Female Inventors and Narratives of Innovation in Late Twentieth-Century Computing

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Introduction

Before the advent of electronic computers in the late 1940s, computation was an occupation in which the predominantly female workers, known as "computers," performed manual calculations.[1] In recent years, popular media and academic historians alike have highlighted the forgotten role of women who were once the backbone of the computing industry, performing the vast majority of programming labor well into the Cold War (1945-1989).[2] Despite the abundance of women in computing during this era, subdivisions within the field reveal that women generally had much less power and performed a completely different type of labor than the authorial innovation privileged in traditional histories of computing. From the inception of mass-scale computation in the late nineteenth century and throughout the beginning of the Cold War, computing was perceived as lowly women's work.[3] As electronic computing shifted to the forefront of American priorities during the Cold War, efforts to accelerate progress in this area led to the nascence of computer science as a formal scientific discipline that blurred the boundaries across military, academia, and industry. As the field gained a professional reputation, its practitioners adopted masculine values that excluded women and other marginalized people from the broadly celebrated forms of labor within the profession.

In the past twenty years, scholars in the history of technology have argued that the image of the "eccentric and exceptional computer genius" has fostered exclusion in the field of computing beginning in the 80s.[4] Historian of computing Nathan Ensmenger writes of this "computer genius," firmly coded as masculine, as a "bright young man" who "work[s] until he drops. Their food is brought to them. They exist, at least when so engaged, only through and for the computers." Their "manly demonstrations" of sleep deprivation, or "sport death," and food

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[1] Grier, David Alan. *When Computers Were Human*. Princeton University Press, 2013.

[2] See Shetterly, Margot Lee. *Hidden Figures: The American Dream and the Untold Story of the Black Women Mathematicians Who Helped Win the Space Race.* United States: HarperCollins, 2016; its film adaptation, Melfi, T., and Margot Lee Shetterly (2017). *Hidden Figures*. Twentieth Century Fox Home Entertainment; Ensmenger, Nathan L. *The Computer Boys Take Over: Computers, Programmers, and the Politics of Technical Expertise.* MIT Press, 2012.; Hicks, Mar. *Programmed Inequality: How Britain Discarded Women Technologists and Lost Its Edge in Computing*. MIT Press, 2017.; Abbate, Janet. *Recoding Gender: Women's Changing Participation in Computing.* MIT Press, 2012.; and Light, Jennifer S. "When Computers Were Women." *Technology and culture* 40, no. 3 (1999): 455-483.

[3] Grier, *When Computers*, 3.

[4] Ensmenger, Nathan. ""Beards, Sandals, and Other Signs of Rugged Individualism": Masculine Culture within the Computing Professions." *Osiris* 30, no. 1 (2015): 38-65.

deprivation serve as ways to prove themselves to their peers.[5] From this perspective, it seems that the exclusion of women from computing is a relatively new phenomenon: the participation of women in computer science increased until the 80s and then declined, while the prominence of the lone genius stereotype has steadily increased since the 80s. This correlation might suggest that beginning in the 80s, the masculine trope of the lone computer genius created implicit norms to which women struggled to assimilate.[6] But such a conclusion ignores the difference between the women-dominated computing labor versus the labor of innovation, a partition that existed well before the 80s. As historian Margaret Rossiter points out, the average proportion of women in a field may obscure the drastic differences in proportion across subfields.[7] This thesis will examine the history of women's labor and representation in the world of programming by studying two distinct categories: women involved in authorial, creative work versus manual, computational labor.

I build off the work of historians of technology not to highlight a new history, but to question why we tell the histories we do about the "forgotten women." The gaps in the histories of computer science innovation are mirrored by shortcomings in the actual practice of computer science: Both the historiography of computer science and the field itself have been shaped by the myth of the lone genius. The idea of the lone genius persists throughout narratives of innovators in computing, including female innovators. It places the onus of success on individuals rather than challenging the structural and cultural obstacles that have barred others from participating in the labor of innovation. This archetype, historically associated with masculinity, elevates individuals' contributions while obscuring the collaborative labor traditionally done by women and other marginalized people.[8] Its legacy continues to foster inequity in the field and contribute to exploitation by ignoring the various forms of labor that contribute to innovation in computing.

In this thesis, I trace these shortcomings throughout the history of modern computer science. Early narratives, such as the development and reputation of the programming language COBOL, created in 1960, demonstrate how collaborative, female-led computer science innovation has

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[5] Ensmenger, "Beards, Sandals," 59.
[6] Ensmenger, "Beards, Sandals," 62.
[7] Rossiter, Margaret W. "Which Science? Which Women?" *Osiris* 12 (1997): 169–85.
[8] See Nathan Ensmenger, Mar Hicks, Jennifer Light, Janet Abbate, op. cit.

been devalued, obscured, and ultimately reshaped to fit these dominant imaginaries and reinforce the exclusionary norms of the discipline. Even as the cultural backdrop shifted, from Title IX initiatives in the 70s to third-wave feminism in the 90s, narratives of female innovators and movements to incorporate more women into computing only perpetuated the assumed connections between individual genius, masculinity, and scientific progress. Finally, I explore community-based perspectives from feminist epistemology as possibilities for shifting away from the myth of the lone genius.

World War II and the Cold War: Women in the Labor Divide

Prior to electronic computers, the term "computers" referred to the humans—usually women—whose jobs involved "accounting tasks" and "electromechanical machine work."[9] This programming "required advanced mathematical training, yet was categorized as clerical work."[10] In 1937, Leslie John Comrie, a "pioneer in mechanical computation,"[11] founded the Scientific Computing Service, an operation that relied on human computers' labor. Like others at the time, he framed computing as clerical work, writing that "women have the capacity to be easily trained to perform this work, along with the secretarial or typing work they might already do in the same office."[12] Comrie asserted that women "diligently did work those young men saw as boring, dead-end drudgery."[13] Such work seemed too tedious for men with college degrees, who engaged in the production of knowledge as theoreticians and inventors or the physical development of these machines as builders and engineers. It was "the job of the dispossessed, the opportunity granted to those who lacked the financial or societal standing to pursue a scientific career."[14] But the work did not engender further opportunities for career advancement. Rather, Comrie mentions how these skills were transferable once these women inevitably moved on from their careers as they "graduate to married life and become experts with the housekeeping accounts!"[15]

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[9] Hicks, *Programmed Inequality,* 118.
[10] Light, "When Computers," 458.
[11] "LJ Comrie." Columbia University Computing History, March 28, 2021, https://www.gla.ac.uk/news/headline_681850_en.html.
[12] Hicks, *Programmed Inequality,* 100.
[13] Ibid, 102.
[14] Grier, *When Computers*, 287.
[15] L. J. Comrie, "Careers for Girls," The Mathematical Gazette 28, no. 280 (1944): 90–95

He characterizes computing labor as a prelude to the eventual inevitability of maintaining a household.

Human computers played a critical role in military efforts during World War II.[16] The U.S. Army facility in Aberdeen, Maryland employed around 200 women to "hand-calculate firing tables for rockets and artillery shells" in 1940.[17] John Tukey, a mathematician on the National Defense Research Committee during the war, defined the unit "'kilogirl,' a term that presumably referred to a thousand hours of computing labor."[18] George Stibitz, whose university website describes him as "the father of the modern digital computer,"[19] "began ranking calculating projects in 'girl-years' of effort."[20]

As the government realized the potential of high-technology weapons, the large-scale development of electronic computers became a new imperative for national security.[21] In 1945, the Secretary of War Robert Patterson declared that "the 'laboratories of America have now become our first line of defense.'"[22] The foundations of modern computer science began taking root as Americans raced to develop machines that could perform "the massive and speedy mathematical calculations required in technowar."[23] Almost all computing research, whether in academic or industrial labs, was geared toward the war effort and funded by the U.S. War Department.[24] For instance, at MIT, the war effort doubled its staff and increased its research budget tenfold. This "military-industrial complex,"[25] as political figures like President Eisenhower deemed this collaboration at the time, was later re-conceived by historians who

[16] Light, "When Computers," 460.
[17] Light, "When Computers," 463.
[18] Grier, *When Computers*, 287.
[19] "George Stibitz", April 30, 2004, http://stibitz.denison.edu/.
[20] Grier, *When Computers*, 287.
[21] Leffler, Melvyn P., and Odd Arne Westad, eds. *The Cambridge History of the Cold War.* Vol. 1. Cambridge University Press, 2010, 379.
[22] Ibid.
[23] Leffler and Westad, *The Cambridge History,* 382.
[24] Edwards, Paul N. *The Closed World: Computers and the Politics of Discourse in Cold War America*. MIT Press, 1996.
[25] Eisenhower, Dwight D. "Farewell Address" Transcript of Final TV Talk, January 17, 1961. Box 38, Speech Series, Papers of Dwight D. Eisenhower as President, 1953-61, Eisenhower Library; National Archives and Records Administration.

included academia into this matrix,[26] referring to this relationship as an "'iron triangle' of self-perpetuating academic, industrial, and military collaboration."[27] The iron triangle only became stronger throughout the Cold War, facilitating the rise of "Big Science," a notion of government-funded science and engineering projects that involved unprecedented amounts of "big money, big equipment, and big teams."[28] The formation of the iron triangle added the permanent elements of "massive government funding and military direction" to computer science, whose long-term effects, in the words of historian Paul Edwards, are "almost impossible to overstate": IBM, which continues to be a major computer company, was established as a giant by military funding in the decades following World War II, and the iron triangle also gave rise to the Stanford Industrial Park, the precursor to Silicon Valley.

