societies

Review

Auditing the 'Social' of Quantum Technologies: A Scoping Review

Gregor Wolbring

Community Rehabilitation and Disability Studies, Department of Community Health Sciences, Cumming School of Medicine, University of Calgary, Calgary, AB T2N 4N1, Canada; gwolbrin@ucalgary.ca

Abstract: Various phrases such as "social implications", social impact" and "ethical, legal and social implications" are used to indicate the impact of a given scientific or technological advancements on the 'social'. The impact on the 'social' is one focus of science and technology governance discussions. Many terms and phrases can be used to audit the engagement of a given technology (such as quantum technologies) with the 'social'. Marginalized groups are particularly impacted by the 'social'. Equity, Diversity, and, Inclusion (EDI) and similar phrases are part of discussing the 'social'. EDI frameworks and phrases are employed as policy concepts to decrease the research, education, and general workplace problems members of marginalized groups such as women, Indigenous peoples, visible/racialized minorities, disabled people, and LGBTQ2S+ encounter at universities and other workplaces. How quantum technologies-focused discussions engage with the 'social' can impact EDI activities, and quantum technologies-focused discussions can be impacted in turn by EDI activities. The objective of this study was to map the engagement with the 'social' in the quantum technologies-focused academic literature. A scoping review coupled with a manifest coding approach was used to answer three research questions: (1) Which terms, phrases, and measures that can be seen to cover aspects of the 'social' are present in the quantum technologies-focused academic literature? (2) To what extent are EDI frameworks and phrases present in the quantum technologies-focused academic literature? (3) Which marginalized groups visible in EDI discourses are covered in the quantum technologies-focused academic literature? Using the academic databases SCOPUS, EBSCO-HOST, Web of Science, Compendex, Inspec Archive, and Knovel, 362,728 English language abstracts were obtained for the manifest coding using 62 Quantum-related technical phrases and 1062 English language abstracts were obtained using 17 non-technical Quantum-related phrases. Within the 362,728 abstracts of the 200 terms and phrases (which did not have to contain the term "social") used to answer the research questions, 87 were not mentioned in any abstracts, 47 were mentioned in less than 10, 30 were mentioned in between 10 and 100, and 29 were mentioned in over 100 abstracts. Within the 1062 abstracts, 164 terms and phrases were not mentioned at all, 19 were mentioned in over 10, 8 were mentioned in between 10 and 100 (all false positive), and one was mentioned in over 100 abstracts (false positive). The term "social" or phrases containing "social" appeared in only 867 of the 362,728 abstracts and only 10 of the 1062 abstracts. EDI frameworks and phrases were not present in the 362,728 abstracts and 1062 abstracts, and many marginalized groups engaged with in EDI discussions were not present in the 362,728 and 1062 abstracts either. The results reveal vast opportunities to engage with the 'social' of quantum technologies in many different ways, including through EDI frameworks and concepts and by engaging with marginalized groups covered under EDI.

Keywords: quantum technologies; equity; equality; diversity; inclusion; social; ethics; well-being

check for updates

Citation: Wolbring, G. Auditing the 'Social' of Quantum Technologies: A Scoping Review. *Societies* **2022**, *12*, 41. https://doi.org/10.3390/soc12020041

Academic Editor: Dwai Banerjee

Received: 22 December 2021
Accepted: 3 March 2022
Published: 5 March 2022

1. Introduction

"Social" is often used as part of the phrase "ethical, legal, social implications" or the phrase "social implication" is used by itself to indicate the impact of a given scientific or technological advancements on the 'social', and the impact on the 'social' is one focus of science and technology governance discussions [1–7]. Various terms are linked to the 'social' in academic and policy literature discussing the ethics and governance of various sciences and technologies. Concepts of the ability to have a good life, quality of life, health, equity and wellbeing fit under the 'social'. Various tools exist to analyze the 'social' [8] of groups and individuals such as social determinants of health, the Organization for Economic Co-operation and Development (OECD) Better Life Index, the Canadian Index of Wellbeing, the Community Based Rehabilitation Matrix, WHOQoL, the Quality of Being Scale, Aqol, Calvert–Henderson Quality of Life Indicators, the Satisfaction With Life Scale, Perceived Life Satisfaction Scale, Flourishing Scale, Scale of Positive and Negative Experience, Comprehensive Inventory of Thriving, Brief Inventory of Thriving, "The Disability and Wellbeing Monitoring Framework and Indicators", and the capability approach (these will be collectively referred to herein as "the measures") [9–39].

Many aspects of the 'social' will be eventually impacted by the ability of quantum-related science and technology to generate new applications or to improve existing applications. As such, one objective of this study was to map out the co-occurrence of various terms and phrases linked to the 'social' with various quantum technology-related terms. Equity, diversity and inclusion; equality, diversity and inclusion; diversity, equity and inclusion and other derivative EDI phrases [40–59] and EDI frameworks such as Athena SWAN ("Scientific Women's Academic Network") [52,60]; "Science in Australia Gender Equity", SAGE-Athena SWAN [53]; "See change with STEMM Equity Achievement", SEA-Change [54]; National Science Foundation (NSF) ADVANCE [55] and "DIMENSIONS: Equity, diversity and inclusion program" [56] are increasingly employed to improve the research, education and general workplace climate at universities [51] and other workplaces for marginalized groups such as women, Indigenous peoples, visible/racialized minorities, disabled people, and LGBTQ2S+. How EDI is engaged with in discussions concerning how to advance quantum-related science and technology will impact how the 'social' is discussed in relation to quantum technologies. As such, a second objective was to map out the co-occurrence of EDI concepts, frameworks and marginalized groups engaged with in the EDI literature with quantum-related terms.

Three research questions were asked: (1) Which terms, phrases, and measures that can be seen to cover aspects of the 'social' are present in the quantum technologies-focused academic literature? (2) To what extent are EDI frameworks and phrases present in the quantum technologies-focused academic literature? (3) Which marginalized groups visible in EDI discourses are covered in the quantum technologies-focused academic literature? The findings are discussed through the lens of how quantum-related policy documents cover the 'social', the existing EDI academic literature and how quantum policy documents cover EDI and through the lens of science and technology governance literature, including quantum technology governance literature.

1.1. The Landscape of Quantum Technologies and the 'Social'

Quantum-related initiatives exist worldwide [61]. Quantum technologies are seen as enabling platforms [62], and many ideas for applications exist [63–65] for civil engineering, disaster relief, geology and natural resources, military security, medicine; space technology; physics [63], autonomous cars [66], climate forecasting, cybersecurity [62], and for "economic development" [63] (p. 75). Global funding is estimated to be around USD 24 billion [61], and researchandmarkets.com forecasts the global quantum technology industry to be worth USD 32 billion by 2026 [67]. Numerous countries have quantum strategies [62,68–75], many of which acknowledge that quantum technologies will impact the 'social'; for example, quantum technologies are described as having the potential to "create economic growth", "realise an ecologically sound society" [63] (p. 72), "help solve some of society's complex problems" [65] (p. 8), build "a healthier, wealthier and more resilient UK" [65] (p. 8), "help to address society's challenges [65] (p. 3), benefit society and its members [66], "develop transformational technologies to benefit society" [63] (p. 75), "unlock innovation across sectors to drive growth and help build a thriving and resilient economy and society" [65] (p. 3), have an "inevitable impact at both the technological and social level" [76] (p. 5), "can have profound and positive impacts on society" [73] (p. 3) and build "a quantum society" [72] (p. 10). One quantum strategy has a section called "Preparing for the societal implications of quantum technology" [77] where it is stated that "the world is now at the precipice of another technological and social revolution—the quantum revolution" [72] (p. 3).

1.2. EDI and Quantum Technologies

Phrases linked to EDI are increasingly employed as policy concepts in many universities [51] and other workplaces, and include "equity/equality, diversity, inclusion"; "diversity, equity and inclusion" [51]; "belonging, dignity, and justice" [40,41]; "diversity, equity, inclusion and belonging" [42,47,57]; "employment equity" [43]; "inclusion, diversity, equity, and accessibility" [44–46]; "justice, equity, diversity, and inclusion" [48,49,58,59] and "equity, diversity, inclusion, and decolonization" [50]. Athena SWAN (Scientific Women's Academic Network) was the first EDI framework for Universities, beginning in 2005 [52]. Subsequently, various countries have generated EDI frameworks for Universities, including Australia (Science in Australia Gender Equity, SAGE-Athena SWAN) [53], the USA (See change with STEMM Equity Achievement, SEA-Change [54] and NSF ADVANCE [55]), and Canada (DIMENSIONS: Equity, diversity and inclusion) [56]. EDI in universities began with a focus on gender [52]; however, the focus has broadened. For example, the EDI framework in Canada for universities (DIMENSIONS: Equity, diversity and inclusion) covers women, Indigenous peoples, visible/racialized minorities, disabled people, and LGBTQ2S+ students, non-academic staff, and academic staff [56].

EDI is present in various ways in Quantum-related policy documents and discussions. For example, it is stated in the Canadian National Quantum strategy document

> "as the university–private sector quantum consortium has pointed out, to reach its full potential, the Canadian quantum sector must draw on a more diverse pool of people from within Canada and around the world. Budget 2021 committed to considering equity, diversity and inclusion in the development and implementation of the National Quantum Strategy. What can be done to ensure that, as Canada's quantum sector grows, it is increasingly representative of our diversity?" [62].

Furthermore, in the 2022 Canadian report "National Quantum Strategy Consultations: What We Heard" [78] the following ideas from the consultation to enhance equity, diversity and inclusion are listed:

> "creating a more inclusive environment to expand the talent pool; offering introductory courses in quantum, especially to students in other STEM fields and undergraduate programs, not just MSc and PhD candidates; targeting diverse colleges, CEGEPs and universities in Canada and abroad; drawing staff from other sectors; increasing diverse representation on panels and in promotional engagement; following the approach outlined in the Government of Canada's Dimensions Charter; replicating programs, such as the Creative Destruction Lab's Apprenticeship program or IBM's Polytechnic program with Six Nations; and facilitating the immigration of qualified candidates" [78].

And it is further stated in the report:

> "A wider range of students is expected as quantum technologies become more broadly adopted. There is huge competition for the relatively few female candidates in quantum technologies, but this has not necessarily translated into more women entering relevant programs of study. More Indigenous students are entering STEM programs, but they sometimes face dilemmas in leaving their communities and culture, particularly if they have to go abroad. To further attract diverse candidates, we should look at human-centric strategies. To this end, online comments included offering better parental leave and childcare, removing labour market impact assessments for PhDs, issuing special visas for experts

> in emerging technologies and making it easier for foreign students to stay in Canada" [78].

Workplace diversity and the need for diversity of skills is covered in many documents [63,65,67,73], and it is noted that such diversity benefits the economy, society and national security [66], and impacts both industry and the wider society [65].

As to engaging with specific marginalized groups covered in EDI discussions such as women, Indigenous peoples, visible/racialized minorities, disabled people, and LGBTQ2S+ [56], in the background searches for this study only gender was found to be covered in quantum policy documents. However, other EDI deserving groups might be covered in quantum policy documents that did not show up in the background searches. As to the ones that showed up, QuantERA II noted wanting to address the gender imbalance in QT research [71]. In a news item on a workshop on gender equality in quantum technology, it is noted that Horizon 2020, a European funding call, aims to tackle societal challenges and it is noted that "the biases within research and the 3 objectives of gender equality, gender balance and integration of the gender dimension in R&I. She stressed the importance of using a systemic approach to target universities to change practices because women now outnumber men in higher education but are not progressing to higher levels" [79]. The news item further showed findings from

> "gender attitude surveys, outlining that both women and men held negative bias towards female researchers. This bias impacted women on a day-to-day basis, leading to a lower rate of research paper acceptance, presentation slots at conferences and likelihood of being hired. Despite the obvious negativity, 56% of men surveyed believed that there were no differences in opportunities for women regarding career advancement. A separate study conducted in Spain, which was not associated with the Action, revealed that a man with children is 4 times more likely to be promoted to full professor than a woman with children. The Action's survey also revealed that sexual harassment was a significant issue, with 50% of women declaring that they had experienced incidents, with this figure rising to 83% of women in senior positions" [79].

The Quantum gender equality working group of the quantum flagship outlined numerous actions such as "network or women, unconscious bias training, mentoring programmes, gender awareness ambassadors to give talks and information about gender inequality in scientific meetings" [80].

1.3. Education and Quantum Technologies

Education is mentioned extensively in the quantum policy literature. Education is seen as essential for a diverse workforce with a diversity of skills [81]. It is argued that quantum awareness versus specialized quantum experts needs to be reflected in university courses [67] and on the K-12 level to inspire the next generation of quantum leaders [82]. It is argued that education has to link more business schools to the quantum industry [67], and that there is a need to raise the "profile of quantum technologies amongst the public and within education syllabuses to facilitate discussions about the role of these technologies in society" [65] (p. 4). It is noted that "along with issues of diversity, equity, and inclusion, consideration of social, societal, ethical and sustainability issues of QISE would be beneficial, in line with directions in engineering education worldwide" [83] (p. 10). It is recognized that there is a need for increased "social support for undergraduate researchers through designated cohorts" because this "can help them build community with their peers and see themselves as engineers and scientists, something that is often difficult for marginalized students who do not see themselves reflected in the celebrated leaders of the field" [83] (p. 16). It is suggested that "a quantum awareness or concepts course" on the undergraduate level, if possible in the first year, "to introduce students to the field early" would be beneficial [83] (p. 18), and that new courses are already being developed [84]. At the same time, it is recognized that the teaching of technical students on the 'social' aspects of technologies is lacking [85–90]. Techno-determinism and techno-optimism are recognized as biased forms of reporting within the STEM education literature [91–94], as is evident as well within statements such as "the need for quantum workforce and a well-educated society with knowledge and attitudes towards the acceptance of QT is imminent" [95] (p. 1). As such, mapping out the 'social' might be useful. The mapping of the 'social' is also useful for "building general quantum awareness for all citizens and a sound preparation for the further education of future quantum engineers–quantum literacy" [95] (p. 6). Indeed, given that students have different interests [96], adding the 'social' might broaden interest in quantum topics, and mapping the 'social' would connect with students beyond their technical work, which could be beneficial given that it is known that making a social difference entices students to a field [97].

