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Social entrepreneurship from margin to centre: Rear Admiral Grace Murray Hopper's contributions in transforming society through practices of opening up

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ABSTRACT

This article explores social entrepreneurship (SE) historically, focusing on the interplay between the US entrepreneurial state, WWII geopolitics, and shifting gender roles. Drawing on the historiography of Rear Admiral Grace Murray Hopper, it traces how SE has historically unfolded as a collective, collaborative, and open endeavour capable of driving social transformation. Hopper's work in computing reveals three situated SE practices: stepping into the labour market, engaging in creative problem-solving in the margins, and building community through reaching out. By engaging bell hooks's concept of the margin as a space of radical openness, the article shows how women were granted access to centre in ways that redefined possibilities for transformation. Hopper's SE made programming languages accessible rather than monopolised systems and challenged gendered boundaries in the ICT field. The article highlights the changing meanings of SE over time and reclaims its roots in democratic, inclusive practices that enable broader social transformations.

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Introduction

Contemporary initiatives of social entrepreneurship (SE) typically refer to purpose-driven businesses or organisations oriented towards the social good (Wong et al., 2023). These organisations address societal issues such as inequality, exclusion, and lack of diversity (Bandinelli, 2019; Calás et al., 2009), often targeting marginalised groups – including women, racialised communities, and others historically excluded from the centre (Boddice, 2009; Clark Muntean & Ozkazanc-Pan, 2016; Dempsey & Sanders, 2010), by adopting market-based methods and strategies to empower these groups and resolve social issues (Peredo & McLean, 2006, Kosmynin, 2022).

Whilst targeted groups are positioned as the primary beneficiaries, the social entrepreneur – often a man – is framed as the enabler, someone with the power to empower (Dempsey &

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Sanders, 2010; Wettermark & Berglund, 2022). This framing can obscure collective efforts in SE (Berglund et al., 2012) and reinforce existing power asymmetries (Clark Muntean & Ozkazanc-Pan, 2016). It also sustains a masculinised SE discourse perpetuating the assumption that the (male) individual entrepreneur is more readily recognised as a creative force (Ogbor, 2000), bringing his (sic!) own human and financial capital to foster, not only economic, but also social change (Dey & Steyaert, 2010). While private companies can indeed play a role in enabling social change, their efforts remain conditioned by market rules and the imperative to find sustainable business models (Kosmynin, 2022). Contemporary SE discourse thus assumes that individual actors or single organisations are responsible for achieving social transformation. With a historical lens, this study shows that SE unfolds as a set of practices and concerted actions by multiple actors – including the entrepreneurial state, public and private organisations, civil society, and individuals – working cooperatively to address social issues.

Our historiography of Rear Admiral Grace Murray Hopper's work shows exactly this: social issues (such as those related to the war efforts and national defence) were tackled through an opening that emerged at the nexus of World War II (WWII), an active US state, and the call for women to step in. We argue that, at the time, this opening unleashed social entrepreneurial practices that enabled women to move 'from margin to centre', bringing their knowledge and competence into computer development to meet the challenges of the war time and its aftermath. By insisting that computing remained a public good, Hopper's work not only fostered future openness in the ICT industry but, more importantly, exemplified how SE once unfolded through a collaborative and inclusive ethos.

What we recognise today as SE - private organisations serving the social good – shares some continuities but also significant differences from how it has unfolded historically. To better understand SE in history, we suggest reappreciating the broader processes and practices that enabled transformative social change. Our article finds that in contemporary society, the space for social transformation has largely been closed off, as private organisations now occupy the 'centre' of SE, focusing on problem-solving within the bounds of existing systems (e.g. Teasdale & Dey, 2019), rather than challenging or transforming the underlying systems and cultural logics themselves (Spinosa et al., 1999). Second, the dominant framing of social entrepreneurs as benevolent actors who empower the disenfranchised further constrains the possibility for 'othered' groups to enact SE from the margins. It also fails to challenge existing power hierarchies – who holds power at the centre and who/what remains at the margin.

To illustrate these arguments, we examine the development of computing during WWII in the US and the role of the emerging entrepreneurial/welfare state, focusing on one of its pioneers, Rear Admiral Grace Murray Hopper. We ask three questions: (1) What practices of opening up can be identified in the case of computing? (2) How can these practices foster social transformation? (3) How might they offer a more nuanced understanding of SE and challenge or revitalise its current forms?

Computing history and the entrepreneurial state

Discussions of the birth and development of computing often centre on men such as Alan Turing, Howard Aiken, John Mauchly and J. Presper Eckert – celebrated for their work in hardware development; Tim Berners-Lee, credited with inventing the World Wide Web; and Bill Gates, Steve Jobs, and Mark Zuckerberg, known for innovations that shaped the

information technology market (Wong et al., 2024). Yet, when we turn our attention to the voices of women like Rear Admiral Grace Murray Hopper – frequently credited as the inventor of the first compiler (A–O) and co-creator of COBOL (Common Business-Oriented Language) – a different story emerges. Through women's stories, we detect forms of SE practices aimed at securing social good. For Hopper, this involved addressing national security demands during WWII and promoting an open computing field in its aftermath. However, women's contributions were often downplayed, erased or even brushed away as mere 'common sense' (as Hopper remarked in her 1980 interview). Hopper's breakthroughs enabled laypeople to 'talk to the computer' and cross organisational and national boundaries - laying the groundwork for modern software development and human centred technologies. Yet, she herself resisted the image of the lone inventor - a portrayal that nonetheless persists.

While Hopper is widely recognised as a pioneering woman in the early computer industry (e.g. Beyer, 2012), less attention has been paid to how her work aligned with an intentional drive for social change – unfolding through the messy, collective, and contingent practices that emerged before, during, and after WWII – practices that resonate with what we today might call social entrepreneurship (SE). The wartime effort created a state-sponsored environment, where solving urgent problems temporarily overrode social boundaries of gender, class, and race. What mattered was not *who* you were, but *what* you could do, in Hopper's words: 'How can you get this done?' This shift of meaning, however, might not only obscure the continuation and experiences of marginalisation of some (Pecis & Berglund, 2021), but also it may posit little attention to the social and collective dimensions of this work. Perhaps for this reason, individualised narratives of the 'inventor' are promoted, while collaborative contributions, which could inform SE, remain hidden between the lines.

Historical accounts show that many women worked at the margins of this male-dominated field (Tassabehji et al., 2021); they were, in bell hooks' words, 'part of the whole but outside of the main body' (Hooks, 1989, p. 20). Through cross-organisational collaboration, these women created a 'community of resistance' (Hooks, 1989), pushing for the creation of 'open languages' that would remain accessible to all, as a public good. Hopper's resistance to the monopolisation of the compiler exemplifies this: a radical defence of broad access to software development, which helped pave the way for today's open and competitive ICT market. Operating in a male-dominated field, Hopper also opened the field to 'others' – women, young people, and laypeople (not just mathematicians) – fostering broader participation in ICT development. To this day, she is recognised as a key figure in empowering women in tech. Listening to women's voices – like Hopper's – shows that this democratic ethos did not go unchallenged, but rather entailed community resistance and the shaking of sedimented power dynamics of i.e. male dominance (Elliott, 2020).

The openings made available to women in shaping the computing field were not accidental. WWII demanded new solutions and afforded technological, social and organisational spaces for experimentation. While the war brought immense hardships, it also enabled social transformation – challenging gender norms and highlighting women's abilities in areas previously considered unsuitable (Armstrong, 1998). If WWI spurred broader demands for women's rights, including suffrage (Greenwald, 1980), WWII laid the groundwork for milestones such as The Equal Pay Act (Aguierre, 2018). It also accelerated technological breakthroughs, including computing and the development of early programming languages -pioneered by women – that made human-computer communication possible. Yet computing continues to be perceived as a male-gendered innovation (Tassabehji et al., 2021; Wong et al., 2024).

During and after WWII, the US state enabled innovation,[1] by providing citizens, voluntary organisations, companies, and universities with resources and incentives to collaborate – often guided by ambitious visions rather than clearly defined goals (Mazzucato, 2013). The welfare US state that emerged alongside WWII, which Mazzucato (2013) terms the 'entrepreneurial state', played a central role in providing long-term state-funded investments in areas as computing. These investments underpinned decades of economic success, not only through inventions of the computer and compiler but also by creating new markets, where the state carried risks beyond the private sector's scope (Dosi et al., 2023; Mazzucato & Semieniuk, 2017). Importantly, the entrepreneurial state pursued not only growth but also democratic welfare, mobilising resources to address social challenges (Mazzucato, 2018).

