Special Issue – Women in Sciences: Historiography of Science and History of Science – on the Work of Women in Sciences and Philosophy

The Impact of Women in Computer Science History: A Post-War American History
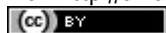
Karina Mochetti[1]

Abstract:

Women have always played an important role in Computer Science findings, but their importance has always been overshadowed by men. Nowadays, men outnumber women by 3 times on computing occupations in the US, but still women prove to be essential on the development of technological fields. This work intends to place women at the forefront of computer science's history. In order to demonstrate that their work was essential for the development of current technologies, a broad historical overview is given. This overview is chronologically and thematically structured in several periods, from the early computer machines (before 1900) to our current digital society (after 2010). Finally, an outlook on the role of women in computing is given. A detailed discussion of individual contributions by women would go beyond the scope of this work. Nor can a sociological analysis of the reasons for the gender gap be provided. Nevertheless, the work wants to be more than a mere quantitative enumeration of women's contributions to computer sciences. The essay wants to plea for the integration of these women in the literature, i.e., in the historiography of computer sciences, which requires to reconsider the self-image of this discipline.

_____

Introduction

The role of women in computing starts long before the Second World War (Margolis and Fisher 2003). In the 19th century, Ada Lovelace wrote the first algorithm to be tested on a computing machine that existed only on paper. However, through the years, women and their main contributions to the field were slowly decreasing, with the big gender gap appearing only on the 1980s. By this time, concern and follow research about this issue grew (Frenkel 1990), gathering the attention of the community. Nevertheless, the number

[1] Karina Mochetti [Orcid: 0000-0003-2269-1087] is a professor at the Fluminense Federal University – UFF (Universidade Federal Fluminense) – Institute of Computing. Address: Av. Gal. Milton Tavares de Souza, s/n, sala 423, Niterói, RJ – Brazil
E-mail: kmochetii@ic.uff.br

of women in the area is still decreasing every year, attracting researchers trying to explain this phenomenon (Cohoon and Aspray 2006). Moreover, a great number of projects and groups were created in an effort to reverse this issue and encourage woman to engage on computer related fields (Gürer and Camp 2002).

With this issue in mind, this work intends to emphasize women's place in Computer Science history (Tatnall 2010), telling it through the women's eyes, not only showing specific moments and momentary discoveries, but placing women in their actual role throughout the history as equal participants of computing development when allowed.

We will start in 1822 with Ada Lovelace, the first computer programmer, and the Analytical Engine, passing through all main discoveries and developments that lead us to the computer we know nowadays focusing on the female achievements. Besides Ada Lovelace (Hollings, Martin, and Rice 2018), Grace Hopper (Beyer 2015) and Margaret Hamilton (Piazza 2018), we will also talk about some not well-known woman, but equally important, such as Mavis Batey, Elizabeth Webb Wilson and Beatrice Worsley.

Therefore, the main goal of this work is to place women at the forefront in Computer Science history, even though men outnumber women by 3 times of all computing occupations in the US (Ashcraft, McLain and Eger 2016). We want to show how their work was not only one-off, but essential for the development of current technologies, also making clear the impact they have in a traditional male science field.

The Early Computer Machines (before 1900)

Although French weaver Joseph Marie Jacquard invented in 1801 a programmable loom that used punched wooden cards, similar to the one used years later by early computers (Delve 2007), the beginning of computer history is always credited to English polymath Charles Babbage. He is considered "the father of computer" (Halacy 2010).

Babbage created the first mechanical computer, the Analytical Engine. It was first described in 1837, and even though it is considered the greatest achievement of Babbage, he never saw it completely built (Bromley 1982). The Analytical Engine had a structure similar to modern computers: an arithmetic logic unit, control flow with conditional branching and loops, and integrated memory. Henry Prevost Babbage, Charles Babbage's son continued his father's work, but was also not able to finish the construction. Only in 1991, the London Science Museum built a complete and working version of the machine, called Difference Engine No 2 (Markoff 2011).

While working on its inventions, Babbage corresponded with Ada Lovelace (Essinger 2014). Ada was the only legitimate daughter of poet Lord Byron but she and her mother were abandoned by him when she was only one month old. Bitter, her mother, who had studied mathematics herself, raised Ada motivating her interest in mathematics and logic in an effort to keep her from becoming a poet like her father (Moore 1977). Ada's correspondence with Babbage began when she was still a teenager and allowed her to develop an algorithm to calculate a sequence of Bernoulli numbers on the Analytical Engine (Hammerman and Russell 2015). For this creation, she is considered the first computer programmer, even though programming languages had not been invented yet (Fuegi and Francis 2003). As the machine was never built by Babbage, Ada never saw her algorithm running, although it was later proved to be correct.

The late 19th century saw the construction of a punch card system that was used to calculate the 1880 census. Herman Hollerith, its inventor, founded the Tabulating Machine Company that later became IBM (Campbell-Kelly 2018). At the same time, Henrietta Swan Leavitt joined one of the first 'computers' at Harvard, groups of human calculators usually composed by women, since at that time women were not allowed to operate telescopes or other machines (Vishveshwara 2015). She did calculations on measuring and cataloging the brightness of stars, discovering the Cepheid variables, a type of star, that led to the

evidence for the expansion of the universe (Johnson 2005).

The Advance During the World Wars (1900 - 1950)

The beginning of the 20th century was marked by the World Wars. These events led to a great advance on several science fields, including computing. It also creates opportunities for women to participate in the process, since many men were fighting at the battlefield.

Women were called during the First World War to do ballistics calculations as human computers. Although Elizabeth Webb Wilson did not take part in the suffrage movement, her actions did reassure it. She had a striking talent for mathematics and refused nine job positions at Washington until she was offered the position of a chief computer (Grier 2013). At the same time, at the United Kingdom, Beatrice Cave-Browne-Cave worked as a human computer for the Ministry of Munitions, carrying out research for the government on the mathematics of aeronautics (Jones 2009). Even after the end of the war, in 1930, NASA kept hiring women to work in their computer pool to analyze data from wind tunnels and flight tests (Atkinson 2015).

During the Second World War, Alan Turing developed the main concepts of a universal machine that would be the base for most of the ideas for modern computers. Also, several American women were recruited to operate the first computing machines such as the WREN Colossus at Bletchley Park (Copeland 2010) and later the ENIAC and MANIAC I computers (Pearson, Frehill and McNeely 2015). Alan Turing is also known for cracking the Enigma Code at age 31. The Enigma was a German naval cipher machine and Alan's work helped to end the war. What is usually forgotten is that Mavis Batey also cracked an Enigma machine, the Italian Naval one, at the age of only 19, along with Dilly Knox. She worked at Bletchley Park and is considered one of the keys to the success of D-Day, breaking important messages from the Germans and Italians. Beside the Italian Naval Enigma machine, she also cracked the Abwehr Enigma and the GGG, considered unbreakable at the time (Batey 2017).

During the same time, actress Hedy Lamarr, along with George Antheil, developed a radio guidance system that used spread spectrum and frequency hopping technology to prevent radio-controlled torpedoes to be jammed. Although never used by the US Navy, the principles of their work were later incorporated into modern technologies, such as Bluetooth and WiFi. She had no formal training and did not fit into the Hollywood style. She spent her free time inventing rather than attending parties or drinking. Her inventions were taken for granted and she was only recognized in the 1990s, when she was in her early 80s (Rhodes 2012).

Regarding companies, in 1939, David Packard and Bill Hewlett founded theirs in a Palo Alto garage, while a few years later, Ruth Leach Amonette was elected the Vice President at IBM, a company with more than 30 years. She was the first woman to hold that role.

By the end of the wars, women were able to keep their roles as being part of the computer developments at that time. Dorothy Vaughan, who left her teaching job to join Langley Research Center as a human computer, was promoted and became the first black supervisor at NACA in 1948. She later specialized in the FORTRAN programming language by teaching herself, and other women, in order to open more opportunities for them. She raised six children while working at NACA and encourage other women to grow their career (Allen 2017).

Also, Gertrude Blanch led the Mathematical Tables Project group from 1938 to 1948, a computing organizations that was part of the Works Progress Administration (WPA), an American agency. The project was closed after the end of the war and unlike most women, Gertrude Blanch did not keep her position within the government. She moved to the University of California in Los Angeles, leading the computing office of its Institute for Numerical Analysis. Supposedly, she was not allowed to continue her work because there

67

was a suspicion that she was secretly a communist during the Cold War, due to her never being married or having children (Grier 1997).

The late 1940s saw one of the greatest advances on computer history: William Shockley, John Bardeen and Walter Brattain of Bell Laboratories invented the transistor, a semiconductor device used to amplify or switch electronic signals which are the fundamental building block of modern computers (Brinkman, Haggan, and Troutman 1997). Meanwhile, Grace Hopper, a United States Navy officer, programmed on the Harvard Mark I, a large eletromechanical computer with 51 feet in length and 8 feet in height, using more than 765,000 components and hundreds of miles of wire (Williams 1999). She developed the first compiler for an electronic computer, known as A-0 and was one the creators of the COBOL programming language. She is also credited for popularizing the term *debugging* after finding a moth on a relay in the Harvard Mark II computer that was causing faults on its programs (Beyer 2015).