1.4. Governance of Quantum Technologies Advancements

Many concepts such as "democratizing science, and technology" [98–106], "participatory technology assessment" [107–114], "technology assessment" [115–117], "parliamentary technology assessment" [118–120], "anticipatory governance" [121–124], "upstream engagement" [125–130], "responsible innovation" [131], "responsible research and innovation" [132–137] and most recently, "transformative vision assessment" [138], as well as fields such as AI-ethics, bioethics, computer science ethics, information technology ethics, nanoethics, neuroethics, and robo-ethics have emerged to engage with the recognized reality that scientific and technological advancements have social, legal, ethical and economic consequences. The authors of several academic articles have begun to highlight the need for the governance of quantum technologies [139–143], covering issues such as predictive powers, literacy limits, and various biases [144–146]. However, language that suggests the need for quantum governance has started to appear in quantum policy documents as well. Responsible research and innovation is mentioned as a competency in the competency framework of the European quantum framework [147]. In the Canadian Quantum strategy document, the question is asked: "How can the National Quantum Strategy best address the societal, ethical, legal and policy considerations that may arise given quantum technologies' disruptive capability?" [62]. In a 2021 report by the Canadian Institute For Advanced Research (CIFAR), it is stated: "some governments explicitly acknowledge in their national policies a need to begin paying attention to the ethical, social, legal and economic implications of quantum technologies" [77] (p. 5), and the report has a section called "Preparing for the societal implications of quantum technology" [77].

In the 2022 Canadian report "National Quantum Strategy Consultations: What We Heard Report" [78], the following is stated under the header "Societal and ethical considerations":

> "It was suggested that, as with artificial intelligence, Canada establish an ethical framework from the start and make a strategic commitment to the responsible and ethical use of quantum technologies for the benefit of humanity. Such an approach would provide Canada with a critical differentiator to attract talent and compete on the international stage with better resourced nations. This is an area in which Canada is well-positioned to be a leader. Business and social science students should be trained in quantum-related issues and build competencies in a holistic way. This could help to diversify the workforce, increase quantum acceptance and contribute to Canada's unique quantum niche. The Social Sciences and Humanities Research Council of Canada could fund studies on the societal and ethical considerations of quantum technologies" [78].

Quantum Delta Nederland's national quantum strategy argues that quantum technologies will impact on all social missions and that the social acceptance and ethical aspects of quantum technology are important [75]; they list many action items, including the formation of a national ELSA Committee and professorship and the development of legal and ethical frameworks for quantum technology [75]. They make the point that

> "most articles and analyses on this topic assume that quantum technology will have a positive influence on the economy and society. However, like any revolutionary new technology, quantum technology is not itself either good or bad. The way that the technology affects society will be determined by the people that use it" [75].

It is noted that it is essential "for government, industry and academia to exchange information on "social/ethical matters of QIST applications" [73] (p. 13). Ethical issues are linked to autonomous cars [66] and the issue of trust [66]. It is noted that the right social context is needed [63] and that responsible innovation should be supported [63]. Within the "Engagement paper: Developing a National Quantum Strategy" from Canada, it is argued that it is important to be "clear about quantum technologies' disruptive capabilities, both positive and negative" [62], and the question is posed "How can the National Quantum Strategy help to ensure that, as quantum technologies and solutions come to fruition, they are adopted by Canadian businesses, academia, government and the public?" [62].

In the "Australian strategy for the quantum revolution", it is argued that:

> "We must look ahead to what a quantum society might entail and how the quantum design decisions being made today might affect how we live in the future. Consider the use of quantum computing to advance machine learning and artificial intelligence (ML/AI). ML/AI technologies are already the subject of ethical frameworks designed to prevent harm and ensure the design of ethical, fair, and safe systems.22 Those frameworks are vital, as potential harms could include the reproduction and amplification of existing socio-economic marginalisation and discrimination, and the reduction of personal privacy. At this time, no ethical framework for quantum technologies exists in Australia, although the CSIRO Quantum Technology Roadmap calls for quantum stakeholders to explore and address social risks.23 As quantum technologies progress, such discussions should build literacy in the societal impacts of quantum technologies. This should be a collaborative effort between quantum physics and social science researchers, industry experts, governments and other public stakeholders, and be led by the proposed office of the minister for critical technologies" [72] (p. 10)

Various quantum policy documents indicate the need for involving stakeholders [71], using wording such as "industry, entrepreneurs, and other potential stakeholders" [63], users and markets [63], end-users [74] expert advice [62,74] and goals such as to "inform European citizens about quantum technologies and engage widely with the public to identify issues that may affect society" [70] (p. 13). It is argued that stakeholders should "review the potential impacts of quantum technologies on society" [72] (p. 11), and countries such as Canada carried out public consultations on their Quantum Strategy [148].

However, as is noted in the "Australian strategy for the quantum revolution":

> "a precondition for social debate about quantum technology is that all participants have a reasonable understanding of the technology and its implications. After all, even 'insiders' are inclined to represent quantum technology as a mysterious manifestation of counterintuitive ideas and processes. That has implications for the participation in the debate of people from other academic disciplines, industry or government, and by the wider community. As a result, the technology's growth and social adoption could be adversely affected: society might be reluctant to accept quantum technology, or might even reject it, thus holding back, counteracting or greatly delaying integration. It is instructive to consider the acceptance issues associated with stem cell therapy, genetic modification, climate solutions and vaccination" [75].

2. Materials and Methods

2.1. Study Design and Research Questions

Scoping studies are useful in identifying the extent of research that has been conducted on a given topic [149,150]. In this case, the aim was to answer the following research questions: (1) Which terms, phrases, and measures that can be seen to cover aspects of the 'social' are present in the quantum technologies-focused academic literature? (2) To what extent are EDI frameworks and phrases present in the quantum technologies-focused academic literature? (3) Which marginalized groups visible in EDI discourses are covered in the quantum technologies-focused academic literature? The study employed a modified version of a scoping review outlined by Arksey and O'Malley [151], namely, identifying the research questions of the review, identifying applicable databases to search, generating inclusion/exclusion criteria, selecting the abstracts for manifest coding of the abstracts, and reporting findings of the manifest coding of the abstracts.

2.2. Data Sources and Data Collection Inclusion Criteria

On 7 December 2021, the academic databases EBSCO-HOST (an umbrella database that includes over 70 other databases itself), SCOPUS (which incorporates the full Medline database collection) and the databases Compendex, Inspec, and Knovel, which include IEEE sources, were searched with no time restrictions. On 22 February 2022, the Web of Science database was searched with no time restriction. These databases contain journals that cover a wide range of topics from areas of relevance to answer the research questions. They cover journals focusing on quantum science and technologies, and many journals that cover societal aspects and science and technology governance content. As inclusion criteria, the abstracts had to be in English for all databases. As to article categories, scholarly peer-reviewed journals were included in the EBSCO-HOST search and reviews, peer-reviewed articles, conference papers, and editorials from SCOPUS. The Compendex, Inspec and Knovel search was set to all document types. Peer-reviewed articles, conference papers, review papers and book chapters were included from Web of Science. Everything else was excluded.

2.3. Data Sources and Search Strategies

The following quantum-based technical search terms were used for the search strategies (Table 1), reflecting search terms used in a recent literature review [152], and the terms "quantum revolution", "quantum science", "cryptography", "quantum systems" and "quantum cosmology" were chosen based on other literature:

("quantum simulation" OR "quantum imaging" OR "quantum sensing" OR "quantum sensor" OR "quantum computation" OR "quantum computing" OR "quantum computer" OR "quantum coding" OR "quantum programming" OR "quantum error correction" OR "quantum error correcting" OR "quantum circuits" OR "quantum algorithm" OR "quantum algorithms" OR "quantum network" OR "quantum networks" OR "quantum channel" OR "quantum channels" OR "quantum cryptology" OR "quantum cryptography" OR "quantum key" OR "quantum teleportation" OR "quantum information" OR "quantum technology" OR "quantum technologies" OR "quantum gates" OR "quantum register" OR "quantum contextuality" OR "quantum decoherence" OR "quantum communication" OR "quantum memory" OR "quantum memories" OR "quantum repeaters" OR "quantum state transfer" OR "quantum zeno dynamics" OR "qubit" OR "qutrit" OR "qudit" OR "quantum correlations" OR "quantum entanglement" OR "quantum discord" OR "quantum noise engineering" OR "quantum state engineering" OR "quantum protocols" OR "quantum annealing" OR "quantum logic gate" OR "quantum internet" OR "quantum repeater" OR "quantum memory" OR "quantum photonics" OR "quantum photonic" OR "quantum biology" OR "quantum machine learning" OR "quantum information" OR "quantum communication" OR "cryptography" OR "quantum systems" OR "quantum cosmology" OR "quantum revolution" OR "quantum science")

Furthermore, the author generated terms that can be seen to focus more on the 'social' and not the technical:

("quantum strategy" OR "quantum goal" OR "Quantum ethics" OR "Quantum responsible" OR "quantum goals" OR "quantum acceptance" OR "quantum aims" OR "quantum barriers" OR "quantum expectation" OR "Quantum purpose" OR "quantum attitude" OR "quantum benefit" OR "quantum implication" OR "quantum policy" OR "quantum recommendation" OR "quantum use" OR "quantum education")

Table 1. Search strategies used to obtain abstracts (first search term) for manifest coding of terms related to the 'social' (second search term).

Strategy	Sources Used	First Search Term (Abstract)	Second Search Term (Abstract)
Strategy 1a	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Technical Quantum terms	-
Strategy 1b	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Non-technical Quantum terms	-
Strategy 2a	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Technical Quantum terms	"Health equity" OR "Social implication" OR "Social impact" OR "Societal impact" OR "Societal implication" OR "Ethic*" OR "Quantum ethics" Or ("wellbeing" OR "well-being" OR "well being") OR "Societal"
Strategy 2b	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Non-technical Quantum terms	As 2a
Strategy 3a	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Technical Quantum terms	"Privacy" OR "data protection" OR "technological deskilling" or "deskilling" OR "Solidarity" OR "dignity" OR "social wellbeing or well-being or well being" OR "environmental wellbeing or well-being or well being" OR "Subjective wellbeing or well-being or well being" OR "Societal wellbeing or well-being or well being" OR "Psychological wellbeing or well-being or well being" OR "Emotional wellbeing or well-being or well being" OR "Economic wellbeing or well-being or well being" OR "Identity" OR "Independence as in do it yourself" OR "Independence as in being in control" OR "Interdependence" OR "Interdependent" OR "Stigma" OR "Stereotype" OR "Justice" OR "Autonomy" OR "Self-determination" OR "good life" OR "social good"

Table 1. *Cont.*

Strategy	Sources Used	First Search Term (Abstract)	Second Search Term (Abstract)
Strategy 3b	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Non-technical Quantum terms	As 3a
Strategy 4a	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Technical Quantum terms	Names of the 21 measures
Strategy 4b	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Non-technical Quantum terms	As 4a
Strategy 5a	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Technical Quantum terms	Indicators of Social Determinants of Health, Community Based Rehabilitation Matrix, Canadian Index of Well-being and the OECD Better Life Index (includes the indicator term "social")
Strategy 5b	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Non-technical Quantum terms	As 5a
Strategy 6a	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Technical Quantum terms	("Athena SWAN" OR "See change with STEMM Equity Achievement" OR "Dimensions: equity, diversity and inclusion" OR "Science in Australia Gender Equity" OR "NSF ADVANCE" OR "equity, diversity and inclusion" OR "equality, diversity and inclusion" OR "diversity, equity and inclusion" OR diversity, equality and inclusion")
Strategy 6b	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Non-technical Quantum terms	As 6a
Strategy 7a	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Technical Quantum terms	"Belonging, Dignity, and Justice: OR "Diversity, Equity, Inclusion and Belonging" OR "diversity, Dignity, and Inclusion" OR "Equity, Diversity, Inclusion, and Accessibility" OR "Justice, Equity, Diversity, and Inclusion" OR "Inclusion, Diversity, Equity and Accessibility" OR "Inclusion, Diversity, Equity and Accountability" OR "Equity, Diversity, Inclusion, and Decolonization"
Strategy 7b	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Non-technical Quantum terms	As 7a

Table 1. *Cont.*

Strategy	Sources Used	First Search Term (Abstract)	Second Search Term (Abstract)
Strategy 8a	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Technical Quantum terms	"gender" OR "women" OR "ethnic groups" OR "racialized minorities" OR "Racialized" OR "Ethnic" OR "People with disabilities" OR "disabled people" OR "Person with a disability" OR "disabled person" OR "Impaired" OR "impairment" OR "deaf" OR "Adhd" OR "autism" OR "neurodiverse" OR "neurodiversity" OR "indigenous peoples" OR "first nations" OR "Metis" OR "Inuit" OR "LGBTQ*" OR "patients"
Strategy 8b	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Non-technical Quantum terms	As 8a
Strategy 9a	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Technical Quantum terms	"democratizing science and technology" OR "participatory technology assessment "OR "technology assessment" OR "parliamentary technology assessment" OR "anticipatory governance"OR "upstream engagement" OR "responsible innovation" OR "responsible research and innovation" OR "transformative vision assessment" OR "AI-ethics" OR "bioethics" OR "computer science ethics" OR "information technology ethics" OR "nanoethics" OR "neuroethics" OR "robo-ethics"
Strategy 9b	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Non-technical Quantum terms	As 9a
Strategy 10a	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Technical Quantum terms	"social*" OR "societal"
Strategy 10b	SCOPUS/EBSCO-HOST/Compendex/Inspec Archive and Knovel/Web of Science	Non-technical Quantum terms	As 10a

Results are reported in the result section in order of the strategies listed in Table 1.

2.4. Data Analysis

To answer the research questions, a descriptive quantitative analysis approach [153,154] (manifest coding [155,156]) was performed, generating hit counts for the search term combinations of the strategies (Table 1). Manifest coding is used to examine " ... the visible, surface, or obvious components of communication" [155] (p. 318), most specifically the frequency and location of a certain "recording unit" [156] (p. 47).

To generate the abstracts for the manifest coding, 61 technical quantum-related terms (most taken from [152]) and 17 non-technical quantum phrases generated by the author were used to obtain the initial abstracts. The technical quantum terms generated 362,728 abstracts and the 17 non-technical phrases generated 2183 abstracts as a starting point (strategy 1a and 1b, Table 1, Figure 1).

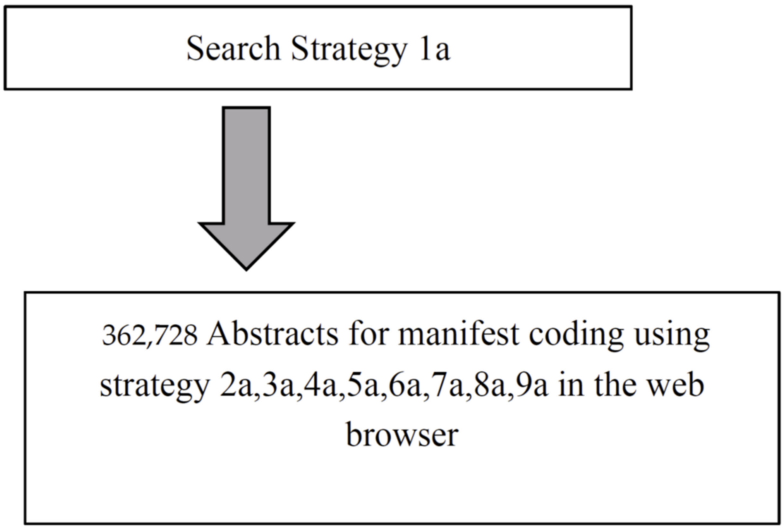

Figure 1. Search strategy for obtaining abstracts for manifest coding for the technical quantum terms in the databases.

