Grace Murray Hopper ; *Grandma COBOL*

Software engineering is a relatively new discipline, with the term only being coined in the 1960's by Nasa engineer Margaret Hamilton (George, 2019). However, a quick google search for 'famous software engineers' would leads one to conclude that software engineering is not as progressive as it seems to be, with women appearing to have made few contributions to the discipline in the past. The first suggested link will lead you to a list of the 'top ten famous software engineers', who are all men (Wegerer, 2021). The next link offer ranking of 'famous software engineers', one must read to number thirty eight on this list before reaching the first *famous* female software engineer; Jutta Degener (Ranker, 2021).

Despite the surface level results, further digging will unveil that in fact many women have been paramount to the success of software development. From Ada Lovelace, a mathematician in the 1800's who is known as the first computer programmer, to Julia Liuson, the vice president of *Visual Studios,* a tool used widely by software engineers today (Tellicherry, 2021). Another noteworthy individual is Grace Hopper; a computer scientist and US Naval officer who played a key role in the development of software engineering as a discipline and who will be the focus of this biographical piece. A pioneer in her field, Grace Hopper is credited with the creation of some of the earliest computers and the invention of the first computer compiler. Additionally, Grace popularized the concept of machine independent programming languages and the practice of documentation of systems in order to encourage their wide spread use by non-technical individuals (YaleNews, 2017).

Born in 1906 in New York City, Grace was the oldest of three children. As an inquisitive child, she would often take apart household items to examine how they worked. It is said that it was only after Grace dismantled seven alarm clocks, that her parents realized that how curious she was. Having a high aptitude in mathematics along with strong ambition, Grace applied for early admission to Vassar College at the age of 16. Despite being initially rejected, Hopper persisted and was accepted into a degree in Mathematics and Physics the following year (scientificWomen, 2021). Hopper graduated from Vassar with a Bachelor's degree in 1928 and graduated from Yale with a Master's degree in Mathematics shortly after . Hopper began teaching mathematics at Vassar College in 1931 while pursing a PhD at Yale under the supervision of renowned mathematician Howard Engstrom. Hopper was one of the first female mathematicians to ever receive a doctorate degree (YaleNews, 2017).

As World War II began in the late 1930's, a high number of opportunities arose for women to enter the workforce. Following the attack on Pearl Harbour, Hopper decided that she wanted to assist in the war efforts. Inspired by her grandfather, who had previously served there, Grace applied to the naval reserve. Being 15 pounds under the minimum required weight, Hopper was initially rejected but once again she did not let this discourage her. In 1943, Hopper was

eventually accepted to the navy's WAVES program (Women Accepted for Voluntary Emergency Service) (YaleNews, 2017). This is where Hoppers contributions to computer science and software engineering began in earnest.

Hopper became a lieutenant and was assigned by the navy to the *Bureau of Ships Computation Project* at Harvard in 1944 (Gregersen, 2021). There, Hopper worked under Howard Aiken on the Mark I, an early protocomputer (Freiberger & Swaine, 2014). The Mark I was a breakthrough of its time being the first large scale automatic calculator and an important precursor to the electronic computer. In 1946, Hopper published *A Manual of Operation for the Automatic Sequence Controlled Calculator,* a 500-page instruction manual for the Mark machines. This was the first documentation which gave instructions on how to program a computer (Gregersen, 2021). Today, clear documentation is a key component of software development, and Hopper played a vital role in encouraging it's adaption.

Hopper turned down a professorship at Vassar University in order to remain working at Harvard under her naval contact. At Harvard, Hopper continued her work on the Mark II and Mark III machines. In 1945, Hopper and her team encountered a problem with the Mark II. Unable to solve the issue, the team dismantled the machine to find that a large moth was stuck in a relay. It is said that the term *debugging* a computer was first coined from this experience. Hopper popularized the term, *bug,* which refers to an unexplainable computer failure and which is now widely used in the programming communities (YaleNews, 2017).

In 1946, Hopper left active service with the Navy as she was denied the regular commissions due to her age. Hopper was also denied tenure at Harvard and consequently left her position at the university soon after (YaleNews, 2017). Yet again, unfazed by these rejections, Hopper went on to bigger and better things. In 1949, Hopper joined *Eckert-Mauchly Computer Corporation* as senior mathematician (Gregersen, 2021). Here, Hopper oversaw the development of the UNIVAC (Universal Automatic Computer), the first all-electronic digital computer (Biography.com, 2021). Keen to continue innovating, Hopper created the first compiler for computer languages. Named *A-0,* Hopper's compiler translated programming instructions into machine readable binary code, something which had never been done before. She remarked "*I had a running compiler and nobody would touch it. They told me computers could only do arithmetic.*" Hopper's forward looking initiative and persistence were clearly reflected in this innovation. The *A-0* was the first step toward allowing programmers to develop programs for numerous machines at once rather than just one. This subsequently allowed for large advancements to be made in computer programming, greatly improving efficiency; a central goal of software engineering today.