At the same time, Irma Wyman was working on a missile guidance project at the Willow Run Research Center when she visited the US Naval Proving Ground, meeting Grace Hopper. Their encounter changed Irma's life, making her an enthusiastic about new technology which led her life's career (Gilbert and Moore 2012). She later joined Honeywell, an American multinational conglomerate company, and eventually became the first female CIO of Honeywell. She, much like most of the women in this field, enjoyed passing her knowledge to young women in computer science, even endowing a scholarship at the University of Michigan's Center for the Education of Women, her alma mater (Bjorhus 2015). Since the beginning, the support among women was essential for their maintenance on the field.

By the beginning of 1950s, women had made some remarkable part on the development of Computer Science all over the world: Canadian scientist Beatrice Worsley had ran, along with her team, the first program on the Electronic delay storage automatic calculator, also known as the EDSAC computer in 1949 (Campbell 2003); Edith Clarke, an American electrical engineer, had filed patents for a graphical calculator and became the first female professor of Electrical Engineering in the United States in 1947 (Layne 2009); and Austrian mathematician Johanna Piesch published two pioneering papers on Boolean algebra, one of the fundamentals of digital computing (Zemanek 1993). Even proving their importance, women kept being taken for granted. German mathematician Grete Hermann, who finished her Ph.D. under Noether, published a foundational paper for computer algebra in 1926, showing her talents. She criticized John von Neumann's proof of the no-hidden-variable theorem in 1935, but was only recognized by the physics community 30 years later. This fact is considered to hold back the development of quantum mechanics (Crull and Bacciagaluppi 2016).

The Born of Programming Languages (1950 - 1970)

One crucial point of development for Computer Science was the creation of programming languages. These languages popularized computers by the use of a more accessible language, closer to humans than the machines. COBOL is considered the first programming language and it was developed by Grace Hopper in 1953 (Bemer 1971). At the same time, a team of programmers at IBM led by John W. Backus created another programming language, FORTRAN, that focused on numeric computation and engineering applications (Backus 1978). This made programming simpler, attracting researchers from other fields, such as engineering and chemistry.

At the early 50s, Ida Rhodes, which had worked with Gertrude Blanch on the Mathematical Tables Project in 1940 (Blanch and Rhodes 1974), along with Betty Holberton, designed a programming language. The C-10 language was used on the UNIVAC I computer and it is considered the prototype of modern programming languages. Holberton also

participated in the early development of COBOL and FORTRAN programming languages along with Grace Hopper (Beyer 2015). She is known for being one of the six women to program the ENIAC along with Kay McNulty, Marlyn Wescoff, Ruth Lichterman, Betty Jean Jennings, and Fran Bilas during World War II. Although they were not classified as "professionals", they performed important calculations for ballistics trajectories electronically having a major impact on Computer Science (Fritz 1996). Later, in 1962, Jean E. Sammet, who also has contact with Grace Hopper and the UNIVAC I team, not only developed a new language, the FORMAC programming language, but also studied the history of programming languages so far. She later became the first female president of the Association for Computing Machinery (Bergin 2009).

The mid-1960s marked the first step towards the popularization of modern computers. Douglas Engelbart developed a machine with a mouse and a graphical user interface (English, Engelbart and Berman 1967). At the same time, women were struggling to maintain their opportunities in the Computer Science field, since men have returned from the battlefield and the Cold War did not demand that from them. While Sister Mary Kenneth Keller became the first American woman to earn a Ph.D. in Computer Science (Gürer 1995), Dame Stephanie Shirley was advocating for the involvement of women in computing. She founded a software company and employed more women than men, having only 1% of male programmers. Unfortunately, that became illegal in the United Kingdom in 1975 (Shirley and Askwith 2017). Due to the extensive sexism, she suffered in her workplace, she decided to adopt the name "Steve" to survive this male-dominant world. She is known to have programmed for the Concorde's black box flight recorder (Tickle 2017).

As Shirley, more women wrote important programs. Mary Coombs, for example, was the first female programmer on LEO, the first business computer back in 1952. At NASA, women kept important roles in the calculation, such as the orbital estimation for the Explorer 1 satellite, done by a group of all-female computers. At the same laboratory at NASA, Dana Ulery, the first female engineer, developed real-time tracking systems using a North American Aviation Recomp II, a 40-bit word size computer, and programmed NASA's Deep Space Network capabilities (Kresser and Sippel 1962). Moreover, some women also achieved high positions, such as Margaret R. Fox who first worked at Naval Research Lab and later changed to the National Bureau of Standards, where she was appointed Chief of the Office of Computer Information in 1966 (Fox 1984).

A great breakthrough happened in 1969, when a group of programmers from the Bell Labs developed UNIX, an operating system written in the C programming language. Its main advantage was to be portable across multiple platforms and it soon became popular among companies and government entities. Personal computers were rare, but UNIX was not the first operating system. A few years before, in 1965, Mary Allen Wilkes designed the first personal computer, the LINC, and wrote LAP, its operating system, considered the first one (Clark 1987). Women were not pioneers only in technical programs, though. Joan Ball started a computer dating service in 1964, years before social networks and dating applications (Ball 2014).

Although not as important as in the Great World Wars, women also played their role in the Cold War especially at NASA. In the late 1960s, Margaret Hamilton worked on the Apollo space program, writing the code for the onboard flight software and its robust architecture. This software was crucial during the abort of the Apollo 11 moon landing (Hamilton and Hackler 2008). She later became a director at MIT Instrumentation Laboratory, where she came up with the term Software Engineering, as the application of engineering to the development of software in a systematic method (Hamilton and Hackler 2007).

The Development of Personal Computer (1970 – 1980)

Great developments on hardware made possible to build smaller and cheaper computers, leading to their popularization. They are not those big machines anymore, only owned by companies, universities and government entities. Now they became also available to consumers. Two inventions from the early 1970s made that possible: the Intel 1103, the first commercially available Dynamic Access Memory (DRAM) chip (Moore 1996) and the floppy disk, developed by Alan Shugart at IBM that allowed data to be shared among computers (Markoff 2006). The British computer scientist Sophie Wilson designed the instruction set of the ARM processor, which will later be used in most smartphones (Garnsey, Lorenzoni and Ferriani 2008). Wilson is a transgender woman and also build the Acorn Micro-Computer leading her to be named one of the 15 most important women in tech history (Bouman 2011).

The communication between computers was the main focus of researches at the time. In 1973, Robert Metcalfe developed Ethernet for connecting multiple computers (Metcalfe and Boggs 1976), initially in a local area network and later expanded for metropolitan area and wide area networks (Santitoro 2003). Two years before, Erna Schneider Hoover, a developer at Bell Laboratories, invents a computerized telephone switching calls method which had software to support large networks. Before working for Bell Laboratories, Hoover was a professor teaching philosophy and logic in 1951, but she was never able to win a tenure-track position, possibly due to her gender (Zierdt-Warshaw 2000). She worked at Bell Labs for 32 years and wrote one of the first software patents ever issued in 1971 (Eckhart and Hoover 1971). Another important advance for networks was the creation of the Domain Name System (DNS). This list of host names is still in use and can be found on most web addresses such as *.gov*, *.edu*, *.org*, and *.com*. It was created by Elizabeth Feinler in 1974, the director of the Network Information Systems Center at the Stanford Research Institute at that time. Feinle, who dropped out of a Ph.D. in biochemistry for this position, also worked as a manager for the NASA Science Internet (Feinler 2010).

With the popularity of personal computers growing, several reach the market by the mid of 1970s, such as Scelbi & Mark-8 Altair, IBM 5100, Radio Shack's TRS-80 and the Commodore PET (Reimer 2005). This encouraged 'computer geeks' into creating their own computers, writing their own software and starting new companies. Therefore, Paul Allen and Bill Gates founded Microsoft in 1975 and Steve Jobs and Steve Wozniak started Apple Computers in the following year (Allan 2001). Both companies are, still today, two of the world's most valuable brands (Badenhausen 2018). Although now more famous, Microsoft and Apple were not the precursors startups in Silicon Valley. In 1972 Sandra Kurtzig founded ASK Computer Systems and became one of the first Silicon Valley's entrepreneurs (Nemeh and Kalte, 2003).

In 1977, Jobs and Wozniak showed the Apple II at the first West Coast Computer Faire, with color graphics and other software features for common users, marking the main feature of Apple Machintosh, its user interface. Yet, many ideas used on this desktop environment came from Adele Goldberg, a researcher at the Xerox Palo Alto Research Center (PARC). She developed the programming language Smalltalk-80 together with various concepts related to object-oriented programming. These concepts became the basis for graphically based user interfaces, replacing the command line systems, such as MS-DOS and UNIX. Steve Jobs became interested in Goldberg's work and wanted a demonstration of the Smalltalk System. Although she first refused, her superiors at PARC ordered her to do it and Jobs ended up using some of Goldberg's concepts on his new system (Cringely 1996).

By the end of 1970s computers were even more popular due to several software releases: VisiCalc, the first computerized spreadsheet software, is released in 1978 by Dan

Bricklin and Bob Frankston (Grad 2007) and WordStar, a word processing program developed by Rob Barnaby, is released in 1979 (Rubinstein 2006). Computers had its usage expanded with Karen Spärck Jones using it for natural language processing, developing algorithms essential to the modern search engines and still used today (Robertson and Tait 2008) and Phyllis Fox trying to deal with the diversity of computers and operating systems by building a portable numerical library (Fox 2005). Due to its popularity, computers also draw attention from several fields. In 1973, for example, Susan Nycum, a computer law scholar, began defining and documenting computer-related crime (Parker, Nycum, and Oüra 1973).