Then, two approaches were employed to obtain the data for analysis.

In the first approach, the manifest coding of the abstracts, two procedures were used. Manifest coding using the secondary keywords (Table 1, strategies 2a–9a) was performed for the 362,728 abstracts (Figure 1) within the search pages of each of the databases without downloading any content, the sum of the hits from the four databases for each secondary keyword was recorded, and one number was generated for the result section without eliminating potential duplications of abstracts. For the 2183 abstracts obtained from the non-technical terms, all 2183 abstract were downloaded as part of the citations into Endnote Software and the Endnote software was then used to delete all duplicate abstracts and non-English documents, ending up with 1062 abstracts. All 1062 abstracts were exported from the Endnote software as one RTF file and converted into a PDF. The manifest coding was performed within the PDF using the CTRL F function of Adobe Acrobat software (Table 1, strategies 2b–9b), making certain that the hitcounts reflected the number of abstracts and not the number of hits, as the searches in the web-based database did (Figure 2).

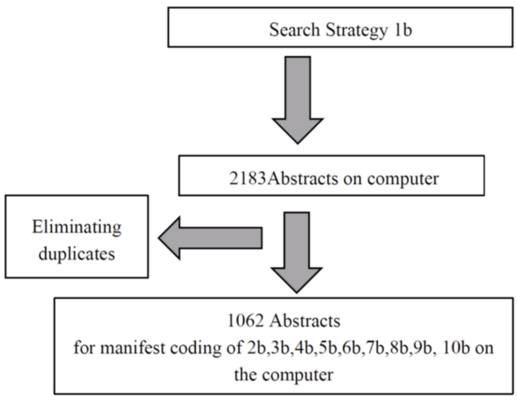

Figure 2. Search strategy for obtaining abstracts for manifest coding on the computer for the non-technical quantum terms.

In the second approach (Figure 3), manifest coding using the secondary keywords (Table 1, strategy 10a) was performed for the 362,728 abstracts within the search pages of each of the databases, obtaining 1552 abstracts for "social" and 126" abstracts for "societal"; these were downloaded as part of the citations into Endnote Software and the Endnote software was used to delete all duplicate abstracts and non-English documents, ending up with 867 abstracts for "social" and 56 for "societal". All these abstracts were exported from the Endnote software as one RTF file for "social" and one RTF file for "societal" and each was converted into a PDF. The manifest coding for "social" or "societal" terms or phrases was performed within the PDF using the CTRL F function of Adobe Acrobat software, making certain that the hitcounts reflected the number of abstracts and not the number of hits, as the searches in the web-based database did (Figure 3).

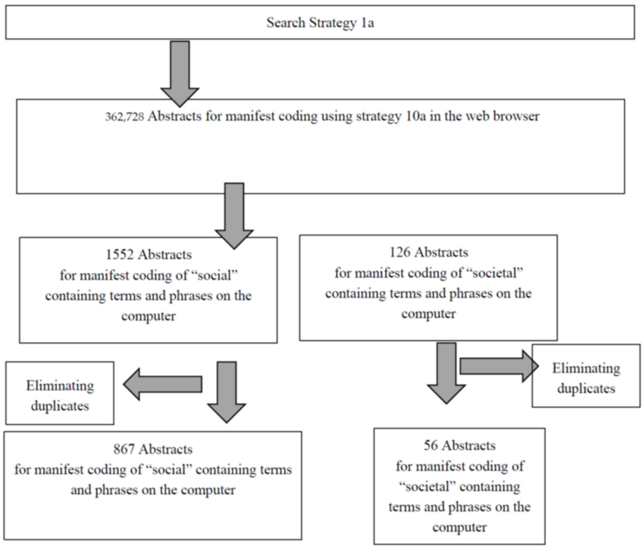

Figure 3. Search strategies for obtaining abstracts for manifest coding for the technical quantum terms in the databases.

As for the nontechnical terms, the 1062 abstracts obtained and downloaded under the second approach (Figure 2) already contained the required content, and were simply used to obtain the terms and phrases containing "social" and "societal".

3. Results

In this section, the order of reporting of the hit counts of the co-occurrence of technical or non- technical quantum terms with the secondary keywords is as follows: (1) co-occurrence with any of the 31 social terms as outlined in strategies two and three and obtained from [8,157–195] (Tables 2 and 3); (2) co-occurrence with 21 wellbeing measure terms obtained from [9–39] (Table 4); (3) co-occurrence with the indicators of four of these measures selected (Social Determinants of Health, Better Life Index, Canadian Index of Wellbeing, and the Community Based Rehabilitation Matrix) [10–15,20,21,36–39] (Tables 5–8); (4) co-occurrence with the presence of EDI terms and frameworks (Table 9) and terms linked to marginalized groups covered under EDI efforts (Table 9); (5) co-occurrence with terms linked to science and technology governance discussions (Table 10) and (6) co-occurrence with terms and phrases containing "social" or "societal"(Table 11).

In short, Tables 2–10 show that within the 362,728 abstracts of the 200 terms and phrases linked to the social (contains some terms using "social" in a phrase), 87 keywords had no hits, 47 had less than 10, 30 had between 10 and 100, and 29 had over 100 hits. Within the 1062 abstracts, 164 keywords had 0 hits, 19 had over 10, 8 had between 10 and 100 (all false positive), and one had over 100 (false positive). Table 11 shows that the term "social" itself appeared in 867 of the 362,728 abstracts containing technical quantum terms. Within the 867 abstracts obtained with the term "social", the phrase found most often, "social network", covered mostly technical aspects, and the second-highest by frequency was a false positive phrase. Most "social" containing phrases showed up in fewer than five abstracts. Furthermore, there were few phrases containing "societal", with none being used in more than five abstracts. As for the 1062 abstracts containing non-technical quantum terms, there were only ten hits with "social" and none for 'societal'.

Table 2. Hit counts for terms linked to the 'social' in conjunction with quantum terms covered.

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
1. Health equity	2	0
2. Social implication *	17	0
3. Social impact *	4	0
4. Societal impact *	10	0
5. Societal implication *	3	0
6. Ethic *	94	5 (all but 1 "quantum ethics")
7. Quantum ethics	3	4
8. ("wellbeing" OR "well-being" OR "well being")	37	2

Table 3. Hit counts for other social indicators from existing literature [8,157–195] in conjunction with quantum terms covered.

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
9. Privacy	10,581	1
10. Data protection	579	0
11. Technological deskilling or deskilling	0	0
12. Solidarity	2	0
13. Dignity	0	0
14. Social wellbeing or well-being or well being	2	1
15. Environmental wellbeing or well-being or well being	0	0
16. Subjective wellbeing or well-being or well being	2	0
17. Societal wellbeing or well-being or well being	0	0
18. Psychological wellbeing or well-being or well being	0	0
19. Emotional wellbeing or well-being or well being	0	0
20. Economic wellbeing or well-being or well being	0	0
21. Spiritual wellbeing or well-being or well being		1
22. Identity	8428 checked some all false positive (FP)	5 all FP
23. Interdependence	57	0
24. Interdependent	52	0
25. Stigma	8	0
26. Stereotype	9	0
27. Justice	39	0
28. Autonomy	80	0
29. Self-determination	4	0
30. "Good life"	2	0
31. "Social good"	3	0

Table 4. Hit counts for the terms used for the various "measures" [9–39] in conjunction with quantum terms covered.

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
32. Aqol	0	0
33. Better life index	0	0
34. Brief Inventory of Thriving	0	0
35. Calvert-Henderson Quality of Life	0	0
36. Canadian Index of well being	0	0
37. Community based rehabilitation	0	0
38. Community based rehabilitation matrix	0	0
39. Community rehabilitation	0	0
40. Comprehensive Inventory of Thriving	0	0
41. Determinants of health	1	0
42. Flourishing Scale	0	0
43. Index of well-being	0	0
44. Perceived Life Satisfaction	0	0
45. Satisfaction with life scale	0	0
46. Scale of Positive and Negative Experience	0	0
47. Social determinants of health	2	0
48. "The Disability and Wellbeing Monitoring Framework and Indicators"	0	0
49. The Quality of Being Scale	0	0
50. Well-being index	0	0
51. Meaning in Life	0	0
52. Capability approach	0	0

Table 5. Presence of Community Based Rehabilitation Matrix indicators in conjunction with the quantum terms covered.

Terms	Secondary Indicator	"Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
53. Health		1427	5
	54. "Healthcare" OR "Health care"	1360	0
	55. "Assistive technology" OR "Assistive technologies" OR "Assistive device" OR "Assistive devices"	0	0
	56. Health promotion	2	0
	57. Health prevention	2	0
	58. Rehabilitation	30	0
59. Education		673	7
	60. Childhood education	0	0
	61. Primary education	0	0
	62. Secondary education	2	0

Table 5. *Cont.*

Terms	Secondary Indicator	"Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
	63. Non-formal	3	0
	64. Life-long learning	0	0
65. Livelihood		4	0
	66. Skills development	5	0
	67. Self-Employment	0	0
	68. Financial services	48	0
	69. Wage employment	0	0
	70. Social protection	0	0
71. Social		867	10
	72. "Social relationship"	48	0
	73. Family	10,279 (technical not social family for the ones checked)	11 (technical not social for all)
	74. Personal Assistance	2	0
	75. Culture	217	2
	76. Arts	16	0
	77. Recreation OR Leisure OR Sport	78	0
	78. Access to justice	0	0
79. Empowerment		4	0
	80. Communication	48,891	29 (all technical communications not social)
	81. Social mobilization	0	0
	82. Political participation	0	0
	83. Self-help groups	0	0
	84. Disabled people's organizations	0	0

Table 6. Presence of Canadian Index of Wellbeing indicators in conjunction with the quantum terms covered.

Terms	Secondary Indicator	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
85. Social Relationships		48	0
	86. Social engagement	0	0
	87. Social Support	0	0
	88. Community safety	0	0
89. Social norms		0	0
	90. Attitudes toward others	0	0
91. Democratic engagement		0	0
	92. Participation	364	0
	93. Communication	48,891	29 (all technical not social)
	94. Leadership	70	0

Table 6. *Cont.*

Terms	Secondary Indicator	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
95. Education		673	7
	96. Competencies	39	0
	97. Knowledge	8498	13
	98. Skill	219	1
99. Environment		ND	25 all FP as not about nature
	100. Air	ND	22 (none about air quality)
	101. Energy	ND	182 (all FP) not about energy in the social sense
	102. Freshwater	0	0
	103. Nonrenewable material	0	0
	104. Biotic resources	0	0
105. Healthy population		1	0
	106. Personal wellbeing	0	0
	107. Physical health	0	0
	108. Life expectancy	2	0
	109. Mental health	5	0
	110. Functional health	0	0
	111. Lifestyle	8	0
	112. Public health	44	0
	113. Healthcare/Health care	1360	0
114. Culture		217	2
115. Leisure		0	0
116. Living standard		1	0
	117. Income	26	1
	118. Economic security	0	0
119. Time		Not determined (ND)	ND

Table 7. Presence of Better Life Index indicators in conjunction with quantum terms covered.

Terms	"Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
120. Housing	50	0
121. Income	267	1
122. Jobs	266	2
123. Community	15,261	10
124. Education	673	7
125. Environment	ND	25 none about nature
126. Physical environment	65	0
127. Civic Engagement	0	0
128. Health	1427	5
129. Life Satisfaction	0	0
130. Safety	2100	0
131. Work life balance	0	0

Table 8. Presence of Social determinants of health (SDH) indicators in conjunction with the quantum terms covered.

Terms	Quantum Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
132. Income	26	1
133. Education	673	7
134. Unemployment	1	0
135. Job Security	2	0
136. Employment	268	0
137. Early Childhood Development	0	0
138. Food Insecurity	0	0
139. Housing	50	0
140. Social Exclusion	0	0
141. Social Safety Network	0	0
142. Health Services	39	0
143. “Aboriginal” OR “first nations” OR “Metis” OR “indigenous peoples” OR “Inuit”	6	0
144. Gender	42	0
145. Women with disabilities 146. Disabled women	0	0
147. Race/racialized	ND	0
148. Immigration	13	0
149. Globalization	40	0
150. Coping	41	0
151. Discrimination	1954 (not group related but technical issues the ones looked at)	15 all FP so not social discrimination
152. Genetic	2218	5
153. Stress	836 (technical issue the ones looked at)	32 all FP as not social
154. Transportation	0	0
155. Vocational training	0	0
156. Social integration	0	0
157. Advocacy	6	0
158. Literacy	19	0
159. Race/racialized	FP	0
160. Ethnic	5	0
161. Walkability	0	0
162. Physical environment	45	0
163. Social engagement	0	0
164. Social status	0	0

Table 9. Presence of EDI terms in the academic literature focusing on quantum technologies.

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
165. (“Athena SWAN” OR “See change with STEMM Equity Achievement” OR “Dimensions: equity, diversity and inclusion” OR “Science in Australia Gender Equity” OR “NSF ADVANCE” OR “Equity, Diversity and Inclusion” OR “Equality, Diversity and Inclusion” OR “Diversity, Equity and Inclusion” OR “Diversity, Equality and Inclusion”)	0	0
166. “Belonging, Dignity, and Justice” OR “Diversity, Equity, Inclusion and Belonging” OR “Diversity, Dignity, and Inclusion” OR “Equity, Diversity, Inclusion, and Accessibility” OR “Justice, Equity, Diversity, and Inclusion” OR “Inclusion, Diversity, Equity and Accessibility” OR “Inclusion, Diversity, Equity and Accountability” OR “Equity, Diversity, Inclusion, and Decolonization”	1	0
Groups focused on in EDI discourses		
167. “Gender” OR “Women”	47	0
168. “Ethnic groups”	1	0
169. “Racialized minorities”	0	0
170. “Visible minorities”	0	0
171. Racialized	0	0
172. Ethnic	2	0
173. “People with disabilities” OR “Disabled people”	1	0
174. “Person with a disability” OR “Disabled person”	0	0
175. “Impaired” OR “Impairment”	122 (all FP) not linked to disabled people	0
176. Deaf	0	0
177. “Adhd” OR “Autism”	6	0
178. “Neurodiverse” OR “Neurodiversity”	0	0
179. “Indigenous peoples” OR “First Nations” OR “Metis” OR “Inuit”	5	0
180. “LGBTQ*”	1	0
181. Patient	901	0

Table 10. Presence of science and technology governance terms in the academic literature focusing on quantum technologies.