In 1945, the Electronic Numerical Integrator and Computer (ENIAC), the world's first programmable digital electronic computer, was funded by the U.S. Army to automate ballistic computations.[29] Media coverage at the time, from the New York Times to the U.S. War Department's press releases, lauded the ENIAC as "an icon of the miracle of government-supported 'Big Science'"[30] in 1945. It was programmed by a group of women known as the "ENIAC girls," who performed "'hard-wired' programming, laboriously setting switches and cables inside the 30-ton black behemoth of a machine."[31] Even as computing became a profession critical to national security, women computers and programmers were still referred to as a collective, nameless entity of "girls" instead of being valued as individual professionals who held advanced degrees in mathematics and related fields.

The success of the ENIAC soon incentivized larger-scale efforts to automate the computations previously conducted by women during the war and after the war ended. In 1952, the Bureau of Standards and the Institute for Numerical Analysis, two of the largest employers of human

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[26] See Giroux, Henry A. *University in Chains: Confronting the Military-Industrial-Academic Complex*. Routledge, 2015. and Leslie, Stuart W. *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford.* Columbia University Press, 1993.
[27] Adams, Gordon. *The Politics of Defense Contracting: The Iron Triangle*. Routledge, 2020.
[28] Leffler and Westad, *The Cambridge History,* 378.
[29] Polachek, Harry. "Before the ENIAC [weapons firing table calculations]." *IEEE Annals of the History of Computing* 19, no. 2 (1997): 25-30.
[30] Edwards, *The Closed World,* 51.
[31] Lohr, S. "Frances E. Holberton, 84, Early Computer Programmer." *New York Times* (2011).

computers, finished building their first electronic computing machines, the Standards Eastern Automatic Computer and the Standards Western Automatic Computer. In 1956, the U.S. Department of Labor produced a report titled "Employment Opportunities for Women Mathematicians and Statisticians." It described "a demand for programers [sic] at the bachelor's and master's levels as well as at the Ph.D. level," with a "good, solid classical background in mathematics" as the most important qualification, as "it is a fact that many industrial laboratories employ only women for their computing groups; others employ a high percentage of women."[32] This report reflects the roles that women transitioned into as operators of electronic computers designed to render their human labor obsolete. They took on jobs programming the electronic computers, either operating the machines or double-checking their results by recalculating them.[33]

Although the work was challenging, precise, and technical, it was not recognized in the field as markers of status or prestige in the ways that scientific publications, lectures, and memberships in professional society are.[34] For instance, the Association for Computing Machinery (ACM), which has now become the largest and most prestigious professional society related to computing, was founded in 1947 by an all-male group.[35] The same journal announcing the ACM's formation describes an annual symposium of the Mathematical Association of America that featured "Howard H. Aiken of Harvard University and John Von Neumann of the Institute for Advanced Study at Princeton University." The article highlights Aiken and von Neumann as the primary developers of computing machines: "Dr. Aiken described the essential design features of the two electro-mechanical digital computing machines, Mark I and Mark II, which were built under his direction… Dr. von Neumann, on the construction of an improved electronic digital computing machine."[36] By excising the challenging labor required to operate these

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[32] Mitchell, James. *Employment Opportunities for Women Mathematicians and Statisticians: Women's Bureau Bulletin, No. 262.* Washington, D.C.: U.S. Government Printing Office, 1956.
[33] Grier, David Alan. "Human computers: the first pioneers of the information age." *Endeavour* 25, no. 1 (2001): 28-32.
[34] Light, "When Computers," 459.
[35] *Mathematical Tables and other Aids to Computation* 1948-01: Vol 3 Issue 21. American Mathematical Society. January 1948. 57.
[36] Ibid.

machines, the article exemplifies the erasure of women programmers from the iron triangle's narratives of computing innovation.

The Lone Genius Narrative in Computer Science Innovation

Historians of science have studied the valuing of innovation throughout the various European paradigms that have shaped western science, from the natural philosophy of Medieval universities to the rationalist imaginaries of the Enlightenment era.[37] The early American identity's emphasis on modernity, a connection established during the 1800s "closely linking technology with the existing social order in the United States," was a precursor to innovation's present-day cultural capital.[38]

The Cold War represented a concerted American effort to not only demonstrate its modernity through dominance in scientific innovation but also promote the ideal of maximizing individual liberty. It was America's "longest continuous wartime mobilization" motivated by a culture that ran on "the ideals of rugged individualism."[39] It comes as no surprise, then, that the trope of individual genius in computing can be traced back to the nascence of electronic computing as part of Big Science. In traditional histories of computer science, the two male engineers who developed the ENIAC, John W. Mauchly and J. Presper Eckert, are recognized as its inventors, while the women who programmed it have been obscured until recent efforts to restore their role in this history.[40] This dichotomy reflects a divide between two types of labor in computing: one perceived as mechanical, non-innovative, and intrinsically female work and the other as legitimate scientific production.

This second type of computing labor—of innovation, creation, scientific progress—has long privileged the male lone genius. In the same way that the legacies of military funding and the iron triangle live on, the lone genius trope continues to shape the field of computer science today. In the popular imagination, inventions are associated with singular computer scientists, such as

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[37] French, Roger, and Andrew Cunningham. *Before Science: The Invention of the Friars' Natural Philosophy*. Routledge, 2016.; Love, Ronald S. *The Enlightenment*. ABC-CLIO, 2008.
[38] Leffler and Westad, *The Cambridge History,* 11.
[39] Resch, John Phillips. *Americans at War: Society, Culture and the Homefront*. Macmillan Reference USA [Imprint], 2004. 37; Leffler and Westad, *The Cambridge History,* 16.
[40] Light, "When Computers," 455-483.

Stanford University's John McCarthy, who is often heralded as the "father of artificial intelligence."[41] Artificial intelligence is a subfield of computing that has now grown so large that more than one in five computer science graduate students specialize in it.[42] Elevating McCarthy as the father of such an important domain, Stibitz as the father of the modern computer, and Comrie as the pioneer of mechanical computation obscures the students, collaborators, people, and communities who enabled their contributions. This is an example of the "Matilda effect" described by historian Margaret Rossiter, in which "individuals at the top of professional hierarchies receive repeated publicity and become part of historical records, while subordinates do not, and quickly drop from historical memory."[43] Rossiter coined the term "Matilda effect" after sociologist of knowledge and feminist Matilda J. Gage, who personally faced and documented the "under-recognition accorded to those who have little to start with," referring to the pattern of women scientists who have been denied credit and excluded from their disciplines.[44]

News outlets and professional organizations alike celebrated the men who designed and built the ENIAC while omitting the larger community of women whose labor enabled its work. Jean Bartik, one of the original programmers of the ENIAC, viewed her community as "a 'technical Camelot,' a tight-knit group advancing the frontiers of computing," but lamented that "the men had professional ratings" while the women programmers were called "subprofessionals" and were paid less.[45]

As temporary workers with "subprofessional" status, the women were cogs in the machinery of ambitious projects.[46] Historian Paul Ceruzzi writes that "in every case we know of, the women's work was subordinate to the work of the men for whom they computed."[47] Despite their

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[41] Rajaraman, Vaidyeswaran. "John McCarthy—Father of artificial intelligence." *Resonance* 19, no. 3 (2014): 198-207. Woo, Elaine. "John McCarthy dies at 84; the father of artificial intelligence." Los Angeles Times (2011).

[42] Stanford Institute for Human-Centered Artificial Intelligence. Artificial Intelligence Index Report. 2021.

[43] Rossiter, Margaret W. "The Matthew-Matilda Effect in Science." *Social Studies of Science* 23, no. 2 (1993); Light, "When Computers," 482.

[44] Rossiter, "The Matthew-Matilda Effect," 325.

[45] Jean Bartik, interview by Janet Abbate, August 3, 2001, interview 576, transcript, IEEE History Center, Piscataway, NJ, USA.

[46] Gray, Mary L., and Siddharth Suri. *Ghost Work: How to Stop Silicon Valley from Building a New Global Underclass*. Eamon Dolan Books, 2019.

[47] Ceruzzi, Paul E. "When Computers Were Human." *Annals of the History of Computing* 13, no. 3 (1991), 240.

contributions to "advancing the frontiers," the women were treated as invisible and interchangeable, doing the tedious work that others were unwilling to perform. A 1942 internal memorandum from the computing facility of the National Advisory Committee for Aeronautics (NACA), precursor of the National Aeronautics and Space Administration (NASA), describes the work as "mere repetitive calculation" yet recalls that "the engineers admit themselves that the girl computers do their work more rapidly and accurately than they would."[48] While the field of computing included women and other marginalized people during this era, endeavors ranging from Comrie's system to the ENIAC relegated these populations to "subprofessional" work and exploited their technical capabilities.

