



A JO♡SR GUIDE TO

THE INNOVATORS BY WALTER ISAACSON

How a Group of Hackers,
Geniuses and Geeks Created
the Digital Revolution

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Created the Digital Revolution

JO♡SR

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What it's about?

Innovators is an in-depth look at the digital revolution and the people, both known and unknown, who brought it about. Most often it is individuals who are credited with each new technological breakthrough, but in fact these advances are usually the result of long collaboration between many people. Isaacson demonstrates that all innovation is the culmination of generations of work and numerous contributions, because creativity is most effective when it is a team process.

Many people are unaware that the digital revolution began long before the advent of the first computer. Isaacson takes us all the way back to the start of the journey: to 1843 and the important scientific and mathematical collaboration of Charles Babbage and Ada Lovelace. Building on those early beginnings each new decade has brought new innovations and breakthroughs which slowly accumulated to usher in the modern age of computers and constant connectivity.

In *Innovators* Walter Isaacson introduces us to the major contributors to modern technology, both past and present, as well as to some of the lesser-known individuals who played an important role in bringing us our advanced digital technology. In the process we find out that, even in the early days, it was not just men who did pioneering work on computers, but in fact most of the first computer programmers were women.

Our knowledge of the digital revolution is often limited to the individuals who were credited for each theory, invention, and idea. But the truth Isaacson wants us to comprehend is that these famous individuals had the support of many others, who have never received credit for their work. As is the case with every innovation, creativity is a team endeavor.

Ada Lovelace used poetry and mathematics to predict the modern computer

Countess Ada Lovelace was the daughter of the infamous poet Lord Byron and his mathematically inclined wife, Anne. Her life was a constant mix of math and art, a combination that enabled her to envision ideas and possibilities way ahead of her time. She was inspired by and collaborated with the scientist and mathematician Charles Babbage after being impressed by his Difference Engine, a machine he built to solve polynomial equations.

Ada believed fervently in the machine that Babbage proposed to build next, which he dubbed the Analytical Engine. He wanted to design a “computer” that could perform a variety of tasks – rather than just one like his previous machine. Ada was captivated by the idea. One feature of the design that particularly pleased her was that it ran on punch cards, like the mechanical weaving looms she loved.

Babbage envisioned that his Analytical Engine would be able to move between different operations and even direct itself. Taking the innovation one step further, Ada theorized that it would be able to process not just numbers but poetry, musical notation, and artistic patterns. Babbage’s machine was described in French in a set of notes written by Luigi Menabrea, which Ada translated into English. This translation, to which she added her own commentary, almost doubling the length of the original, was published in a scientific journal in 1843.

Ada’s version of Menabrea’s notes went on to become much more influential than the original, and predicted the functionality of future computers. The article contained four concepts that would become famous: the machine would be capable of many purposes; it would work based on sequence operations; it would be able to process anything translated into symbols; and it would never be able to think for itself. She also wrote what has been widely recognized as the first example of a computer program, in the form of a diagram and table explaining the use of the punch cards.

Babbage’s machine was never built, but it was a working idea that served as the basis for the digital revolution to follow. His expertise in machinery combined with Ada’s artistic and mathematic imagination produced an idea that would prove to be quite prophetic.

The computer was the product of many minds

The early 20th century saw the development of many computer-like machines but only a few combined the four important features that define the modern computer. These are: electric components in the core; binary language of 0s and 1s; capability to perform multiple functions; and digital rather than analog workings. The first machine to meet all four of these criteria was the Electronic Numerical Integrator and Computer (ENIAC).

Invented by John Mauchly and J. Presper Eckert in 1945, ENIAC would serve as a prototype for future computers. It could perform 5,000 addition and subtraction computations per second, and had a variety of capabilities. Although none of ENIAC's predecessors met the four important criteria of modern computers, some came close. The Atanasoff-Berry Computer (ABC) was, in fact, so similar that it caused Mauchly and Eckert problems in their fight to patent their invention.

The ABC, invented by John Atanasoff in 1942, lacked the ability to be programmed to perform general purpose functions – it could perform only one function, which was solving linear equations. Despite it not being well known, while in the process of the development of his own machine, Mauchly had heard about it and had become very interested. He had discussed the ABC prototype at length with Atanasoff and had even examined it. Through this sharing of ideas he gleaned important concepts that he later used to make the ENIAC a working machine.

Because of the inherently collaborative nature of these innovations, legal disputes over patents were a constant problem. Honeywell, a technology company, challenged ENIAC's 1964 patent based on the claim that the fundamental concepts were not original to those inventors. Atanasoff was a key witness in the ensuing legal action. In the end the judge found that Mauchly and Eckert had derived their ideas from Atanasoff, and their patent was invalidated.

The computer, like most innovations, was not the brainwave of one or two individuals but was rather the result of many people working separately and together toward a common goal. Mauchly and Eckert benefited from the innovative ideas of numerous other inventors that, in one way or another, helped them develop their machine. When it comes to technological innovation, people simply build on the work of others until someone gets it right.

