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Digital Policy Hub – Working Paper

Digital Ethics, Gender-Based Analysis and Canada's Quantum Strategy

Michael P. A. Murphy

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67 Erb Street West
Waterloo, ON, Canada N2L 6C2
www.cigionline.org

Key Points

- The next generation of quantum technologies in computing, sensing, communications and other domains is likely to bring major disruption to Canada's economy, security and society.
- Canada's strategic approach to quantum science and technology research relies on existing strength in research and training capacity and places an emphasis on Canada's international reputation and the Canadian brand.
- Part of the government's branding has been the promotion of gender equality, including through gender-based analysis in domestic politics and the projection of a feminist foreign policy abroad.
- Current quantum strategy in Canada does not consider gender-related issues in a robust manner, often promoting inclusive workspaces as a means to fill high-demand roles.
- Three recommendations for a more gender-sensitive quantum strategy are proposed: an end to the instrumental framing of gender as a tool for hiring highly qualified personnel (HQP); the consideration of gender-sensitive use cases when funding technical research and development; and the expansion of research funding to include the social impacts of quantum technologies.

Introduction

New developments in quantum science and technology are on the precipice of a broad-based revolution in economics and security, bolstered by a new generation of quantum-enabled technologies in computing, sensing, communications and beyond. Although much of the current global attention is focused on how specific use cases will be developed for national security purposes, there is a widespread recognition within expert communities that "developments in the leading areas of quantum technologies…can be expected to produce transformative applications with real practical impact on ordinary people" (European Commission 2016, 7). However, little is known about what effects may actually be felt by individual members of society (Kung and Fancy 2021, 22) or if these social benefits and harms will be differentially experienced by population subgroups. This working paper examines Canada's quantum strategy, paying particular attention to the strategy's alignment with norms of gender equality proposed in broader government policy aims. Drawing on Stéfanie von Hlatky's (2023) concept of "norm distortion," the paper argues that current gender norms have been subordinated to market efficiency goals in Canadian quantum strategy. In light of this critique, three policy recommendations are offered to support a move toward a more gender-sensitive quantum strategy.

Quantum Strategy in Canada

McKinsey's 2023 *Quantum Monitor* — a publication that has been notably bearish compared to other sector forecasts[1] — currently predicts an annual quantum technology market of US$106 billion by 2040. What is perhaps even more impressive is that the actual economic value produced by quantum technology, defined as "the additional revenue and saved costs that the application of quantum computing can unlock," may reach as high as US$1.27 trillion by 2035 (McKinsey 2023, 4). Domestic forecasts envision quantum technologies contributing CAD$42 billion in revenue to the Canadian economy by 2045, potentially reaching a full three percent of Canada's GDP and creating hundreds of thousands of jobs (Government of Canada 2022, 4). In light of persistent concerns about low productivity in the Canadian economy (Robson and Bafale 2023), the high-value quantum technology sector is promising for its potential contribution to national quality of life.

The current state of the quantum technology market presents a mixed record for Canada. In 2022, Canada ranked second in the world for total start-up investment in quantum technologies, behind only the United States, and the major private equity investments received by D-Wave Systems and Xanadu meant that Canada was the only country aside from the United States to see more than one firm enter the top 10 largest deals of the year (McKinsey 2023, 11–12). Canada's quantum ecosystem features a variety of public and private stakeholders pursuing different paths in domestically developing quantum science and technology research (Kung and Fancy 2021, 28). Public investment in Canada lags behind the success of private industry, although sustained funding for the Institute for Quantum Computing — as well as expanded funding for projects through the Natural Sciences and Engineering Research Council of Canada (NSERC), the National Research Council, the Canada Foundation for Innovation, the Canada First Research Excellence Fund and Mitacs — all demonstrate that mechanisms do exist for kick-starting innovative technical research.[2]

There are three key documents outlining Canada's approach to quantum strategy: the 2020 *Quantum S&T Strategy* released by the Department of National Defence and the Canadian Armed Forces (DND/CAF), the 2022 *National Quantum Strategy* released by Innovation, Science and Economic Development Canada (ISED), and the 2023 *Quantum 2030* implementation plan also released by DND/CAF. This paper will begin with a review of the two documents from DND/CAF. The *Quantum S&T Strategy* sets the groundwork for DND/CAF engagement with the existing quantum ecosystem in Canada, aiming to bridge the gap between research on quantum technologies and specific applications in the defence and security sector (Government of Canada 2020). The strategy is organized around three pillars:

- transitioning quantum technologies into defence capabilities;
- establishing and sustaining strong partnerships in quantum technologies; and

1 For a comparison of models, see Council of Canadian Academies (2024, 28–29).

2 See Kung and Fancy (2021, 28) for an overview of stakeholders, and McKinsey (2023, 15) for a comparison of Canada with other nations in terms of public funding.