Given the gendered divide between the clerical drudgery assigned to female laborers and the innovation undertaken by masculine lone geniuses, hiring women at this time did not translate to giving them power or authority—women were not given positions that were high on the job ladder, and the lucky few that wielded authority typically managed other women, positions widely seen as less prestigious than managing men.[49] Women were viewed as low-level labor, undergirding the assumption that women did not contribute to the development of computer science innovation. While jobs as computers empowered individual women toward financial independence, it only furthered the exclusionary myth of the lone genius. Ironically, the more women who joined the workforce as "computers," the less remarkable their contributions seemed to be, and the more precious the efforts of the men at the top of the field seemed in contrast.

One might assume that the gains of women in the labor force and in social movements in the second half of the twentieth century would have shifted the dividing line between unrecognized female labor and that of the male "lone genius." But as participation in the innovative dimensions of the computing profession expanded beyond men against the backdrop of twentieth-century feminism, both male and female superstars perpetuated the imaginary of the lone genius. Stories of the few women who overcame the gender barriers of computer science seemed to suggest that the playing field had been leveled, that marginalized people could not

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[48] Ibid, 243.

[49] Rossiter, Margaret W. *Women Scientists in America: Before Affirmative Action, 1940-1972*. Vol. 2. JHU Press, 1998, 13.

only succeed but also accrue great renown in the field. These narratives only helped to entrench the divide between manual and authorial labor.

Grace Hopper

Grace Murray Hopper is arguably the most famous woman in computer science from the twentieth century. She received various awards throughout her lifetime, from the National Medal of Technology to the Data Processing Management Association's paradoxically titled "Man of the Year" Award.[50] Her eponymous conference, the "Grace Hopper Celebration of Women in Computing" (GHC), is the world's largest annual gathering of women in computing. It hosted more than 30,000 attendees in 2020 and has featured speakers like billionaires Sheryl Sandberg, the chief operating officer of Facebook, and Melinda Gates, former computer scientist at Microsoft. With the popularity of GHC, Hopper's name has become synonymous with initiatives that encourage the inclusion of more women in computer science. The legend of Hopper's career seems to promise (and has been held out as a promise) that women, too, can achieve status as lone geniuses.

After obtaining her Ph.D. in mathematics, Hopper joined the military in 1943 at age 37. Hopper rose through the ranks of the United States Navy to become a rear admiral. During World War II, she was assigned to work under Commander Howard Aiken in his Computation Laboratory at Harvard University. As detailed in historian Kurt Beyer's *Grace Hopper and the Invention of the Information Age*, a leading account of Hopper's career, Aiken was "a difficult man who would be classified as a 'male chauvinist' by today's standards." Despite this reputation, Aiken "found a kinship with Hopper not because she was a rebel but because of her ability to ingratiate herself to Aiken and her fellow workers…She actively erased gender differences through her clothing, her language, her drinking habits, and her humor." Hopper's ability to adapt to the masculine environment by "erasing gender differences" contributed to her success. These actions earned Hopper trust and respect "to the point that she became the most prominent person" in the lab besides Aiken.[51] The Harvard Computation Laboratory belonged to the iron triangle, with

[50] Payette, Sandy. "Hopper and Dijkstra: Crisis, Revolution, and the Future of Programming." *IEEE Annals of the History of Computing* 36, no. 4 (2014): 64-73.
[51] Beyer, Kurt W. *Grace Hopper and the Invention of the Information Age*. MIT Press, 2012. 24.

funding from the government and a leader who "purposely blurred the lines between academia and the military." [52] It was "run like a military institution," and like the "manly demonstrations" of sleep deprivation described by Ensmenger. Hopper recalls, "'You were on duty 24 hours a day. You were lucky if you went home to sleep.'"[53] Hopper was able—and perhaps had no choice but—to assimilate to the masculine gender norms of her environment.

Hopper's association with the programming language COBOL (COmmon Business Oriented Language) fully embodies the lone genius archetype. COBOL was widely used for commercial applications in industry and the government for decades, and it remains in use today.[54] Hopper is referred to as the "mother of COBOL" in the media, a phrase that parallels John McCarthy's title as the "father of artificial intelligence." But, like many legends of scientific discovery by prominent thinkers, the story is more complicated than the popular myth. Hopper describes that she had long been floating the very idea of a "common business language for industry," and helped to coordinate the initial meeting across users and manufacturers alongside representatives from major corporations like IBM and the Radio Corporation of America. Hopper formally served as an adviser to the group overseeing three committees, which focused on short- (three months), medium- and long-range objectives respectively.[55] The short-range committee—whose output would eventually be COBOL—aimed to find a temporary fix that would unify the three known languages of the time.

Beyer's biography acknowledges that while "publications, including the New York Times and the Washington Post, list Hopper as the inventor of COBOL," COBOL's development was a much more complicated narrative that involved many different people and communities. Other accounts describe COBOL as the result of "collaboration of computer manufacturers and users, in cooperation with the United States Department of Defense."[56] Hopper concedes to giving other parties credit for COBOL because "if you gave them credit for it, why they'd go right along with you." She insists "COBOL 60 is 95% FLOW-MATIC…we'd say it was a compound

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[52] Beyer, *Grace Hopper,* 148.
[53] Beyer, *Grace Hopper,* 160.
[54] Mathur, F. P. *A Brief Description and Comparison of Programming Languages FORTRAN, ALGOL, COBOL, and LISP 1.5 from a Critical Standpoint.* No. JPL-TM-33-566. 1972.
[55] Sammet, Jean E. "The Early History of COBOL." In *History of Programming Languages*, pp. 199-243. 1978.
[56] Mathur, *A Brief Description*.

of FLOWMATIC and Commercial Translator and keep the other people happy and wouldn't try to knock us out;"[57] two years prior, Hopper had led the development of the programming language FLOW-MATIC at Remington Rand, a computer manufacturer.[58] Beyer ultimately credits Hopper for "using her prominent position to guide the development of COBOL."[59] His biography matches Hopper's eagerness to take credit for the development and success of COBOL.

However, Jean Sammet, one of the co-creators of COBOL, has firmly stated that Hopper "was not the mother, creator or developer of COBOL."[60] This sentiment is reiterated in Sammet's obituary of Hopper, which reads:

> Hopper's role in COBOL has been generally misunderstood, and I would like to take this opportunity to correct the incorrect statements and impressions that have consistently been conveyed in almost all articles and books, and even by a misleading Navy commendation…[Hopper] did not participate in its work except through the general guidance she gave to her staff who were direct committee members. Regrettably the frequently repeated statements 'Grace Hopper developed COBOL' or 'Grace Hopper was a codeveloper of COBOL' or 'Grace Hopper was the mother of COBOL are just not correct.'[61]

In writing about Hopper's role, Sammet shed light on her own previously obscured labor. As a young woman, she herself belonged to the committee that authored COBOL. She had initially enrolled in a Ph.D. at Columbia University but dropped out after the first year because she had decided that "academia was not for her," deciding instead to take her programming talents to industry.[62] She began working on COBOL as a staff consultant for programming research at the U.S. electronics corporation Sylvania Electric. In 1969, Sammet also wrote a textbook on the history and fundamentals of programming languages, an explicit attempt to shape the narratives

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[57] Grace Hopper, interview by Angelina Pantages, December 1980, Naval Data Automation Command, MD, USA.
[58] Ibid, 202.
[59] Beyer, *Grace Hopper,* 266.
[60] Sammet, Jean E. (March 2000). "The Real Creators of Cobol." *IEEE Software*. 17 (2): 30–32.
[61] Sammet, Jean. "Farewell to Grace Hopper—end of an era!" Communications of the ACM 35, no. 4 (1992): 128-131.
[62] Nyary, S. "Computer pioneer Jean Sammet '48 has died." *Mount Holyoke College News* (2017).

of programming language history.[63] Yet despite contributing to the history of computer science by authoring a textbook and designing a widely used programming language, Sammet's contributions are frequently glossed over by the stronger association between Hopper and COBOL. This misconception is emphasized by Sammet's own obituary, which repeats that "Hopper is often called the 'mother of COBOL,' but she was not one of the six people, including Ms. Sammet, who designed the language—a fact Ms. Sammet rarely failed to point out."[64] Ultimately, in popular narratives of computer science, it is still Hopper—who successfully ingratiated herself with male superiors and had a high-ranking, well-established military career at the time of COBOL's inception—who is celebrated as the inventor of COBOL.