Women kept breaking their way into Computer Science, with Mary Shaw becoming the first woman to earn a Ph.D. in Computer Science from Carnegie Mellon University in 1971 (Shaw 1971) and Irene Greif achieving the same from the Massachusetts Institute of Technology in 1975 (Greif 1975). Also, Christiane Floyd became the first woman to work as a computer science professor in Germany in 1978 (Thumfart 2011), while Margaret Burnett became the first women hired in a management position at Procter & Gamble (Burnett 2017). Burnett is an activist and still as a student created a group for professional women at her hometown and nowadays researches methods to check how gender-inclusive a software is (Beckwith and Burnett 2004). The foundation of the Association for Women in Computing (AWC) by Donnafaye Carroll Finger and Diane Haelsig in 1978 marks the will of women to grow professionally in Computer Science and to support each other in this task (Gay 2000). This support was done informally until now, but showed to be crucial to some women.

Video Games and Computer as a 'Boy-Thing' (1980 - 1990)

Together with the commercialization of personal computers, the development of video games began. The console generation of the early 1980s saw its golden age with Atari and the popular Space Invaders game. Although mainly sold as a 'boy-thing', aiding in the computing unpopularity among female users (Henn 2014), many women contributed to the development of video games. Carol Shaw worked for Atari Corporation developing games for the Atari 2600 console. She later joined Activision, where she designed the major hit River Raid (Suellentrop 2014). She is considered the first female game designer together with Dona Bailey and Carla Meninsky. Bailey created the arcade video game Centipede in 1981 and was the first female developer to work at Atari. Carla Meninsky was the game designer and programmer for several Atari 2600 games, such as Dodge Em and Indy 500 (Kent 2010). Also, Janese Swanson was one of the developers of the Carmen Sandiego game, which had a female protagonist, something uncommon in 1983 (Hocks 1999). Swanson later found Girl Tech, a company that develops products to encourage girls to use technologies (Davidson 2005).

Meanwhile, IBM releases its first personal computer, Acorn, designed by Sophie Wilson (Garnsey, Lorenzoni and Ferriani 2008) and admits its first female fellow, Frances E. Allen (Steele 2011). Microsoft releases MS-DOS operating system and Apple releases Lisa, a personal computer with a user-friendly operating system (Edwards 2013). A couple of years later, Microsoft announces Windows, which also features icons and menus just like Apple's system (Magid 1990). Both systems are considered revolutionary due to the graphical user interface which had its original interface elements created by Susan Kare (Gonzalez 2016). Some of her icons and typefaces are still used today and her work can be seen on Microsoft, IBM, Pinterest and Facebook software. (Kastrenakes 2015).

The start of the Internet occurs in the mid-1980s, with the first *.com* domain being registered by Symbolics Computer Company in 1985 (Moore 2009) and the creation of the HyperText Markup Language (HTML) and the Hypertext Transfer Protocol (HTTP) by British scientist Tim Berners-Lee. Five years later he founded the World Wide Web as we know

today (Berners-Lee 1989). Internet services are now becoming more common and several companies are founded, such as Linksys, selling data networking hardware products. It was co-founded by Taiwanese hardware engineer Janie Tsao and her husband Victor (Lansner 2015). At the same time, Radia Perlman invented the Spanning Tree Protocol (STP), also contributing to Internet development (Perlman 1985). Perlman began her interest in computers during a high school programming class and, although having fears and doubts by being the only girl in the class, she decided to follow a technological career obtaining her Ph.D. in Computer Science from MIT in 1988 (Rosen 2014). Besides working with networks, she is also a pioneer in teaching programming for children, developing TORTIS and the LOGO educational robot Turtle (Morgado, Cruz, and Kahn 2006). This is common for women in computing history, as they usually get involved in teaching young people, especially girls, trying to reverse the gender gap.

While Compaq brings the Deskpro 386 into the market, women kept leaving their marks: Lorinda Cherry developed the dictionary for the Unix spell checker and the Writer's Workbench while working for Bell Labs (Mahoney 1989). Éva Tardos, a Hungarian mathematician, earned the Fulkerson Prize for finding minimum cost circulations in strongly polynomial time in 1988 (Tardos 1985), and later the Gödel Prize for laying the foundations of algorithmic game theory (Roughgarden and Tardos 2002). Although the number of women kept dropping during these years and computing was now known as part of the male culture, some women kept breaking through even whilst not recognized as equals.

The Main Modern IT Companies Emerge (1990 - 2000)

With the Pentium microprocessor advance of graphics and music on PCs, they start to also be used as gaming machines at the mid-1990s. The gaming industry has raised computer sales, but also help to increase the gap for the female users and programmers (Andrews 2017). Even so, some women kept making breakthrough discoveries, such as Donna Dubinsky, which in 1992 introduced the first personal digital assistant, or PDA and later became CEO and co-founder of Palm, Inc. (Marlow 2000). She is now CEO of Numenta and works with machine intelligence (Markoff 2005).

Theoretical computer science was also impacted by women, especially due to its close connection with mathematics. Since computers started to be related to men, many women found their way through math. Shafi Goldwasser graduated in mathematics and science from Carnegie Mellon University and is the inventor of zero-knowledge proofs, an important advance for complexity theory and cryptography (Goldwasser, Micali and Rackoff 1989). It led her to win the Gödel Prize twice, once in 1993 and once in 2001 (Israel 2017). Barbara Liskov also earned her BA in mathematics and in 1993 along with Jeannette Wing, developed the substitutability, an important principle in object-oriented programming (Liskov and Wing 1994). Liskov also developed two programming languages, CLU and Argus and has received several awards, including the Turing Award (Weisman 2009), the most prestigious award in Computer Science.

The year of 1996 marks an important event in computing history with the development of the Google search engine at Stanford University by Sergey Brin and Larry Page (Battelle 2006). But it would take 3 years before they hire their first female engineer, Marissa Mayer (Sutter 2012). She would later be named vice president of Search Product and User Experience at Google until she became the CEO of Yahoo! in 2012 (Chang 2012). As many women, Mayer also taught computer programming at Stanford and changed Yahoo!'s maternity leave policy, lengthening its time allowance. She has been ranked in several lists and she was the first woman to reach the number one position on Fortune magazine's annual list of the top 40 business stars under 40 years old (Morrison 2013).

At the late 1990s, the Internet became popular with about 8 million teens online (McCullough 2015) and Wi-Fi starts to become a common term since now users can connect

to the Internet without wires. The system behind the Internet is based on several protocols that make possible all the information to correctly reach its destination. In 1994, Sally Floyd, a computer scientist from Berkeley, worked on the standard for TCP, the Transmission Control Protocol still in use today (Paxson and Floyd 1997). She later invented the Random Early Detection (RED), a queue management scheme used by almost all Internet routers (Floyd and Jacobson 1993).

The 1990s are also marked by the creation of several awards and institutes to honor women who contribute to Computer Science in an effort to revert the alarming decrease of its female representation. The Grace Hopper Celebration of Women in Computing Conference was first held in 1994 with 500 attendees (Barr 2014) and two years later the Women in Technology International Hall of Fame was established by the Women in Technology International (WITI), founded by Carolyn Leighton (Mardesich 1994). In 1997 Anita Borg, who also organized the first Grace Hopper Celebration along with Telle Whitney (Goyal 1996), founded the Institute for Women and Technology (IWT), renamed Anita Borg Institute in her honor in 2003. She worked in email communication and in 1987 started Systers, the first email network for women in technology providing a private and safe space for its only-female members (Borg 1999). All these organizations are still active today and have a crucial role empowering women in the field, with the Grace Hopper Celebration having 20 thousand attendees in 2018 (Morris 2018).

A Digital Society (after 2000)

The 21st century began with the development of Apple Mac OS X operating system and Microsoft Windows XP. These releases now have a great impact on the population, since computers now are the basis of society, with almost 300 million computers being sold worldwide in 2008 (Bhattacharya 2017). Moreover, internet usage kept growing, with the creation of Mozilla's Firefox, an internet browser, in 2004 (Khomh et. al 2012) and of Facebook, a social networking site (Boyd and Ellison 2007) and YouTube, a video sharing service in 2005 (Gueorguieva 2008). At the same year of its creation, Facebook hires its first woman engineer, Ruchi Sanghvi (Bosker 2011). Sanghvi is an Indian computer engineer and became the product lead for Facebook the following year, due to her work on the platform's new feed. She left Facebook to found her own company after receiving the Best Engineering Leadership Award in 2011 (Peak 2012). Women now are able to reach higher and more important positions: Sara Catz becomes the president of Oracle Corporation (Hesseldahl 2011), Carol Bartz becomes the CEO at Yahoo! (Pepitone 2009) and Meg Whitman becomes CEO of Hewlett-Packard (Yang 2011), more than 70 years after its foundation. Women also contributed with some breakthrough discoveries, such as the crack of the MD5, SHA-0 and SHA-1 data security algorithms by Xiaoyun Wang in 2005. She and her colleagues received a standing ovation for their work at CRYPTO conference (Randall 2005).

Although many human computers during the wars were composed by African American women (Grier 2013), making them essential for numerous advances in Computer Science, only in 2006 the first African American woman was able to hold a patent for a software invention in her name (Bashen, Roach and Moore 2006). Janet Emerson Bashen created a software to aid with web-based Equal Employment Opportunity investigations, after being refused to debate about equity on her previous company (Lynn 2016). She started her own company and was one elected of the most 100 influential African-Americans by Ebony magazine (Ebony 2012).