- bringing coherence to quantum science, technology and innovation investments across DND/CAF (Government of Canada 2020, 10).

These strategic pillars guide the activities of DND/CAF by focusing efforts on incentivizing defence and security applications of quantum research in a coherent manner. An even sharper focus is reached in the *Quantum 2030* implementation plan, where four specific technologies are given a seven-year window to deliver prototypes: quantum-enhanced radar, quantum-enhanced light detection and ranging, quantum algorithms for defence and security and quantum networking (Government of Canada 2023, 3). By focusing on four promising technologies, the implementation plan provides even more specific guidance on the priorities of DND/CAF quantum strategy. However, this depth is also complemented by a renewal of DND/CAF's commitment to a breadth of engagement with the quantum ecosystem in Canada, outlined in the five calls to action:

- identify potential end-users and operations that may be impacted by quantum technology;
- train and upskill implicated personnel to create a base-level understanding of quantum, termed quantum literacy;
- continuously engage with Defence Research and Development Canada on quantum efforts to increase harmonization in quantum investments across the defence team;
- seize opportunities to drive practical experimentation with quantum technologies through Government of Canada innovation programs to access state-of-the-art technologies; and
- engage directly with Canadian quantum experts in academia and industry (Government of Canada 2023, 2).

Quantum 2030 takes the work of the *Quantum S&T Strategy* further by doubling down on deliverable technologies while at the same time building broad-based partnerships and generalized capacity through quantum literacy.

The *National Quantum Strategy* was released in 2022 after extensive consultations. This strategy builds on the momentum toward quantum research funding noted in the innovation strategies of both the Stephen Harper and Justin Trudeau governments. The 2014 *Seizing Canada's Moment* strategy set quantum computing and materials as focus areas of national strategic importance and highlighted the federal government's continued funding of the Institute for Quantum Computing as a linchpin of its innovation efforts (Government of Canada 2014, 20, 37). Similarly, 2019's *Building a Nation of Innovators* highlighted quantum computing as a key technology that is "reshaping the economy, our cities, our jobs, and our lives" (Government of Canada 2019, 6). In addition to continued funding for the Institute for Quantum Computing, *Building a Nation of Innovators* noted support for satellite-enabled quantum key distribution and prominently featured the accomplishments of Canadian quantum researchers (Government of Canada 2019, 71 and passim). The *National Quantum Strategy* focuses on the continued development of Canada's quantum ecosystem through three pillars: research, including basic research as well as applied research in priority areas; talent, consisting of expanded funding for science education through NSERC and industry internships through Mitacs; and commercialization, through

economic development offices and targeted challenge programs (Government of Canada 2022, 17–24). Like the work of DND/CAF, ISED has set quantum computing, communications and sensing as core missions for technological development (ibid., 10–16). Although listed last in the pillars, commercialization actually receives the largest allocation of new investment through the National Quantum Strategy, with CDN$169 million allocated, compared to CDN$141 million allocated to research and CDN$45 million allocated to talent (ibid., 30–32). This funding structure ensures that the technologies closest to market hold the strongest incentives.

What do these documents reveal about the status of Gender-based Analysis Plus (GBA+) in decision making around Canada's quantum strategy? Not much. Table 1 below highlights the appearance of terms related to gender policy in key strategic documents.[3]

Table 1: Appearance of Gender Policy Terms in Strategic Documents

Document Title	Terms			
	Gender	Woman, Women, Girl(s)	Inclusive, Inclusivity	Diverse, Diversity
Quantum S&T Strategy	0	0	0	0
National Quantum Strategy	2	1	4	9
Quantum 2030	1	0	1	1