The conflicting answers to the question "who developed COBOL?", which continued even in Sammet and Hopper's obituaries, obscure the collaborative and diverse nature of the initiative. Its development seems like a shining example of a women-led cooperation within the iron triangle. Sammet was not the only woman whose contributions were obscured by popular retellings of Hopper's leadership, as many women were heavily involved throughout the process: both Sammet and Mary Hawes of Burroughs Corporation not only belonged to the short-range committee that designed COBOL but led subcommittees within the group. According to Sammet's history, the initial meeting of users and manufacturers was at the request of Hawes, not Hopper.[65] Furthermore, Frances Elizabeth "Betty" Holberton, one of the "ENIAC girls," and several other women were involved in the editing process after the six-person group had produced the initial specifications. Holberton made key contributions to the programming of the ENIAC and "went on to program UNIVAC [Universal Automatic Computer] and to write the first major software routine ever developed for automatic programming." While others recall Holberton as "very instrumental in…COBOL—which Grace Hopper never gave her credit for,"[66] Holberton remains largely unknown compared to Hopper. When asked about women in computing, Grace Hopper voluntarily brings up the example of Holberton, who has "[never] been properly appreciated…She wasn't as articulate as I was and she didn't stick her neck out as

[63] Sammet, Jean E. *Programming Languages; History and Fundamentals*. No. 04; QA76. 5, S3. 1969.
[64] Lohr, S. "Jean Sammet, Co-Designer of a Pioneering Computer Language, Dies at 89." *New York Times* (2017).
[65] Sammet, "The Early History," 200.
[66] Bartik, interview by Janet Abbate.

far."[67] Hopper upholds a vision of computing that rewards those who are "articulate" and "stick their neck out"—but only to the point of "erasing gender differences" with their male supervisors and colleagues rather than challenging the masculine norms. Both Bartik and Holberton recall "the masculine business culture…the sea change at Remington Rand, which effectively ended their private-sector careers."[68] The disparity between Hopper's glory and the other women's lack thereof illustrates Rossiter's analysis that the presence of more women in the field, without meaningful changes to the reward structures and culture, does not necessarily empower women, as Hopper embodied the archetype of the lone [fe]male genius rather than serving as an "entering wedge" that broadened opportunities for other women.[69]

The inclusion of women in COBOL's development went hand in hand with COBOL's exclusion from dominant narratives of innovation. Due to the limited timeframe, this committee's goal was not to design the optimal language but to "create only an interim language" by cobbling together existing ones.[70] Offering utility for business applications that its predecessors lacked, "COBOL was good enough to become what appears to be the most widely used language in the late 1970s."[71] However, it did not produce knowledge in the ways that were recognized by the computer science community. The leaders of the community were "simply not interested" in "seeing what good ideas are in [COBOL] which could be further enlarged, expanded or generalized."[72] Eminent computer scientist and Turing Award winner Edsger Dijkstra—an archetypal lone genius in the history of computing—viewed COBOL as immature and unscientific because it relied on English language and anthropomorphic metaphors, which were more accessible to the general population than mathematical abstractions.[73] He went as far as remarking in 1975 that "the use of COBOL cripples the mind; its teaching should, therefore, be

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[67] Hopper, interview by Angelina Pantages.

[68] Beyer, 26. Holberton and Bartik, interview, 27 April 1973 (Computer Oral History Collection, Smithsonian Institution, Archive Center, National Museum of American History, Washington 118).

[69] Rossiter, Margaret W. *Women Scientists in America: Struggles and strategies to 1940*. Vol. 1. JHU Press, 1982. 39.

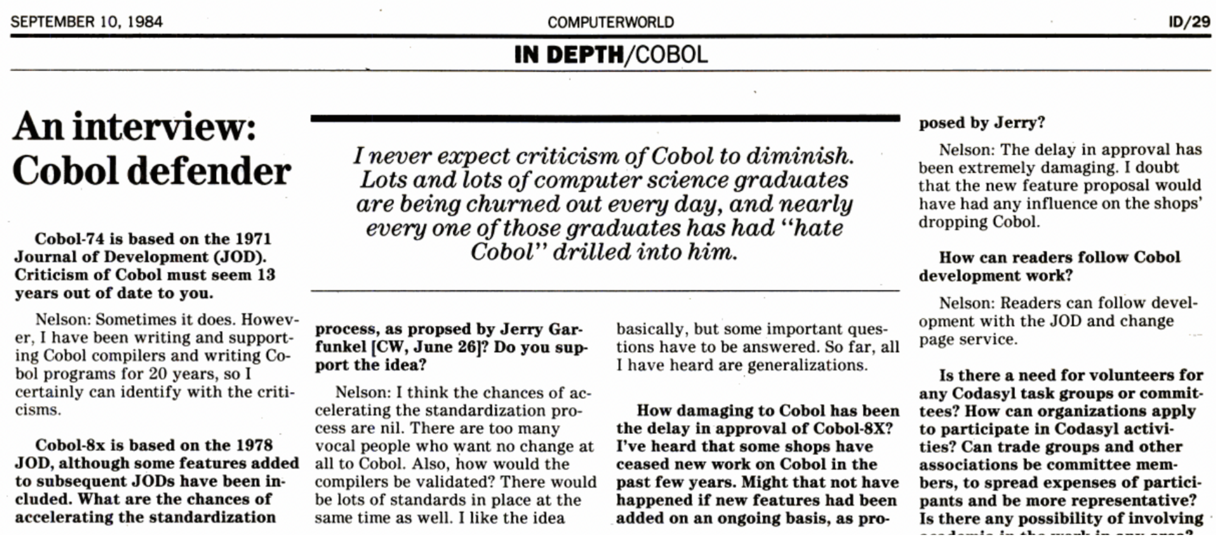
[70] Sammet, "COBOL." 203.

[71] Wexelblat, Richard L., ed. *History of Programming Languages*. Academic Press, 2014.

[72] Coughlan, Michael. "Introduction to COBOL." In *Beginning COBOL for Programmers*, pp. 1-15. Apress, Berkeley, CA, 2014.

[73] Payette, "Hopper and Dijkstra," 69.

regarded as a criminal offence,"[74] disparaging not only the creators but also the users of COBOL. COBOL's usefulness in contexts "that demanded communication and negotiation with diverse professionals"[75] was opposed by Dijkstra's statements, emblematic of academic research paradigms. The opposition to COBOL in academia[76] exemplifies Rossiter's analysis that "when prominent scientists thought that something was too feminized, too feminine, they would deny it the status of a 'science,' whatever its intellectual content."[77]



SEPTEMBER 10, 1984 COMPUTERWORLD ID/29

IN DEPTH/COBOL

An interview: Cobol defender

I never expect criticism of Cobol to diminish. Lots and lots of computer science graduates are being churned out every day, and nearly every one of those graduates has had "hate Cobol" drilled into him.

Cobol-74 is based on the 1971 Journal of Development (JOD). Criticism of Cobol must seem 13 years out of date to you.

Nelson: Sometimes it does. However, I have been writing and supporting Cobol compilers and writing Cobol programs for 20 years, so I certainly can identify with the criticisms.

Cobol-8x is based on the 1978 JOD, although some features added to subsequent JODs have been included. What are the chances of accelerating the standardization process, as propsed by Jerry Garfunkel [CW, June 26]? Do you support the idea?

Nelson: I think the chances of accelerating the standardization process are nil. There are too many vocal people who want no change at all to Cobol. Also, how would the compilers be validated? There would be lots of standards in place at the same time as well. I like the idea basically, but some important questions have to be answered. So far, all I have heard are generalizations.

How damaging to Cobol has been the delay in approval of Cobol-8X? I've heard that some shops have ceased new work on Cobol in the past few years. Might that not have happened if new features had been added on an ongoing basis, as proposed by Jerry?

Nelson: The delay in approval has been extremely damaging. I doubt that the new feature proposal would have had any influence on the shops' dropping Cobol.

How can readers follow Cobol development work?

Nelson: Readers can follow development with the JOD and change page service.

Is there a need for volunteers for any Codasyl task groups or committees? How can organizations apply to participate in Codasyl activities? Can trade groups and other associations be committee members, to spread expenses of participants and be more representative? Is there any possibility of involving

Figure 1. A *Computerworld* magazine from 1984 demonstrates the attitude of academic computer science toward COBOL. On a page interviewing a "COBOL defender," the pull quote reads, "lots and lots of computer science graduates are being churned out every day, and nearly every one of those graduates has had "hate COBOL" drilled into him."[78]

Yet another example of the ways that masculinity and scientific legitimacy are intertwined, COBOL was never meant to belong to the mainstream narrative of computer science innovation. COBOL was, from its nascence, a business-oriented language intended to be accessible and usable by novice programmers and laypeople rather than an innovation pushing the boundaries

[74] Dijkstra, Edsger W. (18 June 1975). "How Do We Tell Truths that Might Hurt?" University of Texas at Austin. EWD498.
[75] Payette, "Hopper and Dijkstra," 69.
[76] Coughlan, 1.
[77] Rossiter, "Which Women?", 185.
[78] Donald Nelson, "An interview: Cobol defender," *Computerworld*, September 1984, 29.

of computer science. As COBOL was developed for business applications, it was targeted toward those traditionally excluded from the circles of academic computer science.[79]

Hopper herself reinforced the mentality of programming as women's work, stating in a 1980 interview that "a gal who was a good secretary was bound to become a programmer, meticulous, careful about getting things right."[80] Hopper's comment resonates with the existing division of labor between computational and authorial, where the former is an occupation in which the most important qualities are being "meticulous" and following instructions. She compares the work of programming to making dinner, firmly drawing the gendered lines between different occupations. She states that "the concept of getting the data all together so you could operate on it was the same thing as getting a dinner ready. You had to get all the parts together and have it finished at one time." These statements, which rely on the gendered norms of women preparing dinner in a household and working as secretaries to explain the work of programming a computer, makes the association of programming with women seem natural. The work was not revered as innovative or exciting but rather a societal necessity that remained in the female domain alongside other domestic labor. Echoing Comrie's statements about the suitability of women for programming, Hopper makes clear that her work as a computer scientist is different from that of these women computers.

