Homenagem

Augusta Ada King, Countess of Lovelace: First computer programmer

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In June 1833, the Honourable Augusta Ada Byron attended a party at the house of mechanical engineer and inventor Charles Babbage. Young Ada was entranced by his demonstration of a working section of the Difference Engine, his mechanical adding machine.

The two struck up a lasting friendship during which Ada developed a deep understanding of his new and more complex Analytical Engine. She went on to become the first person to publish what we would now call a computer program, and the first person to truly understand the impact that such a calculating machine could have not just on mathematics, but on art and music too.

For many people, it is surprising – even shocking – for a woman to be called the first computer programmer. For others, it is a bridge too far, an assertion that needs to be fought and discredited. But that surprise can

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only exist because of an unfamiliarity with the history of computers and computing.

The very earliest computers, before the advent of the electrical computing machine, were women. The work of calculation was boring and repetitive, yet exacting. Women were thought to be perfect for it.

"Women were welcome as computers partly because the work was viewed as a dull, low-status activity," says Clive Thompson in *Smithsonian Magazine* (2019). But as historian Mar Hicks says in the same piece, "In a lot of cases, the women doing these computation jobs actually had to have pretty advanced math skills and math training, especially if they were doing very complex calculations" (Thompson, 2019).

When electrification came to computing, it was natural that women would continue to be preferred for work that was still complex, still required mathematical skill, but was still seen as menial. That the early days of the modern computing era are dominated by women's names should not be a surprise.

Joyce Aylard (Bearne, 2018) Joan Clarke, Margaret Rock, Mavis Lever and Ruth Briggs (Miller, 2014), worked at Bletchley Park, breaking the German Enigma Machine codes using an early computer, the Bombe. Marlyn Meltzer, Betty Holberton, Kathleen Antonelli, Ruth Teitelbaum, Jean Bartik, and Frances Spence programmed the ENIAC computer in 1944 (WITI, 2021). Rear Admiral Grace Hopper worked on the Harvard Mark 1 and invented the compiler (Smith, 2013). She then went on to work on the UNIVAC, which was unveiled in 1951, alongside Adele Mildred Koss, Frances E. Holberton, Jean Bartik, Frances Morello and Lillian Jay (Gürer, 1995).

It wasn't until the mid-1980s that men started to take over computer programming and women were first displaced and then actively discouraged from taking part in the technological revolution.

The percentage of women studying computer science in the USA had, since 1960, been steadily growing, just like medicine, law and the physical sciences. But in 1984, the number of women in computing collapses.

NPR's Planet Money investigated this phenomenon in 2014 and suggested that the reason was simple: This was the beginning of the home computing era and the ads selling those computers were targeted at boys. In films and on TV, computers were used exclusively by boys or men (NPR, 2014).

As computers became more useful, more compact, more affordable, and as they made the transition from toy to essential business equipment, men came to dominate the field. As men entered computing, its status increased and women were pushed out.

"Accompanying men's takeover of the field in the late 1960s was an immense climb in pay and prestige," writes Rhaina Cohen in *The Atlantic* (Cohen, 2016). The stage was set for the widespread exclusion of women from computing. The work of Ada Lovelace was forgotten. The legacy of almost all 20th Century women in computer programming was swept aside. In this male-dominated industry, to suggest that a woman was the first computer programmer was near blasphemy.

Ada Lovelace's story is both an inspiration and a tragedy. Born on 10 December 1815, she was the only legitimate daughter of the romantic poet George Gordon Byron, 6th Baron Byron and Anne Isabella Milbanke (Annabella), 11th Baroness Wentworth. Byron was abusive and Annabella fled to her parents' when Ada was just a month old.

Lady Byron made sure her daughter had a good education and Ada learnt maths and science from some of the UK's best minds. Augustus De Morgan was a mathematician at the forefront of the emerging field of symbolic logic. He exchanged many letters with Ada, and encouraged her to further study mathematics, as she had impressed him mightily with her capabilities. Had Ada been a man, he said, she would have had the potential to become "an original mathematical investigator, perhaps of first-rate eminence" (Hollings et al., 2017a).