The lack of commentary revealed in quantitative terms in the table is only redoubled in examining the content of these documents. The discussions related to inclusivity and diversity in the *National Quantum Strategy* — ostensibly the most gender-sensitive signal in quantitative terms — are padded by the use of "diverse and inclusive workforce" and the promotion of "diversity and inclusion" within the workforce to fill gaps in HQP (Government of Canada 2022, 7, 19, 21). As the author has previously suggested in the *Canadian Foreign Policy Journal* (Murphy 2023), the gender-related discussion in Canada's quantum strategy consists largely of presenting increased representation of women in quantum as a solution to the problem of an employee shortage, rather than as a consideration of how quantum policy might forward gender equality. This appears as a reversion to the earlier framing of gender policy as "equality between men and women," which prioritizes policies focused on numerical increases in representation as opposed to a "gender equality" strategy that seeks to address the root causes of inequalities and inequities (Tiessen and Carrier 2015). By framing the question of gender equality as applying only to the domain of personnel and then presenting the benefit of a quantitative increase in women in quantum as a benefit to workforce needs, the scope of gender analysis is narrowed considerably. To better understand how this framing issue fits into broader policy discourses, the next section discusses precedents in theory and practice.

3 These terms have only been counted when applied to people and not when referring to generic cases (such as "diverse threat profiles").

Precedents for Narrow Gender-Based Analysis

The narrowness of gender considerations identified in Canada's quantum strategy is hardly unprecedented. Indeed, scholarship on gender mainstreaming in a variety of domains of Canadian policy has highlighted gaps between rhetoric and policy, as well as gaps between policy and implementation. Lee-Anne Broadhead and Sean Howard (2019) point to the contradiction between the Justin Trudeau government's rhetorical commitment to feminist foreign policy objectives and its abandonment of Nuclear Ban Treaty negotiations that were steeped in feminist peace proposals. In analyzing the impact of a policy shift toward feminist foreign policy, Srdjan Vucetic (2017) highlights the hypocrisy of major arms exports to countries with poor human rights records, especially around gender equality. In both of these examples, the stated commitments to feminism and a feminist foreign policy are not put into practice when it comes time to make concrete decisions in foreign policy.

But the assumption that feminist policy objectives only fail when they are ignored must be avoided; a second and perhaps more pernicious danger lies in the narrowing and instrumentalization of gender through the implementation process. In her recent book *Deploying Feminism*, von Hlatky (2023) introduces the concept of "norm distortion" to discuss how the North Atlantic Treaty Organization (NATO)'s implementation of the Women, Peace and Security (WPS) agenda has led to a shift in focus from gender equality to the strategic use of women in conflict zones to improve operational effectiveness. "The distortion of WPS norms occurs," von Hlatky argues, "when diversity is instrumentalized and used to make the business case for gender integration, rather than to focus on striking down discriminatory practices because they harm people and corrupt professional culture" (2023, 28). This narrowing of purpose can even create tension in the role of gender norms on the ground. NATO's Female Engagement Teams in Afghanistan, for instance, were tasked with delivering tactical gains through gathering intelligence from Afghan women who may not have been willing to divulge information to male soldiers "while also presenting themselves as helping Afghan women and women's rights more broadly in the country" (von Hlatky 2023, 35). The distortion of gender norms to serve the goal of operational effectiveness defined in non-gender-sensitive terms kneecaps the ability for these policies to achieve their intended aims. As discussed above, despite the policy's release by a government that claims gender sensitivity through a variety of mechanisms, the issue of gender is forced through the narrow frame of quantitative representation in the workplace[4] and is then evaluated as potentially beneficial because of the benefits that increased women's participation in the quantum workforce will bring to employers. This distorts gender norms from framing their own issues and being examined on their own terms; instead, gender is framed as demography and evaluated as labour power.

Other issues in gender-responsive policy making arise when the scope is narrowed temporally, especially if this means that gender is not considered in the agenda-setting stages. In such a case, even if development and implementation are conducted in line with principles of gender-based analysis, the agenda itself may

4 For more on the significance and impact of a frame shift in gender policy, see Tiessen and Carrier (2015).

reinforce gender inequality. Rachael Johnstone and Bessma Momani (2019, 2022) have drawn on Rounaq Jahan's (1995) distinction between "integrationist" and "agenda-setting" approaches to gender mainstreaming in policy making to analyze the promise and shortcomings of official use of GBA+ in Canadian defence and security policy. When gender is not present in the agenda-setting stage, the pressure to conform to institutional norms can be a structural barrier to progress (Johnstone and Momani 2019). In this context, gender policy can appear as an "'add women and stir' approach" rather than as a holistic reckoning of root causes (Bouka et al. 2021). This is not to undermine the contributions that gender analysts have made inside bureaucracies to raise the profile of gender considerations through relational and institutional strategies (see Scala and Paterson 2017), but merely to remain realistic that agenda-setting has a disciplining impact on the work that follows.