In the early 2000s, women began to finally be recognized by their contribution to Computer Science. In 2003, Margaret Hamilton received the NASA Exceptional Space Act Award for scientific and technical contributions (Braukus 2003) and in 2006 Frances Allen earned a Turing Award (McGee 2007), being the first woman to do so for her seminal work

in compilers, program optimization, and parallelization (Allen and Cocke 1976). She was followed by Barbara Liskov in 2008 (Weisman 2009) and Shafi Goldwasser in 2012 (Abazorius 2013). Also, Lixia Zhang a Chinese professor of computer science won the IEEE Internet Award in 2009. She was the only woman at the initial Internet Engineering Task Force, an organization to promote internet standards and is one of the creators of the RSVP protocol (Zhang et. al 1993). Finally, in 2018 Gladys West is inducted into the Air Force Space and Missile Pioneers Hall of Fame (Augustin 2018). She worked at the Naval Surface Warfare Center Dahlgren Division. She was the second black woman ever employed in 1956 (Butterly 2018). She was a human computer, collecting data from satellites, and helped develop GPS technology that is widely used today (West 1986). She was recognized more than 30 years after her discovering.

The late 2000s continued the launch of software and hardware closely watched by the general population. In 2007 Apple releases the iPhone, bringing computer functions to the smartphones (Mather 2007) and a few years later it launches the iPad, changing the dormant tablet computer segment (Kiss 2010). Computers begin to be the basis of our society, which can be supported by Facebook reaching 1 billion users in 2012 (Smith, Segall and Cowley 2012). At the same time, Ginni Rometty becomes the first female president and CEO of IBM, more than one hundred years after its foundation (Metz 2011). Rometty has also been involved in organizations for empowering women, such as its IBM Women in Technology Council (Sim 2018), and has been listed in important rankings, like the world's most powerful people by Forbes in 2014 (Howard 2014). Also, Yoelle Maarek founded and directed the Google Haifa Engineering Center, developing autocompletion for Google search queries in 2006 (Carmel et. al 2008). She is now vice president at Amazon (Orbach 2017).

Computers now are evolving into new paradigms and models. In 2016 the first reprogrammable quantum computer was created by Shantanu Debnath (Choi 2016) and one year later the Defense Advanced Research Projects Agency started developing a program that uses molecules as computers (Hinchliffe 2018). Women, although still outnumbered in the field, kept being pioneers such as Michelle Simmons that founded in 2017 the first quantum computer company in Australia (Davey 2016). Simmons is a professor of quantum physics at the University of New South Wales and her team was the first in the world to develop a working single-atom transistor, essential for building a quantum computer (Fuechsle et. al 2012).

The gender gap on Computing Science has gathered more attention since the 2010s with several groups and organizations being created trying not only to empower and maintain women already engaged in computing, but also to motivate young girls into enrolling in technological courses. In 2011, Ladies Learning Code, an organization aimed at promoting collaborative and technological learning among women, is launched in Toronto by Heather Payne, Melissa Sariffodeen, Breanna Hughes and Laura Plant (Kienapple 2011) and PyLadies, an organization of women who code in Python, is started in Los Angeles by seven women (Shah 2012). Several other nonprofit organizations were creating focusing on encourage girls to pursue careers in software development: Girl Develop It (GDI) was founded in 2010 by Vanessa Hurst and Sara Chipps (Shattuck 2010) and two years later Girls Who Code was founded by Reshma Saujani (Guynn 2014). Focusing not only on the gender issue, but also in race equity, Black Girls Code (BGC) was created in 2010 by Kimberly Bryant and provide technology education for African-American girls (Gilpin 2014). However, one of the first organizations created was LinuxChix, founded in 1999 by Deb Richardson to provide technical and social support for female Linux users (Bowman 1999).

These organizations are important and although giving attention to the gender gap issue, the number of women in Computer and Technological courses remains low. One of the issues is the lack of representation of women in computer history. Since it has been written mainly by men so far, women's contribution has been shadowed and the most

popular and famous computer scientists are men. Trying to reverse this scenario is essential for reaching equal rights, moving towards a new computing environment, one with equality not only of gender, but also race, class, sexuality and disability.

The Role of Woman in Computing

The role of woman in computing nowadays is a complex problem involving several topics, such as the role of woman in society, feminism and pedagogy. Women's accomplishments in any professional field are followed by questions, doubts and hesitation. Few would argue when we say that Alan Turing broke the enigma, although he worked with Dilly Knox (Batey 2017), or that Steve Jobs founded Apple, although Steve Wozniak and Ronald Wayne were also founders (Warner 2012). However, many would complain if we stated that Ada wrote the first algorithm, remembering of Charles Babbage, or that Beatrice Worsley ran the first program on the EDSAC computer, complaining that there were several other programmers on that team. Women's accomplishments carry a bias: while a man can easily achieve a goal by himself, a woman must always have some help. And, although science is usually not done by only one person, it is common to give credit to a single individual, but only when we highlight a woman's role this becomes an issue.

This leads to a misrepresentation of women in all science fields, especially in STEM and Computer Science, and has had a great impact on the number of female newly engaged in it. One of the reasons for keeping women from Computer Science is that they tend to underestimate their abilities to be successful (Ehrlinger and Dunning 2012). This can be closely related to two factors: the lack of role models (Marx, Stapel and Muller 2003) and the use of traditional pedagogy methods in schools (McClure 2000).

The importance of role models to students, not only corresponding to gender but to other characteristics as well, can be essential to diversity. Role models can create an impact, enhancing self-confidence and decreasing stereotype expression. For Computer Science, this includes not only non-male scientists, but also other minority groups such as Afro-Americans (DiSalvo et.al 2011) and LGBT+ representatives (Stout and Wright 2016). Unfortunately, diversity is rare in Computer Science courses, reflecting on the difficulty of recruiting and retention of these groups. This creates a vicious circle, in which there are few role models, attracting even less diverse students, creating even fewer role models and representation. Therefore, there is an urgent need of highlighting women in Computer Science, since it creates role models to female students, helping to recruit them and later retain them in the field, creating more role models and finally, one day, breaking the circle.

Moreover, this lack of representation can clearly be seen on the dissemination of knowledge and websites such as Wikipedia. Not only more than 85% of its registered users are men (Herring 1992), but also, most pages of female scientists are not complete or are frequently the target of vandalism (Stratigakos 2016). Men tend to write about what they know and female scientists receive less attention from editors. This contributes even more for the lack of female role models, aiding to the already stated vicious circle of recruiting and retaining women in the STEM. Although these editors are not historians and usually do not write papers or books, they are writing history for our digital society. Wikipedia, and the internet in general, are the primary source of knowledge nowadays and women do not appear to be welcome in it (Hess 2014). A simple freshmen activity done in a Brazilian university can show not only how women are mistreated on this male-dominant environment but also, how prominent and famous female computer scientist, such as Grace Hopper and Ada Lovelace, are not known by most undergraduate students, either male or female (Mochetti et. al 2017).

It is also important to notice that this gender gap has social and political causes, not biological ones. Women are as capable as men in STEM and Computer Sciences (Fausto-Sterling 2008). Teaching methods, though, can be the producers of a gender distinction.

Education builds society at the same time it is built by society. Thus, it is also necessary to analyze the representations of gender and how they are reaffirmed or questioned during the formation of an individual. Traditional pedagogy tends to reflect all types of inequality, starting with the segregation of adults, the teachers, those who are active in teaching and are already "ready"; from children, passive beings in education who must be shaped by knowledge (Mizukami 1996). Moreover, traditional pedagogy can also increase the distinction by ethnicity, economic class, and even gender, offering different classes and types of knowledge to specific groups of individuals.

Disciplines such as Gym Classes have more explicit gender segregation, using Biology and Health to justify the division of female and male students. However, exact classes, such as math, have a more subtle process of gender distinction. A study showed that when female students have a higher math result than male students, teachers' explanation usually states that female students have worked hard while male students have behavioral and focus problems. Words like "bright" or "potential" are never used to describe girls in exact or science classes (Walkerdine 1995).

Education and pedagogy methods have a fundamental role in the creation of the individual and the implication of power relations. It is its role to problematize this average behavior, allowing subjects to have different thoughts and views, even if this breaks the social rules of "normality" (Louro 1997). In this scenario, gathering the political ideologies of the Feminist Movement of the 60s, feminist pedagogy was created. Its main idea is to bring a new standard in the classroom addressing the power imbalances present in society. This new view of education can be essential in increasing the number of female students enrollment in STEM and Computer Science, but it is still uncommon in most schools around the world.

Thus, the low representation of women in computing can be due to several social factors related mainly to the role of women in society. As pointed out by Simone de Beauvoir years before "Representation of the world, like the world itself, is the work of men; they describe it from their own point of view, which they confuse with absolute truth." (De Beauvoir 1989). Feminist studies, such as Beauvoir's, have analyzed the forms of oppression women suffered and the differences between men and women created by society. Women did not have the same rights and opportunities than men for a long time and even when they finally begin to occupy their professional space, they had only auxiliary and collaborator roles. This becomes clear when we differentiate the role of a school teacher and a university professor. A teacher is usually related to a woman and her maternal role of raising and caring for children, while a professor is related to a man that has great knowledge in some area. For this reason, the number of women in seminal areas that are parts of elementary education, such as math and physics, are not as alarming as in engineering and computing. In society's view, women should not have this function unless teaching and caring for children.

Therefore, the gender gap in Computer Science will only be solved with a deep change in society. Women should have their own space, not only in STEM but in all society's roles. This should not be defined by men, but by the whole society. Women should not be allowed to work in the STEM field only when men are at the battlefields of war. Furthermore, advertisements should not target only a gender such as done with computers and video games in the early 80s. Gender equality is a human right, not a woman's right.