Another of Ada's tutors was the Scottish astronomer and mathematician, Mary Somerville. Somerville became famous in 1831 when she published The Mechanism of the Heavens, a translation of the five volume *Mécanique Céleste* by Pierre-Simon Laplace. It was Somerville who introduced Ada to Babbage. Ada was 17 and Babbage was 42.

Two years later, on 8 July 1835, Ada married William King the 8th Baron King. Over the next four years, the couple had three children: Byron, Anne Isabella, and Ralph Gordon. In 1838, King was made 1st Earl of Lovelace and Ada became the Right Honourable the Countess of Lovelace. In correspondence she signed herself Augusta Ada Lovelace, or AAL, and we know her today simply as Ada Lovelace.

In 1837, Babbage started to draw up plans for the Analytical Engine, a much more complex and capable machine than his earlier Difference Engine. Ada studied it closely and rapidly became an expert.

The Analytical Engine was a general purpose computing machine that had all the elements of a modern computer, including an arithmetical unit, conditional branching and loops, and integrated memory. It could also be programmed to do complex computations using punched cards, just like the Jacquard loom and the early modern computers built in the 1940s, such as the Harvard Mark I. Babbage even designed a printer to go with it.

In 1842, Babbage gave a lecture about the Analytical Engine at the University of Turin. In the audience was an Italian engineer, Luigi Menabrea, whose notes were eventually published in the *Bibliothèque Universelle* de Genève. Babbage's friend Charles Wheatstone asked Lovelace to translate the paper into English from the original French, as she was fluent. That winter, Lovelace set to work. Her knowledge of the machine was far deeper than Menabrea's, so she quietly corrected any errors she came across as she went along.

Lovelace showed her translation to Babbage, who was delighted and asked her to expand on the original as she understood the machine so well. Lovelace added some footnotes, tripling the original paper's length.

In her notes, Lovelace outlines several early computer programmes.

"I want to put in something about Bernoulli's Number, in one of my Notes," she writes, "as an example of how an explicit function may be worked out by the engine, without having been worked out by human head and hands first" (Fuegi & Francis, 2003).

Note G described how to break down the algebra into simple formulae which could be calculated using the basic mathematical instructions that the Analytical Engine could process: addition, subtraction, multiplication or division. It then described how to code those formulae as instructions for the Analytical Engine.

Although there were earlier sketches for programs that had been prepared by Babbage, Lovelace's were the most elaborate and complete, and the first to be published. It is for this achievement that Lovelace is known as the first computer programmer: She was the first person to write and publish a full set of instructions that a computing device could use to reach an end result that had not been calculated in advance.

But Lovelace had a bigger vision. If the Analytical Engine could manipulate numbers, she realised, it could also manipulate symbols. Symbolic logic underpins modern computer programming, but then it was an emerging field, and Lovelace's friend and teacher De Morgan was at its forefront. Symbolic logic would allow the Analytical Engine to take on some very complex tasks.

She made clear that this new machine was a major upgrade to the Difference Engine.

"The bounds of arithmetic were however outstepped the moment the idea of applying the cards had occurred;" she wrote, "and the Analytical Engine does not occupy common ground with mere 'calculating machines.' It holds a position wholly its own; and the considerations it suggests are most interesting in their nature. In enabling mechanism to combine together general symbols in successions of unlimited variety and extent, a uniting link is established between the operations of matter and the abstract mental processes of the most abstract branch of mathematical science" (Menabrea, 1843).

It is this idea of a general purpose computer, much more than Note G, that was the truly groundbreaking concept. Lovelace suggested that such a machine could potentially compose music, writing:

"[The Analytical Engine] might act upon other things besides number, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations, and which should be also susceptible of adaptations to the action of the operating notation and mechanism of the engine. Supposing, for instance, that the fundamental relations of pitched sounds in the science of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent" (Menabrea, 1843).

And inspired by the images woven into rich brocades, Lovelace proposed that Babbage's machine might be capable of creating graphics. The Analytical Engine, she wrote, "weaves algebraic patterns just as the Jacquard loom weaves flowers and leaves" (Menabrea, 1843).