These perceptions may be part of the reason why women like Sammet and Holberton never achieved the widespread recognition that Hopper gained as a luminary and a genius. Sammet and Holberton worked at various companies doing technical programming work but not necessarily presenting it as innovation. Although Hopper was a woman, stories of her career fit the mold of standard narratives of prominent men in computer science, obscuring the labor of others who contributed to developing the COBOL programming language in the 60s. The inconsistencies among claims to fame for inventing COBOL reflects these communities' inability to think beyond the standard structure of innovation where objects are associated with singular inventors.

As women's rights movements gained traction in the United States in the 1960s, initiatives to increase the participation of women in computing permeated the iron triangle. Rather than

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[79] Payette, "Hopper and Dijkstra."
[80] Hopper, interview by Angelina Pantages.

challenging the values undergirding computer science as a scientific discipline, however, these later efforts only further entrenched the myth of the lone genius. In the next section, I explore how including more individual women into the mainstream structures of computer science innovation did not guarantee that all people with marginalized identities would be recognized or enabled to be successful.

1970s: The Title IX Era and McCarthy's Students

In the 1960s, American society was transformed by the New Left, a broad political movement focused on social issues such as civil rights and feminism.[81] The Civil Rights Act of 1964 arose from this momentum, formally prohibiting discrimination based on the protected classes of race, color, and national origin.[82] In the early 70s, activists lobbied Congress to include sex as a protected class, ultimately resulting in Title IX of the 1972 Education Amendments Act.[83] The statute reads: "No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance."[84] Various scholars have documented the complicated ways that protections like Title IX have changed the social and cultural landscape of high schools and universities across the United States and the narratives about women in higher education.[85] In particular, a new pattern emerged within university computer science departments eager to hire more women and give them equal access to opportunities.

At MIT, which had been nominally co-educational since the late nineteenth century, historian Amy Sue Bix writes that "a new sense of crisis" drove the few women faculty who were hired throughout the 1960s to join other staff and students across the institution in "systematically

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[81] Carmines, Edward. *Issue Evolution in Postwar American Politics*. 1997.
[82] Berg, Richard K. "Equal Employment Opportunity under the Civil Rights Act of 1964." Brook. L. Rev. 31 (1964): 62.
[83] Suggs, Welch. *A Place on the Team*. Princeton University Press, 2006.
[84] Title IX, Education Amendments of 1972, 20 U.S.C. §§ 1681-1688.
[85] See Walters, Julie, and Connie L. McNeely. "Recasting Title IX: Addressing Gender Equity in the Science, Technology, Engineering, and Mathematics Professoriate." Review of policy research 27, no. 3 (2010): 317-332.; Pieronek, Catherine. "Title IX and Gender Equity in Science, Technology, Engineering and Mathematics Education: No Longer an Overlooked Application of the Law" *JC & UL* 31 (2004): 291.; Johnson, R. A. (1989). Affirmative Action as a Woman's Issue. *Journal of Political Science*, *17*(1), 10.

pushing the school to improve conditions for women's education and employment."[86] The Ad Hoc Committee on the Role of Women Students at MIT, established in 1972, published a report that highlighted the dearth of women at MIT. The committee advocated for the active recruitment of women at all levels of the institution from undergraduates to faculty. MIT's president Jerry Wiesner embraced this mission of allowing more women to participate in the system. At a 1973 workshop, he publicly stated the importance of "'women's participation in every aspect of our technological society. This is another front in the almost universal battle for equality of opportunity.'"[87] Wiesner's acknowledgement of the "almost universal battle" reflects the wider cultural shift across the nation spurred by feminist movements of this time.

The stories of Barbara Liskov and Ruzena Bajcsy, two of John McCarthy's female graduate students at Stanford, reveal how Title IX and anti-discrimination efforts integrated into the culture of research and innovation. Narratives of their experiences help us understand the limitations of these initiatives. While these individuals were emblematic of policies that seemed to expand the playing field of the demographics that could contribute to computer science innovation, their stories continue to idolize the lone (fe)male genius as the default mode of success in the field.

Like Hopper, Barbara Liskov spent much of her career embedded in a prominent, military-funded computer science department and has become a well-known figure in the history of computer science. Liskov started her Ph.D. at Stanford in 1963 after a chance encounter with McCarthy. However, after concluding her Ph.D., she remembers that she "didn't get any reasonable job offers. Of course, I didn't really know how to apply; but nobody was helping me…" In the "'old boy network'" where you would ask your advisor [for a job]," she explained, "I had an advisor who wasn't particularly active, and I didn't even really think to push on him."[88] Without much support from her advisor, she instead moved to Boston to be with her husband and took on a systems research job at the MITRE Corporation, a federally-funded research and

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[86] Bix, Amy Sue. *Girls Coming to Tech! A History of American Engineering Education for Women*. MIT Press, 2014, 242.
[87] Ruina, Edith. "Women in Science and Technology." Room 10-140, Workshop on Women in Science and Technology, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, 1973.
[88] Barbara Liskov, interview by Janet Abbate, February 8, 2001, interview 609, transcript, IEEE History Center, Piscataway, NJ, USA.

development center. Like the rest of the industry at the time, MITRE had a rigid divide between, in the words of Liskov, "women's work and engineers' work."[89] While engineers were more respected and better paid, Liskov would "[go] on and on about some of the important things that they [the engineers] couldn't do,"[90] i.e. the technical tasks that only the women, and not the engineers, could perform.

These anecdotes are reminiscent of Bartik and Holberton's (two of the "ENIAC girls") recollections of the sharp, gendered divide of labor in computing. If Liskov had continued her career at MITRE, she may perhaps have been relegated to this domain of "women's work." Instead, Liskov took the authorial path. She wrote a paper about her work with the guidance of Judy Clapp, a more senior engineer at MITRE, and submitted it to the Symposium on Operating System Principles (SOSP), a top conference in computer systems. The paper became a turning point in her career. She presented the work at a session chaired by Jerry Saltzer, who was on the faculty at MIT. Liskov acknowledges the role that circumstance played in her career change: "part of what was going on there was that Jerry Wiesner was the president, and he had decided that he needed to increase the number of women on the faculty—so it was sort of an active push."[91] The paper won several prizes in the conference, and Saltzer invited Liskov to apply for a faculty position—an opportunity that may have only existed due to the Wiesner administration's institutional intervention catalyzed by the women's rights movements of the time. Liskov also recognizes the importance of Clapp's support to her career, stating: "nobody had ever—I mean, John McCarthy didn't read and respond to my thesis [after] I submitted it—so I'd never got any feedback on technical writing. Judy was the only person who ever did that for me; but she really helped me write that paper."[92]

Liskov joined the MIT faculty in 1972. There, she began working on programming methodology, developing the ideas of data abstraction, exception mechanisms, and other concepts. She and her graduate students incorporated these ideas into a programming language, which they named CLU. While CLU was never widely used, CLU's concepts would serve as the cornerstone of

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[89] Ibid.
[90] Judy Clapp, interview by Janet Abbate, February 11, 2001, interview 583, transcript, IEEE History Center, Piscataway, NJ, USA.
[91] Liskov, interview by Janet Abbate.
[92] Ibid.

object-oriented programming, a paradigm that is still widely in use today. Liskov's work at MIT, including her development of CLU, was widely acknowledged in the broader discipline of computer science. For "contributions to practical and theoretical foundations of programming language and system design, especially related to data abstraction, fault tolerance, and distributed computing,"[93] Liskov was awarded the Turing Award in 2008. The Turing Award, frequently referred to as the "Nobel Prize of Computing," is the highest distinction an individual can earn in computer science.

Liskov was portrayed as an extremely capable individual who was impervious to the male-dominated, competitive environment of academic computer science. Clapp recalls that although MIT was "cut-throat…everybody either doing their own thing, or competing, or undercutting each other in ways that certainly weren't collaborative, or cooperative, or anything else,"[94] Liskov thrived in this setting and denied that MIT's environment was competitive.[95] Like Hopper's work, Liskov's contributions to the development of programming languages are celebrated by the community, demonstrating how a woman can be supported and uplifted into the image of a lone genius by powerful mentors and institutions.

A few years after Liskov obtained her Ph.D. as John McCarthy's advisee, Ruzena Bacjsy graduated from the same lab at Stanford. Bacjsy went on to enjoy an illustrious career in computer science. She won many accolades and earned titles that have been largely held by men, including becoming the first woman to chair the Department of Computer Science at the University of Pennsylvania in 1985. Bacjsy was hired at the University of Pennsylvania in 1972, the same year that Liskov joined MIT. Bajcsy describes the entire field as having an approach of, "'Here is the water. Swim!'"[96] rather than guiding aspiring computer scientists throughout the process. Like Liskov and Hopper, Bacjsy faced a male-dominated environment. For instance, Bacjsy describes the gendered norms of the field, alluding to the "'screwdriver problem.' You know, it's not viewed as feminine to have a screwdriver in your hand!"[97] Yet as the first and only

[93] Van Vleck, Tom. "Barbara Liskov." https://amturing.acm.org/award_winners/liskov_1108679.cfm.
[94] Clapp, interviewed by Janet Abbate.
[95] Ibid.
[96] Ruzena Bajcsy, interview by Janet Abbate, July 9, 2002, interview 575, transcript, IEEE History Center, Piscataway, NJ, USA.
[97] Ibid.

woman in the engineering department, Bacjsy recalls, “my colleagues did not put up any obstacles. They didn’t prevent me from doing anything.[98]” Throughout her time in the male-dominated lab at Penn, Bajcsy perceived her surroundings as having “no obstacles,” seemingly oblivious to the ways that the “screwdriver problem” could present possible barriers.