Conclusion

Women were essential to the development of computing and their role was outshined by men, leading to the alarming number of women occupying less than one quarter of all computing occupations in the US (Ashcraft, McLain and Eger 2016). This underrepresentation leads to a male dominant environment, hostile to women, as can be

seen in recent issues with big companies such as Google (Wakabayashi 2017) and Facebook (Conger and Frenkel 2018), affecting their development, since diversity is important in any field (Hicks 2017).

Another problem arises from their recognition through rewards and awards. The ACM Turing Award, for example, is an annual prize given by the Association for Computing Machinery (ACM) to individuals with a major technical contribution to the computer science field. By 2019, from the almost seventy awards given, only three were given to women: Frances Elizabeth Allen, Barbara Liskov and Shafi Goldwasser. All were given after 2006, showing how women were erased from the history of computing until recently.

In an attempt to revert this issue, several groups and organizations were created, such as Grace Hopper Celebration of Women in Computing Conference (Gabbert and Meeker 2002) or the Association for Computing Machinery's Council on Women in Computing (Gürer and Camp 2002), with over 36 thousand members. They try to support and empower women already active in the field while encouraging girls to engage in Computer Science and related areas.

In this work, we try to contribute to changing this scenario by not only highlighting these important women, but also showing them throughout the view and heart of a woman in computing. Therefore, although still suffering from several years of shadowing by men, women in computing are fighting for their space and hopefully, with time, we may have a field with more equity.

Acknowledgment

References

Abazorius, Abby. 2013. Goldwasser and Micali win Turing Award. *MIT News*, March 13, 2013. http://news.mit.edu/2013/goldwasser-and-micali-win-turing-award-0313 (accessed January 30, 2018).

Allan, Roy A. 2001. *A history of the personal computer: the people and the technology*. Allan Publishing.

Allen, Frances E., and John Cocke. 1976. A program data flow analysis procedure. *Communications of the ACM* 19 (3): 137.

Allen, Kera Jones. 2017. Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race by Margot Lee Shetterly. *IEEE Annals of the History of Computing* 39 (3): 70-71.

Andrews, T.L. 2017. Silicon Valley's gender gap is the result of computer-game marketing 20 years ago. *Quartz*, February 16, 2017. https://qz.com/911737/silicon-valleys-gender-gap-is-the-result-of-computer-game-marketing-20-years-ago/ (accessed January 30, 2018).

Ashcraft, Catherine, Brad McLain, and Elizabeth Eger. 2016. *Women in tech: The facts.* National Center for Women & Technology (NCWIT).

Atkinson, Joe. 2015. From Computers to Leaders: Women at NASA Langley. *NASA*, August 24, 2015. https://www.nasa.gov/larc/from-computers-to-leaders-women-at-nasa-langley (accessed January 30, 2018).

Augustin, Camille. 2018. Gladys West, Who Influenced GPS Technology, Inducted Into Air Force Hall Of Fame. Vibe, December 24, 2018. https://www.vibe.com/2018/12/gladys-west-gps-inventor-air-force-hall-of-fame (accessed January 30, 2018).

Backus, John. 1978. The history of Fortran I, II, and III. *ACM Sigplan Notices* 13 (8): 165-180.
Badenhausen, Kurt. 2018. The World's Most Valuable Brands 2018. *Forbes*, May 23, 2018.
https://www.forbes.com/sites/kurtbadenhausen/2018/05/23/the-worlds-most-valuable-brands-2018/#77821b05610c (accessed January 30, 2018).

Ball, Joan. 2014. *Just me.* Lulu.com.

Barr, Valerie. 2014. Much ado about salary: Grace hopper and satya nadella. *ACM SIGCAS Computers and Society* 44 (4): 13-14.

Bashen, Janet, Marjana Lindsey Roach, and Donnie Moore. 2006. Method, apparatus and system for processing compliance actions over a wide area network. U.S. Patent 6, 985, 922, issued October 1, 2006.

Batey, Mavis. 2017. *Dilly: The man who broke Enigmas.* Biteback Publishing.

Battelle, John. 2006. The Birth of Google. *Wired*, January 8, 2006.
https://www.wired.com/2005/08/battelle/ (accessed January 30, 2018).

Beckwith, Laura, and Margaret Burnett. 2004. Gender: An important factor in end-user programming environments? In *Visual Languages and Human Centric Computing*, IEEE Symposium (IEEE): 107-114.

Bemer, Robert W. 1971. A View of the History of COBOL. *Honeywell Computer Journal* 5 (3): 130-135.

Bergin, Thomas J. Tim. 2009. Jean Sammet: Programming Language Contributor and Historian, and ACM President. *IEEE Annals of the History of Computing* 31 (1): 76-85.

Berners-Lee, Timothy J. 1989 *Information management: A proposal.* No. CERN-DD-89-001-OC.

Beyer, Kurt W. 2015. *Grace Hopper and the invention of the information age.* BookBaby.

Bhattacharya, Ananya. 2017. Worldwide PC sales are exactly where they were in 2008. *Quartz*, February 13, 2017.
https://qz.com/908201/worldwide-pc-sales-are-exactly-where-they-were-in-2008/ (accessed January 30, 2018).

Bjorhus, Jennifer. 2015. Obituary: Irma Wyman was Honeywell's first female CIO, Episcopal deacon. *Star Tribune*, November 24, 2015.
http://www.startribune.com/irma-wyman-honeywell-s-first-female-cio-episcopal-deacon/353286831/ (accessed January 30, 2018).

Blanch, Gertrude, and Ida Rhodes. 1974. Table Making at NBS. *Studies in Numerical Analysis, Papers in Honor of Cornelius Lanczos*, Royal Irish Academy, Dublin, and Academic Press, New York: 1-6.

Borg, Anita. 1999. What draws women to and keeps women in computing? *Annals of the New York Academy of Sciences* 869 (1): 102-105.

Bosker, Bianca. 2011. Ruchi Sanghvi, Facebook's First Female Engineer: It Was Difficult to Break into The Boys' Club. Huffpost, September 14, 2011.
https://www.huffpostbrasil.com/entry/ruchi-sanghvi-facebook-female-engineer_n_961148?ec_carp=7685636822033041147 (accessed January 30, 2018).

Bouman, Amber. 2011. The 15 Most Important Women in Tech History. *Maximum PC*, March 8, 2011.
http://www.maximumpc.com/article/features/15_most_important_women_tech_history (accessed January 30, 2018).

Bowman, Lisa. 1999. She-geeks confess love for Linux. ZDNet, September 15, 1999.
https://web.archive.org/web/20070625151809/http://news.zdnet.com/2100-9595_22-515695.html?legacy=zdnn (accessed January 30, 2018).

Boyd, Danah M., and Nicole B. Ellison. 2007. Social network sites: Definition, history, and scholarship. *Journal of computer-mediated Communication* 13 (1): 210-230.

Braukus, Michael. 2003. TNASA Honors Apollo Engineer. *NASA News*, September 3, 2003.
http://www.maximumpc.com/article/features/15_most_important_women_tech_history (accessed January 30, 2018).

Brinkman, William F., Douglas E. Haggan, and William W. Troutman. 1997. A history of the invention of the transistor and where it will lead us. *IEEE Journal of Solid-State Circuits* 32 (12): 1858-1865.

Bromley, Allan G. 1982. Charles Babbage's analytical engine, 1838. *Annals of the History of Computing* 4 (3): 196-217.

Burnett, Margaret 2017. Oral history interview with Margaret Burnett. *Valley Library, Oregon State University.*

Butterly, Amelia. 2018. 100 Women: Gladys West - the 'hidden figure' of GPS. BBC News, May 20, 2018.
https://www.bbc.com/news/world-43812053 (accessed January 30, 2018).

Campbell-Kelly, Martin. 2018. *Computer, Student Economy Edition: A History of the Information Machine.* Routledge.

Campbell, Scott M. 2003. Beatrice Helen Worsley: Canada's female computer pioneer. *IEEE Annals of the History of Computing* 25 (4): 51-62.

Carmel, David, Lawrence Adam Darlow, Shai Fine, and Elad Yom-Tov. 2008. Prediction of query difficulty for a generic search engine. U.S. Patent 7,406,462, issued July 29, 2008.

Chang, Andrea. 2012. Google executive Marissa Mayer named Yahoo's new chief executive. *Los Angeles Times*, July 16, 2012.
https://www.latimes.com/business/technology/la-fi-tn-yahoo-ceo-marissa-mayer-20120716-story.html (accessed January 30, 2018).

Choi, Charles Q. 2016. First Reprogrammable Quantum Computer Created. *Live Science*, August 3, 2016.
https://www.livescience.com/55642-reprogrammable-quantum-computer-created.html (accessed January 30, 2018).

Clark, Wesley A. 1987. The LINC was early and small. In *Proceedings of ACM conference on History of medical informatics* (ACM): 51-73.

Cohoon, J. McGrath, and William Aspray. 2006. *Women and information technology: Research on underrepresentation.* The MIT Press.

Conger, Kate and Sheera Frenkel. 2018. Dozens at Facebook Unite to Challenge Its 'Intolerant' Liberal Culture. *New York Times*, August 28, 2018.
https://www.nytimes.com/2018/08/28/technology/inside-facebook-employees-political-bias.html (accessed January 30, 2018).

Copeland, B. Jack. 2010. *Colossus: The secrets of Bletchley Park's code-breaking computers.* Oxford University Press.