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
183. “Democratizing science and technology”	0	0
184. “Participatory technology assessment “	0	0
185. “Technology assessment”	2	0
186. “Parliamentary technology assessment”	0	0
187. “Anticipatory governance”	0	0
188. “Upstream engagement”	0	0
189. “Responsible innovation”	7	0
190. “Responsible research and innovation”	11	0
191. “Transformative vision assessment”	0	0
192. “AI-ethics”	0	0
193. “Bioethics”	0	0
194. “Computer science ethics”	0	0
195. “Information technology ethics”	0	0
196. “Nanoethics”	1	0
197. “Neuroethics”	0	0
198. “Robo-ethics”	0	0
199. “Technology governance”	0	0
200. “Science and technology governance”	0	0

Table 11. Presence of “social” or “societal” linked phrases in the academic literature focusing on quantum technologies including the ones already mentioned within other tables such as Table 2 if present.

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
	“Social” linked phrases	
Social	867	10
Social network *	230 (technical aspects)	0
Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering	58 none with “social” in the abstract so FP	0
Social media	46	0
Social science	45	0
Social system *	19	0
Social implication *	17	0
social trust	15	0
Social interaction *	13	0
Social welfare	12	1

Table 11. *Cont.*

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
Social engineering	12	0
Social issues	10	0
Social problem *	9	0
Socially	9	0
Social behavior	8	0
Social life	7	0
Social computing	6	0
Social context	6	0
Social communication *	6	0
Social construction *	6	0
Social phenomena	6	0
Social control *	6	0
Social justice	5	0
Social group *	5	0
Social web	5	0
Social progress	5	0
Social good	5	0
Social graph *	5	0
Social acceptance	5	0
Social deployments	5	0
Social impact *	4	0
Social factor *	4	0
Social aspect *	4	0
Social data *	4	0
Social evolution	4	0
Social laser *	4	0
Social energy *	4	0
Social responsibility *	3	0
Social benefit *	3	0
Social information *	3	0
Social environment8	3	0
Social VPN	3	0
Social stability	3	0
Social psychology	3	0
Social theor *	3	0
Social milieu	3	0
Social importance	3	0
Social agent *	2	0

Table 11. *Cont.*

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
Social ramification *	2	0
Social technologies	2	0
Social polic *	2	0
Social disadvantage *	2	0
Social change *	2	0
Social internet of things	2	0
Social determinants of health	2	0
Social research	2	0
Socializing	2	0
Social consensus	2	0
Social order	2	0
Quantum social science	2	0
Social spider optimization	2	0
Social software	2	0
Social determinants of knowledge	2	0
Social scientific inquiry	2	0
Social worlds	1	0
Social training	1	0
Socialism	1	0
Human-Inspired Socially-Aware Interfaces;	1	0
Social skills	1	0
Social eldercare	1	0
Social construction of science	1	0
Social ill	1	0
Social concern	1	0
Social robot	1	0
Social demand *	1	0
Social equity	1	0
Social location-based emergency service	1	0
Social inclusion	1	0
Social well-being	1	1
Social cost	1	0
Socialchain	1	0
Social dimension	1	0
Social reward	1	0
Social sector	1	0
Social practices	1	0

Table 11. *Cont.*

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
Social development	1	0
Social convention	1	0
Social democracy	1	0
Social dynamic	1	0
Social footprint	1	0
Social public interest	1	0
Social frameworks	1	0
Social intimacy	1	0
Social influence	1	0
Socio-technical design	1	0
Social consensus	1	0
Social living	1	0
Social production	1	0
Social messaging	1	0
Social censorship	1	0
Social classes	1	0
Social activist	1	0
Social commitment	1	0
Social approaches	1	0
Social computing	1	0
Social outcomes	1	0
Social, economic, political, and environmental ecosystems	1	0
Political, social, historical, ethical, and legal aspects of this evolving discipline	1	0
Social angle	1	0
Social culture	1	0
Political, economic, social, technological, environmental, and legal analysis	1	0
Social education	1	0
Social value	1	0
Physical, social, biological and technological systems	1	0
Social, ethical, legal and political related aspects	1	0
Technological, economic, social, environmental, and institutional dimensions	1	0
Social, economic, and political implications	1	0

Table 11. *Cont.*

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
Social, cultural, and environmental factors	1	0
Social, political, and economical life	1	1
Ecological, social, economic, and political problems	1	0
Social, economic, financial and political systems	1	0
Social, economic, and political power structures	1	0
Social, economic, political, and environmental ecosystems	1	0
Political, social, historical, ethical, and legal aspects	1	0
STEP-Analysis (Social, Technical, Economic and Political)	1	0
Social, ethical, legal and political related aspects	1	0
Incorporating technological, economic, social, environmental, and institutional dimensions	1	0
Social optimum	1	2
Social, political, and cultural needs and expectations	0	1
Social dilemma	0	1
	Societal	
Societal	87	10
Societal impact *	10	0
Societal benefit *	4	0
Societal challenge *	3	0
Societal landscape *	3	0
Societal consequence *	3	0
Societal need *	3	0
Societal implication *	3	0
Societal level driver *	2	0
Problems of Societal importance	1	0
Societal level drivers of health inequity	1	0
Societal, legal and ethical challenges	1	0
Societal-security	1	0
Societal issues	1	0
Societal trust	1	0
Societal polarization	1	0

Table 11. *Cont.*

Terms	Quantum Technical Terms 362,728 Abstracts = 100%	Quantum Non-Technical Terms 1062 Abstracts = 100%
Societal disaffiliation	1	0
Societal thinking	1	0
Societal recommendations	1	0
Societal relevance	1	0
Societal tectonics	1	0
Societal infrastructure	1	0
Societal engagement	1	0
Societal transformation	1	0
Societal pattern	1	0
Societal debate	1	0
Societal denationalization	1	0

Table 11 shows that the term "social" itself appeared in 867 of the 362,728 abstracts containing technical quantum terms, and lists all the remaining "social" containing phrases. Within the 867 abstracts obtained with the term "social", the phrase found most often, "social network", covered mostly technical aspects, and the second-highest by frequency was a false positive phrase. Most "social" containing phrases showed up in fewer than five abstracts. Furthermore, there were few phrases containing "societal", with none being used in more than five abstracts. As to the 1062 abstracts containing non-technical quantum terms, there were only ten hits with the term "social" and none for "societal".

4. Discussion

The findings of this study suggest that the quantum technologies-focused academic literature rarely if ever engages with the 'social' of quantum technologies based on keywords used that link to the 'social'. This is evident in the lack of co-occurrence of the technical quantum terms mostly derived from [152] and 17 non-technical phrases generated by the author with (a) 35 terms and phrases chosen by the author based on academic literature covering other technologies [8,157–195]; (b) the phrases depicting 17 composite wellbeing measures [9–39]; (c) all the indicators used by the four composite measures (Social Determinants of Health, Better Life Index, Canadian Index of Wellbeing, Community Based Rehabilitation Matrix) [10–15,20,21,36–39]; (d) lack of hits for terms depicting science and technology governance concepts; and e) the low frequency to no presence of "social" and "societal" containing phrases. The findings further suggest a lack of engagement of the quantum technologies-focused academic literature with EDI, as judged by the lack of hits obtained for EDI phrases and frameworks used in the discussion focused on EDI in academia and other workplaces [40–59] and the lack of or very low hits for marginalized groups normally covered under EDI [51].

Although the findings around the 'social' are not unique to quantum technology discussions and are evident for the topics of artificial intelligence, machine learning, robotics, neurotechnologies, and human enhancement literature as well [8], they are problematic. The findings are especially troubling given that they are even worse number-wise in conjunction with quantum phrases that are less technical. However, the findings indicate opportunities for broadening the quantum technologies discourse to the 'social' and to EDI, as well as for an increase in inter-intra-trans-disciplinary and intersectional collaborations. These collaborations can occur between groups and individuals involved in quantum technologies and their governance and groups, fields, and individuals involved in the 'social'; for example: (a) groups involved in the measuring of the 'social' [9–39]; (b) groups fields and individuals engaged with and EDI; (c) fields such as disability studies and other identity group studies, social justice studies, health sciences, STEM and AI education and education in general; (d) fields involved in science and technology governance and ethics; and (e) socially disadvantaged groups, practitioners, and policy makers.

In the remaining part, the findings of the study are discussed through the lens of existing quantum technologies policy literature mentioning the 'social', the quantum policy literature mentioning education, the literature around EDI (including how EDI is covered in quantum policy documents), and the literature around science and technology governance, including quantum technology governance.

4.1. Quantum Policy Documents and the 'Social'

Quantum technologies are an enabling platform [62] with many envisioned applications [62–66], and as such their potential impact on the 'social' is vast. Many quantum strategies [62,68–75] mention the impact of quantum technologies on the 'social' using words such as "social revolution", "quantum society", "affect many aspects of our society" [72] (p. 3), benefit society [66], "help to address society's challenges" [65] (p. 3), "solve some of society's complex problems" [65] (p. 8), "build a thriving and resilient economy and society" [65] (p. 3), QIS can have profound and positive impacts on society [73] (p. 3) and "inevitable impact at both the techno-logical and social level" [76] (p. 5).

If quantum technologies are this impactful on society and the 'social', mapping out words, phrases and measures of the 'social' for different potential, anticipated, and already existing quantum applications might be beneficial for quantum technologies that may generate new abilities and fields and quantum technologies that enable improvements to already existing technologies such as sensors, robotics, and artificial intelligence. Mapping out the 'social' using the terms covered in this study engenders a sophisticated map of potential problems and opportunities. It allows for a fruitful collaboration between the quantum technology community and the communities that work on the various 'social'. It allows the quantum technology community to become more knowledgeable on the 'social' and the communities around the 'social' to see the gaps in their indicators in relation to quantum technologies and other scientific and technological advancements.

The gaps in the findings of this study are reciprocal; for example, as much as health equity, community-based rehabilitation, and determinants of health are not covered in quantum technologies-focused academic literature, quantum technologies are not engaged with in academic literature focused on health equity, community-based rehabilitation, and determinants of health. The findings suggest a problem on both sides, and potential benefit for both sides as well. For example, community-based rehabilitation (CBR) guidelines [36] have been developed to create equal opportunities for disabled people in low- and middle-income countries [37], and it is argued that the CBR is guided by the "United Nations Convention on the Rights of Persons with Disabilities" (UNCRPD) [36,38]. A differentiated map of applications and a linkage to a differentiated map of the 'social' would reveal that the CBR misses many indicators that impact the mandate of the CBR. Indeed, one could use the action items of the "United Nations Convention on the Rights of Persons with Disabilities (UNCRPD)" [196] as another set of indicators for the 'social' and analyze which of the quantum applications (in both of the main categories) will impact which action items. The utility of the mapping is true for the other measures as well; for example, the Canadian Index of Wellbeing is "a multifaceted measurement and monitoring tool developed to engage Canadians in conversations about their health and wellbeing that go beyond health care or the economy, and about acting on changes that matter in their lives" [39]. If this is the case, then using their indicators to map out the 'social' of quantum advancement and to highlight which indicators might be needed to fill gaps in the Canadian Index of Wellbeing will be very useful to engage Canadians in the conversations around quantum and the 'social'.

4.2. Governance of Quantum Technologies

Science and technology governance is, among other things, about the 'Social'. As such, this study used keywords depicting various science and technology governance discourses and ethics fields (Table 10). This study did not find any of the 18 governance and ethics field terms in conjunction with the quantum non-technical terms, and found only four governance terms and no ethics fields terms in conjunction with the quantum technical terms, suggesting a gap that needs to be filled and many opportunities to fill it, using mapping of the 'social' of quantum technologies as one tool.

In the Canadian strategy the question is asked: "How can the National Quantum Strategy best address the societal, ethical, legal and policy considerations that may arise given quantum technologies' disruptive capability?" [62]; see also other policy documents [62,63,65,72,73,75,77,78].

In the Australian strategy for the quantum revolution, it is argued that:

> "We must look ahead to what a quantum society might entail and how the quantum design decisions being made today might affect how we live in the future. Consider the use of quantum computing to advance machine learning and artificial intelligence (ML/AI). ML/AI technologies are already the subject of ethical frameworks designed to prevent harm and ensure the design of ethical, fair and safe systems.22 Those frameworks are vital, as potential harms could include the reproduction and amplification of existing socio-economic marginalisation and discrimination, and the reduction of personal privacy. At this time, no ethical framework for quantum technologies exists in Australia, although the CSIRO Quantum Technology Roadmap calls for quantum stakeholders to explore and address social risks.23 As quantum technologies progress, such discussions should build literacy in the societal impacts of quantum technologies. This should be a collaborative effort between quantum physics and social science researchers, industry experts, governments and other public stakeholders, and be led by the proposed office of the minister for critical technologies." [72] (p. 10)

Mapping in detail the applications and the 'social' allows one to see which applications the quantum technology community needs to approach with unique governance actions specific to the quantum arena and which applications can be covered under existing science and technology governance discourses. Mapping out the 'social' within a differentiated map of the applications allows for social risk to be mapped out in a meaningful way as well as to build literacy in the societal implications, as asked for in [72].

The suggested mapping is also useful for another problem, namely, identifying stakeholders. Various quantum policy documents indicate the need to involve stakeholders [62,63,71,72,74]. However, literature in relation to other technologies show problems within that area [197]. Indeed, as is noted in the Australian strategy for the quantum revolution:

> "a precondition for social debate about quantum technology is that all participants have a reasonable understanding of the technology and its implications. After all, even 'insiders' are inclined to represent quantum technology as a mysterious manifestation of counterintuitive ideas and processes. That has implications for the participation in the debate of people from other academic disciplines, industry or government, and by the wider community. As a result, the technology's growth and social adoption could be adversely affected: society might be reluctant to accept quantum technology, or might even reject it, thus holding back, counteracting or greatly delaying integration. It is instructive to consider the acceptance issues associated with stem cell therapy, genetic modification, climate solutions and vaccination." [75]

The authors of several academic articles have begun to highlight the need for the governance of quantum technologies, using the terms "responsible innovation" or "responsible research and innovation [139–143]. Some of these articles are linked to quantum projects such as the "RI team embedded in the Networked Quantum Information Technologies Hub" [140,142]. It is noted that "the team researchers investigated perceptions of RI and their understanding of societal impacts of quantum technologies, and sought to gauge the challenges of embedding RI across a multi-disciplinary, large-scale enterprise such as the UK quantum programme" [142] (p. 1). The mapping, as suggested, would fit with that exercise and answer the questions of "who benefits and who is in control?" [142] (p. 1). Problems with biases are noted for quantum machine learning [142], and these biases could include biases linked to disabled people already identified with 'normal' machine learning [197]. The authors write about the hopes and fears of the public [142] (p. 5). The set of indicators used in the study could be filled out by different groups of the public, and as such would allow for insight into how hopes and fears differ for the 'social' of different groups. The authors suggest that wide democratic access to the technology is seen as essential by their participants [142]. However, not every problem with a given technology can be solved by providing access to the technology [197,198]. Mapping the 'social' would make that evident. Mapping as outlined is beneficial to defining the field, avoiding overselling quantum technologies "in terms of its societally relevant and useful applications" [139] (p. 289) and strengthening a strong RRI approach suggested [139], which "entails linking parliamentary or other core policy processes to structured and prominent stakeholder dialogues, to decision-supporting public engagement activities and to a wide variety of other public communication activities" [139] (p. 291).