Within this context, broader societal transformations – including shifts in women's roles – began to take shape. Like many women who entered knowledge-intensive roles during the war, Hopper faced several exclusions – being denied initial entry to the Navy, disappointing her manager at Harvard simply by being a woman, and being reminded of her childhood realisation that engineering was 'not for girls'. These experiences became sources of resourcefulness, situated knowledge, and new ways of engaging with technology from the margins. Inspired by Dean et al., (2024) who highlight the analytical power of margin and centre in business history, we turn to bell hooks' (1989, 1984/2000) concept of the margin as 'a profound edge' (Hooks, 1989, p. 19) – which enable envisioning movement and crossing of boundaries and tracks. This lens helps us identify SE practices of 'opening up' that enabled women to cross boundaries, moving towards the centre, acting as precursors of wider social transformations.

Recognising SE from the margins paves the way for showing how it has historically unsettled, reimagined, and subtly transformed dominant masculine norms and business practices (Dean et al., 2024). Margin and centre thus offer an analytical entry point to understand how social transformation emerges through challenges to exclusionary structures – structures that sustain inequality by reproducing sedimented boundaries and trajectories. Such practices reflect a democratic ethos - a commitment to inclusion, participation, and the valuing of marginalised voices as vital to reimagining the centre. We suggest this ethos saturates the SE practices explored here.

Following Hopper's trajectory – and the macro shifts affecting women during WWII – allows us to interpret their stories, and how women such as Hopper narrated them, not merely as tales of individual resilience, but as part of a broader history of social entrepreneurial statecraft. Although the historical period under investigation opened up spaces to renegotiate and shake inequalities – leading to progress in diversity and equality – we have recently witnessed a backlash, marked by challenges to democratic norms, and a retreat from human rights (Bastian et al., 2025), and an individualisation of the responsibility for addressing social issues. This echoes in contemporary SE discourse, where a 'closed centre' continues to require the margin to enact change (Dey & Steyaert, 2010; Wettermark & Berglund, 2022). Although private actors increasingly step in to fill the gaps left by a retreating welfare state, a market-driven logic may limit their potential to 'disclose new worlds' (Spinosa et al., 1999) – that is, to enable transformative social change beyond the market's scope. By tracing these shifts – from collective to privatised, from self-enacted to externally delivered SE – the article invites reflection, and perhaps reimagination, of how SE might still offer meaningful possibilities for enacting social change within contemporary configurations.

Methodology

Taking inspiration from what Wadhwani and Lubinski (2017) refer to as 'new entrepreneurial history', we acknowledge the role historical research has played in unearthing theories of entrepreneurship. By approaching Grace Murray Hopper's story from a narrating perspective on history (Maclean et al., 2016), we aim to 'contextualise' (Lippmann & Aldrich, 2014) Hopper's work at the intersection of WWII, the entrepreneurial state and early computer development. As Wadhwani and Jones (2014, p. 194) remind us, 'context is an essential component of entrepreneurship', by shaping both the actions taken and the motivations behind them. From a constitutive/cognitive perspective (Wadhwani & Jones, 2014), historical time is not only relevant to researchers but also to research subjects themselves. Historical experiences influence actors' choices, actions and how micro practices translate to macro-processes. For Hopper, the announcement of Pearl Harbour was a decisive moment. In its wake, she divorced her husband,[2] left her tenured position at Vassar College, and joined the U.S. Navy. We argue that a contextualising historical perspective allows an analysis of SE attentive towards both personal narrative accounts (micro practices) and the broader conditions for emerging computer programming (macro processes).

In what follows, we connect micro practices (personal narrative accounts) to macro level events (broader conditions for emerging computer programming), to capture the transformations providing a rich context to entrepreneurial activities. We also recognise our own selection, reading and evaluation of sources (Wadhwani & Decker, 2017); emphasising how certain actors have been systematically included/excluded historically, but also how SE practices might have originated. For example, we deliberately focus on Hopper's biographies and interviews to foreground women's contributions to computing. Hopper was chosen not only because she is often referred to as 'the heroic pioneer' of the information age (see Beyer, 2012 for a deconstruction of such rhetoric), despite her own resistance to the title, but also because her work has rarely been examined through an SE lens (e.g. Lubinski et al., 2024). While she may have spoken more through action than words, she was clear about the importance of enabling social change: she involved people in building the computing field – removing barriers she and other women faced before and during the war and worked collaboratively within a space of openness created at the intersection of WWII and an entrepreneurial state. This choice inevitably excludes many other women and minorities who contributed to the history of computing.

In this article, we combine primary and secondary sources (see Table 1 for a complete list). Primary sources include archival documents and media clips close in time and space to the events (Wadhwani & Decker, 2017): Hopper's humoristic notes, photographs, oral histories from Hopper and her team, and patents in archival collections - all situated within a specific narrative framework (Barros, 2023). Selected archives are framed within a specific organisational account of the historical emergence of computing as a new field and market. We triangulate (Kipping et al., 2014) these primary sources (archival sources) with secondary sources, such as Kurt Beyer's (2012) analysis of Grace Hopper's contributions to computing and Kathleen Broome Williams (2012) biography of rear Admiral Grace Hopper (included in the Library of Naval Biography series), to 'multiply perspectives, judging their validity and credibility based on their closeness in time to the events and the context of their creation' (Pirani & Lubinski, 2025, p. 743). These secondary sources draw on primary materials, including some not available to us (e.g. archives at the Schlesinger Library, Radcliffe Institute, Harvard University).

We approached the sources in Table 1 by focusing on the contextual explanation of the practices, noticing that some practices are enacted more prominently in specific accounts of Hopper's life. As we read the texts, we asked ourselves: what practices of SE and social transformation do these texts bring out? Our data analysis and theorisation involved a three-fold process that closely followed the data (Charmaz, 2006), which are summarised in Appendix A (Practice of stepping in), Appendix B (Practice of creating problem solving), and Appendix C (Practice of collective community building through reaching out). In the first step, we independently read the sources and took notes on the practices that emerged from the texts. We then discussed our observations and focused on the sources that most clearly illustrated SE practices. The second step involved grouping quotes into sub-practices that described patterns of action. The third step involved further theorisation of these sub-practices into broader themes – namely, SE practices. This final step adopted a more deductive approach, applying a margin/centre lens to the analysis of SE. Appendices A, B, and C illustrate the process, sub-practices identified, and representative quotes (available as online supplemental material).

Notably, macro processes – the start of the war, Pearl Harbour and the changes in labour market configurations – were especially present in the first practice and its sub-practices. As the narrative progressed the sources increasingly highlighted the micro level of practices, while still connecting to macro level changes occurring in the post-war context. We thus understand the sub-practices in the three appendices as interwoven elements in a narrative of macro–micro processes that have historically sustained SE.

For clarity, the article presents Hopper's contributions and the unfolding of SE practices in a broadly chronological order.

Going to war: *catalysing social change by stepping in*

Just before 9 am on Sunday, 7 December 1941, Pearl Harbour, an U.S. naval base near Honolulu, Hawaii, was devastated by a surprise attack as hundreds of Japanese fighter planes descended upon the base. The attack killed more than 2,400 Americans, including civilians, and wounded another 1,000. Nearly 20 American naval vessels, including eight battleships, and over 300 aeroplanes were destroyed. The following day, President Franklin D. Roosevelt declared war on Japan. Men left for active duty, and women entered the workforce. World War II created unprecedented opportunities for American women to take on jobs previously closed to them, particularly in the defence industry (Aguierre, 2018). Following the attack, the influx of women into the labour market accelerated (Hepler, 1998), although many women were already employed by 1941(Yesil, 2004). A quarter of the women in major war manufacturing jobs had been working in other industries the week before the attack, and 24% had been employed in other sectors of the economy (Kossoudji & Dresser, 1992). The rise of women in the labour market had already begun during the Great Depression, when the participation of mostly white married women increased by 28% between 1929 and 1940, despite strong public opposition and legislative efforts to restrict married women's employment (Helmbold, 1987).

With the advent of WWII, resistance to women's employment quickly diminished. Wartime propaganda actively sought to recruit women, and the working woman was idealised 'as the strong, competent, courageous 'unsung heroine of the home front' (Yesil, 2004, p. 103). The propaganda targeted housewives, urging them to work in factories for

Table 1. List of historical sources.