The first computer programmers were women and so was the first program writer

Computers can only be truly multi-purpose machines if they are programmable. Programming a computer involves creating a sequence of instructions for the machine and then storing these in its electronic memory. The development of this capability paved the way for the fulfillment of Countess Ada Lovelace's dream of a machine that can perform any logical operation and, as already noted, she wrote the very first example of a computer program way before computers even existed.

Nowadays we think of computer programming as a male-dominated industry, but in the early days of computers the process of programming was considered tedious and secondary, and so for this reason the task was relegated to women. The very first computer programmer after Ada Lovelace and her punch cards was Grace Hopper. Hopper was a math professor who signed up for the US Navy during World War II and was subsequently assigned to work on the Mark I computer at Harvard University.

Hopper's remit was to develop a detailed programming manual for the Mark I. With single-minded dedication, she methodically perfected subroutines for frequently performed operations, and approached programming in a collaborative fashion to create instructions of the utmost precision. With the help of her team, she kept refining the manual until each process was perfect. Thanks to Hopper, by 1945 the Mark I was found to be the most easily programmable computer in existence.

Programming early computers was incredibly complex and it could take days to input each new program. The process involved moving cables between outlets, resetting switches, and making constant, minute adjustments. Around the same time that Grace Hopper was working on the Mark I, an all-female team handled all of the programming responsibilities for the ENIAC.

From the very creation of the computer, thanks to the work of Grace Hopper and the ENIAC programmers the world of technology has been just as much the realm of women as of men.

The invention of the transistor paved the way for personal computers

Early computers were massive compared to modern personal computers, with the ENIAC taking up around 1000 square feet of floor space. This made them far too large and costly for public use, and for many years they were limited to universities, government entities, and large corporations. But the invention of the tiny semiconductor known as the transistor paved the way for smaller and cheaper machines by making it possible for complex programs to be run on much smaller devices. This groundbreaking innovation made its way into computer history with the help of three collaborators at Bell Laboratories.

Bell Labs, founded by Alexander Graham Bell for AT&T, has long been famous for the collaborative culture of its research and development teams. From its early days Bell Labs strove to promote individual talent alongside effective teamwork because its pioneers understood the fundamental importance of collaboration to successful innovation. Consequently, they encouraged employees to share and develop ideas together, which has produced excellent results. This collaborative environment created the perfect conditions for innovators John Bardeen, Walter Brattain, and William Shockley to revolutionize the world of computers forever.

Until this point, computers were built using vacuum tubes, which were devices capable of amplifying electronic signals. However, the size and number of these vacuum tubes required computers to be so big that they filled entire rooms, and also meant that they consumed huge amounts of power. This made computers expensive and impractical for general use. The goal of these three innovators at Bell Labs was to eradicate the need for vacuum tubes by switching to semiconductors, thereby shrinking computers and making them much more efficient.

By 1947 the team had fulfilled their goal by inventing the transistor, which used a semiconductor to both amplify an electrical signal and turn it on and off. This device paved the way for the personal computers that are ubiquitous today. Bardeen, Brattain, and Shockley won a Nobel Prize in 1956 for their innovation, but they were only able to achieve this important development through close collaboration and the sharing of knowledge.

Hippies and hackers brought the computer to individuals

It was not until the 1970s that the personal computer became a mass product. Up until that time computers had mostly been used for research. But thanks to the concerted efforts of technology enthusiasts and entrepreneurs, they were put into the hands of the public in general. These “hippies and hackers” congregated in the southern San Francisco Bay Area and began developing hands-on experience and understanding of computers from the inside out. This is the region that has come to be known as Silicon Valley, a leading hub for high-tech innovation and development.

These technology enthusiasts felt passionately that personal computers would empower individuals and change the way people learned, connected, and communicated. Among them was Ed Roberts, who joined forces with his friend Forrest Mims to form Micro Instrumentation and Telemetry Systems (MITS). In 1974 MITS designed the first kit for a basic home computer, the Altair 8800.

This computer needed to be assembled by the buyer, and had no input devices like keyboards or mice. It was incredibly rudimentary by today's standards, but any technology geek with the patience to learn could use it. Technology enthusiasts now had a way to directly interact with computers, which were no longer exclusively controlled by the military or by business. In the first month alone the Altair 8800 was bought by hundreds of individuals, and some were shared socially in tech clubs and circles.

One of these technology social groups was called the Homebrew Computer Club, which was a place where “tech nerds” could collaborate about computer technology, philosophy, and culture. It was here that many techies were inspired by their first experience of the Altair 8800, including two young future programmers, Steve Wozniak and Steve Jobs. This basic computer taught Wozniak about the microprocessor, which he used to design a new computer that would come preassembled and would include a screen and keyboard. It was called the Apple II.

As the components for computers shrank in size, the possibilities for what computers could do grew exponentially. The hippie and hacker counterculture was based on the fundamental principle of the free sharing of ideas and technology in the hope of inspiring and empowering others to take technology into the future. By building on the work of previous innovators, these “tech nerds” made computers personal and brought the technological revolution into our homes.