4.3. EDI and Quantum Technologies

One can make a strong linkage between the 'social' of quantum technologies and the very engagement of the quantum community with EDI. Employing EDI phrases such as "equity, diversity, and inclusion" [51]; "equality, diversity, and inclusion" [51]; "diversity, equity, and inclusion" [51]; "belonging, dignity, and justice" [40,41]; "diversity, equity, inclusion and belonging" [42,47,57]; "employment equity" [43]; "inclusion, diversity, equity, and accessibility" [44–46]; "justice, equity, diversity, and inclusion" [48,49,58,59] and "equity, diversity, inclusion, and decolonization" [50] and EDI frameworks [52–56], EDI-linked actions, and discussions in many countries try to improve the 'social' for marginalized students, academic and non-academic staff at universities and other workplaces.

EDI as a phrase is mentioned, for example, in the Canadian National Quantum Strategy:

> "As the university-private sector quantum consortium has pointed out, to reach its full potential, the Canadian quantum sector must draw on a more diverse pool of people from within Canada and around the world. Budget 2021 committed to considering equity, diversity and inclusion in the development and implementation of the National Quantum Strategy. What can be done to ensure that, as Canada's quantum sector grows, it is increasingly representative of our diversity?" [62]

Furthermore, in the 2022 Canadian report "National Quantum Strategy Consultations: What We Heard Report" [78], the following ideas from the consultation to enhance equity, diversity, and inclusion are listed:

> "creating a more inclusive environment to expand the talent pool; offering introductory courses in quantum, especially to students in other STEM fields and undergraduate programs, not just MSc and PhD candidates; targeting diverse colleges, CEGEPs and universities in Canada and abroad; drawing staff from other sectors; increasing diverse representation on panels and in promotional engagement; following the approach outlined in the Government of Canada's Dimensions Charter; replicating programs, such as the Creative Destruction Lab's Apprenticeship program or IBM's Polytechnic program with Six Nations; and facilitating the immigration of qualified candidates" [78].

And it is further stated in the report:

> "A wider range of students is expected as quantum technologies become more broadly adopted. There is huge competition for the relatively few female candidates in quantum technologies, but this has not necessarily translated into more women entering relevant programs of study. More Indigenous students are entering STEM programs, but they sometimes face dilemmas in leaving their communities and culture, particularly if they have to go abroad. To further attract diverse candidates, we should look at human-centric strategies. To this end, online comments included offering better parental leave and childcare, removing labour market impact assessments for PhDs, issuing special visas for experts in emerging technologies and making it easier for foreign students to stay in Canada" [78].

How EDI frameworks are implemented and how EDI phrases are used and understood within the discussions around quantum technologies impacts quantum technology research, education, policies, and product development both in general and in relation to the 'social', and quantum technology research, education, policies, and product development and the engagement with the 'social' of quantum technologies impacts EDI discussions and actions.

Therefore, it is problematic that the quantum-focused academic literature does not mention EDI phrases and frameworks at all (Table 9). Mapping out the 'social' of quantum technologies might both advance EDI efforts and link quantum technology governance and the understanding of the impact of the 'social' of quantum technologies to EDI.

The EDI discussions in universities and other workplaces cover many marginalized groups, such as women, Indigenous peoples, visible/racialized minorities, disabled people, and LGBTQ2S+ (see for example [56]), and cover students, non-academic staff, and academic staff. Quantum policy document and discussions have begun to engage with gender under EDI [71,78–80], and one document covered Indigenous peoples [78].

All EDI groups are impacted by different indicators of the 'social', and many are impacted differently by the same given specific indicator of the 'social'.

Disabled people's experience of the 'social' for example can be impacted by quantum technologies in various ways:

(a) as potential non-therapeutic users (consumer angle);
(b) as potential therapeutic users;
(c) as potential diagnostic targets (diagnostics to prevent disability', or to judge 'Disability');
(d) by changing societal parameters caused by humans using quantum technologies;
(e) by changes in societal parameters caused by quantum technologies related sales pitches;
(f) Quantum technologies adding to AI/ML outperforming humans (e.g., workplace);
(g) Quantum technologies increasing autonomy of AI/ML (AI/ML judging disabled people) (modified from [197].

The findings of this study found little to no engagement with EDI-covered groups in the quantum technologies-focused academic literature (Table 9), which suggests a gap in the quantum technologies-focused academic literature that should be filled. Mapping the effects of different quantum technologies on the 'social' for different marginalized groups is essential, and enhances EDI efforts, quantum technology governance, and the understanding of the impact of the 'social'. It might increase the interest in quantum technologies by students, as it makes quantum technologies more real and might trigger more diverse engagement with quantum technologies in general and especially in relation to the 'social' of quantum technologies, thereby facilitating the generation of a more diverse quantum workforce.

The gap in the coverage of EDI groups in the quantum technologies-focused academic literature must be filled, because many EDI groups encounter harassment and other problems that prevent a positive EDI climate at the workplace for them which influences their engagement with quantum technologies in a negative way. For example, according to a 2019 Statistics Canada survey:

"35% of disabled University professors, instructors, teachers, or researchers "experienced unfair treatment or discrimination in the past 12 months" and 47% saw themselves "subjected to at least one type of harassment in the past 12 months" [199]. With that, the numbers for disabled University professors, instructors, teachers, or researchers are the highest of all groups recorded" [199]. The numbers for "no self reported disability" were 15.4% and 26.0% [199].

The numbers for other EDI groups were: "female gender", 23.0% and 34.0%; "visible minorities", 23.0% and 28.0%; and "indigenous identity", 30.0% and 37.0%" [199]. The numbers for "male gender" were 11.0% and 22.0%; "not a visible minority" 15.2% and 28%; non-indigenous identity 16.5% and 28%.

EDI actions in relation to gender suggested by the "Quantum gender equality working group of the quantum flagship" are "generation of network of women, unconscious bias training, mentoring programmes, gender awareness ambassadors to give talks and information about gender inequality in scientific meetings" [80]. However, such actions are as much needed for the other marginalized groups covered in EDI discourses [51], and quantum technologies-focused academic studies are needed to generate data on the topic.

Research agendas and engagement are EDI topics as well [51,200]. The focus on the non-social in quantum research thus far is understandable given the early stage of quantum technologies; however, it is an opportunity to engage with the 'social' in a differentiated way giving voice to marginalized groups including researchers from marginalized groups. It is noted that there is a need for increased "social support for undergraduate researchers through designated cohorts" because it "can help them build community with their peers and see themselves as engineers and scientists, something that is often difficult for marginalized students who do not see themselves reflected in the celebrated leaders of the field" [83] (p. 16). However, from an EDI perspective, it has to include undergraduate students as researchers from all EDI groups including disabled undergraduate students as researchers, which is, for example, a group missing from the EDI research agenda in general [201] and the quantum technologies-focused academic literature of the 'social' in particular. The 'social' could be a way to add many disabled people as researchers that cannot or do not want to focus on the technical research aspect of technologies in general [200], which includes quantum technologies, and instead could and want to contribute to quantum technology knowledge by looking at the 'social'. The 'social' could broaden the involvement of researchers from other marginalized groups in quantum technologies research beyond their being involved in the technical side of quantum research.

4.4. Quantum Technologies and Education

The mapping of the 'social' could be very useful in secondary education and other educational settings for "building general quantum awareness for all citizens and a sound preparation for the further education of future quantum engineers–quantum literacy" [95] (p. 6).It is noted that "along with issues of diversity, equity, and inclusion, consideration of social, societal, ethical and sustainability issues of QISE would be beneficial, in line with directions in engineering education worldwide" [83] (p. 10). Indeed, given that students have different interests [96], adding the 'social' might broaden the interest into quantum. The mapping exercises might counter the recognized problem that the teaching of technical students in 'social' aspects is lacking [85–90] and that techno-determinism and techno-optimism are recognized as biased forms of reporting within the STEM education literature [91–94], which also seems to be evident in quantum policy views on education, as evident from statements such as "the need for quantum workforce and a well-educated society with knowledge and attitudes towards the acceptance of QT is imminent" [95] (p. 1). It is suggested that "a quantum awareness or concepts course" on the undergraduate level, if possible in the first year "to introduce students to the field early" would be beneficial [83] (p. 18). If this would include the 'social', it might broaden the interest into quantum research. The mapping exercises would connect with students beyond their technical work. It would be useful for teaching non-technical students of the 'social' of other technologies as well.

The suggested mapping exercise of the 'social' could be used as a pedagogical tool in EDI curricula content and other courses, engaging with the concept of stakeholder and citizen engagement in society. Indeed, in a 2017 academic article it is stated, "a preamble to a societal debate about quantum technologies is that all stakeholders understand these technologies to a reasonable degree, and the current framing of quantum theory as enigmatic in not helpful to meeting this" [143] (p. 241). The mapping would help with that. Several articles engaged with the issue of the predictive power of quantum applications [144,145] for looking into literacy limits. The mapping allows for outlining various biases linked to predictions based on biased data. Another article suggested the design of "digital infrastructure that can better accommodate multicultural and pluralistic views from its foundations. It is insufficient to look at only the responses and influences of culture on technology without considering how the technology can be adapted in anticipation of, and to support, pluralistic multicultural perspectives in its original design" [146] (p. 399). That could be facilitated by the mapping and be used as part of EDI curricula.

4.5. Limitations

The search was limited to a limited number of databases and to English language literature. As such, the findings are not to be generalized to the whole academic literature, non-academic literature, or non-English literature. Furthermore, only abstracts were searched. This means that relevant content that would only be evident in the main body of an article would have been missed. As the data produced are based on the co-occurrence of terms, the hit counts by themselves do not indicate whether the keyword combinations really engage content-wise with each other or what the actual content is. The hit count results are a maximum and do not account for duplication between databases and false positives for the technical terms. Although this study has various limitations, the findings allow for conclusions to be made within the parameters of the searches and the character of the analysis.

5. Conclusions and Future Research

The findings suggest that the quantum technologies-focused academic literature thus far engages rarely to not at all with the 'social' of quantum technologies. The findings further suggest a non-engagement with EDI phrases and frameworks used in the academic literature to discuss EDI and a lack of engagement with social groups covered by EDI.

The findings indicate opportunities for broadening the quantum discourse to the 'social', linking the 'social' to EDI and for an increase in inter-intra-trans-disciplinary and intersectional collaborations around the 'social' and around EDI. These collaborations could be between groups and individuals involved in quantum technologies and their governance and between groups, fields, and individuals involved in the 'social', for example: (a) groups involved in the measuring of the 'social' [9–39]; (b) groups, fields, and individuals engaged with EDI; (c) fields such as disability studies and other identity group studies, social justice studies, health sciences, STEM and AI education, and education in general; (d) fields involved in science and technology governance and ethics; and (e) socially disadvantaged groups, practitioners, and policy makers.

The findings of this study suggest many possible future research agendas, one being that a differentiated map of the 'social' and quantum applications could be generated, which is an endeavour that would benefit from inter-intra-trans-disciplinary and intersectional collaborations. Given the precarious 'social' of disabled people as evident in The "United Nation Convention on the Rights of Persons with Disabilities" and the "United Nations 2018 Flagship Report on Disability and Development: Realization of the Sustainable Development Goals by, for and with Persons with Disabilities" [196,202], these two documents could be used to indicate which indicators of the 'social' used in the study presented here are reflected in the two documents, and to add indicators of the 'social' that are not already covered by the list of indicators. Having a map of the 'social' could encourage the quantum community and other groups and individuals, including students, to provide their sentiments on the impact of the social indicators for society as a whole and in relation to different social groups, which could include the groups covered by EDI discourses, and to analyze which social groups are seen to benefit more than others; this assessment must be carried out for separate quantum applications and not quantum as a whole. Such an endeavour could be used along with the "Transformative Vision Assessment Approach" of technology assessment [138], as the mapping can reveal different visions.

Research could be performed on the usefulness of the mapping of the 'social' of quantum technologies as pedagogical tools in formal and informal education settings, including lifelong learning to increase literacy on and interest in the 'social' of quantum technologies.

Given the increasing visibility of EDI in universities, it is valuable to understand the impact of quantum technologies on EDI discourses and the impact of EDI discourses on quantum technology research and policies.

