But she had taken a freshman seminar called 'Physics of music' that got her interested in acoustics. So, in her second semester, she switched her major to physics and mathematics because acoustics was taught in physics. She graduated with a BS in physics and a BA in mathematics in 1976 [11].

After completing her undergraduate studies at the University of Rochester, Busch-Vishniac went to Massachusetts Institute of Technology, where she continued to study acoustics and earned her MS and PhD in mechanical engineering in 1978 and 1981, respectively [11]. As a graduate student, she developed computer tools for studying noise in the suburbs and investigated how to produce quieter computer printers.

Soon after, Busch-Vishniac worked as a postdoctoral fellow and researcher at Bell Labs. There she developed devices for microphones and earphones, and improved conference calling systems to eliminate echo. In constructing a microphone suitable for teleconferencing, the scientists at Bell Labs initially designed a directive microphone consisting of an array of small microphones put in a line about 28 inches long. However, Busch-Vishniac challenged conventional wisdom and designed a single microphone of the same size as the array of small microphones. The microphone she designed was easier and cheaper to produce and also had a much lower reverberant noise level than the conventional microphone. Her idea of a single long microphone encountered stiff resistance from the scientific community initially but emerged as an exemplar subsequently.

In 1982, Busch-Vishniac joined the faculty at the University of Texas at Austin and was later named Temple Professor of Mechanical Engineering. At Austin, she developed novel optical sensors capable of monitoring the precise position of an object without surrounding it, and sensors for automated blood pressure monitoring and miniaturised microphones. She also designed underwater sound sources of various sorts. In addition, she worked on ways to reduce the level of noise that comes from motorway traffic. She investigated methods of building more effective but less expensive highway noise barriers. The solution appears to lie in the geometric design of the barrier, and not in its composition. She and her collaborators have found a solution to the problem by randomly varying the height of the barriers, which breaks up the sound waves.

In 1998, Busch-Vishniac was appointed Dean at Johns Hopkins University's Whiting School of Engineering, in Baltimore. During her tenure as Dean, the School became recognised as one of *US News & World Report's* top engineering schools in a range of fields, including biomedical engineering (ranking first) and environmental engineering (ranking sixth). She has been credited with helping to attract additional research funding, and thus enabling the externally funded research of the School to increase by more than 50%. She also initiated a large-group effort to revamp the standard curriculum in a mechanical engineering undergraduate degree programme in order to make it more attractive to women and minorities without sacrificing technical rigour. This work has had a great impact on how engineering schools think about enhancing diversity in the undergraduate population. Prior to this work, the diversity issue was tackled in terms of projects related to pedagogy or social infrastructure, but not to curricular change.

Busch-Vishniac stepped down from Deanship on 30 June 2003, and remained with Johns Hopkins University as a professor in the Department of Mechanical Engineering. In making this decision, she cited both the need to spend more time with family and her election as President of the Acoustical Society of America. She and her collaborators are currently working on two technical projects. The first is a long-term and large-scale study of noise in hospitals, with the aim of achieving significant reductions in noise levels. Their work at Johns Hopkins Hospital has received a great deal of attention and they have introduced two noise interventions, which have been very successful. The second project is to produce new materials suitable for use in acoustic sensors. They are aiming to develop new polymer piezoelectric materials, which produce a voltage when compressed and which expand and contract when stimulated electrically. This work is in its infancy but has the potential to have a major impact on microphones and loudspeakers everywhere.

Busch-Vishniac is counted among the world's leading authorities on electromechanical sensors and actuators. She has held nine US patents and collected a number of honours and awards for her work. In 1987, she received the Acoustical Society of America's Lindsay Award. In 1995, she was named a US National Science Foundation Presidential Young Investigator, and also received the American Society of Engineering Education's Curtis McGraw Research Award. In 1997, she won the Society of Women Engineers' Achievement Award. In 2001, she received the Silver Medal in Engineering Acoustics from the Acoustical Society of America, and was also named Inventor of the Week for the Lemelson-MIT Program.