Hopper, Liskov, and Bacjsy’s statements implicitly place the responsibility on individuals to overcome such obstacles rather than fundamentally challenging their existence. Jean Sammet, whose career took shape a decade earlier when women’s participation in computing differed greatly, reveals that the efforts of an individual woman alone cannot overcome these structural obstacles. On the surface, Sammet shares many similarities to Liskov and Bacjsy. All three are white women who obtained bachelor’s degrees in mathematics and went on to careers in computer science. Their passion for challenging, exciting technical work is well-documented.[99] Liskov and Sammet both contributed to the development of programming languages: Liskov’s team created the CLU language, which although never widely used, contained novel concepts that serve as the backbone of object-oriented programming today. Twenty years before CLU, Sammet helped to create COBOL, which is also an object-oriented language. But COBOL was perceived as a cobbled-together, means-to-an-end fix that was never in the running to belong to histories of innovation, while Liskov’s CLU is celebrated in the historical record and earned her the Turing Award. Also, unlike Liskov and Bacjsy, Sammet did not complete her Ph.D., a prerequisite to professorship, while Liskov benefited from her academic networks as well as the mentorship from Clapp to write and present her work in ways that highlight the novelty of her individual contributions—exactly the ways that are valued by dominant institutions. Moreover, while COBOL’s development was situated in a time when programming was lowly clerical work, Liskov and Bacjsy’s contributions came from within the academy during a push for not only more inclusion of women into the field but also the professionalization of programming and computing.

[98] Ibid.

[99] Liskov, interviewed by Abbate; Bacjsy, interviewed by Abbate; and Bergin, Thomas J. Tim. "Jean Sammet: Programming Language Contributor and Historian, and ACM President." *IEEE Annals of the History of Computing* 31, no. 1 (2009): 76-85.

Bacjsy and Liskov's successes as women in computer science can be attributed to structural factors that Sammet, and many other women of her time, lacked. This disparity reveals how institutional networks, cultural norms, and power structures play implicit roles in developing the myth of the lone genius and determining who gets recognized as such. The former group's work was viewed as innovative and valuable because it contributed novel ideas to academia. They had the privilege of studying under John McCarthy, the "father of artificial intelligence," and of being professors at top institutions, where they were able to lead graduate students and publish seminal papers. Bacjsy's sentiments about the culture at Penn echo Hopper and Liskov's stories of their experiences at Harvard and MIT. Tightly interwoven into the iron triangle, Hopper, Liskov, and Bacjsy had positions of power in university laboratories that enabled their recognition as lone geniuses despite their gender.

Pitfalls of the Lone Genius Myth

Historical accounts of scientific innovation elevate notable scientists, from Thomas Edison to Albert Einstein, and exemplify the distinctly masculine archetype of the lone genius,[100] while the critical labor performed by surrounding people—often women—is often nameless and unrecognized.[101] This myth is grounded in the legacy of innovation as a professional intellectual pursuit, in contrast to other forms of work, such as domestic and reproductive labor, which have been feminized and undervalued despite their importance to scientific progress.[102] Mar Hicks writes of this phenomenon as "gendered and classed labor ideals predicated on the heteronormative concept of a male breadwinner," in contrast to the "unpaid domestic work for women within the nuclear family."[103]

The discipline of computer science is no exception. As the narratives of Bacjsy, Liskov, and Hopper illustrate, even efforts to include and uplift women still perpetuate the same narrative that celebrates individual genius—the very myth that has fostered an exclusionary

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[100] Koditschek, Theodore. ""Genius and the Household Mode of Intellectual Production: 1795-1885." *Journal of Social History* (2005): 429-449.

[101] Pang, Alex Soojung-Kim. "Gender, culture, and astrophysical fieldwork: Elizabeth Campbell and the Lick Observatory–Crocker eclipse expeditions." *Osiris* 11 (1996): 17-43.

[102] Vogel, Lise. "Domestic Labor Revisited." *Science & Society* (2000): 151-170.

[103] Hicks, *Programmed Inequality,* 103.

environment.[104] Legal scholar Iram Valentin notes the insufficiency of equal access, which does not necessarily translate to equitable outcomes. This paradigm "may serve to discount the existence of these prejudices by seeking to put the onus for change on the victims, thus serving to legitimize their oppression." Allowing women to compete alongside men fails to confront the insidious effects of deep-seated cultural values and other roots of exclusion.[105]

It is worth noting that the Turing Award's namesake, Alan Turing, was a British computer scientist who was famous for, among other accomplishments, decoding the German Enigma machines during World War II. Hicks challenges the lone genius trope that this legend creates, noting that "lone codebreakers, notably Alan Turing, receive much of the credit for British intelligence operations during World War II, but the most important and voluminous intelligence work of the war was machine-aided and feminized. Codebreaking operations employed thousands of women and hundreds of machines in addition to the elite cadre of men who led the work."[106] Both in the United States and across the pond in Britain, the celebration of individual genius led to the obscuring of the labor of the many. While the Turing Award has since added "diversity and inclusion" to its list of core values, it continues to recognize only one or two individuals a year who have made "contributions of lasting importance to computing." Thus, it continues to exacerbate Rossiter's Matilda effect, where only the individuals at the top of the hierarchy—regardless of their gender—are recognized for their labor in narratives of computer science.

Bacjsy made some of her greatest contributions while embedded in and supported by the Penn engineering community, and similarly, Liskov and Hopper thrived at MIT and Harvard. These success stories are forms of what anticolonial scholar Max Liboiron refers to as "'inclusion into empire,' where groups who are defined by their difference from dominant groups are assimilated into dominant structures of what is good, what an opportunity looks like, and what is valued."[107] Successful women's abilities to ignore gendered norms or adapt to the status quo overlook the myriad ways that such environments may exclude other women and underrepresented people

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[104] Geringer, Steven. "ACM'S Turing Award Prize Raised To $250,000." (2008).
[105] Valentin, Iram. "Title IX: A brief history." Holy Cross JL & Pub. Pol'y 2 (1997), 132.
[106] Hicks, *Programmed Inequality,* 106.
[107] Liboiron, Max. *Pollution Is Colonialism*. Duke University Press, 2021.

who cannot fit into these spaces. This dilemma is underscored by a 2015 survey finding rampant sexism across technology firms[108] as well as a 2009 study that describes how many women in engineering "actively perform masculinity, attempting to fit in with their male colleagues by showing that they did not require special treatment and by sharing their camaraderie."[109] Elizabeth Holmes, the notorious former CEO of a Silicon Valley startup, is a more recent example of a woman in power who has leveraged these norms. In the media, she was frequently compared to Steve Jobs, who is perhaps the quintessential "lone genius" figure of the neoliberal era. Holmes consciously aimed to become "the next Steve Jobs" in all her actions, from clothing style to management techniques. During her rise to fame in the early 2010s, one of her most well-known physical attributes was her extremely deep, masculine voice, which she performed to gain more respect.[110] Conforming to masculine norms enables select women in the field to have power and authority, while closing the doors for others who are unable or unwilling to assimilate.

These critiques connect to recent scholars' work on gender inequality in computing, including Mar Hicks's analysis of gender and technology in *Programmed Inequality* and Catherine Rottenberg's critiques of neoliberal feminism in *The Rise of Neoliberal Feminism*. Hicks, whose work examines the decline of women programmers as the field of electronic computing matured in the United Kingdom, argues that "individual career choices" cannot undo the effects of well-established power structures, especially when the individuals "belong to groups that lack the power to participate in the structures of dominance and control that created institutionalized discrimination in a given organization or industry in the first place."[111] Thus, even if individual women were to dominate the field of computing and its narratives, injustice would continue to arise from the very structure of the field, where a select few are celebrated for contributing to innovation while benefiting from the labor of anonymous programmers.

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[108] Mullaney, Thomas S., Benjamin Peters, Mar Hicks, and Kavita Philip, eds. *Your Computer is On Fire.* MIT Press, 2021.
[109] Powell, Abigail, Barbara Bagilhole, and Andrew Dainty. "How Women Engineers Do and Undo Gender: Consequences for Gender Equality." *Gender, Work & Organization* 16, no. 4 (2009): 411-428.
[110] Dundes, Lauren, Madeline Streiff Buitelaar, and Zachary Streiff. "Bad witches: Gender and the Downfall of Elizabeth Holmes of Theranos and Disney's Maleficent." *Social Sciences* 8, no. 6 (2019): 175.
[111] Hicks, *Programmed inequality,* 238.

Similarly, Rottenberg criticizes the neoliberal feminist notion that the success of an individual woman is assumed to be a feminist success. Narratives of the lone genius contribute to an individualistic framing of innovation that deters from collective justice.[112] While Rottenberg's analysis addresses the modern brand of Sheryl Sandberg's "Lean In" feminism, her analysis is also more broadly applicable to our discussion. The narratives of women that we have discussed, while acknowledging sexism, offer a perspective "so individuated that it has been completely unmoored from any notion of social inequality and consequently cannot offer any sustained analytic of the structures of male dominance, power, or privilege."[113] They corroborate Rossiter's observation that even in "participatory" fields where women are a relatively larger proportion of the workforce, the "women leaders rather than becoming more feminist or militant and possibly changing the field significantly, would shy away from such confrontation and become willing collaborators in antifeminism."[114] The inclusion of women seems like progress, but the narratives of women who have been remembered as individuals, rather than as collective efforts, exhibit Rossiter's observed pattern of "shy[ing] away from confrontation" and failing to challenge the status quo.