Recommendations

This working paper has reviewed the current limitations of Canada's quantum strategy in terms of gender-sensitive policy making. The first section examined the position of Canada within the context of quantum science and technology development, presented the content of core documents articulating the *national quantum strategy* and considered the current status of gender in the policy conversation. The second section then explored broader precedents of gender considerations being narrowed in Canadian policy debates, drawing particular attention to the concept of norm distortion introduced by von Hlatky (2023). This section provides three policy recommendations informed by the premise that Canada's quantum strategy suffers from a distortion of gender equality norms. The consideration of these three policy recommendations provides initial direction toward a more gender-sensitive quantum strategy.

- **Stop framing gender as a means for filling HQP roles:** Within the limited attention that current quantum strategy pays to gender, gender equality is considered as an instrumental good that can help support the operational effectiveness of the quantum industry. In this context, the promotion of gender equality is subordinated to market demands for labour and contributes not by ensuring historically under-represented groups feel welcome and included in the quantum technology sector, but by turning to historical non-participants to address shortfalls in highly qualified personnel. Just as von Hlatky (2023) observed in the case of gender integration in NATO, this practice is a norm distortion that adjudicates supposedly gender-sensitive initiatives only in terms of their ability to deliver on operational effectiveness. This norm distortion limits the ability of the policy to address substantive concerns about the influence of gender in constituting hierarchy and inequality (Sjoberg 2012, 2013). In the context of existing quantum strategy, where gender-sensitive policy making has been equated with hiring women to fill empty positions, the norm has been so distorted that little room remains for a more fulsome conversation about the gendered impacts of quantum science and technology.

  A first step toward a more gender-sensitive quantum strategy, therefore, consists of excising the distortion. The knee-jerk association of gender equality with filling sticky vacancies forecloses a more rigorous debate on quantum strategy by setting very narrow terms for the debate. Liberating gender-related conversations from

job market demands can help to create space for a more robust, gender-sensitive quantum strategy. None of the foregoing should be understood as an opposition to quantum workplaces being welcoming places, or as a rejection of the claim that the addition of people from historically under-represented groups will help address labour shortages. The argument instead is that by distorting and constricting the consideration of gender to labour participation and HQP needs, there is no examination of how a broader array of phenomena might be taken into account.

- **Consider gender-sensitive use cases when funding technical research and development:** One of the impacts of the HQP framing of gender considerations in Canada's quantum strategy has been the absence of the clear influence of GBA+ in the agenda-setting stage, where use-case priorities are set. In addition to GBA+ as a policy-making approach within the Canadian government, gender policy commitments, such as feminist foreign policy and the feminist international assistance program (see Morton, Muchiri and Swiss 2020; Rao and Tiessen 2020; Smith and Ajadi 2020), may have led to the expectation that further strategies would include clear language around gender policy in guiding documents. As noted above, the core documents of Canada's quantum strategy lack this language and do not clearly identify how prioritized use cases for quantum technologies forward gender-sensitive or feminist policy objectives.

  Even if specific language-identifying initiatives for feminist purposes do not exist, the question of how feminist discourses and sensibilities are reflected in strategic documents might be considered in more general terms. However, the discursive framing of the quantum strategy documents as an entirely technical domain is incommensurable with social policy goals (Murphy 2024). As Carol Cohn (1987) observed, specialized technostrategic discourse can foreclose feminist policy proposals by limiting the kinds of questions and concerns that can be raised; a focus on narrowly defined industrial development and defence innovation limits the possibility of promoting feminist policy proposals. International examples within the Five Eyes countries demonstrate that this is not necessary. For example, when the Australian government funded its Centre of Excellence for Engineered Quantum Systems, health-care applications of quantum technologies were present as a priority from day one (Engineered Quantum Systems 2011).[5] In the United Kingdom, research funding for quantum sensors' applications to geomagnetic measurement of groundwater to prepare for climate change-induced extreme weather events similarly foreground social use cases for quantum technologies (UK Quantum Technology Hub 2023). Although individual policies in health care and climate-related policies may or may not be proposed for feminist reasons, the existence of broader use-case priorities in allied nations demonstrates that Canadian quantum strategy could consider a wider range of applications for quantum technologies. By ensuring that principles of GBA+ inform agenda-setting and use case-defining stages, Canada's quantum strategy can align with the broader aims of feminist foreign policy and gender-sensitive policy making. This is not a matter of developing one track of "traditional" priorities and a second set of "feminist" priorities. Rather, by approaching agenda setting from a more holistic perspective — instead of one framed from the outset as a techno-strategic discourse — the quality of the policy can be improved at the agenda-setting stage.