The concept of a general computer that could do anything, given the right programming and inputs, was an extraordinary leap for Lovelace to make and one that many of her male peers struggled to understand. She was easily 100 years ahead of her time.

But Babbage's Analytical Engine was a computing evolutionary cul-de-sac. It was never built. Lovelace never had the opportunity to test her program on it, she never got to find and fix any bugs, to iterate and improve her understanding of how software worked. And Babbage never produced the error-free log, trig and other tables of numbers that were the initial purpose of the project.

But Lovelace's ideas found their way into modern computing via Alan Turing. During WWII, as he was working at Bletchley Park on decoding German communications, Turing discovered Lovelace's Menabrea translation and its attendant notes.

In his seminal paper Computing Machinery and Intelligence, Turing explored the question "Can machines think?", launching the field of artificial intelligence. He also listed "contrary views" on his position that machines could at least imitate thinking, and discusses what he calls Lady Lovelace's Objection.

Lovelace had written, "The Analytical Engine has no pretensions to originate anything. It can do whatever we know how to order it to perform" (Lovelace, 1843), which might be taken to mean that she thought machines could not learn. However, Turing points out that "the evidence available to Lady Lovelace did not encourage her to believe" that machines could do such a thing (Turing, 1950).

He goes on to say, "The Analytical Engine was a universal digital computer, so that, if its storage capacity and speed were adequate, it could by suitable programming be made to mimic the machine in question. Probably this argument did not occur to the Countess or to Babbage. In any case there was no obligation on them to claim all that could be claimed" (Turing, 1950).

More modern voices have, as with so many women who have contributed greatly to the fields of science, technology, engineering and maths through the centuries, either downplayed or rejected Lovelace's achievements. There are two main objections: Firstly, it is said that Lovelace didn't understand calculus and thus could not have had the capacity to prepare the Bernoulli program.

It is true that Lovelace struggled with calculus. She wrote to De Morgan in some frustration about the chapter on "notation of functions" that she was studying.

"I do not know when I have been so tantalised by anything," she said, "and should be ashamed to say how much time I have spent up on it, in vain. These functional equations are complete will-o'-the-wisps to me. The moment I fancy I have really at last got hold of something tangible and substantial, it all recedes further and further & vanishes again into thin air" (Hollings et al, 2017b).

Lovelace and De Morgan wrote many letters to each other as part of what might be considered an informal correspondence course in mathematics. Only 63 letters survive, spanning a period of about eighteen months.

The suggestion that Lovelace was bad at maths features in Dorothy Stein's 1985 biography, *Ada: A Life and a Legacy*. She argues that two letters from Lovelace dated 16th and 27th November 1842 prove that Lovelace was struggling with functional equations some two years after she had started studying with De Morgan and just before she started work on her translation of Menabrea's paper (Stein, 1985).

But modern research by Christopher Hollings, Ursula Martin and Adrian Rice has shown that the letters in question have been misdated. That conversation took place two years earlier than Stein assumed, giving Lovelace plenty of time to learn calculus.

A second, and potentially more damning, objection to calling Lovelace the first computer programmer comes from the idea that she did not actually write the Bernoulli program. Historian Bruce Collier wrote in his 1990 book, *The Little Engine That Could've*:

"It would be only a slight exaggeration to say that Babbage wrote the Notes to Menabrea's paper, but for reasons of his own encouraged the illusion in the minds of Ada and the public that they were authored by her. It is no exaggeration to say that she was a manic depressive with the most amazing delusions about her own talents, and a rather shallow understanding of both Charles Babbage and the Analytical Engine… To me, [correspondence between Ada and Babbage] seems to make obvious once again that Ada was as mad as a hatter, and contributed little more to the Notes than trouble" (Collier, 1990).

Allan G Bromley and Doron Swade both claimed that Babbage did the work in the years before the 1842 publication of Lovelace's translation. Benjamin Woolley says that Lovelace made just "some contribution".