Using role models

The author has presented classes of trainee teachers with examples of female engineering role models. The Appendix lists other outstanding female mechanical engineers and their achievements. Mechanical engineers of diverse backgrounds have been selected to help trainee teachers begin to view mechanical engineers as individuals, rather than as stereotypes. The mechanical engineers excelled in different fields. They represent different ethnic groups, so that trainee teachers can identify with their role models culturally. Some women avoid pursuing a career in engineering because of a perception of the difficulties of coping with both work and family life. Hence, examples of mechanical engineers who married and had children as well as those who remained single are included. It is hoped that through the use of such examples, potential female engineers will gain some assurance that it is possible to balance a career in engineering with family responsibilities. To dispel trainee teachers' stereotypical perception of engineers, mechanical engineers are also presented working in various settings, such as in the field and in computer laboratories.

The exposure to female mechanical engineers does not have to be restricted to lectures; it can also be carried out through sketches, group discussions or given as reading or written assignments. One approach the author has used is to ask trainee teachers to carry out research on particular mechanical engineers, and to do a written assignment. They have to design various documents to give an overview of a mechanical engineer's life, such as a birth certificate, educational certificates, a marriage certificate and a resumé for a research post. They also have to prepare a news article based on a fictional interview with the mechanical engineer just after she has received an 'outstanding engineer' award. The interviewer may ask questions such as the following. Who or what inspired you to become an engineer? What are your research interests? What are your major research findings and how did they influence the current knowledge then? What are the challenges faced by you in your research or work and how did you overcome them? What are some issues in your life which are unusually inspiring for girls studying engineering-related subjects? The author has asked these trainee teachers to compile a list of websites and references used in doing the assignment. Grading took into account their creativity in completing the assignment but information and ideas should have been based on facts in the mechanical engineer's life. Using this approach, it was found that trainee teachers seemed to show greater enthusiasm than anticipated.

Conclusion

From my experience, administering a survey in which respondents are asked to name female and male engineers or scientists to unsuspecting trainee teachers is a powerful way to make them aware of their stereotypical perception of engineers or scientists. Teachers must be aware of their own perceptions before they can correct the misconception among girls that a career in engineering or science is not suited for them. Teachers need to take every opportunity to assure girls that females can contribute as equally as males in science and engineering, as illustrated by the outstanding woman mechanical engineer described here. As the economy in the US and the world becomes increasingly reliant on a technologically literate workforce, the nation cannot afford to overlook the talent and potential contributions of half the population. If it does, societies, nations and our world will suffer.

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Appendix. Outstanding women in mechanical engineering and their achievements

Alice Merner Agogino

Mechanical and computer engineer. Recognised for her contributions to intelligent learning systems, multi-objective and strategic product design, non-linear optimisation, probabilistic modelling, intelligent control and manufacturing, MEMS design, design theory and methods, artificial intelligence and decision and expert systems. Elected a member of the US National Academy of Engineering in 1997 [12].

Cristina H. Amon

Mechanical engineer. Pioneered the development of computational fluid dynamics for formulating and solving thermal design problems. Developed numerical tools for predicting sub-micron and nano-scale thermal transport in semiconductors. Recognised for her contributions to thermal engineering of microelectronics. Elected a member of the US National Academy of Engineering in 2006 [13].

Mary Anderson

Mechanical engineer. Patented her idea for a windshield wiper that it allowed the driver to manipulate a lever from the inside that activated a swinging arm that mechanically swept off ice and snow. The windshield wiper became standard equipment on American cars after 1913 [14].

Rodica A. Baranescu

Mechanical engineer. Recognised for her contributions to low-emission diesel engines for truck applications, simulation and modelling of combustion, emissions, processes and systems in diesel engines, development and evaluation of alternative fuels for heavy-duty engines, and statistical optimisation of engine design. Held two patents. Elected a member of the US National Academy of Engineering in 2001 [15].

Martha J. Coston

Mechanical engineer. Awarded a patent in 1859 for using fireworks technology to develop an elaborate system of flares called 'night signals'. Awarded another patent in 1871 for a twist-ignition device, which was an improvement over her first invention. Her system of bright and durable flares was effective for ship-to-ship and ship-to-land communications and continues to be in use today [16].

Nancy DeLoye Fitzroy

Mechanical engineer. Invented a thermal chip to measure temperature in integrated circuits. Invented an advanced thermal protection system for hardened radar antennas used in an early-warning system in the US. Authored General Electric's *Heat Transfer and Fluid Flow Data Book*. Received the Society of Women Engineers Achievement Award in 1972. Became the first woman President of the American Society of Mechanical Engineers, in 1986. Elected a member of the US National Academy of Engineering in 1995 [17].