Perpetuating the Myth of Meritocracy

The implicitness of these expectations, as reinforced by the narratives of Liskov, Hopper, and Bacjsy, makes them even more powerful, dictating who is qualified to be a computer scientist and make meaningful contributions to the field. Hicks notes that computing seems to embody the American Dream, offering the promise of "a field where cleverness can trump credentials and success is dictated by ingenuity and hard work."[115] Such beliefs are predicated on the fiction of computer science as a meritocracy, where individuals' success is based solely on their abilities as computer scientists rather than structural causes or cultural prejudices. This illusion ignores the personal or political factors at play in what Barbara Liskov referred to as an "old boys" network, where personal connections offer opportunities and lead to unfair, gendered distribution of social

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112 Rottenberg, Catherine. *The Rise of Neoliberal Feminism.* Oxford University Press, 2020.
113 Ibid, 425.
114 Rossiter. "Which Science? Which Women?", 172.
115 Hicks, Mar. "Against Meritocracy in the History of Computing." CORE: The Magazine of the Computer History Museum 20 (2016): 29.

capital.[116] As sociologist Ruth Sidel writes in her criticism of the American economic system and its myth of the American Dream, the fiction of meritocracy hurts marginalized people by imposing a mentality that blames failure solely on the individual rather than environmental factors.[117]

The concept of merit in computer science has long been tied to masculinity and the idea of the lone genius. Margaret Rossiter observes that “if a field is held to be manly and—especially during the Cold War—if it was valued by the military services, it was massively funded and rapidly embraced by prestigious institutions,” pointing to the inextricable links between the power and prestige of computer science, masculinity, and the military influence of the Cold War era. For example, without existing criteria for successful computer scientists in the 1960s, companies attempting to hire computer scientists resorted to “Darwinian selection mechanisms” of aptitude tests and personality profiles that sought out people with “‘detached’ personality (read antisocial, mathematically inclined, and male).”[118] Under the guise of merit, these tests reinforced the image of computer science as inherently masculine. More recently, a 2010 study demonstrated the “paradox of meritocracy”: “when an organization is explicitly presented as meritocratic, individuals in managerial positions favor a male employee over an equally qualified female employee.”[119] The authors of the study suggest that the facade of meritocracy makes individuals less aware of their prejudices and thus more likely to act on them.

Framing the system as a meritocracy—and thus upholding the myth of the individual genius—places the responsibility on individuals to overcome structural and cultural obstacles and suggests that they are better off having done so, rather than asking the question of why these obstacles exist and for whom they exist. It furthers the dichotomy between the few women who benefit from the institutional structures of power to be included in histories of innovation, such as Bajcsy, Liskov, and Hopper, versus the many women who served in clerical programming positions, such as Holberton and her fellow “ENIAC girls.” The latter have only been recognized

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[116] McDonald, Steve. “What's In The ‘Old Boys’ Network? Accessing Social Capital in Gendered and Racialized Networks.” *Social Networks* 33, no. 4 (2011): 317-330.
[117] Sidel, Ruth. *Women and Children Last: The Plight of Poor Women in Affluent America*. Penguin Group USA, 1992.
[118] Ensmenger, “Beards, Sandals”, 51.
[119] “Emilio J. Castilla and Stephen Benard, “The Paradox of Meritocracy in Organizations,” Administrative Science Quarterly 55 (2010): 543–568.

in retrospective attempts to identify women in computing and celebrate them,[120] rather than being embedded in the mainstream history of computer science. Many of these recent efforts, which I will detail in the next section, are built on the assumption that "having more women in the leadership position will automatically ensure fairer treatment for all women, because shared experience leads to empathy."[121] Hopper's claims to credit for COBOL as well as Bacjsy's and Liskov's insensitivity to the structural obstacles at MIT and Penn prove to the contrary.

1990s: The Grace Hopper Celebration

In the 90s, against the backdrop of third wave "difference feminism" which "valorized women's characteristics,"[122] female computer scientists led initiatives to create explicit spaces, separate from existing institutions, for women in computing. In 1994, the Grace Hopper Celebration of Women in Computing (GHC) was co-founded by Anita Borg and Telle Whitney in response to the field's gender discrimination. Starting with approximately 500 attendees, the conference grew exponentially to more than 15,000 participants in 2015 and 30,000 in 2020.[123] Each year, the conference hosts a career fair where representatives from hundreds of prominent tech companies look to recruit and hire women from among the conference's attendees. The setup seems, at first glance, a net positive—women break into the field and companies increase the diversity of their workforces. However, GHC entrenches the same dichotomy of earlier eras, where women are recruited on a massive scale to do programming work that is less respected without being offered pathways to positions of power and recognition.[124] While distinct spaces for "women in computing" offer community and support, they promote narratives of female innovators that replicate the same fiction of the lone genius as earlier generations. Consequently, these efforts value only a subset of labor: that which is innovative, creative, authorial, and backed by the established institutional networks of the iron triangle.

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[120] Fritz, W. Barkley. "The Women of ENIAC." IEEE Annals of the History of Computing 18, no. 3 (1996): 13-28.
[121] Rottenberg, *Neoliberal Feminism,* 427.
[122] Epstein, Steven. *Inclusion: The Politics of Difference in Medical Research*. University of Chicago Press, 2008.
[123] "Grace Hopper Celebration Impact Reports," Grace Hopper Celebration, AnitaB.org, 15 Mar 2022, https://ghc.anitab.org/impact-reports.
[124] Posner, Miriam. "We can teach women to code, but that just creates another problem." *The Guardian* 14 (2017).

The origins of GHC can help us understand the values that motivated its founders and early participants. After obtaining her Ph.D. in computer science, Anita Borg became a researcher at the Digital Equipment Corporation (DEC). At the 1987 SOSP (the same conference that, in 1972, led to Liskov's opportunity at MIT), she was struck by how few women were in the subfield. She created a mailing list for women computer professionals called Systers. While initially intended for her immediate community of women in operating systems research—hence the "Sys" in "Systers"—the mailing list quickly expanded to encompass all women in computing. In a 2001 oral history, Borg recounts that "opening it up wider has done something incredible for women in the field. Before Systers existed, there was no community of women in computing. It didn't exist."[125] Borg's account, half a century after the creation of the ENIAC, is a far cry from the "technical Camelot" about which Jean Bartik and the other women of the ENIAC era reminisce. Not long after, Borg left the company due to gender discrimination. She recounts:

> I hit a glass ceiling. I had helped put together a group to work on a new project…I loved it, and I pulled together a team of people—who never would have worked together before—and talked to the product groups, talked to all these people, got everybody excited. They were charged, they really wanted to do it. Then the head of Research called me in and let me know that they actually needed somebody older—with gray hair, who was male—to run it.

This not only killed the project but also made Borg realize that, despite her best efforts, she could not overcome the field's sexism alone. Unlike Liskov, Hopper or Bacjsy, who seemed impervious to gendered barriers, Borg describes a "glass ceiling" that prevented her success, recognizing an institutional barrier to her career's advancement.

To address these issues, Borg began to work on, as she puts it, "technology for women's stuff." Encouraged by the existing community from the Systers mailing list, Borg and her co-founder Telle Whitney organized the first GHC with the intention of "a top-notch technical conference" for women. GHC was funded by various corporations, including Hewlett-Packard (HP), an

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[125] Anita Borg, interview by Janet Abbate, January 5, 2001, interview 580, transcript, IEEE History Center, Piscataway, NJ, USA.

industry giant. Borg notes that "HP has been a very, very strong supporter from early on." Barbara Liskov, whose "lone genius" narrative we have previously discussed, was one of the speakers for the first GHC. From its inception, GHC relied on resources from the very institutional networks that had fostered the exclusionary environments making the conference necessary in the first place. GHC aimed to replicate the status quo of SOSP and other well-respected conferences in computer science, with the only difference being that the participants were all women.

Attempting to mimic SOSP proved impossible without addressing the field's deeper structural barriers for women. Inspired by the book *The Futures of Women* by Pamela McCorduck and Nancy Ramsey, Borg remembers becoming fixated on the question of "what do women—all women—want and bring to technology?"[126] This legacy lives on in the current tagline of GHC, which "brings the research and career interests of women in computing to the forefront." This framing presents several limitations.

First, relying on the broad expression "women in computing" erases the intersections across gender, race, class, and other elements of identity that compound oppression.[127] In the same way that there are "larger cultural and historical reasons why so many more women than men…have to start from the very bottom and often get stuck there," Hicks observes that there are also "so many more black women than white women" who face these struggles in computing.[128] At "the very bottom" are the manual, feminized, dead-end labor to which marginalized people were relegated—and slightly above that are positions like the one that Borg found herself in, unable to advance because of her identity. Centering the stories of white women like Hopper and Liskov as representative of "women in computing" idealizes a career that is not only challenging for other women to attain but perhaps flat-out impossible for women belonging to other marginalized groups, whose differences in their relationship to systems of power and oppression are well-documented throughout U.S. history.[129]

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[126] Ibid.
[127] Crenshaw, Kimberlé W. *On Intersectionality: Essential Writings*. The New Press, 2017.
[128] Hicks, "Against Meritocracy," 33.
[129] Davis, Angela Yvonne. *Women, Race, and Class*. Knopf Doubleday Publishing Group, 1983.

