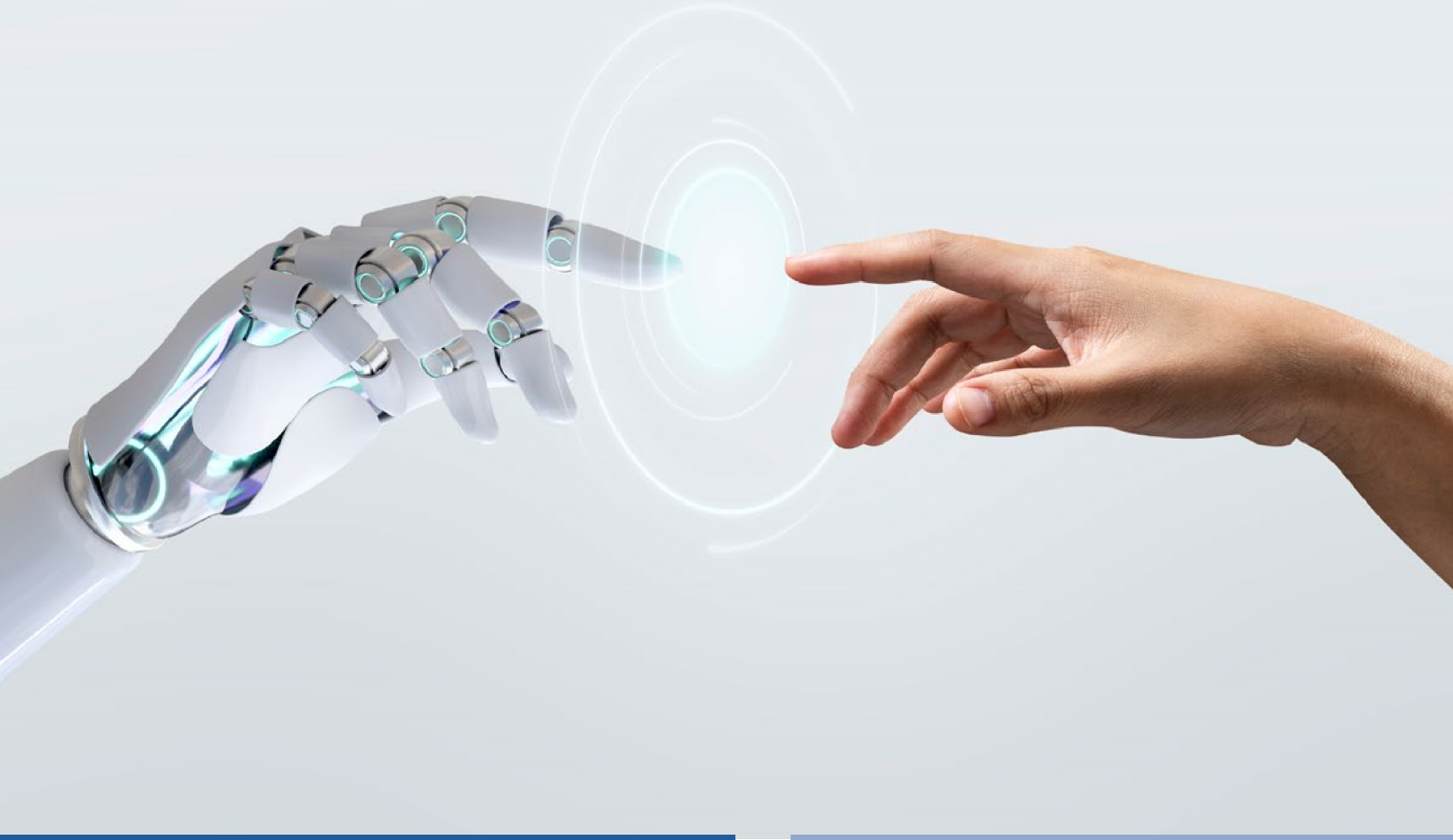
Draft Discussion Paper



BEYOND ENDLESS FRONTIERS:

Rethinking the Social Contract for Science & Innovation

SKILLS FOR INCLUSIVE AND COLLABORATIVE INNOVATION

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FOREWORD

At the core of today's science system is an implicit agreement between science and society whereby society, through government, provides public funds and a high degree of autonomy to the scientific community in return for the considerable but unpredictable benefits that science can provide society in the form of health, economic prosperity, environmental preservation, and national security.

Yet, this relationship between science and society is not a healthy one. In recent years science has been described as divorced from or out-of-touch with society while the relationship between the two has been described as under strain, broken, out-dated and drifting apart. What is certain is that the implicit agreement implemented at the end of the second World War has evolved in a manner which its architects did not envision. At the same time, science has an increasingly important role to play to address challenges facing society such as climate change, energy security, poverty.