Type of source	Source name	Author/s and location	Year	Length	Acronym for the paper
Article	Grace Murray Hopper (1906–1992): A legacy of innovation and service	Yale News	2017	2270 Words	YN17
Oral history	Oral History of Captain Grace Hopper	Angelina Pantages, Computer History Museum	1980	54 Pages	AP80
Video interview	Interview to Grace Murray Hopper	Late Night show, David Letterman	1986	9.37 Min	LNS86
Biography	Grace Hopper and the invention of the information age	Kurt Beyer	2012	404 Pages	KB12
Biography	Gracer Hopper Admiral of the Cyber Sear	Kathleen Broome Williams	2012	240 Pages	KBW12
Article	To the editor	Judy Green and Jeanne LaDuke in ISIS	2011	2 Pages	JGJL11
Oral history	Interview to Grace Hopper (July)	Uta C. Merzbach, Archives Centre, National Museum of American History	1968	37 Pages	UM68-J
Oral history	Interview to Grace Hopper (November)	Uta C. Merzbach, Archives Centre, National Museum of American History	1968	11 pages	UM68-N
Oral history	Interview to Grace Hopper (January)	Uta C. Merzbach, Archives Centre, National Museum of American History	1969	18 Pages	UM69-J
Oral history	Interview to Grace Hopper (February)	Uta C. Merzbach, Archives Centre, National Museum of American History	1969	13 Pages	UM69-F
Oral history	Interview to Grace Hopper	Beth Luebbert and Henry Tropp, Archives Centre, National Museum of American History	1972	48 Pages	BLHT72
Oral history	Interview to Howard Aiken	Henry Tropp and I.B. Cohen, Archives Centre, National Museum of American History	1973	180 Pages	HA73
Oral history	Interview to Robert V. D. Campbell	Charles Babbage Institute, The Centre for the History of Information Processing University of Minnesota, Minneapolis	1984	60 Pages	RC84
Oral history	Interview to Richard Bloch	William Aspray (Charles Babbage Institute, The Centre for the History of Information Processing University of Minnesota, Minneapolis)	1984	30 Pages	RB84
Oral history	Interview with Arnold Cohen	Charles Babbage Institute, The Centre for the History of Information Processing University of Minnesota, Minneapolis	1983	117 Pages	AC83
Oral history	Interview with Presper Eckert	Charles Babbage Institute, The Centre for the History of Information Processing University of Minnesota, Minneapolis	1977	61 Pages	PE77
Oral history	Interview with Earl Edgar Masterson	Charles Babbage Institute, The Centre for the History of Information Processing University of Minnesota, Minneapolis	1986	63 Pages	EEM86

the sake of their country (Aguierre, 2018). Jobs were presented as glamorous, whilst stressing the self-censorship expected of women in these new roles (Brock et al., 2015). Women's entry into the labour market had a clear social purpose: to support the nation and the men at war (Aguierre, 2018). Iconic media representations, such as Norman Rockwell's Rosie the Riveter poster (e.g. Brock et al., 2015; Kossoudji & Dresser, 1992), helped shape the narrative. Movies like 'Since you went away' (1944), and theatre plays productions (i.e. Rosie the Riveter, 1944)[3] further popularised the image of the patriotic working woman. Whilst government primarily propaganda targeted middle-class white women, many minority women took new roles – despite continuing discrimination and marginalisation (Pecis & Berglund, 2021). Hopper was among the 6.5 million American women who entered the workforce during the war years (Tobias & Anderson, 1974), answering the call to join the defence effort.

Rear Admiral Grace Murray Hopper[4] was born Grace Murray in 1906 in New York City, the eldest child of Walter Fletcher Murray and Mary Campbell Van Horne. Accounts of her early life portray her as a brilliant and curious mind. As a young girl in her adventurous endeavours, she was often reminded by her mother to 'remember your great grandfather, the admiral' (KBW12, pp. 1–2). Hopper was described as 'strong-willed, irreverent, sharp-tongued, and brilliant' (YN17). She had a privileged upbringing: she was educated in private schools; graduated in 1928 from Vassar College with a degree in mathematics and physics, and in 1930 with a master's degree in mathematics from Yale.

Despite these privileges, some paths remained closed. Hopper wanted to become an engineer, 'but there was no place for women in engineering when I graduated', she explained (AP80, p. 11). Yet, marginality can act as a place of radical openness (Hooks, 1989). Encouraged by her father – 'My dad always made things, and I've always been fascinated with how things work and making things work' (UM1968-J) – Hopper found alternative routes by embracing mathematics and physics. Her path exemplifies boundary-crossing, or what Hooks (1984/2000) calls 'crossing the tracks': holding on to a dream while finding new ways to approach it. Hopper's approach was not to stand on the barricades, but to develop subtle, persistent practices that brought her closer to her vision of engineering.

Institutions such as Vassar College – founded in 1861 with the goal of offering women an education equal to that of the best men's colleges (Beyer, 2012, p. 26) – enabled Hopper to challenge the dominant power structures of male-dominated fields and to carve out space for alternatives. While completing her PhD in mathematics at Yale under computer pioneer Howard Engstrom, Hopper began teaching at Vassar. After earning her doctorate in 1934, she secured a full-time faculty position, where she remained (apart from a sabbatical) until the events of December 7, 1941. Like many women of her era, Hopper married in 1930 while still pursuing her doctoral studies. This phase of her life illustrates the tensions women often faced between societal expectations and academic ambition. Her decisions reflect a negotiation with dominant white, patriarchal norms rather than simple conformity.

Vassar, in Hooks' (1989) terms, provided a 'home' where women could explore new ways of seeing and becoming. It fostered a supportive environment and networks that helped Hopper pursue her ambitions (UM68-J). Still, Hopper's academic journey was shaped by enduring gendered norms. She began by teaching neglected courses, the ones that 'had gotten into terrible doldrums' and revitalised them: 'I brought in new texts and new materials and above all I brought in new applications', she recalled (UM68-J, p. 18). Beyer (2012)

suggests that her pedagogical innovations crossed disciplinary boundaries, making mathematics relevant and engaging for students in other fields. Through her pedagogical efforts, Hopper acted as both connector and translator between the margins and the centre, opening up new ways of teaching mathematics as a hands-on, applied discipline.

At Vassar, she also developed her communication skills, mastering public speaking and navigating institutional structures. This made her, as KBW12 (p. 29) notes, 'an agent of change in the face of institutional inertia'. While some colleagues supported her, others were dismissive: 'The younger groups – older than I was but younger still – they disapproved of practically everything I did because I wasn't doing the right things, and I was going off into things which were not mathematics' (UM1968-J, p. 21). Hopper's pedagogical style, rooted in boundary-breaking and innovative approaches, reflected her ethos of making the world better through applied knowledge (KBW12, p. 6).

In 1941, Hopper began studying under mathematician Richard Courant, then at New York University. She described him as 'one of the most delightful people to study with […] of course he scolded me at intervals…because I kept on doing unorthodox things' (UM68-J, p. 28). Her reflection underscores her self-awareness in challenging disciplinary norms – learning the language of the centre, as Hooks (1989) might say, to renegotiate its boundaries. The attack on Pearl Harbour marked a turning point for Hopper. On a personal level (UM68-J), she divorced her husband, took leave from Vassar, and attempted to join the Navy. Though initially rejected due to age and size, she persisted. In 1942, she taught a summer mathematics course at Barnard College in support of the war effort. That same year, President Roosevelt established the Women Accepted for Volunteer Emergency Service (WAVES), and Hopper ultimately joined the U.S. Naval Reserve in December 1943. By stepping in, women like Hopper encountered a centre newly opened to them – gaining insight into both the workings of power and the limits of their participation. This move from margin to centre was in itself a form of social transformation. It enabled women to observe the dynamics of domination from within and to imagine alternatives.

Women's entrance into the wartime workforce can be understood as a form of social intervention – a moment that disrupted the norms of the centre (Hooks, 1989). Although still marginalised, women began to discern, articulate, and act upon injustices. Their experiences resonate with contemporary social entrepreneurs, though in a reversed dynamic. Women during WWII moved from the margins to briefly experience power at the centre. Today, many social entrepreneurs begin from within the centre and seek to 'step in' to address social issues such as poverty, inequality, and marginalisation (Dempsey & Sanders, 2010).

From the margins, SE can open possibilities for radical transformation, of conditions, structures, and relationships. Stepping in transforms not only the system but also the person. For the women of WWII, this shift enabled a new awareness of injustice and their capacity to challenge it. Schumpeter saw this tension as central to entrepreneurial activity: his 'Man of Action' defied the status quo and stirred change (Swedberg, 2006). Similarly, we suggest that stepping in involves a visceral experience (Dempsey & Sanders, 2010) that reshapes one's understanding of power and justice – an internal transformation (i.e. empowerment) that often precedes what can be discerned as SE activity. During WWII, these openings were offered to women at the margins. Today, the dynamic is often reversed: it is the centre that claims to support the margins – on its own terms, defining both the problems and the acceptable solutions (Wettermark & Berglund, 2022).

Making it in the men's world: *practicing creative problem-solving in the margins*

During wartime, propaganda emphasised women's patriotic commitment. While these stories intended to rally women to support the home front, they also served to diminish their contributions. Women were portrayed as the 'second best' expected to do 'their part' during the war and to 'gracefully' step aside when men returned (Milkman & Milkman, 1976). Just as men's involvement in the war was viewed as temporary, so too was women's participation in the workforce. The idealised image of Rosie the Riveter (e.g. Aguierre, 2018) failed to recognise the diversity of women's experiences. While Rosie became a symbolic figure of WWII, African American women, older women, married women, and newly widowed women were largely silenced and relegated to the background (Kessler-Harris, 1982). Yesil (2004) illustrates how 'recruitment messages relied on male approval as a major selling point, depicting women as working not for themselves but for their men, and not by personal choice but by public duty' (p. 110). Women's invitation to the centre was both temporary and conditional. Still, this movement between margin and centre created openings for women to challenge norms and push for social transformation.