It may be that the confusion comes from Babbage's own autobiography, which he wrote when he was nearly 80. In it, described the conversation he'd had with Lovelace about how she might expand on Menabrea paper with her own notes. He writes:

"We discussed together the various illustrations that might be introduced: I suggested several, but the selection was entirely her own. So also was the algebraic working out of the different problems, except, indeed, that relating to the numbers of Bernoulli, which I had offered to do to save Lady Lovelace the trouble. This she sent back to me for an amendment, having detected a grave mistake which I had made in the process" (Babbage, 1854).

We have to ask what Babbage meant by "algebraic working out". The Bernoulli note is made of up equations, and a table and diagram which describes how the punch cards should be prepared for the programming of the Engine. It is the table and diagram that are the program, not the equations. So even though Babbage worked on the equations, he did so to save Lovelace time, not because she couldn't do them herself. Indeed, if she had not been capable of understanding the equations, how could she have detected his "grave mistake"?

Their correspondence illuminates the matter further. Having sent Note G to Babbage for his feedback, Lovelace was disappointed to discover that either he, or possibly the printer, had lost it. She would have to start over again. She wrote to Babbage, "I suppose I must set to work to write something better, if I can, as a substitute, the same precisely I could not recall. I think I should be able in a couple of days to do something. However I should be deucedly inclined to swear at you, I will allow" (Fuegi & Francis, 2003).

Babbage responded to the new version, "I like very much the improved form of the Bernoulli Note but can judge of it better when I have the Diagram and Notation" (Hammerman & Russell 2015).

It would have been a most peculiar exchange were the assertion that Babbage wrote the program true. Had Babbage written the Note, he wouldn't need the Diagram and Notation in order to fully understand it.

The truth is that Babbage and Lovelace collaborated closely, discussing and refining their ideas, Babbage working on some parts, Lovelace on others. Babbage was living in London and Lovelace an hour away in Ockham Park, and letters flew back and forth between them in a great flurry. The post in Victorian England was delivered several times a day and, if they couldn't wait, they both had personal messengers that they could rely on.

Lovelace often worked 18 hours days, refining her notes, asking Babbage to clarify a point or send over a diagram, a request that he couldn't always meet as the design was constantly in flux and sometimes the drawings he had to hand were out of date.

Eventually, translation and notes were done and, in August 1843, they were published in Taylor's Scientific Memoirs, to great acclaim. Menabrea asked Babbage to pass on his congratulations to Lovelace, and Faraday told Babbage that the paper was so complex that it went right over his head.

Lovelace and Babbage worked as a team, and as with many teams there is no definitive documentation to explain exactly who did what. But the evidence that we do have supports the idea that Lovelace was instrumental in the development of the Bernoulli program, and that it was not the work of Babbage alone.

Lovelace's brilliance had become obvious very early on in her life but, however strong the powers of her mind, she couldn't prevent her body's frailty from betraying her. She developed cancer, an illness from which she would never recover. She died on 27 November 1852 at just 36 years old, the same age as her father.

Since the early 1980s, Ada Lovelace has become a more widely celebrated figure, particularly over the last twenty years. A programming language, medals, conferences, businesses, campaigning organisations, communities, schools, buildings and fellowships have been named after her. She appears now in the British passport, and there's even an Ada Lovelace gin. And there have been many, many news articles, podcasts, blog posts and books about her.

When I began working on Ada Lovelace Day in late 2008, few people had heard of her. She is now much more widely known, if not yet a household name. And although criticism of her has waned, it still remains in quarters where scepticism about the role of women, both historical and modern, in computing persists.

And it is this criticism, this derogation of Lovelace's work and, indeed, of her personally, that is one of the reasons she is such a powerful figurehead. Here is a woman whose story we recognise. After devoting so much time, energy and passion to her groundbreaking work, her achievements are largely ignored by her peers then derided by those who do not wish to believe a woman could be so capable. We see this story play out again and again, on greater or lesser scales, to women we know and even to us, ourselves.

In Lovelace we see our kind reflected, and in celebrating her, we celebrate every woman.

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