Cringely, Robert X. 1996. *The Triumph of the Nerds: The Rise of Accidental Empires. Transcription.* Directed by Robert X. Cringely. Portland: Oregon Public Broadcasting.

Crull, Elise, and Guido Bacciagaluppi. 2016. *Grete Hermann-Between Physics and Philosophy.* Springer.

Davey, Melissa. 2016. Meet the woman leading the race to build the world's first quantum computer. *The Guardian*, January 1, 2016.
https://www.theguardian.com/technology/2016/jan/02/meet-the-woman-leading-the-race-to-build-the-worlds-first-quantum-computer (accessed January 30, 2018).

Davidson, Martha. 2005. Innovative Lives: Janese Swanson, Beyond Pink and Fluffy. *Lemelson Center*, March 3, 2005.
http://invention.si.edu/innovative-lives-janese-swanson-beyond-pink-and-fluffy (accessed January 30, 2018).

De Beauvoir, Simone. 1989. *Le deuxième sexe.* Vintage.

Delve, Janet. 2007. Joseph Marie Jacquard: Inventor of the Jacquard Loom. *Annals of the History of Computing* 29 (4): 98-102.

Ebony. 2012. EBONY reveals 2012 Power 100! *Ebony*, November 1, 2012.
https://www.ebony.com/entertainment/ebony-reveals-its-2012-power-100-list-100/

79

(accessed January 30, 2018).

Eckhart, Barry J., and Erna S. Hoover. 1971. Feedback control monitor for stored program data processing system. U. S. Patent 3,623,007, issued November 23, 1971.

Edwards, Benj. 2013. E30 years of the Apple Lisa and the Apple IIe *Macworld*, January 18, 2013. https://www.macworld.com/article/2025408/macs/30-years-of-the-apple-lisa-and-the-apple-iie.html (accessed January 30, 2018).

English, William K., Douglas C. Engelbart, and Melvyn L. Berman. 1967. Display-selection techniques for text manipulation. *IEEE Transactions on Human Factors in Electronics* (1): 5-15.

Ehrlinger, Joyce, and David Dunning. 2003. How chronic self-views influence (and potentially mislead) estimates of performance. *Journal of personality and social psychology* 84 (1): 5.

Essinger, James. 2014. *Ada's algorithm: How Lord Byron's daughter Ada Lovelace launched the digital age.* Melville House.

Fausto-Sterling, Anne. 2008. *Myths of gender: Biological theories about women and men.* Basic Books.

Feinler, Elizabeth. 2010. The Network Information Center and its Archives. *IEEE Annals of the History of Computing* 32 (3): 83-89.

Floyd, Sally, and Van Jacobson. 1993. Random early detection gateways for congestion avoidance. *IEEE/ACM Transactions on networking* 1 (4): 397-413.

Fox, Margaret R. 1984. Oral history interview with Margaret R. Fox. *Charles Babbage Institute.*

Fox, Phyllis. 2005. Oral history interview with Phyllis Fox. *Society for Industrial and Applied Mathematics.*

Frenkel, Karen A. 1990. Women and computing. *Communications of the ACM 33* (11): 34-46.

Fritz, W. Barkley. 1996. The women of ENIAC. *IEEE Annals of the History of Computing* 18 (3): 13-28.

Fuechsle, Martin, Jill A. Miwa, Suddhasatta Mahapatra, Hoon Ryu, Sunhee Lee, Oliver Warschkow, Lloyd CL Hollenberg, Gerhard Klimeck, and Michelle Y. Simmons. 2012. A single-atom transistor. *Nature nanotechnology* 7 (4): 242.

Fuegi, John, and Jo Francis. 2003. Lovelace & Babbage and the creation of the 1843 'notes'. *IEEE Annals of the History of Computing* 25 (4): 16-26.

Gabbert, Paula, and Paige H. Meeker. 2002. Support communities for women in computing. *ACM SIGCSE Bulletin* 34 (2): 62-65.

Garnsey, Elizabeth, Gianni Lorenzoni, and Simone Ferriani. 2008. Speciation through entrepreneurial spin-off: The Acorn-ARM story. *Research Policy* 37 (2): 210-224.

Gay, Martin. 2000. *Recent Advances and Issues in Computers.* Greenwood Publishing Group.

Gilbert, Lynn and Gaylen Moore. 2012 *Grace Murray Hopper: Women of Wisdom.* Lynn Gilbert Inc.

Gilpin, Lyndsey. 2014. Black Girls Code founder Kimberly Bryant: Engineer. Entrepreneur. Mother. *TechRepublic*, April 7 2014. https://www.techrepublic.com/article/black-girls-code-founder-kimberly-bryant-engineer-entrepreneur-mother/. (accessed January 30, 2018).

Goldwasser, Shafi, Silvio Micali, and Charles Rackoff. 1989. The knowledge complexity of interactive proof systems. *SIAM Journal on computing* 18 (1): 186-208.

Gonzalez, Robbie. 2016. Iconic Designer Susan Kare Explains How ⌘ Came to Be. *Wired*, April 2, 2016. https://www.wired.com/2016/02/iconic-iconographer-susan-kare-explains-how-%E2%8C%98-came-to-be/ (accessed January 30, 2018).

Goyal, Amita. 1996. Women in computing: historical roles, the perpetual glass ceiling, and current opportunities. *IEEE Annals of the History of Computing* 18 (3): 36-42.

Grad, Burton. 2007. The creation and the demise of VisiCalc. *IEEE Annals of the History of Computing* 29 (3).

Greif, Irene. 1975. Semantics of communicating parallel processes. PhD diss., Massachusetts Institute of Technology.

Grier, David Alan. 1997. Gertrude blanch of the mathematical tables project. *IEEE Annals of the History of Computing* 19 (4): 18-27.

Grier, David Alan. 2013. *When computers were human.* Princeton University Press.

Gueorguieva, Vassia. 2008. Voters, MySpace, and YouTube: The impact of alternative communication channels on the 2006 election cycle and beyond. *Social Science Computer Review* 26 (3): 288-300.

Gürer, Denise, and Tracy Camp. 2002. An ACM-W literature review on women in computing. *ACM SIGCSE Bulletin 34* (2): 121-127.

Gürer, Denise. 1995. Pioneering women in computer science. *Communications of the ACM 38* (1): 45-55.

Guynn, Jessica. 2014. No boys allowed: Girls Who Code takes on gender gap. *USA Today*, August 12 2014. https://www.usatoday.com/story/tech/2014/08/12/girls-who-code-facebook-sheryl-sandberg/13784445/ (accessed January 30, 2018).

Halacy, Daniel Stephen. 2010. *Charles Babbage, father of the computer.* Crowell-Collier Press.

Hamilton, M., and William R. Hackler. 2007. Universal Systems Language for Preventative Systems Engineering. In *Proc. 5th Ann. Conf. Systems Eng. Res.*

Hamilton, Margaret H., and William R. Hackler. 2008. Universal systems language: lessons learned from Apollo. *Computer* 41 (12): 34-43.

Hammerman, Robin, and Andrew L. Russell. 2015. *Ada's Legacy: Cultures of Computing from the Victorian to the Digital Age.* Morgan & Claypool.

Henn, Steve. 2014. When women stopped coding. *NPR Planet Money* (21).

Herring, Susan C. 1992. Gender and Participation in Computer-Mediated Linguistic Discourse. *ERIC Clearinghouse on Languages and Linguistic.*

Hess, Amanda. 2014. Why women aren't welcome on the Internet. *Pacific Standard* (6).

Hesseldahl, Arik. 2011. Oracle Co-President Safra Catz Adds CFO Duties as Jeff Epstein Leaves. *All Things D*, April 25, 2011. http://allthingsd.com/20110425/oracle-co-president-safra-catz-adds-cfo-duties-as-jeff-epstein-leaves/ (accessed January 30, 2018).

Hicks, Marie. 2017. *Programmed inequality: How Britain discarded women technologists and lost its edge in computing.* MIT Press.

Hinchliffe, Tim. 2018. DARPA launches AI chemistry program to develop new molecules for military use. *The Sociable*, October 5, 2018. https://sociable.co/technology/darpa-ai-chemistry-molecules-military/ (accessed January 30, 2018).

Hocks, Mary E. 1999. Feminist interventions in electronic environments. *Computers and Composition* 16 (1): 107-119.

Hollings, Christopher, Ursula Martin, and Adrian Rice. 2018. *Ada Lovelace: The Making of a Computer Scientist*. BoD.

Howard, Caroline. 2014. Putin Vs. Obama: The World's Most Powerful People 2014. *Forbes*, November 5, 2014. https://sociable.co/technology/darpa-ai-chemistry-molecules-military/_ (accessed January 30, 2018).

Israel, Brett. 2017. Shafi Goldwasser appointed director of the Simons Institute for the Theory of Computing. *UC Berkeley News*, October 10, 2017. https://news.berkeley.edu/2017/10/10/shafi-goldwasser-appointed-director-of-the-simons-institute-for-the-theory-of-computing/ (accessed January 30, 2018).

James DiSalvo, Betsy, Sarita Yardi, Mark Guzdial, Tom McKlin, Charles Meadows, Kenneth

Perry, and Amy Bruckman. 2011. African American men constructing computing identity. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (ACM): 2967-2970.

Johnson, George. 2005. *Miss Leavitt's stars: The untold story of the woman who discovered how to measure the universe.* WW Norton & Company.

Jones, Claire. 2009. Femininity and Mathematics at Cambridge circa 1900. In *Women, Education, and Agency* 1600–2000 (Routledge): 163-183.