Author Contributions: All by G.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data sharing is not applicable to this article.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Marcuse, H. Some social implications of modern technology. *Z. Für Soz.* **1941**, *9*, 414–439. [CrossRef]
2. Bebgeb, F.M. Social Implications of Psychotropic Drugs. *Adv. Pharmacol.* **1972**, *10*, 105–118. [CrossRef]
3. Hibino, Y. Non-commercial surrogacy in Thailand: Ethical, legal, social implications in local and global context. *Asian Bioeth. Rev.* **2020**, *12*, 135–147. [CrossRef] [PubMed]
4. Singh, I. ELSI Neuroscience Should Have a Broad Scope. *AJOB Neurosci.* **2010**, *1*, 11–12. [CrossRef]
5. Graf, W.D.; Nagel, S.K.; Epstein, L.G.; Miller, G.; Nass, R.; Larriviere, D. Pediatric neuroenhancement Ethical, legal, social, and neurodevelopmental implications. *Neurology* **2013**, *80*, 1251–1260. [CrossRef]
6. Greenbaum, D. Expanding ELSI to all areas of innovative science and technology. *Nat. Biotechnol.* **2015**, *33*, 425–426. [CrossRef]
7. Callier, S.L.; Abudu, R.; Mehlman, M.J.; Singer, M.E.; Neuhauser, D.; Caga-Anan, C.; Wiesner, G.L. Ethical, Legal, and Social Implications of Personalized Genomic Medicine Research: Current Literature and Suggestions for the Future. *Bioethics* **2016**, *30*, 698–705. [CrossRef]
8. Wolbring, G. Auditing the Impact of Neuro-Advancements on Health Equity. *J. Neurol. Res.* **2021**. online first. [CrossRef]
9. World Health Organization. Constitution of the World Health Organization. Available online: https://www.who.int/governance/eb/who_constitution_en.pdf (accessed on 20 December 2021).
10. Marmot, M.; Friel, S.; Bell, R.; Houweling, T.A.; Taylor, S.; Commission on Social Determinants of Health. Closing the gap in a generation: Health equity through action on the social determinants of health. *Lancet* **2008**, *372*, 1661–1669. [CrossRef]
11. Raphael, D. *Social Determinants of Health: Canadian Perspectives*; Canadian Scholars' Press: Toronto, ON, Canada, 2009.
12. Commission on Determinants of Health. Closing the Gap in A Generation: Health Equity through Action on the Social Determinants of Health. Available online: https://www.who.int/social_determinants/thecommission/finalreport/en/ (accessed on 20 December 2021).
13. Canadian Index of Wellbeing Organization. What Is Wellbeing? Available online: https://uwaterloo.ca/canadian-index-wellbeing/what-wellbeing (accessed on 20 December 2021).
14. Michalos, A.C.; Sharpe, A.; Muhajarine, N. *An Approach to the Canadian Index of Wellbeing*; Atkinson Charitable Foundation: Toronto, ON, Canada, 2010.
15. Tanton, R.; Miranti, R.; Vidyattama, Y.; Sajeda, T. Index of Wellbeing of Older Australians (IWOA). Available online: https://www.iwoa.org.au/ (accessed on 20 December 2021).
16. Stanojević, A.; Benčina, J. The Construction of an Integrated and Transparent Index of Wellbeing. *Soc. Indic. Res.* **2019**, *143*, 995–1015. [CrossRef]
17. Linares-Luján, A.M.; Parejo-Moruno, F.M. Height, Literacy and Survival: A Composite Index of Wellbeing Based on Data from Military Recruitment (1880–1980). *Soc. Indic. Res.* **2019**, *144*, 999–1019. [CrossRef]
18. Atkinson, S.; Bagnall, A.-M.; Corcoran, R.; South, J.; Curtis, S. Being Well Together: Individual Subjective and Community Wellbeing. *J. Happiness Stud.* **2019**, *21*, 1903–1921. [CrossRef]

19. OECD. OECD Better Life Index. Available online: http://www.oecdbetterlifeindex.org/#/11111111111 (accessed on 20 December 2021).
20. World Health Organization. About the Community-Based Rehabilitation (CBR) Matrix. Available online: http://www.who.int/disabilities/cbr/matrix/en/ (accessed on 20 December 2021).
21. World Health Organization. Community-Based Rehabilitation. Available online: http://www.who.int/disabilities/cbr/en/ (accessed on 20 December 2021).
22. WHOQOL Group. The World Health Organization quality of Life Assessment (WHOQOL): Position Paper from the World Health Organization. *Soc. Sci. Med.* **1995**, *41*, 1403–1409. [CrossRef]
23. Wolbring, G. HTA Initiative #23 the Triangle of Enhancement Medicine, Disabled People, and the Concept of Health: A New Challenge for HTA, Health Research, and Health Policy. Available online: http://www.ihe.ca/download/the_triangle_of_enhancement_medicine_disabled_people_and_the_concept_of_health_a_new_challenge_for_hta_health_research_and_health_policy.pdf (accessed on 20 December 2021).
24. Hawthorne, G.; Richardson, J.; Osborne, R. The Assessment of Quality of Life (AQoL) instrument: A psychometric measure of health-related quality of life. *Qual. Life Res.* **1999**, *8*, 209–224. [CrossRef]
25. Henderson, H.; Lickerman, J.; Flynn, P. *Calvert-Henderson Quality of Life Indicators*; Calvert Group: Bethesda, MD, USA, 2000.
26. Diener, E. Subjective well-being. *Psychol. Bull.* **1984**, *95*, 542–575. [CrossRef]
27. Mulderrig, K.; Rogers, S. Deaf cultural identification, cochlear implants, and life satisfaction. *Can. Acoust.* **2019**, *47*, 20–21.
28. Wolbring, G. Subjective Wellbeing, Body-Related Ability Expectations and Peace. *Int. J. Peace Stud.* **2013**, *18*, 27–39.
29. Huebner, E.S.; Dew, T. Validity of the perceived life satisfaction scale. *Sch. Psychol. Int.* **1993**, *14*, 355–360. [CrossRef]
30. Losada-Puente, L.; Araújo, A.M.; Muñoz-Cantero, J.M. A Systematic Review of the Assessment of Quality of Life in Adolescents. *Soc. Indic. Res.* **2020**, *147*, 1039–1057. [CrossRef]
31. Fortune, N.; Badland, H.; Clifton, S.; Emerson, E.; Rachele, J.; Stancliffe, R.J.; Zhou, Q.; Llewellyn, G. The Disability and Wellbeing Monitoring Framework and Indicators: Technical Report. Available online: https://melbourne.figshare.com/articles/online_resource/Disability_and_Wellbeing_Monitoring_Framework_and_Indicators_Technical_Report/12094113 (accessed on 20 December 2021).
32. Fortune, N.; Badland, H.; Clifton, S.; Emerson, E.; Rachele, J.; Stancliffe, R.J.; Zhou, Q.; Llewellyn, G. The Disability and Wellbeing Monitoring Framework: Data, data gaps, and policy implications. *Aust. N. Z. J. Public Health* **2020**, *44*, 227–232. [CrossRef]
33. Silva, A.J.; Caetano, A. Validation of the flourishing scale and scale of positive and negative experience in Portugal. *Soc. Indic. Res.* **2013**, *110*, 469–478. [CrossRef]
34. Su, R.; Tay, L.; Diener, E. The development and validation of the Comprehensive Inventory of Thriving (CIT) and the Brief Inventory of Thriving (BIT). *Appl. Psychol. Health Well-Being* **2014**, *6*, 251–279. [CrossRef] [PubMed]
35. OECD. *Economic Valuation of Environmental Health Risks to Children*; OECD: Paris, France, 2006.
36. World Health Organization; UNESCO; International Labour Organization; International Disability Development Consortium. Community-Based Rehabilitation: CBR Guidelines. Available online: https://www.who.int/publications/i/item/community-based-rehabilitation-cbr-guidelines (accessed on 20 December 2021).
37. Eskandar, M.; Otadi, M.; Mojibi, T. Ranking the Desirability Indicators of Community-Based Rehabilitation (CBR) Based on Analytical Hierarchy Process. *Int. J. Psychol. Behav. Sci.* **2018**, *8*, 7–11. [CrossRef]
38. Mannan, H.; MacLachlan, M.; McAuliffe, E. The human resources challenge to community based rehabilitation: The need for a scientific, systematic and coordinated global response. *Disabil. CBR Incl. Dev.* **2012**, *23*, 6–16. [CrossRef]
39. Muhajarine, N.; Labonte, R.; Winquist, B.D. The Canadian Index of Wellbeing: Key findings from the healthy populations domain. *Can. J. Public Health* **2012**, *103*, e342–e347. [CrossRef] [PubMed]
40. Mikus, J.; Grant-Smith, D.; Rieger, J. Cultural Probes as a Carefully Curated Research Design Approach to Elicit Older Adult Lived Experience. In *Social Justice Research Methods for Doctoral Research*; IGI Global: Hershey, PA, USA, 2022; pp. 182–207.
41. Simpson, A. The Sovereignty of Critique. *South Atl. Q.* **2020**, *119*, 685–699. [CrossRef]
42. National Science Foundation. Geoscience Opportunities for Leadership in Diversity (NSF). Available online: https://ezproxy.lib.ucalgary.ca/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=151210247&site=ehost-live (accessed on 20 December 2021).
43. Henry, F.; Dua, E.; Kobayashi, A.; James, C.; Li, P.; Ramos, H.; Smith, M.S. Race, racialization and Indigeneity in Canadian universities. *Race Ethn. Educ.* **2017**, *20*, 300–314. [CrossRef]
44. Free, D. IDEAL '19: Advancing Inclusion, Diversity, Equity, and Accessibility in Libraries and Archives. *Coll. Res. Libr. News* **2019**, *80*, 130. [CrossRef]
45. Zallio, M.; Clarkson, P.J. Inclusion, diversity, equity and accessibility in the built environment: A study of architectural design practice. *Build. Environ.* **2021**, *206*, 108352. [CrossRef]
46. Mullin, A.E.; Coe, I.R.; Gooden, E.A.; Tunde-Byass, M.; Wiley, R.E. Inclusion, diversity, equity, and accessibility: From organizational responsibility to leadership competency. *Healthc. Manag. Forum* **2021**, *34*, 311–315. [CrossRef]
47. Schnabel, R.B.; Benjamin, E.J. Diversity 4.0 in the cardiovascular health-care workforce. *Nat. Rev. Cardiol.* **2020**, *17*, 751–753. [CrossRef] [PubMed]

48. Davies, S.W.; Putnam, H.M.; Ainsworth, T.; Baum, J.K.; Bove, C.B.; Crosby, S.C.; Cote, I.M.; Duplouy, A.; Fulweiler, R.W.; Griffin, A.J.; et al. Promoting inclusive metrics of success and impact to dismantle a discriminatory reward system in science. *PLoS Biol.* **2021**, *19*, e3001282. [CrossRef] [PubMed]
49. Wells, J.C. Does intra-disciplinary historic preservation scholarship address the exigent issues of practice? Exploring the character and impact of preservation knowledge production in relation to critical heritage studies, equity, and social justice. *Int. J. Herit. Stud.* **2021**, *27*, 449–469. [CrossRef]
50. Congress Advisory Committee on Equity Diversity Inclusion and Decolonization (AC-EDID) Canada. Igniting Change: Final Report and Recommendations. Available online: http://www.ideas-idees.ca/about/CAC-EDID-report (accessed on 20 December 2021).
51. Wolbring, G.; Lillywhite, A. Equity/Equality, Diversity, and Inclusion (EDI) in Universities: The Case of Disabled People. *Societies* **2021**, *11*, 49. [CrossRef]
52. Advance, H.E. Athena Swan Charter Encouraging and Recognising Commitment to Advancing Gender Equality. Available online: https://www.advance-he.ac.uk/equality-charters/athena-swan-charter (accessed on 20 December 2021).
53. Science in Australia Gender Equity. Science in Australia Gender Equity. Available online: https://www.sciencegenderequity.org.au/ (accessed on 20 December 2021).
54. AAAS. See Change with STEMM Equity Achievement. Available online: https://seachange.aaas.org/ (accessed on 20 December 2021).
55. National Science Foundation. Advance at a Glance. Available online: https://www.nsf.gov/crssprgm/advance/ (accessed on 20 December 2021).
56. Government of Canada. Dimensions: Equity, Diversity and Inclusion Canada. Available online: http://www.nserc-crsng.gc.ca/NSERC-CRSNG/EDI-EDI/Dimensions-Charter_Dimensions-Charte_eng.asp (accessed on 20 December 2021).
57. El-Amin, A. Improving Organizational Commitment to Diversity, Equity, Inclusion, and Belonging. In *Social Justice Research Methods for Doctoral Research*; IGI Global: Hershey, PA, USA, 2022; pp. 208–221.
58. Thorpe, R.J., Jr.; Odden, M.C.; Lipsitz, L.A. *A Call to Action to Enhance Justice, Equity, Diversity, and Inclusion in the Journal of Gerontology Series A: Medical Sciences*; Oxford University Press: New York, NY, USA, 2022; Volume 77, pp. 89–90.
59. Johri, S.; Carnevale, M.; Porter, L.; Zivian, A.; Kourantidou, M.; Meyer, E.L.; Seevers, J.; Skubel, R.A. Pathways to Justice, Equity, Diversity, and Inclusion in Marine Science and Conservation. *Front. Mar. Sci.* **2021**, *8*, 696180. [CrossRef]
60. Advance, H.E. Race Equality Charter. Available online: https://www.advance-he.ac.uk/equality-charters (accessed on 20 December 2021).
61. Qureca. Overview on Quantum Initiatives Worldwide—Update Mid 2021. Available online: https://www.qureca.com/overview-on-quantum-initiatives-worldwide-update-mid-2021/ (accessed on 20 December 2021).
62. Government of Canada. Engagement Paper: Developing A National Quantum Strategy. Available online: https://www.ic.gc.ca/eic/site/154.nsf/eng/00001.html (accessed on 20 December 2021).
63. UK Government. A Perspective of UK Quantum Technology Prepared by and for the UK Quantum Technology Community UK Quantum Technology Landscape. 2016. Available online: https://uknqt.ukri.org/files/ukquantumtechnologylandscape2016/ (accessed on 20 December 2021).
64. University of Cambridge IfM Education and Consutancy services Technology Strategy board. Quantum Technology Roadmap Report Consolidated from Workshops in London and Glasgow. Available online: https://www.ifm.eng.cam.ac.uk/uploads/Resources/Quantum-Technologies-Roadmap-Report.pdf (accessed on 20 December 2021).
65. UK National Quantum Technologies Programme. Strategkc Intent. Available online: https://uknqt.ukri.org/files/strategicintent2020/ (accessed on 20 December 2021).
66. Middleton, A.; Till, S. Quantum Information Processing Landscape 2020: Prospects for UK Defence and Security. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/899418/20200331-DSTL-TR121783-FINAL-pdfa.pdf (accessed on 20 December 2021).
67. Discover. The Quantum Technology Industry Is Creating Entirely New Jobs. Available online: https://www.discovermagazine.com/technology/the-quantum-technology-industry-is-creating-entirely-new-jobs (accessed on 20 December 2021).
68. Jiang, S.Y.; Chen, S.L. Exploring landscapes of quantum technology with Patent Network Analysis. *Technol. Anal. Strateg. Manag.* **2021**, *33*, 1317–1331. [CrossRef]
69. Wolf, S.A.; Joneckis, L.G.; Waruhiu, S.; Biddle, J.C.; Sun, O.S.; Buckley, L.J. Overview of the Status of Quantum Science and Technology and Recommendations for the DoD. Available online: https://www.ida.org/research-and-publications/publications/all/o/ov/overview-of-the-status-of-quantum-science-and-technology-and-recommendations-for-the-dod (accessed on 20 December 2021).
70. Various. Quantum Manifesto. Available online: https://qt.eu/app/uploads/2018/04/93056_Quantum-Manifesto_WEB.pdf (accessed on 20 December 2021).
71. Quantera. Quantum Technologies: Public Policies in Europe. Available online: https://www.quantera.eu/114-quantum-technologies-public-policies-in-europe (accessed on 20 December 2021).
72. Brennen, G.; Devitt, S.; Roberson, T.; Rohde, P. An Australian Strategy for the Quantum Revolution. Available online: https://s3-ap-southeast-2.amazonaws.com/ad-aspi/2021-05/Quantum%20revolution-v2.pdf?VersionId=tST6Nx6Z0FEIbFDFXVZ2bxrGp2X8d.iL (accessed on 20 December 2021).