The resulting difference in practice from theory is that Canadians are upholding an agreement that may no longer be designed for purpose. The goal of this SSHRC Partnership Development Grant is to examine the post-war social contract that underpins Canada's scientific enterprise and explore the elements of a new policy framework that meets the needs of contemporary Canadian society, organized into the following six themes:

- Innovation is much more than an implicit outcome of a linear pipeline of activity from basic research through applied (natural) science and into commercialization, and it should include more than a subset of the most elite members of our society. **Inclusive Innovation** offers an opportunity to rethink invention, adoption and innovation so that no one is left behind.
- Science is much more than the Western adaptation of producing and codifying knowledge that has dominated Canadian discourse. As Canada works towards reconciliation with Indigenous Nations, **Indigenous and Other Ways of Knowing** can provide the greater science ecosystem with alternative approaches to improve the advancement and application of knowledge.
- The post-war contract rejected scientific "planning" and argued that science best advances through "the free play of free intellects, working on subjects of their choice." Yet, serendipity is not a strategy. Many innovation scholars today argue for more **Mission-directed Research and Innovation** or challenged-based efforts.

- The benefits of science – from any knowledge system – will only enrich the lives of a society where there is a culture of appreciation of science and knowledge, and where the requirement to communicate science demands language that is meaningful for and accessible to the recipients. The **Science Communications, Outreach and Public Engagement** theme explores these issues.
- What **Skills and Knowledge** do scientists require to promote an ideal of scientific integrity that is compatible with increased trust and social acceptance of science? What do we know about current practices of university-based scientists when it comes to participating in policy processes?
- Under the logic of the post-war contract (and Michael Polanyi's 'republic of science') only science can judge science. Yet a culture of trust in science requires a common understanding and appreciation for ethics and integrity and their applications to the production of scientific knowledge and its use in our daily lives. The **Trust, Integrity and Ethics of Science** theme explores these issues.

The objectives of the project are to (1) identify and examine elements, assumptions, values, and biases of the post-war contract; (2) work with a multisectoral coalition of actors to research policy solutions, within and across the 6 themes described above, that address and update the terms of the contract consistent with the contemporary context; and (3) disseminate and mobilize these insights and offer practical ways to reshape the policy framework for science and innovation.

The paper that follows – and the other five in this body of work – set the stage for a series of roundtable discussions, one per theme, occurring in May and June 2023. The roundtable discussions will explore the potential each theme offers to update the governance framework that underpins the relationship between science and society in Canada.

At the roundtable, participants will be invited to consider the questions included herein as well as:

- What are the elements of this conversation that should inform the New Social Contract?
- Are there elements that were missing from today's conversation that should inform the New Social Contract?

EXECUTIVE SUMMARY

- While skills needs at the science-society interface are not all domain-specific, their application revolve around activities that vary across different zones of innovation or impact:
- Policy: Knowledge use at the policy interface focuses on “evidence-support” for policy makers and revolves around activities of a broad range of actors across sectors.
- Social Sector: In education and health, knowledge mobilisations practices typically revolve around intermediaries whose role is to support practitioners. knowledge use and impact in the social sector revolves around community-engagement, participatory approaches to research and “social innovation”.
- Economy: Technological innovation is generally framed in terms of “technology transfer” and its impact is primarily measured as an outcome of commercialisation or connected activities (e.g. patenting, licensing) that are specifically designed to be captured by financial and/or economic metrics.
- Knowledge use and innovation are impeded when organizational capacity is low. But low levels of organizational connectivity – partnerships, collaborations, networks – are equally detrimental. Lack of connectivity creates obstacles for accessing to research, evidence and intellectual property and may have its sources in post-secondary institutional cultures in which academic output and outcome are prioritised over the knowledge needs of communities.
- The main driver for knowledge use is connectivity, that is, the existence of networks and effective collaborative practices that are anchored in high levels of trust. Connectivity can be supported by boundary spanning actors or enablers and intermediaries and should be guided by commitment to diversity, inclusion, equity and accessibility.
- The skills needed to support connectivity at any of the interfaces between science and society need to revolve around inclusive and collaborative innovation. The capacity to use knowledge and/or innovate requires high levels of ability for problem-solving, deliberation, reflection and creativity. The capacity to collaborate and foster inclusive teams and/or organizational cultures requires high levels of intercultural competence, integrity, communication and teamwork. From a holistic standpoint, integrity and self-management support collaborative innovation.

INTRODUCTION

What science and innovation policy do we need to ensure that Canada builds and rewards the skill sets and knowledge of scientists who work at the interface of science and society, and what they need to support inclusive innovation?

The topic all by itself is challenging: skills-needs are activity-specific, but activities at the science-society interface are multifaceted and diverse and their purpose, scope and audiences can vary in a manifold of manners. Because the literature is already crowded by assumptions that overlook important nuances we wanted to take a critical step back, and propose a reboot of the discussion, and one that focuses on conceptual clarity.

The most general thing one can say of activities at the science-society interface is that they pertain to knowledge use and innovation broadly construed. Knowledge use as we understand it is an umbrella term for a wide range of activities relating to the production and use of research expertise, evidence and results, including but not limited to knowledge synthesis, knowledge dissemination, knowledge transfer, knowledge exchange, and co-creation or co-production by researchers, knowledge users and other stakeholder[1].

In many contexts, the term "knowledge mobilisation" has an equivalent meaning. Likewise, because technological knowledge and innovation have high commercial potential, technological context, the mobilisation of technological knowledge is typically the purview of "tech transfer" offices whose role is to support the management of intellectual property and commercialisation. Technology transfer represents only a subset of activities around knowledge use and innovation and the model cannot be generalised.