Kastrenakes, Jacob. 2015. Pinterest hires early Apple designer Susan Kare. *The Verge*, July 31, 2015. https://www.theverge.com/2015/7/31/9080511/susan-kare-pinterest-hires-as-product-design-lead (accessed January 30, 2018).

Kent, Steven L. 2010. *The Ultimate History of Video Games: from Pong to Pokemon and beyond... the story behind the craze that touched our li ves and changed the world.* Three Rivers Press.

Khomh, Foutse, Tejinder Dhaliwal, Ying Zou, and Bram Adams. 2012. Do faster releases improve software quality?: an empirical case study of Mozilla Firefox. In *Proceedings of the 9th IEEE Working Conference on Mining Software Repositories,* (IEEE): 179-188.

Kienapple, Bronwyn. 2011. 'Ladies Learning Code' Helping Women Crack the Coding Ceiling. *Torontoist*, October 11, 2011. https://torontoist.com/2011/10/ladies-learning-code-helping-women-crack-the-coding-ceiling/ (accessed January 30, 2018).

Kiss, Jemima. 2010. Steve Jobs on Adobe, Gizmodo and why iPad came before iPhone. *The Guardian,* June 2, 2010. https://www.theguardian.com/media/pda/2010/jun/02/apple-steve-jobs (accessed January 30, 2018).

Kresser, S. L., and R. J. Sippel. 1962. Publications of the Jet Propulsion Laboratory, July 1961 through June 1962.

Lansner, Jonathan. 2015. Linksys sheds merger blues: Irvine firm that once dominated router industry has returned to its roots after years under Cisco. *Orange County Register*, July 18, 2015. https://www.ocregister.com/2015/07/18/linksys-sheds-merger-blues-irvine-firm-that-once-dominated-router-industry-has-returned-to-its-roots-after-years-under-cisco/ (accessed January 30, 2018).

Layne, Margaret E. 2009. *Women in Engineering: Pioneers and Trailblazers.* ASCE Publications.

Liskov, Barbara H., and Jeannette M. Wing. 1994. A behavioral notion of subtyping. *ACM Transactions on Programming Languages and Systems (TOPLAS)* 16 (6): 1811-1841.

Louro, Guacira Lopes. 1997. *Gênero, sexualidade e educação.* Petrópolis: vozes.

Lynn, Samara. 2016. How Janet Bashen became a software pioneer. *Black Enterprise*, February 9, 2016. https://www.blackenterprise.com/how-janet-bashen-became-a-software-pioneer/ (accessed January 30, 2018).

Magid, Lawrence. 1990. Windows 3.0 opens up a new world for users of IBM and its clones. *The Washington post,* May 28, 1990. https://www.washingtonpost.com/archive/business/1990/05/28/windows-30-opens-up-a-new-world-for-users-of-ibm-and-its-clones/88ef230c-89a3-4560-8bf4-bbbcbdb77d71/?noredirect=on&utm_term=.6e8bedb57c2d (accessed January 30, 2018).

Mahoney, Michael S. 1989. *An oral history of Unix.* Princeton University.

Mardesich, Jodi. 1994. Networking Groups Strive to Put Women Back in Loop. *InfoWorld*, October 17, 1994, 84.

Margolis, Jane, and Allan Fisher. 2003. *Unlocking the clubhouse: Women in computing.* MIT

82

press.

Markoff, John. 2005. A New Company to Focus on Artificial Intelligences. *New York Times*, March 24, 2005.
https://www.nytimes.com/2005/03/24/technology/a-new-company-to-focus-on-artificial-intelligence.html (accessed January 30, 2018).

Markoff, John. 2006. Alan F. Shugart, 76, a Developer of Disk Drive Industry, Dies. *New York Times*, December 15, 2006.
https://www.nytimes.com/2006/12/15/obituaries/15shugart.html?_r=1&oref=slogin (accessed January 30, 2018).

Markoff, John. 2011. It Started Digital Wheels Turning. *New York Times*, November 7 2011.
https://www.nytimes.com/2011/11/08/science/computer-experts-building-1830s-babbage-analytical-engine.html (accessed January 30, 2018).

Marlow, Vanda. 2000. Silicon Giants: Palm's pilot makes Handspring fly. *The Telegraph*, August 13, 2000.
https://www.telegraph.co.uk/finance/personalfinance/comment/4461726/Silicon-Giants-Palms-pilot-makes-Handspring-fly.html (accessed January 30, 2018).

Marx, David M., Diederik A. Stapel, and Dominique Muller. 2005. We can do it: the interplay of construal orientation and social comparisons under threat. *Journal of personality and social psychology* 88 (3): 432.

Mather, John. 2007. iMania. *Ryerson Review of Journalism*, February 19 2007.
https://web.archive.org/web/20070303032701/http://www.rrj.ca/online/658/ (accessed January 30, 2018).

McClure, Laura. 2000. Feminist Pedagogy and the Classics. *The Classical World* 94 (1): 53-55.

McCullough, Brian. 2015. The web in 1999. *Internet History Podcast*, June 12 2015.
http://www.internethistorypodcast.com/2015/06/how-teens-spent-time-on-the-web-in-1999/ (accessed January 30, 2018).

McGee, Marianne Kolbasuk. 2007. There's Still A Shortage of Women In Tech, First Female Turing Award Winner Warns. *InformationWeek*, February 23 2007.
https://www.informationweek.com/theres-still-a-shortage-of-women-in-tech-first-female-turing-award-winner-warns/d/d-id/1052276 (accessed January 30, 2018).

Metcalfe, Robert M., and David R. Boggs. 1976. Ethernet: Distributed packet switching for local computer networks. *Communications of the ACM* 19 (7): 395-404.

Metz, Cade. 2011. IBM names Virginia Rometty as first female CEO. *Wired*, October 25 2011.
https://www.wired.com/2011/10/virginia-rometty/ (accessed January 30, 2018).

Mizukami, Maria da Graça Nicoletti. 1986. *Ensino: as abordagens do processo*. São Paulo: Editora Pedagógica e Universitária.

Mochetti, Karina, Raquel Bravo, Luciana Salgado, Carla Leitao, Camille Braga, Gabriela Hecksher, and Kayalla Pontes. 2017. Discussao da posiçao de calouras de ciência da computaçao. In *11° Women in Information Technology* vol. 11 (SBC).

Moore, Doris L. 1977. *Ada, Countess of Lovelace: Byron's legitimate daughter.* HarperCollins Publishers.

Moore, Gordon E. 1996. Intel: Memories and the Microprocessor. *Daedalus* 125 (2): 55-80.

Moore, Matthew. 2009. Oldest domain name on the internet symbolics.com is finally sold. *Telegraph*, September 1, 2009.
https://www.telegraph.co.uk/technology/6120694/Oldest-domain-name-on-the-internet-symbolics.com-is-finally-sold.html (accessed January 30, 2018).

Morgado, Leonel, Maria Cruz, and Ken Kahn. 2006. Radia Perlman - A pioneer of young children computer programming. *Current developments in technology-assisted education*. (m-ICTE): 1903-1908.

Morris, Meredith Ringle. 2018. Reflections – the Grace Hopper Conference past and present. *Microsoft*, September 26, 2018.
https://www.microsoft.com/en-us/research/blog/reflections-the-grace-hopper-

83

conference-past-and-present/ (accessed January 30, 2018).

Morrison, Sara. 2013. Yahoo CEO Marissa Mayer First Female to Top Annual 40 Under 40 List. *The Wrap*, September 19, 2013.
https://www.thewrap.com/fortunes-40-under-40-twitter-tops-facebook/
(accessed January 30, 2018).

Nemeh, Katherine H., and Pamela M. Kalte. 2003. *American men & women of science a biographical directory of today's leaders in physical, biological and related sciences American men and women of science* v. 4, Thomson Gale.

Orbach, Meir. 2017. Yahoo Senior Executive Yoelle Maarek Moves to Amazon *CTech*, September 19, 2017.
https://www.calcalistech.com/ctech/articles/0,7340,L-3721562,00.html
(accessed January 30, 2018).

Parker, Donn B., Susan Nycum and S. Stephen Oüra. 1973. *Computer abuse: final report.* Stanford Research Institute.

Paxson, Vern, and Sally Floyd. 1997. Why we don't know how to simulate the Internet. In *Proceedings of the 29th conference on Winter simulation* (IEEE): 1037-1044.

Peak, Krystal. 2012. Dropbox acquires Cove for strong leadership team. *Vator*, February 27, 2012.
https://vator.tv/news/2012-02-27-dropbox-acquires-cove-for-strong-leadership-team
(accessed January 30, 2018).

Pearson Jr, Willie, Lisa M. Frehill, and Connie L. McNeely. 2015. *Advancing women in science: An international perspective.* Springer.

Pepitone, Julianne. 2009. Yahoo names Bartz new CEO. *CNN Money*, January 13, 2009.
https://money.cnn.com/2009/01/13/technology/yahoo_ceo/index.html (accessed January 30, 2018).

Perlman, Radia. 1985. An algorithm for distributed computation of a spanningtree in an extended lan. In *ACM SIGCOMM Computer Communication Review*, vol. 15 (4): 44-53.

Piazza, Domenica Di. 2018. *Space Engineer and Scientist Margaret Hamilton.* Minneapolis: Lerner Publications.

Randall, James. 2005. Hash function update due to potential weakness found in sha-1. *RSA Laboratories*, Technical Note.

Reimer, Jeremy. 2005. Total share: 30 years of personal computer market share figures. *Ars Technica* 15.