73. Subcommittee on Quantum Information Science Committee On Science of the National Science & Technology Council. National Quantum Initiative Supplement to the President's FY 2022 Budget. Available online: https://www.quantum.gov/wp-content/uploads/2021/12/NQI-Annual-Report-FY2022.pdf (accessed on 20 December 2021).
74. The White House National Quantum Coordination Office. Quantum Frontiers Report on Community Input to the Nation's Strategy for Quantum Information Science. Available online: https://www.quantum.gov/wp-content/uploads/2020/10/QuantumFrontiers.pdf (accessed on 20 December 2021).
75. Quantum Delter Nederland. National Agenda for Quantum Technology. Available online: https://quantumdelta.nl/TUQ/wp-content/uploads/2020/04/NAQT-2019-EN.pdf (accessed on 20 December 2021).
76. López, M.A. Quantum Technologies Digital Transformation, Social Impact, and Cross- Sector Disruption. Available online: https://publications.iadb.org/publications/english/document/Quantum_Technologies_Digital_Transformation_Social_Impact_and_Crosssector_Disruption.pdf (accessed on 20 December 2021).
77. Kung, J.; Fancy, M. A Quantum Revolution: Report on Global Policies for Quantum Technology. Available online: https://cifar.ca/wp-content/uploads/2021/04/quantum-report-EN-10-accessible.pdf (accessed on 20 December 2021).
78. Government of Canada. National Quantum Strategy Consultations: What We Heard Report. Available online: https://www.ic.gc.ca/eic/site/154.nsf/eng/h_00002.html (accessed on 20 December 2021).
79. COST (European Cooperation in Science and Technology). The challenges for Women in Quantum Technologies. Available online: https://www.cost.eu/the-challenges-for-women-in-quantum-technologies/ (accessed on 20 December 2021).
80. Gender Equality Work Group. Gender Equality Work Group. Available online: https://qt.eu/about-quantum-flagship/the-quantum-flagship-community/working-groups/working-group-5/ (accessed on 20 December 2021).
81. United States Government Accountability Office. Technologyassessment Quantum Computing and Communications Status and Prospects. Available online: https://www.gao.gov/assets/gao-22-104422.pdf (accessed on 20 December 2021).
82. National Q-12 Education Partnership. Growing the Future Quantum Workforce. Available online: https://q12education.org/ (accessed on 20 December 2021).
83. Asfaw, A.; Blais, A.; Brown, K.R.; Candelaria, J.; Cantwell, C.; Carr, L.D.; Combes, J.; Debroy, D.M.; Donohue, J.M.; Economou, S.E. Building a Quantum Engineering Undergraduate Program. Available online: https://arxiv.org/abs/2108.01311 (accessed on 20 December 2021).
84. Aiello, C.D.; Awschalom, D.D.; Bernien, H.; Brower-Thomas, T.; Brown, K.R.; Brun, T.A.; Caram, J.R.; Chitambar, E.; Di Felice, R.; Edmonds, K.M. Achieving a quantum smart workforce. *Quantum Sci. Technol.* **2021**, *6*, 030501. [CrossRef]
85. Garibay, J.C. STEM students' social agency and views on working for social change: Are STEM disciplines developing socially and civically responsible students? *J. Res. Sci. Teach.* **2015**, *52*, 610–632. [CrossRef]
86. Canney, N.E.; Bielefeldt, A.R. Differences in engineering students' views of social responsibility between disciplines. *J. Prof. Issues Eng. Educ. Pract.* **2015**, *141*, 04015004. [CrossRef]
87. Bielefeldt, A.R. Intersectional Complexities of Race/Ethnicity and Gender in Engineering Students' Professional Social Responsibility Attitudes. Available online: https://peer.asee.org/intersectional-complexities-of-race-ethnicity-and-gender-in-engineering-students-professional-social-responsibility-attitudes-research (accessed on 20 December 2021).
88. Tomblin, D.; Mogul, N. STS Postures: Responsible innovation and research in undergraduate STEM education. *J. Responsible Innov.* **2020**, *7*, 117–127. [CrossRef]
89. Schiff, D.S.; Logevall, E.; Borenstein, J.; Newstetter, W.; Potts, C.; Zegura, E. Linking personal and professional social responsibility development to microethics and macroethics: Observations from early undergraduate education. *J. Eng. Educ.* **2021**, *110*, 70–91. [CrossRef]
90. Børsen, T.; Serreau, Y.; Reifschneider, K.; Baier, A.; Pinkelman, R.; Smetanina, T.; Zandvoort, H. Initiatives, experiences and best practices for teaching social and ecological responsibility in ethics education for science and engineering students. *Eur. J. Eng. Educ.* **2021**, *46*, 186–209. [CrossRef]
91. Vigdor, L. A techno-passion that is not one: Rethinking marginality, exclusion, and difference. *Int. J. Gend. Sci. Technol.* **2011**, *3*, 4–37.
92. Collett, C.; Dillon, S. AI and Gender: Four Proposals for Future Research. Available online: http://lcfi.ac.uk/media/uploads/files/AI_and_Gender___4_Proposals_for_Future_Research_210619_p8qAu8L.pdf (accessed on 20 December 2021).
93. Cormier, D.; Jandrić, P.; Childs, M.; Hall, R.; White, D.; Phipps, L.; Truelove, I.; Hayes, S.; Fawns, T. Ten Years of the Postdigital in the 52group: Reflections and Developments 2009–2019. *Postdigital Sci. Educ.* **2019**, *1*, 475–506. [CrossRef]
94. Garcia, P.; Scott, K. Traversing A Political Pipeline: An Intersectional and Social Constructionist Approach toward Technology Education for Girls of Color. Available online: http://stelar.edc.org/sites/stelar.edc.org/files/Garcia%20%26%20Scott%202016.pdf (accessed on 20 December 2021).
95. Mishina, O.; Sherson, J.; Kroon, L.-V.; Brand, C.; Müller, R.; van Joolingen, W.; Peeters, W.; Macchiavello, C.; Wilhelm-Mauch, F. Strategic Agenda Summary: Education for QT. Available online: https://qt.eu/app/uploads/2019/04/Strategic-Agenda-Summary-Education-for-QT_08.04.19.pdf (accessed on 20 December 2021).
96. Moraga-Calderón, T.S.; Buisman, H.; Cramer, J. The relevance of learning quantum physics from the perspective of the secondary school student: A case study. *Eur. J. Sci. Math. Educ.* **2020**, *8*, 32–50. [CrossRef]
97. Bennett, D.; Knight, E.; Bawa, S.; Dockery, A.M. Understanding the career decision making of university students enrolled in STEM disciplines. *Aust. J. Career Dev.* **2021**, *30*, 95–105. [CrossRef]

98. Turner, J. Democratizing Science: A Humble Proposal. *Sci. Technol. Hum. Values* **1990**, *15*, 336–359. [CrossRef]
99. Levidow, L. Democratizing technology—Or technologizing democracy? Regulating agricultural biotechnology in Europe. *Technol. Soc.* **1998**, *20*, 211–226. [CrossRef]
100. Bader, V. Sciences, politics, and associative democracy: Democratizing science and expertizing democracy. *Innovation* **2014**, *27*, 420–441. [CrossRef]
101. Mollick, E.; Robb, A. Democratizing innovation and capital access: The role of crowdfunding. *Calif. Manag. Rev.* **2016**, *58*, 72–87. [CrossRef]
102. Kullenberg, C.; Kasperowski, D. What is citizen science?—A scientometric meta-analysis. *PLoS ONE* **2016**, *11*, e0147152. [CrossRef] [PubMed]
103. Woolley, J.P.; McGowan, M.L.; Teare, H.J.A.; Coathup, V.; Fishman, J.R.; Settersten, R.A., Jr.; Sterckx, S.; Kaye, J.; Juengst, E.T.; Settersten, R.A., Jr. Citizen science or scientific citizenship? Disentangling the uses of public engagement rhetoric in national research initiatives. *BMC Med. Ethics* **2016**, *17*, 33. [CrossRef] [PubMed]
104. Schickler, E. Democratizing technology: Hierarchy and innovation in public life. *Polity* **1994**, *27*, 175–199. [CrossRef]
105. Feenberg, A. Democratizing technology: Interests, codes, rights. *J. Ethics* **2001**, *5*, 177–195. [CrossRef]
106. Jansma, S.R.; Dijkstra, A.M.; de Jong, M.D. Co-creation in support of responsible research and innovation: An analysis of three stakeholder workshops on nanotechnology for health. *J. Responsible Innov.* **2021**, *latest article*, 1–21. [CrossRef]
107. Goulet, D. Participatory technology assessment: Institution and methods. *Technol. Forecast. Soc. Change* **1994**, *45*, 47–61. [CrossRef]
108. Hennen, L. Participatory technology assessment: A response to technical modernity? *Sci. Public Policy* **1999**, *26*, 303–312. [CrossRef]
109. Joss, S. Toward the public sphere—Reflections on the development of participatory technology assessment. *Bull. Sci. Technol. Soc.* **2002**, *22*, 220–231. [CrossRef]
110. Tavella, E. How to make Participatory Technology Assessment in agriculture more "participatory": The case of genetically modified plants. *Technol. Forecast. Soc. Chang.* **2016**, *103*, 119–126. [CrossRef]
111. Skorupinski, B. Putting precaution to debate—About the precautionary principle and participatory technology assessment. *J. Agric. Environ. Ethics* **2002**, *15*, 87–102. [CrossRef]
112. Van Oudheusden, M. Learning in, through, and about participatory technology assessment: The case of Nanotechnologies for Tomorrow's Society (NanoSoc). *Technol. Anal. Strateg. Manag.* **2014**, *26*, 825–836. [CrossRef]
113. Durant, J. Participatory technology assessment and the democratic model of the public understanding of science. *Sci. Public Policy* **1999**, *26*, 313–319. [CrossRef]
114. Kaplan, L.R.; Farooque, M.; Sarewitz, D.; Tomblin, D. Designing Participatory Technology Assessments: A Reflexive Method for Advancing the Public Role in Science Policy Decision-making. *Technol. Forecast. Soc. Chang.* **2021**, *171*, 120974. [CrossRef]
115. Grunwald, A. Technology assessment and design for values. In *Handbook of Ethics, Values, and Technological Design: Sources, Theory, Values and Application Domains*; Springer: Dordrecht, The Netherland, 2015; pp. 67–86. [CrossRef]
116. Grunwald, A. The objects of technology assessment. Hermeneutic extension of consequentialist reasoning. *J. Responsible Innov.* **2020**, *7*, 96–112. [CrossRef]
117. Büscher, C.; Ufer, U. The (Un) availability of Human Activities for Social Intervention: Reflecting on Social Mechanisms in Technology Assessment and Sustainable Development Research. *Sustainability* **2022**, *14*, 1394. [CrossRef]
118. Delvenne, P.; Fallon, C.; Brunet, S. Parliamentary technology assessment institutions as indications of reflexive modernization. *Technol. Soc.* **2011**, *33*, 36–43. [CrossRef]
119. Van Est, R. Thinking parliamentary technology assessment politically: Exploring the link between democratic policy making and parliamentary TA. *Technol. Forecast. Soc. Chang.* **2019**, *139*, 48–56. [CrossRef]
120. Vater, C.; Geitz, E. Künstliche Intelligenz parlamentarisch (mit) gestalten: Vergangene technische Zukünfte in den Berichten der Enquete-Kommissionen des Deutschen Bundestags. *TATuP-Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis* **2021**, *30*, 50–55. [CrossRef]
121. Guston, D. Understanding 'anticipatory governance'. *Soc. Stud. Sci.* **2014**, *44*, 218–242. [CrossRef]
122. Diep, L.; Cabibihan, J.-J.; Wolbring, G. Social Robotics through an Anticipatory Governance Lens. In *Social Robotics*; Beetz, M., Johnston, B., Williams, M.-A., Eds.; Springer International Publishing: Cham, Switzerland, 2014; Volume 8755, pp. 115–124.
123. Guston, D. The Anticipatory Governance of Emerging Technologies. *J. Korean Vac. Soc.* **2010**, *19*, 432–441. [CrossRef]
124. Nelson, J.P.; Selin, C.; Lambert, L.; Guston, D.H. Amplifying the call for anticipatory governance. *Am. J. Bioeth.* **2022**, *22*, 48–50. [CrossRef]
125. Wilsdon, J.; Willis, R. *See-through Science: Why Public Engagement Needs to Move Upstream*; Demos: London, UK, 2004.
126. Rogers-Hayden, T.; Pidgeon, N. Moving engagement "upstream"? Nanotechnologies and the royal society and royal academy of engineering's inquiry. *Public Underst. Sci.* **2007**, *16*, 345–364. [CrossRef]
127. Pidgeon, N.; Rogers-Hayden, T. Opening up nanotechnology dialogue with the publics: Risk communication or 'upstream engagement'? *Health Risk Soc.* **2007**, *9*, 191–210. [CrossRef]
128. Krabbenborg, L.; Mulder, H.A.J. Upstream Public Engagement in Nanotechnology: Constraints and Opportunities. *Sci. Commun.* **2015**, *37*, 452–484. [CrossRef]
129. Wang, X. Revisiting "Upstream Public Engagement": From a Habermasian Perspective. *Nano Ethics* **2016**, *10*, 63–74. [CrossRef]