5 Specifically, the research teams hope to use nanodiamond quantum sensors to improve MRI screenings for the early detection of cancer.

- **Research social impacts, including gender:** To accomplish these aims of a more gender-sensitive quantum strategy, resources must be allocated to the study of the social impacts of quantum technology. If expert analysis is proven right and the next generation of quantum technologies are revolutionary for government institutions as well as the lives of everyday people, then the social impacts will be massive. Current quantum strategy has not yet considered in practical terms the potential social impacts of quantum technologies, and none of the CDN$360 million promised in Canada's *National Quantum Strategy* was allocated to understanding these impacts (Murphy 2024). At the same time as quantum strategy documents rely on the scale and pace of social disruption to justify investment in scientific research, no resources whatsoever are allocated to the better understanding of what exactly those social disruptions may mean (or how to prepare for them). Canada's quantum strategy includes a wilful ignorance of the social impacts of an entire generation of revolutionary technologies.[6]

  This wilful ignorance of the social impact of the next generation of quantum technologies is all the more surprising given the recent example of how the public roll-out of only one suite of technologies — generative artificial intelligence (AI) — can have far-reaching impacts. Indeed, as the capabilities of ChatGPT were discovered by the general public over the winter of 2022–2023, use cases were discovered across a staggering range of areas in human society, producing a wide continuum of positive and negative outcomes (Baldassarre et al. 2023; Ray 2023; Haque and Li 2024). Significantly for the purposes of this paper, many negative impacts of generative pre-trained transformers have been the reification of biases existing in their training data; this has resulted in ChatGPT perpetuating gender bias and stereotyping (Gross 2023). The case of ChatGPT is a recent, widely known and directly relevant example of how an emerging technology can have social and gendered impacts.

Conclusion

The *National Quantum Strategy* has allocated substantial funding through the federal research granting agencies, just as the *Quantum S&T Strategy* has witnessed DND/CAF earmark funds through its internal funding programs. These funds have largely been targeted at natural sciences and engineering disciplines, such as through transfers to NSERC and the Innovation for Defence Excellence and Security (IDEaS) program. This paper does not advocate for the reallocation of these committed funds or for cuts being made to them; rather, new funding should be extended through the equivalent institutions supporting social science research in each case. For NSERC, this would involve the targeted support of quantum impacts research through the Social Sciences and Humanities Research Council of Canada, either through existing grant programs or targeted funding streams. For the IDEaS program within DND, additional funds through the Mobilizing Insights in Defence and Security program would permit specific support for research on the social impacts of quantum innovations in defence and security. Although the dearth of existing research provides little footing to specify which social impacts should be prioritized, concerns

6 The *National Quantum Strategy* reveals that investments in social research into the impacts of quantum technologies were recommended during stakeholder consultations, but the actual allocation of resources is discussed only in hypothetical terms (Government of Canada 2022).

around gender, economic inequality and similar social impacts observed in the recent case of generative AI may be illustrative in identifying thematic clusters.

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About the Author

Michael P. A. Murphy is a post-doctoral fellow both at the Digital Policy Hub and at Queen's University's Department of Political Studies and Centre for International and Defence Policy. He is the author of *Quantum Social Theory for Critical International Relations Theorists* (Palgrave, 2021), *Weak Utopianism in Education* (Routledge, 2024) and more than 40 peer-reviewed articles, receiving more than 1,800 citations. He serves as the editorial assistant at *Security Dialogue* and is vice president of the Canadian region of the International Studies Association.

Acronyms and Abbreviations

AI	artificial intelligence
CAF	Canadian Armed Forces
DND	Department of National Defence
GBA +	Gender-based Analysis Plus
HQP	highly qualified personnel
IDEaS	Innovation for Defence Excellence and Security
ISED	Innovation, Science and Economic Development
NATO	North Atlantic Treaty Organization
NSERC	Natural Sciences and Engineering Research Council of Canada
WPS	Women, Peace and Security

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