What matters here is the connection we make between knowledge use and innovation (Lapointe & Underdown 2022). All innovation processes invariably involve knowledge use: at the most general level, what leads to innovation is a series of actions or steps designed to create, improve, or implement knowledge (research, discovery, evidence, expertise) in the form of new ways of doing, framing, knowing, or thinking, intended to create new value, whether that value is economic or otherwise. Innovation, in other terms, is a knowledge-driven process and we speak of innovations in reference to the output or product of such process.

The contexts in which knowledge, evidence and research are used to create impact and/or innovation are wildly diverse and we wanted to do justice to at least some of the differences that emerge around knowledge use and innovation in different zones of impact. Specifically we want to answer the following questions:

[1] https://www.sshrc-crsh.gc.ca/funding-financement/policies-politiques/knowledge_mobilisation-mobilisation_des_connaissances-eng.aspx

1. What processes underpin knowledge use and/or innovation at a specific interface?
2. What are the barriers to knowledge use and/or innovation at a specific interface?
3. What are the drivers to knowledge use and/or innovation at a specific interface?
4. Finally, what skillsets and know-how are required of individuals working at these interfaces (on all sides) to support these processes in the organizations in which they evolve and to reduce barriers to knowledge use and innovation?

Questions (1)-(3) are not only a necessary prelude to question (4), they are an integral part of it. Generally speaking, the effectiveness of the processes that make it possible for knowledge and evidence produced in communities, including Indigenous communities, universities or other research institutions to be used depend on far more than individuals' having some specific skillsets. Indeed, while skills gaps may impede use of scientific, practical, and other knowledges in creating innovations or resolving global challenges and emerging crises, and while high levels of competencies may bolster it, drivers and barriers in different zones of impact also have their roots in institutional practices, organizational cultures and or systems-level features which also need to be addressed.

Skills do not evolve in a vacuum. What this means is that while individuals on all side of the science-society interface do need to build skills and acquire competencies to bolster knowledge use, skills also evolve in organizations and organizations need to be structured in such a manner as to enable them. A strong science society interface requires that these organizations have sufficient knowledge capacity. Most importantly, ensuring that actors at the science-society interface have the skills and knowledge they need and can deploy them fully also requires apt, inclusive policy that targets not only education and training, but also support across the ecosystem for capacity building for knowledge and change management and the bolstering of the kinds of cross-sectoral partnerships on which the innovation ecosystem thrives.

An answer to 1-4 of course leaves the question open: What policy do we need to ensure that Canada builds and rewards the skill sets scientists need at the interface between science and society. But this question should also not be answered on separately from other questions that drive the project Beyond Endless Frontier. At the very least, what follows will provide some clarity toward a concerted answer to the question.

FRAMEWORK

We framed our main question in reference to a putative interface between "science and society":

> *What science and innovation policy do we need to ensure that Canada builds and rewards the skill sets and knowledge of scientists who work at the interface of science and society, and what they need to support inclusive innovation?*

But the literature does not typically take "science" and "society" in general, nor does it seem to assume that science and society meet at a single, unique interface. Knowledge use and research practices are shaped by the specific knowledge needs of specific knowledge users whose activities revolve around **broad and overlapping, yet different zones of innovation and/or impact.**

What happens at a specific innovation or impact interface can be understood along three questions:

- What is the typical zone of impact/innovation?
- Who are the typical knowledge users, i.e. targeted knowledge-using organizations
- What types of knowledge are being used?

We use this initial framing to organise what we found in our literature review about what is needed to create economic, social, or political innovation and change. The table below summarises the main elements of the framework.

Typical zones of impact/innovation	Main Types of knowledge being used	Typical knowledge users (organizations)
Policy	Social, human, scientific, community-based	Provincial, federal, municipal governments, think tanks, civil society
Social Sector	Social and Human, including social, ethical, cultural, legal, health, community-based	Social services, education, health
Economy	Technological, including engineering, medical, management, community-based	Industry, business, health

We added community-based and Indigenous knowledges to the framework because they too contribute to innovation and should be valued. However, these knowledges are not properly acknowledged in the context of discussions of knowledge use and innovation in the literature. This is a situation that would need to addressed. What literature does say about the processes involved in ensuring that the relevant knowledge is being used by the right people to produce impact and innovation is summarized in the next three section, each corresponding to a zone of impact/interface: Policy, Social Sector, Economy.

Knowledge Use at the interface with **Policy**

Knowledge use at the interface with policy is intrinsically interdisciplinary. Good policy rests on a good understanding of society and humans, but it often requires decision maker to leverage scientific data of all sorts to inform the process. At the science-policy interface, knowledge users include provincial, federal and municipal governments as well as private "think thanks" and civil society stakeholders.

The literature on knowledge use in policy- and decision- making tends to be copious and diverse. One way to begin to capture the breadth of the landscape is to map the vast array of different actors, both individual and organizational (Fafard 2005; Howlett 2009; Hughes and Romero-Lankao 2014; Jetzkowitz et al. 2018; Jolibert and Wesselink 2012; Kirk 2015; Newman et al. 2017; Oliver et al. 2014; Rajnarain 2014; Stewart et al. 2022; Stone 2009) noting however that while focus is often predominantly on policy-making in government, organizations in all sectors also have policy needs, if only as a matter of being able to identify, understand and implement new policies to which their organizations are subjects.