As the war progressed, many women – particularly African American women, married women (with or without children), and older women – left low-wage jobs for higher-paying positions in the defence industry (Yesil, 2004). This required constant negotiation of their legitimacy within a white, male-dominated world and professions previously closed to them. The breaking of traditional gender roles across class and race lines brought forth tensions among both men and women. As hooks reminds us (Hooks, 2013), 'representation alone is simply not enough to create a climate supportive of sustained diversity' (Hooks, 2013, p. 27). The persistent sexual division of labour continued to dictate what counted as 'men's' and 'women's work'. Even when men and women worked side by side, men received higher pay and additional compensation for poor working conditions (Milkman & Milkman, 1976). These hierarchies – both gendered and racial – shaped the wartime workplace.

Despite the advantage of her privileged background, Hopper remained at the margins of a military environment steeped in masculine norms and hierarchies. She joined the Midshipmen's School, which she described as 'mentally demanding – all those youngsters came in, they could still memorise and I had forgotten how to' (LNS86, min. 2). Hopper graduated first in her class, earning the top rank of battalion commander in 1944. Her decision to join the Navy and undergo specialised training, despite challenges, reveals her early problem-solving orientation. The urgent problem was national defence; to trace missiles trajectories rapidly and accurately: 'Get it built. Get it running. It was critical. That was done awfully fast' (BLHT72, p. 4). The goal was not market-based value creation (e.g. Kosmynin, 2022) but survival, national freedom, and minimising the loss of lives.

Whilst Hopper was at Midshipmen's school, IBM delivered a new calculating machine – the Automatic Sequence Controller Calculator – later known as Mark I – to Harvard University. Upon graduation, she was assigned to the Bureau of Ships Computation Project at Harvard, where she began working under the supervision of Howard Aiken, the machine's creator. Mark I was used to calculate rocket trajectories, proximity fuses, and mines, and other war-related problems. Because the missions were top-secret, Hopper and her team rarely knew what their calculations supported. They often ran the machine around the clock to meet urgent military demands. Working alongside Richard Bloch and Robert Campbell, Hopper

now realised her long-held dream of becoming an engineer. No one knew exactly how to operate the machine – it was all trial and error. 'There was no so such thing as a programmer at that point. We had a code book for the machine and that was all. It listed the codes and what they did, and we had to work out all the beginning of programming…and writing programs and all the rest of it' (AP80, p. 6). Through persistence and experimentation, the team developed a systematic approach to coding using punched tape and plugboards. Mark II was later built in haste, in parallel with ENIAC – yet, being based on a relay-based design, it was soon rendered obsolete and largely forgotten.

Despite her privileged background, Hopper encountered many of the challenges faced by working during wartime (Milkman & Milkman, 1976). She may have stood out as a PhD-holding mathematician and naval officer, but she was still a woman. When she arrived at the Computation Project at Harvard, Aiken reportedly asked where she had been, noting that he had already told 'Bureau of personnel that she did not need midshipmen's school, because she already had a doctorate' (KBW12, p. 27), and thus expected her arrival immediately. When she finally arrived, he dismissed her with the order: 'Well, get to work and you can find a place to live tomorrow' (UM68-J, p. 29).

Whilst Hopper stood out in the Navy Computation project, Aiken seems to 'fit her' back in into his existing gendered team. He introduced her to the other team members and showed her the machine, treating her as one of his 'boys'. Despite his initial hesitations, Aiken soon started appreciating her efforts: 'Grace would come out and pull her mirror out of her pocketbook and stick them in front of the cams and look for sparks. Grace was a good man'. (HA73, p. 43–44). Aiken 'second-ordered' (Pecis, 2016) Hopper's gender to the interests of solving computational problems for the war efforts. When her work pleased Aiken, she was one 'one of the boys' and accepted by the centre. Yet, when Hopper for some reason 'stood out' as a woman, she was ignored by Aiken and made invisible at the margin.

Hopper defined Aiken as 'probably one of the toughest bosses and also one of the best' (UM69-J, p. 18), a very possessive man who built a crew as he defined as his own. He demanded hard work, constant availability and accountability for any problems. Hopper met these expectations, making herself indispensable to him. This may have been her strategy for staying close to the centre of power; power that, in turn, could help open opportunities for others, including more women.

Under Aiken's leadership, Hopper learned to speak a language of the centre – what Hooks (1989) called the oppressor's language. Still, she used her marginal position to 'translate' for others, keeping the door open for those in the margins. Hopper developed her communication and translation skills in a way that allowed her to navigate between different 'languages', enabling her to move through the social terrain with her ideas – making herself invisible while making others and their contributions more visible. She said: 'You leave yourself out…' (AP80, p. 20), highlighting her strategy of putting others first while focusing on collective problem-solving. From this marginal position, Hopper approached her work differently, fostering relational practices and collective care within her team to address wartime challenges.

She also openly acknowledged the work of other women, like Betty Holberton, who 'never received the credit for the work she did', noting that 'everybody's forgotten that she wrote the first program that wrote a program' (AP80, p. 8). Hopper reflected on Holberton's influence: 'I'm not sure that I would necessarily have gotten done what I did get done if she hadn't been ahead of me, so to speak' (AP80, p. 8). Such recognition created a 'counter-hegemonic

discourse' (Hooks, 1990), one that framed women and collaboration as alternative modes of entrepreneuring – contrasting sharply with individualised, market-driven approaches to innovation.

This collaborative spirit was also supported by the state's role in orchestrating innovation for the common good (Mazzucato, 2013). Hopper emphasised the collective nature of working with machines: solving problems required collaboration, not conflict. She acted as a 'switch', redirecting attention towards problems that needed collective solutions – a form of social entrepreneuring capable of transforming society (Berglund et al., 2012). Through care, humour, and emotional competence, she offered a different way of working – developing ideas quietly at the margins while avoiding unnecessary attention or reprimands from Aiken. The margin became a site of creativity and power – a space where Hopper nurtured her engineering identity and skills, and a space of inclusion and recovery (Hooks, 1989). It was, we imagine, this very space that energised her capacity to solve the urgent problems at the centre.

The shaping of a computing community and COBOL (1947-onwards): community building through reaching out

Post-war periods are often seen as decisive in shaping future developments, often viewed as times of hope and endless opportunities for social transformation. However, they are also characterised by ambiguity and instability, presenting a choice between learning from wartime experiences to push for social change (e.g. women's rights) or reverting to pre-war unjust social conditions (Armstrong, 1998). One legacy of the war was a permanent shift for women as a social group: by the 1950s, the number of women in employment exceeded even wartime levels (Milkman & Milkman, 1976). Not only did many remain in work, but those who had organised during wartime continued their social and political activism, leveraging the skills and networks they had developed to advocate for equal rights and expanded opportunities.

Wartime labour demands also led to the establishment of childcare facilities and expanded healthcare services, indirectly supporting women's continued employment, for example by passing the Lanham Act in 1941in the USA. Wars have also historically stimulated economic development through the emergence of new industries and technologies. Women involved in these sectors acquired skills and opportunities that allowed them to continue as innovators, engineers, and entrepreneurs (Aguierre, 2018). The expansion of women's access to work – facilitated by WWII and the active role of the state – gave women the power to transform not only markets but the broader social landscape. We suggest that this transformation was achieved through social entrepreneurship (SE) practices.

In the context of the computing, the SE practice of community building through reaching out marked a shift from state-based innovation to the commercialisation of computing ideas. Under Aiken's supervision, post-war work continued at Harvard with Hopper as a key player in cultivating the computing community. Hopper frequently stressed in interviews the importance of 'moving on' and building on what had been learned during the war. Unlike Aiken, who believed computers were 'merely a tool for the scientific elite' (Beyer, 2012, p. 312), Hopper envisioned computing as a collaborative process involving broader participation.

While Aiken resisted formalising the community, Berkeley did, and the Association for Computing Machinery (ACM) was formed. Hopper acknowledged that this formalisation

allowed open discussions of work previously kept secret due to wartime restrictions (UM69-J). In 1949, what she called 'the first real exchange' (UM69-J, p. 7) took place, drawing participants from across Europe and the US. She recalled that, for the first time, 'everybody stayed up all night talking about things' (UM69-J, p. 7). These interactions sparked cross-fertilisation and collaborative innovation. To her, focus was on developing a shared human understanding of how to use computers. With her talent for 'selling ideas', she emphasised the inclusion of people with diverse backgrounds in developing a common computer language (LNS86, min. 3:40). Hardware, for Hopper, was a means to a higher end: 'I've always seen computers as much as a screwdriver or a lever or anything else' (AP80, p. 34).