130. Barnhill-Dilling, S.K.; Kokotovich, A.; Delborne, J.A. The Decision Phases Framework for Public Engagement: Engaging Stakeholders about Gene Editing in the Wild. *Hastings Cent. Rep.* **2021**, *51*, S48–S61. [CrossRef]
131. Stahl, B.C. Responsible innovation ecosystems: Ethical implications of the application of the ecosystem concept to artificial intelligence. *Int. J. Inf. Manag.* **2022**, *62*, 102441. [CrossRef]
132. Owen, R.; Stilgoe, J.; Macnaghten, P.; Gorman, M.; Fisher, E.; Guston, D. A Framework for Responsible Innovation. In *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*; Wiley Publishing: Hoboken, NJ, US, 2013; pp. 27–50. [CrossRef]
133. Stilgoe, J.; Owen, R.; Macnaghten, P. Developing a framework for responsible innovation. *Res. Policy* **2013**, *42*, 1568–1580. [CrossRef]
134. Čeičyte, J.; Petraite, M. The concept of responsible innovation. *Public Policy Adm.* **2014**, *13*, 400–413. [CrossRef]
135. Expert Group on Policy Indicators for Responsible Research and Innovation of the European Commission. Indicators for Promoting and Monitoring Responsible Research and Innovation. Available online: http://ec.europa.eu/research/swafs/pdf/pub_rri/rri_indicators_final_version.pdf (accessed on 20 December 2021).
136. Grunwald, A. The hermeneutic side of responsible research and innovation. *J. Responsible Innov.* **2014**, *1*, 274–291. [CrossRef]
137. Jensen, E.A. A conceptual framework for monitoring socially responsible research and innovation (RRI) aligned to the UNESCO-led Recommendation on Science and Scientific Researchers. *Open Res. Eur.* **2022**, *2*, 21. [CrossRef]
138. Schneider, C.; Roßmann, M.; Lösch, A.; Grunwald, A. Transformative Vision Assessment and 3-D Printing Futures: A New Approach of Technology Assessment to Address Grand Societal Challenges. *IEEE Trans. Eng. Manag.* **2021**, 1–10, latest articles. [CrossRef]
139. Coenen, C.; Grunwald, A. Responsible research and innovation (RRI) in quantum technology. *Ethics Inf. Technol.* **2017**, *19*, 277–294. [CrossRef]
140. Inglesant, P.; Ten Holter, C.; Jirotka, M.; Williams, R. Asleep at the wheel? Responsible Innovation in quantum computing. *Technol. Anal. Strateg. Manag.* **2021**, *33*, 1364–1376. [CrossRef]
141. Johnson, W.G. Governance Tools for the Second Quantum Revolution. *Jurimetrics* **2019**, *59*, 487–521.
142. Ten Holter, C.; Inglesant, P.; Jirotka, M. Reading the road: Challenges and opportunities on the path to responsible innovation in quantum computing. *Technol. Anal. Strateg. Manag.* **2021**, *latest articles*, 1–13. [CrossRef]
143. Vermaas, P. The societal impact of the emerging quantum technologies: A renewed urgency to make quantum theory understandable. *Ethics Inf. Technol.* **2017**, *19*, 241–246. [CrossRef]
144. Möller, M.; Vuik, C. On the impact of quantum computing technology on future developments in high-performance scientific computing. *Ethics Inf. Technol.* **2017**, *19*, 253–269. [CrossRef]
145. DiVincenzo, D.P. Scientists and citizens: Getting to quantum technologies. *Ethics Inf. Technol.* **2017**, *19*, 247–251. [CrossRef]
146. Israel, M.J.; Amer, A. Ethical implications of digital infrastructures for pluralistic perspectives. *Ethics Inf. Technol.* **2021**, *23*, 399–417. [CrossRef]
147. Greinert, F.; Müller, R. Competence Framework for Quantum Technologies. Available online: https://qt.eu//app/uploads/2021/09/CompetenceFrameworkQuantumTechnologiesV1.pdf (accessed on 20 December 2021).
148. Government of Canada. Government of Canada Launches Public Consultations on National Quantum Strategy. Available online: https://www.canada.ca/en/innovation-science-economic-development/news/2021/07/government-of-canada-launches-public-consultations-on-national-quantum-strategy.html (accessed on 20 December 2021).
149. Grant, M.J.; Booth, A. A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Inf. Libr. J.* **2009**, *26*, 91–108. [CrossRef] [PubMed]
150. Davis, K.; Drey, N.; Gould, D. What are scoping studies? A review of the nursing literature. *Int. J. Nurs. Stud.* **2009**, *46*, 1386–1400. [CrossRef] [PubMed]
151. Arksey, H.; O'Malley, L. Scoping studies: Towards a methodological framework. *Int. J. Soc. Res. Methodol.* **2005**, *8*, 19–32. [CrossRef]
152. Seskir, Z.C.; Aydinoglu, A.U. The landscape of academic literature in quantum technologies. *Int. J. Quantum Inf.* **2021**, *19*, 2150012. [CrossRef]
153. Hsieh, H.-F.; Shannon, S.E. Three approaches to qualitative content analysis. *Qual. Health Res.* **2005**, *15*, 1277–1288. [CrossRef]
154. Edling, S.; Mooney Simmie, G. Democracy and emancipation in teacher education: A summative content analysis of teacher educators' democratic assignment expressed in policies for Teacher Education in Sweden and Ireland between 2000–2010. *Citizsh. Soc. Econ. Educ.* **2017**, *17*, 20–34. [CrossRef]
155. Downe-Wamboldt, B. Content analysis: Method, applications, and issues. *Health Care Women Int.* **1992**, *13*, 313–321. [CrossRef]
156. Cullinane, K.; Toy, N. Identifying influential attributes in freight route/mode choice decisions: A content analysis. *Transp. Res. Part E* **2000**, *36*, 41–53. [CrossRef]
157. Coin, A.; Mulder, M.; Dubljević, V. Ethical aspects of BCI technology: What is the state of the art? *Philosophies* **2020**, *5*, 31. [CrossRef]
158. Burwell, S.; Sample, M.; Racine, E. Ethical aspects of brain computer interfaces: A scoping review. *BMC Med. Ethics* **2017**, *18*, 60. [CrossRef]
159. Hosseini, N.; Kumar, P. Gaps in Neuroethics in Relation to Brain Computer Interfaces: Systematic Literature Review. In *International Conference on Human-Computer Interaction*; Springer: Cham, Switzerland, 2020; pp. 448–474. [CrossRef]

160. Aas, S.; Wasserman, D. Brain–computer interfaces and disability: Extending embodiment, reducing stigma? *J. Med. Ethics* **2015**, *42*, 37–42. [CrossRef] [PubMed]
161. Wolbring, G.; Diep, L. Cognitive/Neuroenhancement through an Ability Studies lens. In *Cognitive Enhancement*; Jotterand, F., Dubljevic, V., Eds.; Oxford University Press: Oxford, UK, 2016; pp. 57–75.
162. Diep, L.; Wolbring, G. Who Needs to Fit in? Who Gets to Stand out? Communication Technologies Including Brain-Machine Interfaces Revealed from the Perspectives of Special Education School Teachers Through an Ableism Lens. *Educ. Sci.* **2013**, *3*, 30–49. [CrossRef]
163. Sample, M.; Sattler, S.; Blain-Moraes, S.; Rodríguez-Arias, D.; Racine, E. Do publics share experts' concerns about brain–computer interfaces? A trinational survey on the ethics of neural technology. *Sci. Technol. Hum. Values* **2020**, *45*, 1242–1270. [CrossRef]
164. Yumakulov, S.; Yergens, D.; Wolbring, G. Imagery of Disabled People within Social Robotics Research. In *Social Robotics*; Ge, S., Khatib, O., Cabibihan, J.-J., Simmons, R., Williams, M.-A., Eds.; Springer: Berlin/Heidelberg, Germany, 2012; Volume 7621, pp. 168–177.
165. Vesnic-Alujevic, L.; Nascimento, S.; Polvora, A. Societal and ethical impacts of artificial intelligence: Critical notes on European policy frameworks. *Telecommun. Polocy* **2020**, *44*, 101961. [CrossRef]
166. European Group on Ethics in Science and New Technologies. Statement on Artificial Intelligence, Robotics and 'Autonomous' Systems. Available online: https://ec.europa.eu/research/ege/pdf/ege_ai_statement_2018.pdf (accessed on 20 December 2021).
167. The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems, T.I.G.I. Ethically Aligned Design: A Vision for Prioritizing Human Well-Being with Autonomous and Intelligent Systems (A/IS). Available online: http://standards.ieee.org/develop/indconn/ec/ead_v2.pdf (accessed on 20 December 2021).
168. Malti, T.; Peplak, J.; Zhang, L. The Development of Respect in Children and Adolescents. *Monogr. Soc. Res. Child Dev.* **2020**, *85*, 7–99. [CrossRef] [PubMed]
169. Steckermeier, L.C.; Delhey, J. Better for Everyone? Egalitarian Culture and Social Wellbeing in Europe. *Soc. Indic. Res.* **2019**, *143*, 1075–1108. [CrossRef]
170. Kahneman, D.; Krueger, A.B. Developments in the measurement of subjective well-being. *J. Econ. Perspect.* **2006**, *20*, 3–24. [CrossRef]
171. Kahneman, D.; Krueger, A.B.; Schkade, D.; Schwarz, N.; Stone, A. Toward National Well-Being Accounts. *Am. Econ. Rev.* **2004**, *94*, 429–434. [CrossRef]
172. Diener, E. Subjective well-being: The science of happiness and a proposal for a national index. *Am. Psychol.* **2000**, *55*, 34–43. [CrossRef]
173. Warr, P.; Cook, J.; Wall, T. Scales for the measurement of some work attitudes and aspects of psychological well-being. *J. Occup. Psychol.* **1979**, *52*, 129–148. [CrossRef]
174. Rook, K.S. The negative side of social interaction: Impact on psychological well-being. *J. Personal. Soc. Psychol.* **1984**, *46*, 1097–1108. [CrossRef]
175. Ryff, C.D.; Keyes, C.L.M. The Structure of Psychological Well-Being Revisited. *J. Personal. Soc. Psychol.* **1995**, *69*, 719–727. [CrossRef]
176. Ryff, C.D. Psychological Well-Being in Adult Life. *Curr. Dir. Psychol. Sci.* **1995**, *4*, 99–104. [CrossRef]
177. Abbey, A.; Caplan, R.D. Effects of Different Sources of Social support and Social Conflict on Emotional Well-Being. *Basic Appl. Soc. Psychol.* **1985**, *6*, 111–129. [CrossRef]
178. Ostir, G.V.; Markides, K.S.; Black, S.A.; Goodwin, J.S. Emotional well-being predicts subsequent functional independence and survival. *J. Am. Geriatr. Soc.* **2000**, *48*, 473–478. [CrossRef]
179. Menardo, E.; Scarpanti, D.; Pasini, M.; Brondino, M. Usability of virtual environment for emotional well-being. In *Methodologies and Intelligent Systems for Technology Enhanced Learning, 9th International Conference*; Springer: Cham, Switzerland, 2019; Volume 1007, pp. 45–52.
180. Brunstein, J.C.; Schultheiss, O.C.; Grässmann, R. Personal Goals and Emotional Well-Being: The Moderating Role of Motive Dispositions. *J. Personal. Soc. Psychol.* **1998**, *75*, 494–508. [CrossRef]
181. Yellen, S.B.; Cella, D.F. Someone to live for: Social well-being, parenthood status, and decision-making in oncology. *J. Clin. Oncol.* **1995**, *13*, 1255–1264. [CrossRef]
182. Keyes, C.L.M. Social well-being. *Soc. Psychol. Q.* **1998**, *61*, 121–137. [CrossRef]
183. Wadsworth, M.E.J.; Montgomery, S.M.; Bartley, M.J. The persisting effect of unemployment on health and social well-being in men early in working life. *Soc. Sci. Med.* **1999**, *48*, 1491–1499. [CrossRef]
184. Pedersen, D. Political violence, ethnic conflict, and contemporary wars: Broad implications for health and social well-being. *Soc. Sci. Med.* **2002**, *55*, 175–190. [CrossRef]
185. Smith, T.W. A life events approach to developing an index of societal well-being. *Soc. Sci. Res.* **1992**, *21*, 353–379. [CrossRef]
186. Brown, L.M. Compassion and societal well-being. *Pac. Philos. Q.* **1996**, *77*, 216–224. [CrossRef]
187. Stiglitz, J.E. Employment, social justice and societal well-being. *Int. Lab. Rev.* **2002**, *141*, 9–29. [CrossRef]
188. Kim, A.E. Religious influences on personal and societal well-being. *Soc. Indic. Res.* **2003**, *62–63*, 149–170. [CrossRef]
189. Signore, M.; Fazio, D. A European framework for measuring progress: Fostering the understanding of individual and societal well-being and sustainability. *Sustain. Account. Manag. Policy J.* **2014**, *5*, 313–324. [CrossRef]

190. Fratczak, P.; Goh, Y.M.; Kinnell, P.; Soltoggio, A.; Justham, L. Understanding human behaviour in industrial human-robot interaction by means of virtual reality. In Proceedings of the Halfway to the Future Symposium 2019, New York, NY, USA, 19–20 November 2019.
191. West, D.M. *The Future of Work: Robots, AI, and Automation*; Brookings Institution Press: San Francisco, CA, USA, 2018; pp. 1–205.
192. Borjas, G.J.; Freeman, R.B. From immigrants to robots: The changing locus of substitutes for workers. *RSF* **2019**, *5*, 22–42. [CrossRef]
193. Khosla, R.; Chu, M.T. Embodying care in matilda: An affective communication robot for emotional wellbeing of older people in Australian residential care facilities. *ACM Trans. Manag. Inf. Syst.* **2013**, *4*, 18. [CrossRef]
194. Abeles, T.P. Send in the robots. *Horiz.* **2016**, *24*, 141–144. [CrossRef]
195. Reddy, R. Robotics and intelligent systems in support of society. *IEEE Intell. Syst.* **2006**, *21*, 24–31. [CrossRef]
196. United Nations. Convention on the Rights of Persons with Disabilities (CRPD). Available online: https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities.html (accessed on 20 December 2021).
197. Lillywhite, A.; Wolbring, G. Coverage of Artificial Intelligence and Machine Learning within Academic Literature, Canadian Newspapers, and Twitter Tweets: The Case of Disabled People. *Societies* **2020**, *10*, 23. [CrossRef]
198. Wolbring, G. Employment, disabled people and robots: What is the narrative in the academic literature and Canadian newspapers? *Societies* **2016**, *6*, 15. [CrossRef]
199. Statistics Canada. Table 37-10-0169-01 Unfair Treatment, Discrimination or Harassment among Postsecondary Faculty and Researchers. Available online: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3710016901 (accessed on 20 December 2021).
200. Lillywhite, A.; Wolbring, G. Undergraduate Disabled Students as Knowledge Producers Including Researchers: Perspectives of Disabled Students. *Educ. Sci.* **2022**, *12*, 77. [CrossRef]
201. Lillywhite, A.; Wolbring, G. Undergraduate disabled students as knowledge producers including researchers: A missed topic in academic literature. *Educ. Sci.* **2019**, *9*, 259. [CrossRef]
202. United Nations. United Nations 2018 Flagship Report on Disability and Development: Realization of the Sustainable Development Goals by, for and with Persons with Disabilities. Available online: https://www.un.org/development/desa/disabilities/publication-disability-sdgs.html#:~:text=%E2%80%9CThe%20UN%20Flagship%20Report%20on,can%20create%20a%20more%20inclusive (accessed on 20 December 2021).