People[2]

- knowledge and research producers (in post-secondary institutions and beyond),
- experts (broadly construed to include practitioners and business professionals),
- facilitators
- knowledge brokers
- policymakers and government officials
- community stakeholders (including Indigenous knowledge keepers)

Organizations

- universities and colleges
- governments
- think tanks
- commissions, committees, and panels

Knowledge use at the policy interface is mainly a matter of "evidence-support": decisions made by policy makers need to be informed by the best available knowledge and evidence. Evidence-support revolves around a cluster of approaches to knowledge mobilisation whose origins can be traced directly to the field of evidence-based medicine (Black 2001; Solesbury 2001; Exworthy et al. 2006 as cited in Marais and Matebesi 2013). This, and the focus on public health policy during the recent Covid-19 Pandemic means that many domains of application for evidence-support in policy, e.g. policy support and scientific advice in municipalities and cities or evidence-based decision making in large corporation still need to be charted.

The types of knowledges that may be used at the science-policy interface include fundamental and mission-driven research results, data, and expertise (Farfard 2015; Hughes and Romero-Lankao 2014; Jetzkowitz et al. 2018; Krick 2015; Lavis et al. 2003;

[2] Policy champions and policy entrepreneurs (Oliver et al. 2014) are also mentioned to illustrate how people in positions leadership and authority can leverage their influence to support policy innovation (i.e. policy champion) or exploit opportunities to promote their own goals (i.e. policy entrepreneurs).

Molinengo et al. 2021; Newman et al. 2017; Stewart et al. 2022; Stone 2009). Successful knowledge mobilisation and impact typically happen when evidence is successfully and meaningfully incorporated into decision making to inform policy. More recently, models of "knowledge transfer", "knowledge brokering" and "knowledge exchange" have emerged, with the latter acknowledging explicitly that in order to be used successfully for policy-making, approaches to knowledge mobilisation must go beyond one-way communication and gives equal importance to what researchers can learn from decision makers in addition to what decision makers can learn from researchers (Graham et al. 2006; Lavis et al. 2003; Mitton et al. 2007; Molinengo et al. 2021).

Knowledge Use at the interface with the **Social Sector**

The knowledge used in the social sectors is vast and extends to social, human ethical, cultural, legal, education and health research. It revolves around the activities of a broad range of actors across sectors of activities that are far from uniform. Here we understand the zone of impact that corresponds to the interface between science and the social sector to be comprised predominantly of the "social sector" that comprises business, community and government nonprofits.[3] In 2020, the social sector contributed an estimated $316.2 billion CAD to Canada's Gross Domestic Product[4][5][6]. Research and education made for 19.6% of activity in the social sector, while healthcare occupied 42.2% of the space. Because both education and healthcare are predominantly funded and operate under governments mandates that are subject to measures of accountability, the demand for evidence to inform practice in education and health is high.

Education and Health

In education and health, knowledge mobilisations practices typically revolve around intermediaries whose role is to support practitioners. For instance, Cooper (2012) identifies 4 types of such intermediaries: governmental (e.g. provincial ministry research branches, evaluation, standards organizations), nonprofit (university based research centre and advocacy organization), for-profit (textbook publishers) and membership-based (e.g. Unions and other professional associations). A similar division of labor exist in the health sector between government (e.g. Genome Canada) nonprofits (hospitals), for profits (e.g. consulting companies), and membership based organizations (e.g. Medical Council of Canada).

Intermediaries play various roles, but their work is often framed as requiring the translation of evidence produced through research to make it usable to practitioners, and by channelling it where it is needed in the practical field (Schröer 2021). Intermediaries typically exists between stable organizational structures, e.g. between schools of education and schoolboards, or between medical research programs and hospitals: they are also stable parts of the ecosystem. (Lavis et al. 2003).

[3] https://www150.statcan.gc.ca/n1/pub/13-605-x/2022001/article/00002-eng.htm
[4] https://www.imaginecanada.ca/en/About-the-sector
[5] https://www150.statcan.gc.ca/n1/pub/13-605-x/2022001/article/00002-eng.htm
[6] https://www.imaginecanada.ca/sites/default/files/Infographic-sector-stat-2021.pdf

Social Services

Social services organizations represent around 12.9% of the social sector, a segment that is incredibly diverse and dynamic.[7] Social sector organizations, sometimes called "social purpose organizations" offer basic provisions that range from community health, food services, community housing and emergency relief to religious organizations, advocacy groups, sports associations and recreational centres.

The fact that the social sector includes nonprofits in education and research and health as well as social purpose organizations in ecosystems that are often "place-based" and closely connected means that knowledge mobilisation in the social sector involves actors, organizational structures and needs that can be formidably diverse. Organizations include universities, colleges, and nonprofit organizations of countless sizes, whose lifespan and capacity can often be unpredictable, and that provide vastly different types of services to immensely diverse communities that are often amongst the most vulnerable.

The one difference that is relevant when thinking about knowledge use in the social sector is one that exists typically between social services, on the one hand, and health and education sectors, on the other. Education in primary and secondary schools and health professional typically receive "professional" training that is subject to certification and qualification standards. However, if we exclude social workers whose training is also subject to certication, work in social purpose organizations rarely gravitates around practices that can be associated professional standards. This makes the question of mobilising knowledge to benefit "practitioners" in non-profits considerably more complex.