That same year, Hopper's fellowship at Harvard ended. She joined the Eckert-Mauchly Computer Corporation (EMCC) to help design and programme UNIVAC I, the first commercial electronic computer. Her decision was also informed by the inclusive environment at EMCC: 'The bright young men were all in uniform… And he [Mauchly] started hiring bright young women… I'd say close to half of the people… working on programming… were women. And his right-hand assistant… was Betty Holberton' (AP80, p. 32). Necessity met opportunity: women stepped in, and their skills were recognised.

Over time, Hopper became frustrated with the increasing complexity of the giant mainframes and operating systems – and competitive, hierarchical structures that accompanied them. She started to visualise smaller and distributed computing, stressing the need for a shared language that could support more democratic development. In 1951, she developed the first compiler, A-0, and later, as Director of Automatic Programming Development for the Univac Division of Sperry Rand, she led the development of B-0, an English-language compiler later known as Flow-Matic, and a precursor to COBOL (AP80).

Although Hopper created the compiler, she soon released it to a wider programming community. Innovation was not an individualised or proprietary activity but a collaborative good and process. In 1959, Hopper gathered forty representatives from different organisations and roles (programmers, mathematicians, educators, vendors, and users) to join forces in the Conference on Data Systems Languages (CODASYL). Their shared aim was to develop a more accessible computing language for use in emerging, decentralised systems. via CODASYL Hopper transgressed organisational boundaries (Hooks, 1984/2000) and catalysed a collective effort that led to COBOL. As Beyer (2012) documents, the CODASYL team reached the consensus on a language that 'should be problem-oriented and machine independent' and that would have more democratic tones than current versions, as suggested 'all participants agreed that it was necessary to broaden the base of those who could state problems to computers' (Beyer, 2012, p. 286). COBOL, therefore, was both a technical tool, a democratically developed innovation and a public good that enabled open access and thus wider participation in computing. Both COBOL as a 'product' and the process of shaping it supported broader processes of social transformation.

Building a community around computing also meant redefining how work was organised. Hopper promoted network-based organising over hierarchies, aligning with the more horizontal and open structures that would come to define the ICT sector and laid the ground for human centred technologies. She understood this shift as pedagogical: creating a language that enabled ordinary people to communicate through computers (KBW12). Hopper acknowledges how young people 'have no hesitation whatsoever using a calculator. They step right into a computer. […]. They also are not afraid of making mistakes, they have no prestige to live on, and they have no fear of failure yet' (AP80, p. 14). Hopper indicates that

younger generations might be more apt at scrutinising and questioning knowledge and language of the centre, and to listen to the margin as a site of knowledge. This is a radical move from the practice of letting mathematicians and programmers' 'own' processes to opening up for others to step in in – what we argue is a move between margin and centre (Hooks, 1984). Pushing those at the centre of the computing community to talk to and acknowledge efforts of women and minorities/marginalised, implied a move away from computing as a domain of specialists towards inclusive participation by users with varied experience.

By circumventing organisational boundaries Hopper involved participants from different sectors, state departments and universities. This way of constructing a network of compiler developers through CODASYL was unique because amid the commercialisation race, 'Hopper did not view software as a commodity to be patented and sold. Rather, she took her cue from the mathematics community. Like most other academics, mathematicians shared information universally, to advance knowledge' (KBW12, p. 238). We share this interpretation. Hopper's democratising approach to software likely reflected her training as a mathematician and academic, where knowledge was understood as a public good. But such public goods required institutional frameworks: 'The only way we could all work together and not throw our companies into fits was under the jurisdiction of an university or the government' (Hopper interview, 1982, cited in KBW12, p. 281).

In retrospect, Hopper's practice of reaching out to continuously opening up to those at the margins prefigured what Mazzucato (2013) later theorised as 'the entrepreneurial state': a system of cross-sector collaboration that brings together public, private, and civil society actors to push innovation for the common good.

Concluding discussion

In this article, we have explored SE historically, by paying attention to 'the role of the state and other social institutions at different levels' (Wong et al., 2023) in facilitating social entrepreneurship practices, and broader processes of transformation. Grace Hopper's story has served as an example of the possibilities emerging from the intersection of the US entrepreneurial state (Mazzucato, 2013), the geopolitical context of WWII, and women's entrance in previously foreclosed spaces. Whilst the state played a central role in providing long-term state-funded investments, it also offered a space for social transformation, experimentation and invention, giving way to the birth of the computing field. Our historical approach to SE challenges established theories and provides new insights into the history of entrepreneurship (Wadhwani & Lubinski, 2017), showing how social entrepreneurial practices can spur social transformation (Spinosa et al., 1999). In our exploration of Hopper, we have sought to avoid anachronistic interpretations of SE during and after WWII, a concept that did not exist at the time. This is not to say that social entrepreneurship practices did not take place during those years, quite the contrary. Our historical study shows that SE practices (of stepping in, creative problem solving in the margins, and collective community building) existed, albeit not being termed at such. These practices are also indicative of a historical double shift we see in discourses of SE: whilst initially the margins (marginalised communities) acted as the site for social change, today it is private organisations (the centre) addressing a social issue or problem. The second shift refers to the progressive closing of spaces for social

transformation to the margins. We have argued this double shift limits our capacities for disclosing new worlds (Spinosa et al., 1999).

To locate SE in time, we frame its practices within the broader macro context of social transformation, viewed through the lens of centre and margin (Hooks, 1984/2000), along with the role of the entrepreneurial state in enabling cross-organisational collaborations. Within this macro context, we identify three situated practices of SE in the life of Rear Admiral Grace Murray Hopper. These practices connect individual actions to broader historical transformations in women's lives, while also reflecting – and at times diverging from – how social entrepreneurship unfolds today.

The first practice, *stepping in*, involves a visceral recognition of one's position in relation to power and justice. In contemporary SE discourse, those in positions of power (centre) often engage in bricolage, pooling resources to benefit those in need (at the margin) (e.g. Wettermark & Berglund, 2022). Interestingly, our analysis traces this practice historically as emerging from the margins, rather than from the centre, and being enabled by the crossing of tracks, of boundaries between margin and centre. Hopper, along with many women and minorities of her time, experienced part of her life in the margin and leveraged this perspective to challenge power structures through their actions when stepping into previously closed spaces.

The second practice of *creative problem-solving in the margins*, shows creativity being born within marginalised spaces. During WWII, Hopper and other women used their marginality to experiment for the social good, innovating new technologies and work structures. Today, however, we see that this creative space has been re-appropriated by the centre, which now positions itself as the legitimate actor of social change (Clark Muntean & Ozkazanc-Pan, 2016; Dey & Steyaert, 2010). This move (i.e. the privatisation of this collaborative creative space) also results in the perpetration of gendered and racialised assumptions in entrepreneurship (Bruton et al., 2023; Pecis & Ge, 2025), where the often-white male individual entrepreneur is more readily recognised as a creative force (Ogbor, 2000).

The third practice, *community building through reaching out*, was a hallmark of the entrepreneurial state and played a role in the development of the world wide web. Reaching out once valorised individuals and groups at the margins. However, in today's SE discourse and practice, private-public collaboration often manifests as public-private partnerships aimed at providing market solutions (Kosmynin, 2022). These initiatives are frequently driven by those in power, leaving little influence in the hands of marginalised groups. Whilst we recognise that innovation can emerge from small, privatised spaces constrained by proprietary rights and restricted knowledge-sharing, we argue that Hopper's work exemplifies how the entrepreneurial state, through openness and cross-institutional collaboration, fostered innovation as a public good. In contrast, when entrepreneurship becomes confined by private ownership and intellectual property concerns, even socially motivated initiatives labelled as SE may risk undermining their potential as catalysts for broader social change and inclusion.

By highlighting these three practices through a power lens and employing bell hooks' concepts of margin and centre, we can observe how they have evolved and diverge when comparing past and present contexts. While SE practices are historically bound, they share important commonalities, contributing to the further theorisation of their historical development. For example, stepping in has been recognised as a critical entrepreneurial practice for gaining legitimacy in new fields (De Clercq & Voronov, 2009), often sparked by a visceral

experience (Dempsey & Sanders, 2010). Similarly, problem-solving approaches echo modern themes in SE discourse, where market methods are employed to tackle complex problems (Bandinelli, 2019). Finally, community building through reaching out has evolved from the image of the lone male entrepreneur to a more collective endeavour (Berglund et al., 2012).

Finally, our analysis shows that historically, SE carried a more democratic tone. Rather than being confined to formal organisations, it united economic and social value creation in less divided ways than is often the case today, where SE is either enacted at the marketplace or channelled through charities, nonprofits, or philanthropic ventures (Wong et al., 2023). By retracing the roots of SE, we aim to reclaim its socially transformative potential – especially its role in enabling movements between margin and centre.