Competing software makes for better products

The Altair 8800 also inspired two more modern computer giants, Paul Allen and Bill Gates, to develop software for personal computers, and together they formed the company that would later become Microsoft. Their software language, written on punched paper tape, was known as Beginner's All-purpose Symbolic Instruction Code (BASIC), and it became the basis for all software for many decades. It was freely borrowed and copied so that it spread like wildfire. At first, Gates was dismayed by this rampant use of their software, but in the long run it ended up being a positive thing.

With all of the copying, their software spread quickly and BASIC was soon established as the industry standard for personal computer software. It held this position for more than thirty years, and computer hobbyists used it to create their own programs. One of the major reasons for the software's success was that Allen and Gates designed it with the ideal in mind that it would work with almost any computer hardware, regardless of make. As time went on, other companies also began writing computer software and this competition resulted in steady improvement and innovation in the development of software, constantly enhancing the user experience.

Whilst Microsoft promoted the separation of software from hardware, Apple integrated the two to make them a package deal. The Apple computer had its own bespoke software, which was also continually developed to make the user experience better than ever. It was the first instance of a graphical user interface (GUI), which made use of icons instead of typed commands. This gave Apple an advantage over Microsoft and other competitors, until eventually GUI became the standard in all software.

Because the software companies were in constant competition, they were forced to keep making improvements to their products. This collaboration while not entirely voluntary resulted in each company contributing new ideas to the software industry, which would later be incorporated into the new products of their competitors. With their hard work and innovation constantly driving technology forwards, personal computers quickly became easy and enjoyable to use and this contributed to their success.

The internet was a collaboration made public by the government

Personal computers were a very exciting innovation, but it was the invention of the internet that really helped them to take off. Originally the internet was an entirely collaborative effort between the military, universities, and corporations. Professor Vannevar Bush of MIT urged the government to fund internet research between these three entities and, as a result, computer geniuses and enthusiasts from various sectors were able to work together to develop something truly innovative.

The National Science Foundation was created to bring together experts from each of the three groups. One of these experts was J.C.R. Licklider, who came up with the idea to create decentralized networks that would facilitate the free-flow of information and allow people and machines to interact in real time.

From Licklider's idea the ARPANET network was built, and it facilitated social networking and easy communication. Modern email was born when Ray Tomlinson devised the @ symbol method for instructing messages to go to certain folders. Later virtual communities began to appear, including The Well by Stewart Brand, The Source by William von Meister, and America Online (AOL) by Steve Case. In a short space of time the internet became so popular that Senator Al Gore supported the National Information Infrastructure Act of 1993, opening the internet up for public use.

The internet changed the personal computer forever, connecting everyone via the World Wide Web. As the network grew, people found it easier and easier to connect to the internet and access seemingly endless amounts of information while communicating with people all around the world. And this internet explosion truly changed the world forever, but it wouldn't have been possible without the collaborative sharing of ideas across a vast network of people and disciplines.

Final summary

From Ada Lovelace and Charles Babbage to Steve Jobs and Bill Gates, the technological revolution could not have taken place without the work of thousands of talented individuals. Each new and extraordinary breakthrough has been built upon the work that came before it, whether or not the inventors identified themselves as a collaborative team.

Creativity is at its most powerful when people share ideas and then build on the results. It spans generations and gender, blurring who said or did what first, sometimes making the race for credit a point of contention. However, as the technological revolution demonstrates, innovation is best cultivated when a team works together, and throughout history most successful inventors and entrepreneurs have understood this fact. Often the genius and talent of these people combined with the work of their colleagues and even competitors to achieve the best results. And thanks to the extraordinary advancements in this fast-moving field, no one will ever be able to rest on their achievements. The major players have to constantly keep innovating and developing to stay ahead of the game, and this has ultimately contributed to rapid and unending improvement for the end-users – us!

By sharing and exploring great ideas as a team, great minds discover even more exciting possibilities and find new ways to bring them about. The internet has made sharing and collaboration easier than ever, and who knows where it will take us next?

Now read the book

Walter Isaacson is the CEO of the Aspen Institute, and has been the managing editor of *Time* magazine as well as the chairman of CNN. The author of *Steve Jobs*, *Benjamin Franklin: An American Life*, and *Einstein: His Life and Universe*, he is an experienced biographer with a gift for telling the stories of his chosen subjects' lives.

In *The Innovators*, Isaacson recounts the epic saga of the technological revolution through the personal tales of the greatest minds involved in digital innovation. All of the people featured played important roles in bringing technology to its current, exciting state. The author delves beneath the surface to give a detailed picture of each individual and their work, as well as how that work related to that of their predecessors and contemporaries.

Walter Isaacson gives life to these figures, both famous and not-so-famous, and makes the digital revolution a rich and riveting human experience. By reading the full book, you will get a clear and thorough introduction to the many varied personalities and challenges that shaped the digital revolution. You will learn about the individual and group motivations behind the development of great ideas, and you will better understand the lengthy and collaborative nature of true innovation.

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