This complexity might explain why the literature often emphasises the role of putatively specially skilled individuals like social entrepreneurs, social intrapreneurs, champions, change agents as well as that of bridging agents (similar to knowledge brokers) whose pivotal role in driving knowledge mobilisation, impact and innovation in the social sector is also well documented (Aiello et al. 2021; Kumari et al. 2019; Lenz and Schier 2021, Molloy et al. 2020; Schroer 2021). But emphasis on individual actors misses and point. Knowledge users in the social sector, just as in any other sector, are organizations whose strategies would benefit from being designed to cater to the needs of organizations – not individuals - whose everyday activities aim to sustain social sector activities. The latter involve nonprofits of various sizes, missions, and capacity. Because they often share the responsibility to deliver social programs, the knowledge needs of social purpose organizations should also be seen to overlap with those of others in local communities, such as schools, hospitals, and municipal governments.

Higher Education and Research Institutions

From the perspective of research institutions like universities and colleges, knowledge use and impact in the social sector are increasingly seen to revolve around community-engagement and participatory approaches to research (Aiello et al. 2018; Kumari et al. 2021, Lenz and Shier 2021; Taylor et al. 2020. Community-based stakeholders often frame knowledge needs in terms of needs around "social innovation". Whether they are

[7] https://www150.statcan.gc.ca/n1/pub/13-605-x/2022001/article/00002-eng.htm

understood in terms of participatory research or social innovation, the principles that guide knowledge mobilisation and integration processes revolve around co-creation. More on this below.

Knowledge Use at the interface with **Economy**

Talk of knowledge use at the interface between science and the economy is meant to reflect the observation that while technological innovation extends to virtually all aspects of human lives, it revolves around processes and practices whose targeted output and metrics proved to be distinctive. Knowledge mobilisation for the purpose of technological innovation is generally framed in terms of "technology transfer" and its impact is primarily measured as an outcome of commercialisation or similar other activities (e.g. patenting, licensing) that are specifically designed to be captured by financial and/or economic metrics (Hayden et al. 2018; Kinnunen et al. 2018; Kumari et al. 2019; Olmos-Penuela et al. 2014; Yarime et al. 2012). In the technology transfer space, intellectual property plays a central role. Universities, governments, and industry often co-operate on a large scale in order to create technology-driven growth (Yarime et al. 2012).

Relation between actors in the technology transfer space are also supported by intermediaries that are usually connected to research institutions, e.g. industry liaison offices and knowledge mobilisation units whose role is to "push" research output, "pull" investment of partners and oversee other aspects of the commercialisation of intellectual property. Kinnunen et al. (2018) specifically identifies academics participating in consulting as being able to serve as knowledge brokers between academia and external organizations. At this interface, knowledge use is more likely to be viewed to benefit the economy and industry (Hayden et al. 2018).

BARRIERS

The conditions in which barriers to knowledge use and innovation emerge may be specific to individual science-society interfaces (Policy, Social Sector, Economy) and some of the issues may seem to be context-dependent. For instance, market led technological research is often frowned upon in Europe because researchers in academia are civil servants funded with publicly sourced money whose values are to a certain extent incompatible with profit-making. (Jasanoff et al. 2001). In the medical fields, there can be tension between what evidence suggests and other economic, political, social and/or cultural factors that are relevant to decisional processes, such as what is more cost efficient for an institution (Lavis et al. 2009; Messac et al. 2013; Oliver et al. 2014). In some other contexts, what drives decision-making is not evidence "research-based ideas" (Fafard 2015). Mitton et al. (2007) adds to this that experience can be taken as a substitute for research and evidence (see also Trostel et al. 1999). In turn, an abundance of data and evidence can make a path forward unclear or data can be skewed to fit the desires of policymakers resulting in data being used to promote evidence-for-policy rather than evidence-based-policy(Stone 2009). In the social sector, institutional hierarchies can impede innovation (Popov et al. 2016; Schroer 2021). Specifically, organizations that do not dedicate proper resources to knowledge management can see their capacity to absorb and contribute to innovation reduced. In some cases, organizations can find themselves contending with competing organizational pressures that make change and innovation a low priority (McEwen et al. 2008). In conditions of uncertainty, risk aversion can be high especially where social innovation is inherently experimental and not guaranteed to work (McEwen et al. 2008; Popov et al. 2016).

In spite of the differences, it's reasonable to assume that these issues may at least in principle not be domain-specific and that they manifest themselves in different ways across all zones of impact. Interestingly, the literature shows that many of the barriers to knowledge use and innovation can be filed under the same four rubrics: low capacity, lack of networks, limited access to research, and institutional cultures. We review each of them in this section.

Low Organizational Capacity

Low organizational capacity can take various forms:

- Lack of time (Lavis et al. 2003, 2009; McEwen et al. 2008; Oliver et al. 2014; Schroer 2021; Stone 2009),
- Lack of resources (Howlett 2009; Lavis et al. 2009; McEwen et al. 2008; Oliver et al. 2014),
- Lack of skills or analytical capacity on the part of individuals (Howlett 2023; McEwen et al. 2008; Mitton et al. 2007; Newman et al. 2017; Oliver et al. 2014; Popov et al. 2016; Stone 2009).