Notes

1. The context of computing is also particularly fruitful for investigating SE historically. It has been recognised to be one of the historical roots of SE (Boddice, 2009). Programming languages (such as COBOL) and computers (like Mark I and Mark II) reconfigured work processes and marked the emergence of a new industry that dramatically altered societal structures and daily practices, both socially and economically (Spinosa et al., 1999), for example, digitalization has been a key driver of contemporary SE practices (Kosa & Dhliwayo, 2024).
2. Little is known about Hopper's personal life. Her interviews do not indicate a reason for her divorce. In our source KBW12, there are references to the moment Pearl Harbour was announced; Hopper and her husband listened together from their study to the radio announcement. There is also mentioning of potential existing problems in Hopper's marriage at the time of Pearl Harbour. However, Hopper never mentioned the reasons for her divorce, nor corrected the erroneous reports of her husband's death in some media outlets.
3. Rosie the Riveter is a cultural icon (Brock et al., 2015; Kossoudji & Dresser, 1992). The term was also used as the title of an American musical film directed by Joseph Santley in 1944.
4. We acknowledge Rear Admiral Grace Murray Hopper's full titles, and that Hopper is the last name she adopted after her marriage to Vincent Hopper. For conciseness reasons, we use 'Hopper' throughout the paper.

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Appendix A

Table A1. Social entrepreneurship practice 1: stepping in.

Representative quotes on practicing entrepreneurship for social change	Practice description and contextual explanation	Sub-practice
'Well, I had worked, you remember, Henry Seely White […] But he's just one of the most delightful people to study with I've ever known in my life. I had a perfectly gorgeous year. Of course, he scolded me at intervals, just as all of the others did because I kept doing unorthodox things and wanting to tackle unorthodox problems'. (UM68-J, p. 28).	Adopting unorthodox ways of tackling problems albeit making others uncomfortable	Unorthodox ways of working
'One thing is that people try to make me something extra. I think they've failed to realise that everything I've done, the so-called big accomplishments – like writing the first compiler and starting the business about distributed computing and all of that. They totally fail to realise that everything I've ever done was not genius effect. It was all straightforward common sense at the time: how can you get this done?' (AP80 – p. 20)	Unmaking the 'hero' as a key figure in the computing community	Stepping back
'After everybody else began to go play with Mark II then they left me in charge of Mark I. Which was a victory on my side because when I walked in there he had not wanted a woman officer and I had said he was going to want a woman officer. You see, in 1946 for instance, the Navy turned me down for regular navy. I was two years too old. It took me twenty years to win that one. (LAUGHTER). I kind of make a habit of winning. It's taken five years with this triple standard'. (BLHT72, p. 47)	Standing out as one of the few women making contributions in the Navy	Standing out as a woman (becoming visible)
'Aiken: Yes, and that 1944 was probably around September or October, so that we had just about gotten going and learned how to run a computing machine, when we were given the added responsibility of a second one. We started the second one down in the basement of the Research Laboratory of Physics, so that Grace Hopper, when I came in one morning, she'd been there most of the night struggling with Mark I, and I said, "What have you been doing here all night?" And she said, "Chaperoning these two damn computers", (Laughter.) Typical of Hopper, eh?' Tropp: 'Yes. One of her comments on the early days was that she was the only one she knew who had to program a brand new machine every day, every time she would come up in the morning'. (HA73, p. 55–56)	Recognising Hopper's engagement and dedication to the project whilst demeaning her struggles in an ironical way, framing her as a complaining woman	
Campbell: 'Dick Bloch was really the primary force as far as I'm concerned. He did program two of the most important problems. Grace Hopper came along a little bit later, but her main contributions to the field were after she went to UNIVAC. She had one major task in helping to document the Mark I user's manual, and she was involved in the Mark II user's manual also. But her real contributions to the field didn't come until she was at UNIVAC later. As far as Mark II was concerned, Aiken and I wrote the original prospectus. Of course, it was his initiative. Bob Wilkins did the main mechanical design. Other people also participated in aspects of the design'. (RC84, p. 58–59) Bloch: Oh yes, there was no question about that. I had other officers in the Navy that I would bring in to do programming under my wing. As a matter of fact, one of the first ones was Grace Hopper. She came from Vassar and, as I like to remind her, she didn't know a computer from a tomato basket at the time. She does know the difference between them now, without a doubt. But this was her first experience in the field and I remember sitting down, I think, long into the night, going over how this machine worked, how to program this thing, and so on. Later we got additional staff in and when either Harvard or the Navy--Harvard had some contracts also with the Navy and so indirectly those things might filter through--I was involved. We had correlation, multiple correlation problems. We had those curve fitting problems. We had ordinance problems. These various problems were brought in and were some of the primary problems that we dealt with. There was a great deal of activity in this business of curve fitting and using polynomial coefficients of polynomials, and we spent though an enormous amount of time on those Bessel functions. (RB84, p. 15–16) 'Tropp: Somebody told me the story occasionally of using Grace Hopper's mirror to check to see where the sparks were occurring. Aiken: Yes. The cams were somewhat difficult to see, and when cams were in trouble, Grace would come out and pull her mirror out of her pocketbook and stick them in front of the cams and look for sparks. Grace was a good man'. (HA73, p. 43–44)	Fitting in a male-dominated environment by performing traditional male practices	
Cohen: 'Were people like Dick Block and Grace Hopper just sent to you, or did you pick them?' Aiken: 'I picked them. Let me tell you about Dick. I went to the Naval Research Laboratory, Bryce and me, to get the backing of Admiral Ventura for some calculations which we wanted to perform but[…] And […] said "yes", it sounded reasonable to him, but he'd get one or two of his young men to look at things. And the man he called was Dick Bloch. So I expressed my full appreciation for what Ventura had done for us by recruiting Bloch and taking him away. (Laughter.)' Tropp: 'Where did you find Bob Campbell? You know, I asked Bob, and he couldn't remember'.(HA73, p. 44)	Silencing Hopper's involvement in innovation	Becoming invisible

Appendix B

Table B1. Social entrepreneurship practice 2: Practicing creative problem-solving in the margins.

Representative quotes on practicing entrepreneurship for social change	Practice description and contextual explanation	Sub-practice
'There was no future of computers, there was nothing but get those problems going' (BLHT72, p. 10) 'It was a steady evolution to doing things easier and better, more correctly. Dick Bloch was the only person I ever knew who could write a program in ink correctly the first time. He could, we did. And, I guess during those years, up as far as 1946, we didn't think ahead. The whole thing was the war, the end of the war, getting a job done, terrific pressure. We didn't think ahead at all'. (AP80, p. 6) 'Don't forget that Mark II was built under wartime pressure. Get that thing built fast. Use existing components. Nothing new. Get it built. Get it running. It was critical. That was done awfully fast. The whole design and development'. (BLHT72, p. 4) 'No, we each had different problem that we worked on. Problems were assigned us to solve', (BLHT72, p. 7) 'TROPP: I guess what maybe Beth is trying to get to is the intercommunication, the casual coffee conversations that you exchanged problems and ideas. HOPPER: There wasn't any time for that. I find it extremely difficult to explain to anybody today what a wartime environment was like. It seems to be extremely difficult for the young people who are non-allied to realise that this whole nation could be operating on just one idea. That everybody saw it as an idea, the whole drive was on, just one thing, just win that war. That we were all there because of it and we couldn't have been there otherwise. The one thing was to get your job done and make your contribution. It seems to be impossible to recreate that atmosphere unless you were there, to explain it. People ask me, why did you joint the Navy? And I have only one answer, there was a war on. TROPP: I went through that same period and I know what you are talking about in terms of that kind of dedication. But in terms of your actual operating time at the Laboratory at Harvard, was the time pressure and the press to solve problems so great that there wasn't time for exchange of ideas and sort of a corridor kind of …(voice fades out). HOPPER: We didn't worry about the future at all. We didn't worry about mathematics except that it solved a particular problem. Remember if we had a problem running we were in there twenty four hours a day, the number of days it was running. I can remember leaving there in '44 for instance. We had been there three days and three nights and there was a hurricane on. Three of us went home by holding hands. (Brendle?) and I and another girl, all three were Waves, we held hands and one would hold on to the lamp post or a tree while the other two would string out and get to the next one and hang on and we made our way up by laughing from tree to post because we had been there for three days we were going out even in a hurricane, we were going to get home and get washed'. But there was no theorising, there was no higher mathematics. There was no future of computers, there was nothing but get those problems going, and what the computer was doing. The future in a sense, didn't exist. (BLHT72, p. 9–10)	Experiencing pressure to solve problems that continuously emerged and finding solutions, in the heat of the moment, with limited future vision.	Immediacy of problem solving