The creation of explicit space for women also sets the category of women apart as different from the imagined "default" people (i.e. men) in computer science, entrenching masculinity—and in particular the fiction of the masculine lone genius— as a cornerstone of computer science. Rather than questioning the norms regarding who can do what types of work, a separate community perpetuates the "screwdriver problem" that Bacjsy laments. Such phrasing only contributes to the divide between manual and authorial labor by establishing the latter as inherently male-dominated.

Ultimately, efforts like GHC fail to challenge the underlying values of computer science, instead furthering the myth of individual genius. By naming the conference after Hopper, this conference implicitly endorses the values that Hopper represents. Her eagerness to discuss individually overcoming obstacles embeds the expectation for women to single-handedly overcome any adversity that comes their way to succeed in their career. The story of GHC demonstrates the difficulty of challenging the dominance of innovation by lone masterminds over other types of contributions. The lone genius archetype in narratives of computer science, including those celebrating female innovators, only furthers the fiction of computing as a meritocracy.

Perspectives from Feminist Epistemology

My analysis of mainstream narratives in computing connects to criticisms of empiricism from feminist epistemology, which suggest that we cannot escape the exploitative norms of scientific progress, and more broadly the dominant modes of knowledge production, without moving beyond the veneer of merit. Philosopher Sandra Harding criticizes the "feminist empiricist" view that "sexism and androcentrism could be eliminated from the results of research if scientists would just follow more rigorously and carefully the 'fundamentally empiricist' existing methods and norms of research."[130] The "existing methods and norms of research" in computer science uphold the idea of computing as an objective, neutral discipline that is not influenced by social constructions like gender.[131] While Harding is discussing the "results" of science, I apply these ideas to understanding the meritocratic organization of computer science labor and its narratives.

[130] Harding, Sandra. "Rethinking Standpoint Epistemology: What is 'Strong Objectivity?'." *The Centennial Review* 36, no. 3 (1992): 437-470.
[131] Daston, Lorraine, and Peter Galison. *Objectivity*. Princeton University Press, 2021.

Harding suggests that "naive feminist empiricism" offers an avenue to "grasp the importance of feminist research…without feeling disloyal to the methods." It does not require change from the status quo in terms of valuing merit, and it is thus much easier for computer scientists to sympathize with and adopt. Thus, narratives linked to the everyday exclusion of women and other marginalized groups persist, while the few who manage to become the exception only prove the rule.

As COBOL demonstrates, even collaborative efforts can be repackaged into the individual genius narrative. Despite the reality of the collaborative process during the creation of COBOL, recognition of COBOL's creators has nonetheless aligned with dominant narratives of innovation. COBOL's legacy has been associated by a single individual, Grace Hopper, and the popular story of the development of COBOL represents a failure to recognize the collaboration involved in the process. The missing elements in the popularly received story of COBOL reflect exclusionary discourses. Telling a community-centered story of COBOL's creation and valuing it as innovation would not only challenge the ways that progress in the field is narrativized but also more accurately reflect the history of women in computing.

Feminist epistemology offers possibilities for recognizing the labor of knowledge production that push beyond authorial innovation and its lone genius archetype. Harding and Donna Haraway offer radical alternatives that incorporate the perspectives of a larger community, which may potentially shift the rigid lines between collective labor and individual achievement. Harding's theory of strong objectivity helps challenge existing narratives of computer science innovation by valuing the perspectives of the historically marginalized. A feminist and postcolonial theorist, Harding writes about the importance of "starting thought from marginalized lives" and "taking everyday life as problematic."[132] She goes on to note that the mainstream does not "voice or hear… thought that begins from the lives of the oppressed." In so writing, Harding emphasizes the idea that marginalized people have a clearer vision of the systems that marginalize them than those who benefit from those systems since the latter have little incentive to understand them fully. Harding's writings provide a framework for telling the story of COBOL in a way that gives voice to the women whose contributions to COBOL have been devalued and obscured.

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132 Harding, "Rethinking Standpoint Epistemology," 438.

Unlike Harding, Haraway does not advocate for starting from any one position, instead believing in the "radical multiplicity of local knowledges." Haraway maintains that "only partial perspective promises objective vision"[133] because no single perspective can provide a "faithful account of a 'real world.'"[134] She advocates "webbed connections" which arise from "partial sight and limited voice," with each perspective adding a small piece to the "web."[135] Since nobody can know everything—any individual person has "partial sight and limited voice"—this approach incorporates the perspectives of different people. Rather than choosing particular perspectives to center, Haraway's framework helps us imagine COBOL as the result of a community of "webbed connections" that includes not only the various committees and women who have been overlooked but also the prominent, powerful figures like Hopper. An alternative narrative of the development of COBOL might involve a constellation of people of all genders, from various communities, uniting to make a programming language more accessible to a broader population.

While Harding and Haraway's paradigms differ, as the former proposes an inversion of the hierarchy while the latter deconstructs it altogether, both are forms of feminist refusal that ultimately challenge the extant power structures as well as the cultural imaginaries that undergird their continued dominance. Using feminist epistemology to rethink the COBOL narrative demonstrates a way to deconstruct the narratives of the lone genius that have permeated the collective memory of computer science.

Feminist Possibilities

The implicit values of the computing industry's laissez-faire attitude present structural obstacles that have not been overcome by narratives of female innovators nor the creation of explicit spaces for "women in computing." Beyond reshaping the historical narratives, feminist commitments also present possibilities for the field of computer science itself, as demonstrated by recent feminist initiatives within. Unlike COBOL, whose community-based creation arose

[133] Haraway, Donna. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective" In *Feminist Theory Reader*, pp. 303-310. Routledge, 2020. 583.
[134] Ibid, 579.
[135] Ibid, 585.

from military-industrial-academic partnerships, the examples described in this section are explicit in stating their aims to restructure power dynamics in the field.

First, there is increasing interest in computing scholarship based on principles of participatory design, which arose in the 70's to give power and agency to users and the people that systems affect.[136] Unlike previous collaborations within the iron triangle, participatory design emphasizes the importance of explicit political commitments to community.[137] MIT is now home to the Data Feminism laboratory, whose work explicitly includes "(1) Examining power – i.e. structural privilege and oppression – and understanding how it shows up in our data, AI, ML, and information systems, and then: (2) Challenging power (3) Valuing lived experience (4) Committing to co-liberation (5) Using participatory methods of co-design and knowledge production."[138] The laboratory presents a framework for challenging the existing power structures in computing and with them the underlying value of individual genius.

In 2020, the International Conference on Machine Learning (ICML) hosted a workshop on "Participatory Approaches to Machine Learning," with the mission statement of "exploring methods that, by design, enable and encourage the perspectives of those impacted by an algorithmic system to shape the system and its decisions. Involving affected populations in shaping the goals of the overall system, we hope to move beyond just tools for enabling human participation and progress towards a redesign of power dynamics in ML systems."[139] This workshop signals a shift in research interests toward challenging the power structures of the field, as ICML is one of the most influential computer science conferences.[140]

Other scientific disciplines also provide models of how technological innovation and scientific progress can be motivated by feminist ideologies. For example, at the Memorial University of Newfoundland and Labrador, the Civic Laboratory of Environmental Action Research (CLEAR)

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136 Spinuzzi, Clay. "The Methodology of Participatory Design." *Technical Communication* 52, no. 2 (2005): 163-174.
137 Ibid, 164.
138 "Data + Feminism Lab," accessed May 25, 2022, https://dataplusfeminism.mit.edu/.
139 Kulynych, Bogdan, David Madras, Smitha Milli, Inioluwa Deborah Raji, Angela Zhou, and Richard Zemel. "Participatory Approaches to Machine Learning." In *International Conference on Machine Learning Workshop*. 2020.
140 "Top publications, Engineering and computer science." Google Scholar, accessed May 28, 2022, https://scholar.google.com/citations?view_op=top_venues&hl=en&vq=eng

runs based on the CLEAR Lab Book, a "living manual of values and guidelines." The manual articulates, among other values, community priorities as the source of the lab's core research questions and the lab's rejection of hyper-individualism.[141]

The figure of the lone genius as a cultural icon cannot engage wholeheartedly with the impacts of computer science on communities. Meaningful inclusion relies not on individualistic sparks of innovation and markers of success but on continued efforts toward incorporating community perspectives into computing. Yet the idea of the lone genius has shaped narratives of modern computer science from its start during World War II throughout recent efforts toward diversity and inclusion, suggesting that this myth is inextricably linked to the very existence of the field as we know it. Shifting away from the individual genius archetype toward feminist possibilities requires a radical reimagining of computer science—one that is fundamentally opposed to the values on which the field's power and prestige is built.

[141] Liboiron, Max. "CLEAR Lab Book: A living manual of our values, guidelines, and protocols (Version 3)." (2021).

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