Often organizations are grappling with all of these. Knowledge use and innovation are more likely to succeed where collaborative approaches, stakeholder engagement, and co-design are supported by long-term relationship building strategies and skilled

individuals. Knowledge use and innovation are not linear "outputs" that naturally arises from knowledge production. They are processes that require time and resources. When time and resources are not made available to individuals through their organizations, they often find themselves unable to participate in or pursue knowledge mobilisation and innovation activities in addition to the day-to-day requirements of their work.

Lack of Connectivity

Across all zones of impact, the literature conveys a picture of a science-society interface characterised by disconnect. Lack of connectivity (i.e. relationships, social capital, networks) is often cited as a barrier:

- Lack of connectivity between knowledge producers and decision makers (Mitton et al. 2007; Stone 2009)
- Lack of connectivity amongst researchers needed for interdisciplinary research (Heubach and Lambini 2018), and
- Lack of connectivity between different organizations working at the science-society interfaces (Stewart et al. 2022; see also Milton et al. 2007; Oliver et al. 2014; Stone 2009).

Lack of connectivity is arguably the results of a failure to adopt an ecosystems approach to infrastructural connectivity to bring actor- and enabler-organizations together at a systems level. As Paasi et al. (2023) explain, knowledge use for the purpose of innovation to address major challenges are increasingly systemic, and such that individual innovation may fail to create value or impact. Clusters of innovation are needed – for instance smart transportation in urban environments integrates solution of smart logistics to connects vehicles with customers and vehicles to smart infrastructure, safety, and maintenance systems – and an ecosystem of actors is needed to co-create them (Paasi et al. 2023). Lack of connectivity impedes innovation: it results in waste of usable research, knowledge and expertise as well as missed opportunities.

Knowledge use is best understood as a feature of organizations/institutions, and strategies for knowledge use and innovation should be embedded in organizational routines. (Chalmers and Balan-Vnuk, 2012; Kong, 2013, Schröer, 2021; Shier et al., 2019) Because the issue is organizational, it can be framed using management theory in terms of a need for "external metaroutines" designed to increase knowledge absorption and use. Connectivity is the outcome of those routines established to link external knowledge that was brought into the organization with in-house capabilities. Chalmers and Balan-Vnuk (2012) found that transferring knowledge back into the organization often happens in an informal manner in the social sector organizations they examined (e.g., over coffee, via social media). Less common was the transfer of external knowledge through formal routines like forums and seminars. Be it as it may, creating shared spaces for knowledge exchange, such as labs and working spaces is increasingly seen as an expedient, although this is not something over which social sector organizations have full control nor something they always have the capacity to do (Marcelloni, 2019; Nardini et al., 2022; Strasser et al., 2019).

Without ecosystem connectivity, organizations cannot effectively share resources and coordinate innovation across broader networks (Kumari et al. 2019; Molloy et al. 2020). Connectivity is rarely organic and requires intentional approaches. For instance, the Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES) was designed to be an interdisciplinary platform with the specific intention to incorporate SSHA and indigenous knowledges through local representatives (Heubach and Lambini 2018). However, a review of one of the project nodes found that the number of social scientists participating in the project fell significantly short of their target and there were no Indigenous knowledge participants (Heubach and Lambini 2018). Participation in this project was done through nominations, and the authors of this review highlight how the lack of networks on both individual and institutional levels resulted in, what were primarily STEM, researchers having difficulty tapping into new networks to reach SSHA and Indigenous community members (Heubach and Lambini 2018).

Network- and relationship building are time intensive processes. Building networks across at a systems level requires a lot of resources, time, and institutional support. Lack of capacity compounds lack of connectivity as organizations' time, resources and talent are necessary to build and maintain knowledge networks. This creates a vicious feedback loop, as connectivity across the ecosystem helps organizations build capacity (Kumari et al. 2019; Molloy et al. 2020).

Access to research and evidence

Access to research and evidence is often cited as a barrier for organizations and individuals working in a decision-making capacity at the science-society interfaces (Lavis et al. 2003; McEwen et al. 2008; Oliver et al. 2014; Stone 2009). The factor most often cited to explain the disconnect resides in existing academic practices, cultures and incentives, for instance around tenure and promotion. To achieve academic success, researchers focus their knowledge mobilisation strategies on peer-reviewed academic products (e.g. articles, conferences) which are not designed to meet the needs of non-academic knowledge-users and often exist behind pay-walls. Cost and/or funding is often citer as one of the barriers to knowledge use (Howlett 2009; Lavis et al. 2009; McEwen et al. 2008; Oliver et al. 2014) Specifically, the cost of access to research publication databases that require licensing or purchasing fees creates a barrier that results in a lack of access to research and decreased capacity to incorporate and integrate knowledge into policy or organizational decision making (Lavis et al. 2009; Oliver et al. (2014).

However, even when partner organizations can pay to access research other barriers exist to knowledge use. (Farfard 2015; Lavis et al. 2003; Milton et al. 2007; Rajnarian 2014; Stewart et al. 2022; Stone 2009) Discipline-specific language and the structure of articles in academic journals do not lend themselves to being easily picked up and used by non-academic audiences, thus contributing to issues around a lack of research accessibility in addition to simple access.

Insularity of disciplinary scholarship and siloed academic management also affects research/knowledge production, especially in universities as it reduces the ability to engage across disciplines to address complex problems that require ecosystem approach.