Rhodes, Richard. 2012. *Hedy's Folly: The life and breakthrough inventions of Hedy Lamarr, the most beautiful woman in the world.* Vintage.

Robertson, Stephen, and John Tait. 2008. Karen Spärck Jones. *Journal of the American Society for Information Science and Technology* 59 (5): 852-854.

Rosen, Rebecca J. 2014. Radia Perlman: Don't Call Me the Mother of the Internet. *The Atlantic*, March 3 2014.
https://www.theatlantic.com/technology/archive/2014/03/radia-perlman-dont-call-me-the-mother-of-the-internet/284146/ (accessed January 30, 2018).

Roughgarden, Tim, and Éva Tardos. 2002. How bad is selfish routing? *Journal of the ACM (JACM)* 49 (2): 236-259.

Rubinstein, Seymour. 2006. Recollections: The rise and fall of wordstar. *IEEE Annals of the History of Computing* 28 (4).

Santitoro, Ralph. 2003. Metro Ethernet Services - A Technical Overview. In *Metro Ethernet Forum*, vol. 2006.

Shah, Angilee. 2012. Geek Chicks: PyLadies, a Gang of Female Computer Programmers. *LA Weekly*, February 16 2012.
https://www.laweekly.com/arts/geek-chicks-pyladies-a-gang-of-female-computer-programmers-2373431 (accessed January 30, 2018).

Shattuck, Justin. 2010. Herding Code 90: Sara Chipps on Girl Develop IT and Girls

84

Developing Software. *Herding Code*, August 12 2010.
http://herdingcode.com/herding-code-90-sara-chipps-on-girl-develop-it-and-girls-developing-software/ (accessed January 30, 2018).

Shaw, Mary. 1971. Language Structures for Contractible Compilers. PhD diss., Carnegie-Mellon University.

Shirley, Dame Stephanie and Richard Askwith. 2017. *Dilly: Let IT Go: The Memoirs of Dame Stephanie Shirley.* Andrews UK Limited.

Sim, Bérengère. 2018. In Davos, Pioneering Women Are Chosen to Lead Again. *The New York Times*, January 21 2018.
https://www.nytimes.com/2018/01/21/business/davos-world-economic-forum-women-leaders.html (accessed January 30, 2018).

Smith, Aaron, Laurie Segall and Stacy Cowley. 2012. Facebook reaches one billion users. *CNN Business*, October 4 2012.
https://money.cnn.com/2012/10/04/technology/facebook-billion-users/index.html (accessed January 30, 2018).

Steele, Guy L., Jr. 2011. An Interview with Frances E. Allen. *Communications of the ACM* (January 2011): 39-45.

Stevenson, Angus. 2010. *Oxford dictionary of English.* Oxford University Press, USA.

Stout, Jane G., and Heather M. Wright. 2016. Lesbian, Gay, Bisexual, Transgender, and Queer Students' Sense of Belonging in Computing: An Intersectional Approach. *Computing in Science & Engineering* 18 (3): 24-30.

Stratigakos, Despina. 2016. Unforgetting Women Architects: From the Pritzker to Wikipedia. *Places Journal.*

Suellentrop, Chris. 2014. Saluting the Women Behind the Screen. *New York Times*, April 19, 2014.
https://www.nytimes.com/2014/08/20/arts/video-games/those-underappreciated-female-video-game-pioneers.html (accessed January 30, 2018).

Sutter, John D. 2012. Marissa Mayer: From Google 'geek' to Yahoo CEO. *CNN Business*, July 18, 2012.
https://edition.cnn.com/2012/07/16/tech/web/marissa-mayer-bio/index.html (accessed January 30, 2018).

Tardos, Éva. 1985. A strongly polynomial minimum cost circulation algorithm. *Combinatorica* 5 (3): 247-255.

Tatnall, Arthur. 2010. History of Computing: Learning from the Past *IFIP WG 9.7 International Conference*, vol. 325 (Springer).

Thumfart, Von Johannes. 2011. Emanzipation durch Computer. *Zeit Online*, March 19, 2011.
https://www.zeit.de/digital/internet/2011-03/floyd-informatik-frauen/komplettansicht (accessed January 30, 2018).

Tickle, Louise. 2017. Dame Stephanie Shirley: we were part of a crusade to get women into business. *The Guardian*, March 8, 2017.
https://www.theguardian.com/small-business-network/2017/mar/08/dame-stephanie-shirley-flexible-remote-working-glass-ceiling (accessed January 30, 2018).

Vishveshwara, C. V. 2015. The First Rung of the Cosmic Ladder. In *Universe Unveiled*, Cham (Springer): 121-133.

Wakabayashi, Daisuke. 2017. Google Fires Engineer Who Wrote Memo Questioning Women in Tech. *New York Times*, August 7, 2017.
https://www.nytimes.com/2017/08/07/business/google-women-engineer-fired-memo.html (accessed January 30, 2018).

Walkerdine, Valerie. 1995. O raciocínio em tempos pós-modernos. *Educação & Realidade* 20 (2).

Warner, Malcolm. 2012. *Adventures of an Apple Founder: Atari, Apple, Aerospace and Beyond.* 512K Entertainment.

85

Weisman, Robert. 2009. Top prize in computing goes to MIT professor. *The Boston Globe*, March 10, 2009.
http://archive.boston.com/business/technology/articles/2009/03/10/top_prize_in_com
puting_goes_to_mit_professor/ (accessed January 30, 2018).

West, Gladys B. 1986. *Data Processing System Specifications for the GEOSAT Satellite Radar Altimeter.* No. NSWC/TR-86-149. Naval Surface Weapons Center Dahlgren VA.

Williams, Kathleen Broome. 1999. Scientists in Uniform: The Harvard Computation Laboratory in World War II. *Naval War College Review* 52 (3): 90.

Yang, Jia Lynn. 2011. Meg Whitman named CEO of Hewlett-Packard. *The Washington Post*, September 22, 2011.
https://www.washingtonpost.com/business/economy/2011/09/22/gIQAYe1UoK_story.
html?noredirect=on&utm_term=.fe2137269017 (accessed January 30, 2018).

Zemanek, Heinz. 1993. Johanna Piesch. *Ann. Hist. Comp.* 15 (3): 72.

Zhang, Lixia, Steve Deering, Deborah Estrin, Scott Shenker, and Daniel Zappala. 1993. RSVP: A new resource reservation protocol. *IEEE network* 7 (5): 8-18.

Zierdt-Warshaw, Linda. 2000. *American women in technology: an encyclopedia.* Santa Barbara, Calif.: ABC-CLIO.

Appendix

The following women were presented at this paper:

- Frances Elizabeth Allen (1932 –)
- Ruth Leach Amonette (1916 – 2004)
- Joan Ball (1934 –)
- Carol Bartz (1948 –)
- Janet Emerson Bashen (1957 –)
- Mavis Batey (1921 – 2013)
- Dona Bailey
- Fran Bilas (1922 – 2012)
- Gertrude Blanch (1897 – 1996)
- Anita Borg (1949 – 2003)
- Margaret Burnett (1949 –)
- Sara Catz (1961 –)
- Beatrice Cave-Browne-Cave (1874 – 1947)
- Lorinda Cherry
- Edith Clarke (1883 – 1959)
- Donna Dubinsky (1955 –)
- Elizabeth Feinler (1931 –)
- Christiane Floyd (1943 –)
- Sally Floyd (1953 –)
- Margaret R. Fox (1916 – 2006)

- Phyllis Fox (1923 –)

- Irene Greif

- Adele Goldberg (1945 –)

- Shafi Goldwasser (1958 –)

- Margaret Hamilton (1936 –)

- Grete Hermann (1901 – 1984)

- Betty Holberton (1917 – 2001)

- Erna Schneider Hoover (1926 –)

- Grace Hopper (1906 – 1992)

- Betty Jean Jennings (1924 – 2011)

- Karen Spärck Jones (1935 – 2007)

- Susan Kare (1954 –)

- Sister Mary Kenneth Keller (1913 – 1985)

- Sandra Kurtzig (1947 –)

- Hedy Lamarr (1914 – 1953)

- Henrietta Swan Leavitt (1868 – 1921)

- Ruth Lichterman (1924 – 1986)

- Barbara Liskov (1939 –)

- Ada Lovelace (1815 – 1852)

- Yoelle Maarek

- Marissa Mayer (1975 –)

- Kay McNulty (1921 – 2006)

- Carla Meninsky

- Radia Perlman (1951 –)

- Johanna Piesch (1898 – 1992)

- Ida Rhodes (1900 – 1986)

- Ginni Rometty (1957 –)

- Jean E. Sammet (1928 – 2017)

- Ruchi Sanghvi (1982 –)

- Carol Shaw (1955 –)

- Mary Shaw (1943 –)

- Michelle Simmons (1967 –)

- Dame Stephanie Shirley (1933 –)

- Janese Swanson (1958 –)

- Éva Tardos (1957 –)

- Janie Tsao (1953 –)
- Dana Ulery (1938 –)
- Dorothy Vaughan (1910 – 2008)
- Xiaoyun Wang (1966 –)
- Marlyn Wescoff (1922 – 2008)
- Gladys West (1930 –)
- Sophie Wilson (1957 –)
- Elizabeth Webb Wilson (1896 – 1980)
- Mary Allen Wilkes (1937 –)
- Jeannette Wing (1956 –)
- Meg Whitman (1956 –)
- Beatrice Worsley (1921 – 1972)
- Irma Wyman (1928 – 2015)
- Lixia Zhang (1951 –)