Continued

Table B1. Continued

Representative quotes on practicing entrepreneurship for social change	Practice description and contextual explanation	Sub-practice
'There was so much of the technique of handling the typewriter that had to be invented and all of the dress-up we had to learn how to do'. (UM68-N, p. 2) 'When we were debugging Mark II, it was over in another building, and the windows had no screens on them and we were working on it at night, of course, and all the bugs in the world came in. And, one night she [Mark II] conked out and we went to look for the bug and found and actual large moth, about four inches wing span, in one often relays beaten to death, and we took it out and put it in the log book and pasted Scotch tape over it'. (UM68-N, p. 6)	Adapting different and emergent techniques as building a train whilst it was rolling.	Constant emergence of new problems
'For many of the problems we just didn't know what their application was. We were just told to make tables of certain functions. Practically everything was connected with the war. It wasn't until after the war that we tried anything else. We had a hotline straight from the laboratory down to the Navy Bureau of Ordinance'. (AP80, p. 24) 'They began to appear as early as Mark I – in the earliest days of Mark I. The major Navy laboratories sent people; that's how A.E. Smith, (Gene Smith) now in Bureau of Ships, came. He came with problems from the Bureau of Ships, and then stayed with us finding out how we were doing and then he took that information back with him. And they came from Dahlgren; they came from the other Navy laboratories (Naval Ordnance Laboratory), and so on. Then they began showing up from MIT, and then from some of the other major universities. Fairly early in the game, some Air Force and Army officers turned up, too, in that first summer, to find out what this was all about and what we were doing. And then, later when we moved to the new building, (by the time we got to the new building) this was so important that a classroom was actually built in, so that we could give lecture series. It was built (a lecture room was built) in the new building because this had become such a frequent process, this training and giving seminars – three-day seminars, one-week and so on; I did a lot of the lecturing in those because I had been a college professor. And at first, it was entirely within the government – (it was almost) towards the end of the war there, in '46 it was almost entirely government, but then afterwards it began to be more general, and they began to come from the other universities and everything'. (UM68-N, p. 9–10) 'It was wartime. It was wartime and there was a war coming. All new ideas were being implemented. Anything that might help and might be useful (they were grabbing for everything?). […] They had to have it to get those rocket tables. They had to have it. They had to have for the radar equipment. They Navy was building them for crypto analysis. They had to have it. It was the Navy that helped find the money that set up the RA Office in St. Paul after the War was over when they took the whole of Communications Annexe and moved them to St. Paul. It was the Navy that helped them find the money. I was there when they had them go ahead'. (BLHT72, p. 36–37) 'Hopper did not view software as a commodity to be patented and sold. Rather, she took her cue from the mathematics community. Like most other academics, mathematicians shared information universally, in order to advance knowledge'. (Beyer, 238) … 'a communal view of information'; software was for Hopper a 'public good'.	Recognising the role of the government as propellor of innovation for the public good during and after the war	Public good orientation

Continued

Table B1. Continued

Representative quotes on practicing entrepreneurship for social change	Practice description and contextual explanation	Sub-practice
'The Mark II was the first one that had a real bug in it – did I ever tell you about that? […] The building that we built Mark II in was a leftover from World War I and there were no screens in the windows and they were all working nights in there and it was loaded with bugs and mosquitoes and one night … went down to track the bug and found beaten to death by one of the relays about a three-inch moth. So they took it and put it in a log book and covered it over with cellophane tape and as far as I know it's still in the log book up at Harvard. And that was one computer that had a real, honest-to-goodness bug in it – that was the biggest one anyway. It was also the day that I went down I happened to be down town and saw in one of these shops on the street some of these fake bed bugs and I bought a box of them and I put them in the back part Mark I and it caused utter panic. They tried to track down where they were living in that back wiring and they brought in all kinds of you know spray stuff and powders and everything to get the bugs out and I didn't have the guts to admit that they were fake bugs. I never mentioned them but finally somebody discovered that they were fake bugs, but I don't think that they ever did find out who put them there. But that caused a two-day uproar, trying to get the bugs out of the machine. I thought it was quite obvious that if it had bugs, it should have bugs, but…[…] Well, it took two days they were scared to death that they found bugs in the machine and there was a good deal of accumulation of dust and dirt around those big cables back there around the motor generator set'. (UM69-J, p. 13) 'Our minds were full of what we were doing. You remember Mark I stopped very quickly when we couldn't find out what the bugs were. When you have to find the bugs in a machine, they used to borrow regularly. I had a mirror, something like this one which came with my handbags. This is a later one, but I always had a small mirror about this big and one way to find the bugs in Mark I was that they were very often caused by the fraying of the brushes on the counters in which case they would spark. So they would turn out all the lights and then they would borrow my mirror and they would go along and run it and they would look for the sparks in the counters and the mirror would pick up the sparks you see. Because otherwise you couldn't see down in to find the sparks. They used my mirror for it all the time. Because I always had it in my handbag, it came with the handbag'. (BLHT72, p. 22)	Describing the practice of debugging the first compilers as a problem to be solved	Debugging as an example of problem-solving orientation

Appendix C

Table C1. Social practice 3: Practice of collective community building through reaching out.

Representative quotes on practicing entrepreneurship for social change	Practice description and contextual explanation	Sub-practice
Edward Elgar Masterson: 'Next name is Grace Hopper and I previously talked about knowing her and all the tricks she was up to keep people entertained. As everyone knows she seems to run her own press agency and gets published all the time'. (EEM86, p. 39)	Recognition of Hopper's work in reaching out and relating to others	Reaching out
'He taught us all how to communicate. I've come to feel that there is no use doing anything unless you can communicate. And I include that in my talks. One of the most important things we have to do with our young people is teach them to communicate'. (AP80, p. 25) Edward Elgar Masterson: 'I think reasonably well. I don't think UNIVAC I would ever have been finished without Wiener trying to reason with him. I saw Grace Hopper a few times, she was… Now, remember in those days, again it's not in my field, but the programming was done with machine code and it was almost like a sweatshop to program for the UNIVAC I. I talked to some of the people that worked in programming and they were just really depressed because it was such a laborious job to do the simplest job on the machine. I guess at that time, Grace was trying to come up with some kind of a language that would get around this major problem. Grace was another character and I guess she just never stopped. I see her on television once in a while. One of the stories that I didn't see personally, but one day her group had written a multi-page report of some kind and it needed to be collated so they put the stack of page one here on the table and page two here and page three here and page four there all around the big conference table and then she got all her people to walk around the table and pick up a page so they'd collate into their arm books from page one through page n and, of course, it got to be out of control so they started dancing and singing and they were going around the conference table having a great time when one of the new management people from Norwalk came in and saw this performance which, of course, didn't phase Grace'. (EEM86, p. 24)	Learning how to communicate from others for the mobilisation of a process	Learning to be a good communicator
I think possibly in writing reports and things I had been a little more, I'd written a little better English. I had been brought up to write things and I'd had good training (in writing things?) and I'd always bugged all my students about writing things. When they came into my probability course, the first thing I did was give them a lecture on Sterling's formula and then asked them to write it up as a (?) and them I'd cover it up with ink and I would get a rebellion that they were taking a maths course not an English course. Then I would explain, it was no use trying to learn maths or learn anything about it unless they could communicate with other people and they should be able to write things clearly. So I have always been a little bit of a something or other about getting things written clearly even back when I was teaching, and I taught thirteen years before I went in the Nav (BLHT72, p. 1)	Learning to communicate to a wider audience emerges	

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Table C1. Continued

Representative quotes on practicing entrepreneurship for social change	Practice description and contextual explanation	Sub-practice
'We found that we had to change from being research and development people and turn ourselves into salesmen and get out and sell the idea of writing programs this way' (Hopper, keynote address 1–3 June 1978 (HPL, 3–8), 27 as cited in Beyer, 236)	Learning to become a translator using different vocabularies	Learning to be a translator
'Anyhow and then the background history of scientific thought and all those – all that background for the philosophical side of it and then I also got off into bacteriology, biology, zoology, plant horticulture, I took more chemistry and more physics and I took some architecture and that background has been of inestimable value as I got into the computers because I could talk to the people who wanted to use them, because there are dialects and there are vocabularies and unless you can understand what a person's saying to you, you can't really make the – And in those early days you were trying to explain to the people how they could use the computer and they were trying to tell you what their problem was and there was no language, no nothing; you were trying to communicate across gaps. And I think that was one of the reasons for the slowness of the computers going into some of the sciences and things. Because where the mathematicians and physicists and chemists were talking the same language with the same symbols, this was not true in the geology, the biomedicine and all of those areas. And it wasn't 'til we could begin to communicate with them and find out what their problems were and what the mathematical computer people could hope to do for them and you needed people with more vocabularies. And this slanted me. Those years were learning about all of the sciences and some of the arts, you see, and getting that tremendous background which I would not have had otherwise. Even with intelligent, grown-up reading without a basic course which gives you concepts, a way of thinking, the way they attack and handle problems, what the major problems are, the problem areas, where then could see the future coming, all of that you don't get from reading'. (UM68-J, p. 17)		
[…] I decided there were two kinds of people in the world who were trying to use these things. One was people who liked using symbols – mathematicians and people like that. There was another bunch of people who were in data processing who hated symbols, and wanted words, word-oriented people very definitely. And that was the reason I thought we needed two languages. (AP80, p. 10)	Contributing to a language that made it possible 'for the many people' to interact with computers	
Yesterday, John Solerno, over at Federal Reserve, called me up and he had a question about some programming. But, then, he said, 'I want to know – somebody asked me – what do you consider your greatest achievement? And, without thinking (and it's curious how you do these things), I said, "Well I guess it was realising we had to make it easier for people to use computers, and underline the people". And he said, "I thought it was the compiler". I said, "Well that comes out of that". I said, "The greater thing was to realise that it needed to be done; then, of course, comes the first compiler and the first English language compiler, and so on. But, I think, that the real achievement was to realise that this type and class of thing had to be done, and what could be done – not the actual doing of it. […] I think he would have put the A-0 compiler first, you see". But I still think that the realisation of what was needed and what could be done was more important than the actual doing of it. […] I hadn't thought of that before that way either, because I had always said this – well, where do you start – well, A-0 compiler. And yet, there was a knowledge back of that, and a thinking, and a work, and everything else, of what can be done to make these things so that people can use them, and I still think that job is not finished. And there again, you see, the training of the young people is (because I won't be around that long is) part of that same principle – to make it easier for people to use computers, because that's the only way they'll ever come into their own or be properly used, or we'll find out all the things we can do with them. We can't keep professionals alone, so we've got to bring it more and more, so more and more people can make use of them, and can use them. So then, it all ties together if you go in from that point of view'. (UM69-J, p. 1)		