For instance, diverse types of expertise, across multiple stakeholder groups are needed to contribute to the design of policies that address systems level challenges. The problem is not solved by resorting to non-academic research intermediates (think-thanks): when research is done outside university channels, the expertise of academic researchers is often not properly engaged, and academics in turn find themselves lacking access to research that's kept within the organization who did the research (Rajnarain 2014).

Institutional Cultures

Institutional cultures on both sides of the science-society interface create misalignments that directly impede knowledge use. The problem is often framed in terms of a disconnect between "knowledge producers" (primarily universities in this case) and "knowledge users". However, as Stone (2009) suggests, how we perceive a problem guides how we construct solutions. While discourse that assumes two autonomous communities of "knowledge producers" and knowledge users/decision makers (Fafard 2015) creates a conceptually manageable framework - there are two communities that need to be bridged – the science-society interface does not revolve around two autonomous communities: there are several mutually constitutive communities. (Stone 2009) Challenges around knowledge use and innovation at the science-society interface require a proper conceptualisation of the complexity involved.

This said, academic cultures in higher education and universities in particular create a formidable barrier to knowledge use. Universities are generally described as having priorities that lack relevance for the multiple purposes of knowledge users, e.g. decision makers and decision making organizations (Milton et al. 2007; Oliver et al 2014; Rajnarain 2014; Stewart et al. 2009; Stone 2009). Because research culture in universities is driven by discovery and exploration, new data and ideas tend to provide insights into future research rather than to identify solutions to issues identified by knowledge users (Farfard 2015; Lavis et al. 2003; Milton et al. 2007; Rajnarian 2014; Stewart et al. 2022; Stone 2009). Rajnarian (2014) argues that because applied research, stakeholder engagement and implementation are considered as peripheral to the research mandate of universities - i.e. production and transmission of scientific knowledge – they are rarely adequately supported. But most importantly, overall, disciplinary silos impede the diversity in disciplinary collaborations and the creation of interdisciplinary networks and relationships that are crucial to driving the sort of cross-sectoral approaches that have become crucial to producing knowledge that can address society's needs (Heubach and Lambini; Jetzkowitz et al. 2018).

According to Kumari et al. (2021) because higher education institutions are reluctant to change, the traditional emphasis on teaching and academic research activities limits their capacity to play a role in dealing with place-based innovation, which is exacerbated by the fact that restrictive institutional structure and a narrow definition of academic mission, especially as regards systems innovation, create a gap in the pathway to impact and implementation. Researchers often need to justify participating in "non-traditional" knowledge mobilisation activities within academic settings (Mitton et al. 2019; Stone 2009). Stewart et al. (2022) contend that universities' social impact mandates are in some cases superficial and/or perfunctory: by focusing on "knowledge transfer" and commercialisation models, they avoid addressing the gap in research relevance and

legitimacy that affect the relationship between universities and society and creating proper pathways for impact and knowledge use.

The emphasis on bibliometric output, and specifically the pressure on academics to publish in peer-reviewed journals and is at the top of the barriers to knowledge use associated to academic culture (Oliver et al. 2014). Academic publishing sequesters research and knowledge behind paywalls that force knowledge user to prioritise access given their limited resources (Lavis et al. 2003; Oliver et al. 2014). Academic research institutions therefore often produces knowledge that cannot be used or that is not actually needed (Farfard 2015; Lavis et al. 2003; Milton et al. 2007; Rajnarian 2014; Stewart et al. 2022; Stone 2009) Even when research is relevant, it often needs to be translated to be implemented into actionable steps, which creates middle-man complexities and research translation challenges (Farfard 2015; Lavis et al. 2003; Oliver et al. 2014; Stone 2009).

However, institutional cultures on the other side of the interface create barriers as well. Knowledge-using organizations do not always properly value the impact evidence and research can have (McEwen et al. 2008; Newman et al. 2017). This translates into a lack of commitment to developing routines and strategies that foster knowledge absorption and knowledge use, and lack of support for staff at an organizational level (McEwen et al. 2008; Newman et al. 2017). When organizations do not value research cultures, the resources their staff's needs to make evidence-driven decisions (e.g. time, skills training, access to research) are not prioritised. Organizations that value, reward, and incentivise knowledge – and this goes much beyond the existence of R&D units – can help promote the creation of organizational capacity around absorbing knowledge and promoting knowledge mobilisation and innovation (Huberman 1994; Mitton et al. 2007; Lavis et al.2003: 227; Roos and Shapiro 1999).

DRIVERS: CONNECTIVITY

Drivers to knowledge use and innovation at the science-society interface can be summed up under one overarching theme: Connectivity. According to Lenz and Shier (2021), connectivity helps increase capacity as organizations benefit from each other's knowledge and resources. But it also helps establish the shared goals that help build the types of relationships that support and maintain collaborative infrastructure. Connectivity can promote eco-system level agility as it helps create self-sustaining networks (Kumari et al. 2019). Systems level agility is not a feature of the social innovation ecosystem, it is a driver of knowledge use and innovation in every sector of activity/impact. Oliver et al. (2014) and Mitton et al. (2007) both highlight previous research (e.g. Granados et al. 1997) that demonstrates that personal contact and relationships between researchers and policymakers was more effective at getting policymakers to incorporate research into their work than producing printed materials for them to read.