Kate Gleason

Mechanical engineer. Co-designed a machine that could produce bevelled gears quickly and cheaply. Turned her father's machine-tool factory, Gleason Works, into a leading US producer of gear-cutting machinery. Developed a method for pouring concrete, which was subsequently used for many suburban developments [18].

Lois Graham

Mechanical engineer. First woman in the US to receive a PhD in mechanical engineering. Recognised for her contributions as an educator to thermodynamics and cryogenics [19].

Beatrice Alice Hicks

Mechanical engineer. Pioneer in the design, development and manufacture of pressure and gas density controls for aircraft and missiles. Of particular interest is her invention of the gas density switch, a key component in systems using artificial atmospheres. Became the first President of the Society of Women Engineers (1950–52). Received the Society of Women Engineers Achievement Award in 1963 [20].

Margaret Ingels

Mechanical engineer. Recognised for her contributions to air conditioning, ventilation and refrigeration systems. Developed the 'effective temperature' scale to incorporate humidity and air movement in the equation for human comfort. Authored the book, *Willis Carrier, The Father of Air Conditioning* in 1952 [21].

Margaret E. Knight

Mechanical engineer. Invented a stop–motion device for shutting down machinery, a paper-feeding machine, a machine for making square-bottomed paper bags, a machine for cutting shoe soles, a numbering machine and a compound rotary engine. Held 26 patents [22].

Moyra J. McDill

Mechanical engineer. Developed special elements and techniques useful for analysing welds, heat transfer and stress in many manufacturing processes [23].

Roberta J. Nichols

Mechanical engineer. Designed alternative fuels and promoted their use in transportation vehicles worldwide. Supervised the design and development of engines using alternative fuels. Directed studies of material components suitable for use with alcohol fuels. Developed systems to evaluate the effectiveness of alternative fuel vehicles. Held three patents. Received the Society of Women Engineers Achievement Award in 1988. Elected a member of the US National Academy of Engineering in 1997 [24].

Elaine S. Oran

Mechanical and aerospace engineer. Designed numerical methods to simulate complex fluid dynamics, and used these methods to solve a broad range of problems in combustion and propulsion, atmospheric physics, solar physics and astrophysics. Elected a member of the US National Academy of Engineering in 2003 [25].

Ada Irene Pressman

Mechanical and power engineer. Pioneer in combustion control and burner management for supercritical power plants. Directed the design of control systems for 900 MW nuclear plants. Managed 18 design teams for over 20 power-generating plants throughout the world. Received the Society of Women Engineers Achievement Award in 1976 [26].

Mabel MacFerran Rockwell

Mechanical and electronics engineer. Influenced the use of special instrumentation for underwater propulsion systems and submarine guidance. Developed production processes for the Lockheed Aircraft Corporation. Invented the Serjdetour telephone protector. Developed a shipboard missile launcher. Designed transmission and distribution systems for the San Joaquin Valley District in California. Received the Society of Women Engineers Achievement Award in 1958 [27].

Johanna Maria Henrica Levelt Sengers

Mechanical and chemical engineer. Elucidated the critical behaviour and thermophysical properties of industrially important fluids and fluid mixtures, and researched their scientific and practical applications. Elected a member of the US National Academy of Engineering in 1992 [28].

Maria Telkes

Mechanical engineer. Devised a portable distilling system using solar energy to convert seawater to drinking water on life rafts. Designed a heating system based on the latent heat of fusion of salt hydrates for the first solar home at Dover, Massachusetts. Designed, built and tested solar thermoelectric generators for terrestrial and space uses. Developed solar ovens and solar heaters using air and liquid heat exchangers. Held 20 patents for solar devices. Received the Society of Women Engineers Achievement Award in 1952 [29].

Sheila E. Widnall

Mechanical and aerospace engineer. Recognised for her contributions to fluid mechanics, specifically in the areas of aircraft turbulence and spiralling airflows called vortices. Studied noise of VSTOL aircraft in forward flight. Researched aircraft wake turbulence to expand runway capacity. Conceived and implemented Massachusetts Institute of Technology's wind tunnel facility. Held three patents on airflow technology. Received the Society of Women Engineers Achievement Award in 1975. Elected a member of the US National Academy of Engineering in 1985. Served as Secretary of the US Air Force from 1993 to 1997 [30].

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