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Table C1. Continued

Representative quotes on practicing entrepreneurship for social change	Practice description and contextual explanation	Sub-practice
'One curious thing that seems to have always happened and I don't know quite how it happened but every time I'd get into a blank wall in industry somehow or other by some accident the Navy would send for me to do something and somehow enabled me to get out and get loose again and then come back into things again - sort of every time I hit a blank wall, I'd somehow seem to get a lift from the Navy and usually I'd go in training duty or something would happen and they'd open another door for me just as they had in the very beginning. And, it's just a series of coincidences and yet it seems to have happened'. (UM68-J, p. 6) So that, it did not feel the influence of electronics, however, the Mark III, of course, did. And I can remember when just towards…it must have been in '46 some time (because they came from Germany), the first of the cores appeared. Nobody, today, would recognise them as a core – they were picked up by the Army, in Germany. They were about four inches square, of iron (you know) rings but they were square, and they were the first of the coils that had the proper hysteresis loops and could be used for storage – and we had that. There were three of them that came, very preciously, from Germany by airmail. The Navy had located them in Germany, and they came to the laboratory for us to look at and consider. And also, oh, as early as 1945, we were beginning to experiment with magnetic recording'. (UM68-N p. 3)	Role of the entrepreneurial state in fostering innovation	Intervention of the entrepreneurial state
'As I watch people try to get things, they try to sell everything. That's not the way to do it; what you do is figure out why the other guy needs it and then you tell him that. You leave yourself out; you explain to that guy why he needs it, why it is good for the company, if he sponsors this he might get to be manager or vice president'. (AP80, p. 20) 'And I've seen too many people – professors and businessmen everywhere – where the boss, even though all he'd done was to tell other people what to do, took all the credit for it. I never thought that was fair when you had people working for you who were developing things and inventing things. Anyway, what I did learn was the more you give it away, the more it always comes back to you in the long run anyway'. (AP80, p. 25-26) [When the interviewer remarks that she is a sales lady, Hopper answers]: 'Only of ideas tough. Íve always seen computers as much as a screwdriver or a lever or anything else' […] That again is the practical. Think about the other guy and his position and his interest. You are always trying to work with people rather than against them. You've got a new idea; give the boss credit for it. It doesn't cost you anything. (AP80, p. 34)	On the importance of being fair – seeing others – including others – relational skills	Paying it forward
That was – Aiken's concept was that it was time to get everybody together and talk about what was going to happen next. Nobody realised it was an industry – it was a branch of research of some kind. There were beginning to be more people; it was time to pull them together. Berkeley wanted to form an association, of course. Aiken didn't; he didn't think it was time for it, yet. In fact, he was dead against ACM for quite a while, but he did feel that they should get together, and everybody should bring everybody else up to this state of the art. And that's how that symposium came to be held. They were invited to Harvard, and that was an outstanding group of people – all the beginners were there – the starters. And that was published later as a volume of the series, and that was really tremendous. I don't suppose, ever again, we'll have that group of people all together at once. But that was because Aiken felt it was time – there was enough development to get together. And we'd all been isolated during the war, you see, classified contracts and everything under the sun. It was time to get together and exchange information on the state of the art, so that we could all go on from there. (UM69-J,p. 6)	Coming together and forming the computing community (birth of ACM)	Creating a sense of community
'I think maybe there weren't more than 300 when I got there – probably around 300 – and we knew everybody in the building. And we regularly talked to the people in engineering who were building it because we wanted to know when we'd get…for instance, we started running with only one…only a couple of the tanks in the memory working and we'd have to go to ask so and so how many tanks we had today before we would find out whether we could run something. We knew all those people. It was a good deal of cross-mixing'. (UM69-F, p. 5)	Working collaboratively in the after-war innovation efforts	Working in collaboration with others

Continued

Table C1. Continued

Representative quotes on practicing entrepreneurship for social change	Practice description and contextual explanation	Sub-practice
'At the interview there was both John and Betty Holberton. And Betty has never received the credit for the work she did and should have received long since. […] Everybody's forgotten that she wrote the first program that wrote a program. She wrote that sort-merge generator, and what she did was feed in the specs for the data you were handling and the keys and that sort of thing, and then it generated the sort program for that specific data. That's the first time to my knowledge that anyone used the computer to write a program. Betty did that. I don't think she's ever fully received the credit for what she did in that case. […] Then she got out and got buried in NBS. Nobody heard from her after that, which is just a shame'. (AP80, p. 8)	Recognising the important work of other women in the making of innovation	Recognition of others' contributions
'HOPPER: IBM never gave the credit they should have to Aiken. They gave credit to their own engineers but they did not give it to Aiken. LUEBBERT: We were reading IBM's…(voice fades out). HOPPER: When they came down to take the pictures when Watson visited us, they took the picture of Watson and the IBM enlisted men, but not the officers that ran the machine. Not the, just the pictures of the ex-IBMers'. (BLHT72, p. 39)		
'Connie Rossen was a Vassar graduate that I brought over there, a mathematician and did some beautiful programming and began to convince people that women made good programmers'. (UM69-J,p. 14)		
(speaking of Betty Holberton) 'The first time I really remember sitting down and talking to her was that night we met at Ed Berkeley's house and John brought her down and we talked about my coming down to Eckert-Mauchly. And then she was in charge of all the programming at Eckert-Mauchly. So, I was working directly for her. One thing you see, we never had to have at Harvard, and we didn't use flow charts. Because everything was a perfectly simple sequence of operation because it just rode right along that tape. So that the BINAC and UNIVAC I with the ability to modify instructions and loop and everything were brand new to me. And the first thing I had to learn was flow charting and Betty taught me that. I think I brought to you once her first original write-up on what a flow chart should be like and first symbols and everything. Much of that developed is primarily due to Betty's work. She never says it but it is true that she did develop those techniques of flow charting to a very large extent. And she taught me that and gave me little things to program for BINAC and so on and got me on the computer and got me thinking in another dimension because you see the MARK programs had all been linear, and now I had two-dimensional programs to think about so that there was a lot to learn when I first got there, and Betty was terrific'.(UM69-F, p. 3)		
(speaking of Marge Lee) 'I'm trying to think of that other gal's name. There's one whose name I can't think of at the moment and then there was Marge? Lee. Marge had been one of the group with Betty who had done the computing for Aberdeen in Philadelphia and had come with Eckert-Mauchly and she's still with UNIVAC. She was one of the brightest programmers there ever were. She would take time off enough to have a member of the family and come back to work again – an extremely attractive woman and she became the instructor and hostess. She could just handle people like nothing human; she was terrific, very very good-looking and she is still with UNIVAC in the systems programming group. I guess she had been there six months or 8 months before I joined them, because I think she is due to get her twenty-year pin any minute now or just got it or something, but she was there'. (UM69-F, p. 4)		
'See Mauchly had been building his team for ENIAC during the war. The bright young men were all in uniform and were in France or the Pacific. And he started hiring bright young women. I'd say close to half of the people that worked on all the beginning work on programming and the non-hardware side of ENIAC were women. And his right hand assistant in building the C-10 code was Betty Holberton. And he encouraged her to write that first sort/merge generator, which was the first time anybody used the computer to write a program. And part of it was necessity. The young men weren't available. And the bright young women were'. (AP80, p. 27)		