In 1954, *Eckert-Mauchly* named Hopper their first ever Director of Automatic Programming. Hopper's department soon released the *Flow Matic* programming language. This was the first compiler based programming language that used English like commands (scientificWomen, 2021). As data processors weren't often mathematicians or engineers, Hopper believed that

word-based programming languages would be easier to use and grasp. Hopper explained this in a 1980 interview stating "*What I was after in beginning English language [programming] was to bring another whole group of people able to use the computer easily … I kept calling for more user friendly languages*" (YaleNews, 2017). Hopper was correct. Today the majority of software engineers work with user friendly languages such as Python and C#.

In the late 1950's as the utilization of computers expanded, there was a strong need for a standard computer programming language. Common Business Orientated Language known as COBOL was introduced for this purpose in 1959. This was the first standardized general business computer language. The COBOL language evolved from the *Flow Matic* language, earning Hopper the nickname "Grandma COBOL." (scientificWomen, 2021). Although Hopper did not invent COBOL, she was a fundamental to its success. Hopper adamantly promoted COBOL's adoption in the US military and in private sectors. In addition, Hopper developed validation software for COBOL and its associated compiler for the US Navy. As a result of these contributions, COBOL became the mostly broadly used computer language in the world by the 1970's (YaleNews, 2017).

During all this time, Hopper had remained as a reserve for the US Navy as well as a visiting and adjunct lecturer at Moore School of Electrical Engineering. However, in what Hopper described as the saddest day of her life, in 1966, she was forced to retire from the navy as a commander due to her age. (Biography.com, 2021)

Unsurprisingly, Hopper's skills were greatly yearned in her absence, and she was recalled to active service just 7 months after her retirement. Hopper spent another 19 years working with the Navy working on standardizing the Navy's computer languages. During this time Hopper implemented standards for testing computer systems for languages such as Fortran and COBOL. These tests were eventually taken on board by the National Bureau of Standards known today as NIST in the 1980 (Gregersen, 2021). Hopper also spent some of this period as a professor at George Washington University, lecturing in management sciences (YaleNews, 2017) .

As the oldest serving officer in the US armed forces, Hopper retired from the Navy for good at the age of 79. However, unable to sit idle and with many more ideas to share, Hopper went on to work as a senior consultant in public relations at Digital Equipment Corporation. Hopper remained working there up until a year before her death. Hopper passed away peacefully in 1992, knowing the huge impact she had on computer and software evolvement and development.

Throughout her lifetime, Hopper received over forty honorary degrees along with many other awards (YaleNews, 2017). In 1962, Hopper was elected a fellow of the Institute of Electrical and Electronic Engineers. In 1969, she was named as the inaugural Data Processing and

Management Association *Man* of the Year (Gregersen, 2021). Soon after this, in 1973, Hopper was the first woman to be titled as a distinguished fellow of the British Computer Society (Norwood, 2017). Moreover, Hopper was awarded the National Medal of Technology by president George Bush in 1991 ; The US's most prestigious technology award at the time. On a more recent note, Barack Obama posthumously awarded Hopper the Presidential Medal of Freedom in 2016 (Gregersen, 2021).

Despite these esteemed and distinguished accomplishments, Hopper's true passion and talents lay with teaching. When asked what she was most proud of on receipt of the National Medal of Technology, Hopper replied "*all the young people I've trained over the years; that's more important than writing the first compiler*" (YaleNews, 2017).Throughout her life, Hopper organized a multitude of conferences, seminars and workshops to encourage the study of computer programming. Hopper spent more than half of her life teaching and she left a tremendous legacy of encouraging young people to learn computer programming. Amid this legacy is the *Hopper Murray* award for the young computer professional of the year offered by the Association for Computing Machinery (Association for Computing Machinery, 2021). Furthermore, in 1944, Anita Borg, an American computer scientist, set up the *Grace Hopper Celebration of Women in Computing.* This celebration involves a series of conferences aimed at highlighting women's research in computer science, encouraging women to pursue careers in this field (anitb.org, 2021).

It is unquestionable that Grace Murray Hopper has had a significant influence on computer programming and software engineering today. From encouraging the widespread use of *debugging* to supporting the large scale adaption of programming through the concept of user friendly programming languages. In addition, Hopper placed a large emphasis on strong use of documentation and testing by software developers; two key principles of software engineering today. Hopper saw the importance of being able to explain this complex systems and languages to others, famously remarking "*I have come to the conclusion that there is no use in doing anything unless you can communicate it*" (YaleNews, 2017).

It is easy to forget that Hopper accomplished all of this while simultaneously working within a male dominated field and gender-biased organizations. This alone highlights her tenacity and unwavering determination, which serve as an inspiration to many students today. Hopper's progressive ideas and positive mindset set her apart from others in the field, making her a memorable and influential figure in the history of software engineering. She has undoubtably inspired a generation of young female software engineers, whose names will soon infiltrate the Google search results for '*famous software engineers'*….

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