Trust

Connectivity in and between organizations depends on a range of mutually reinforcing factors such as the extent and relevance of institutional networks, the effectiveness of collaborative and co-creative practices, stakeholder engagement and the support from intermediary organizations. While there is no unique recipe to generate connectivity, the collaborations and relationships that drive knowledge use and innovation require trust, integrity, and credibility (Lavis et al. 2003; Lenz and Schier 2021; Mitton et al. 2007; Molinengo et al. 2021; Nardini et al. 2021; Popov et al. 2016). Trust is needed to build strong, lasting, reciprocal relationships that form the basis of effective collaborations between organizations and across networks (Lavis et al. 2003; Lenz and Schier 2021; Mitton et al. 2007; Molinengo et al. 2021; Nardini et al. 2022). Trust is also a crucial component of relationships between persons working collaboratively in any ecosystem (Molinengo et al. 2021).

The recipe for trust may depend on broad cultural factors that vary depending on the context. Those who broker knowledge or act as intermediaries between different actors and institutions need to be trusted (Lavis et al. 2003; Mitton et al. 2007). But being trusted to provide the right evidence to support health policy, and being trusted to provide the right technological solution in the context of, say, green transportation initiatives have vastly different implications, including risks. The risks associated with trust are at their highest in collaborations that involve vulnerable and disenfranchised groups (Nardini et al. 2022). Building trust, however, takes time (Lavis et al. 2003). Organizations need to make room for their staff to dedicate the time they need to building trust and maintaining meaningful relationships.

Networks

Network building drives knowledge use and innovation (Aiello et al. 2021; Jollibert and Wesselink 2012; Lenz and Shier 2021; Molloy et al. 2020; Nardini et al. 2022). Networks are especially important in contexts in which knowledge use and innovation needs to happen across a systems, i.e. needs to be implemented through several organizations that each play a different role in the outcome. For this reason perhaps, talk of network is especially frequent in relation to innovation in the social sector. Networks that serve to connect actors, organizations or institutions across sectors are especially crucial to knowledge use. These can take various form. Partnerships between nonprofits and local governments working towards transformational social innovation (Lenz and Shier 2021), or with other stakeholder organizations allows nonprofits to access and utilise knowledge, resources, and influence of other organizations to amplify their own impact (Molloy et al. 2020).

Networks that connect experts and decision makers around policy revolve around slightly different needs and mechanisms. For instance, policy benefits when chief scientific advisors and policy-stakeholders are connected in ways that support the continuous flow of evidence across organizations (Stewart et al. 2022). But other types of networks are designed to provide support to decisions makers by streamlining access to knowledge, help discern conflicting perspectives and identify actions that can be implemented (Hughes and Romero-Lankao 2014). Expert networks can also bring together researchers whose specialisation range across disciplines to help drive the type of interdisciplinary

work that is needed to address wicked societal and human challenges, for instance (Phipps et al. 2012, Heubach and Lambini 2018; Hughes and Romero-Lankao 2014; Krick 2015). Building interdisciplinary networks between fields that currently aren't well connected is important for supporting technological adoption as well: the treatment of illnesses through vaccination and genomics, for instance, have human implications that require insights that god vastly beyond proper technology.

Effective Collaborative Practices

Connectivity and networks that link organizations increases knowledge use and innovation but only to the extent that individuals are effectively able to work together. Collaboration is thus also crucial (Aiello et al. 2021; Graham et al. 2006; Heubach and Lambini 2018; Lenz and Shier 2021; Mitton et al. 2006; Nardini et al. 2022; Oliver et al. 2014; Schroer 2021; Yarime et al. 2012). To be reliably successful, collaboration between individuals around a project or initiative needs to revolve around intentional "co-creation" processes. Co-creation is a foundational component of knowledge-use and innovation in the social sector (Aiello et al. 2018; Kumari et al. 2021; Lenz and Shier 2021; Taylor et al. 2020), but it is applied at all science-society interfaces, although terminology varies (Heubach and Lambini 2018; Jollibert and Wesselink 2012; Molinengo et al. 2021). Co-creation revolves around a series of processes that can be organised around three different types of activities:

- co-design
- co-production
- co-dissemination

We can talk about co-creation whenever at least one of these three processes is involved. But a maximally co-creative process would involve joint framing and collaborative work involving all stakeholders (e.g. researchers, end-users, other stakeholders) to (i) define the problems that requires research (co-design), (ii) generate the knowledge to be used (co-production), and (iii) then assess how that knowledge can most effectively be operationalised (co-dissemination) (Heubach and Lambini 2018).

In the social sector, co-creation is generally recognised by practitioners and experts as essential for ensuring that knowledge use and social innovations actually meets a community's needs and have positive social impact (Nardini et al. 2022). However, the need to ensure meaningful, positive impact is shared across all science-society interfaces and it is reasonable to assume that collaboration would play a role in policy and technological context, though it may take a different form.

Stakeholder engagement

Stakeholder engagement can contribute more or less formally to co-creation, and can increase uptake and knowledge use and ultimately enhance impact (Aiello et al. 2021; Graham et al. 2006; Heubach and Lambini 2018; Mitton et al. 2006; Molinengo et al. 2021; Yarime et al. 2012). When it is closely collaborative, stakeholder engagement can serve to help reduce barriers associated with institutional cultures (Aiello et al. 2021; Graham et al. 2006; Yarime et al. 2012). For instance, involving decision makers in the research process

helps ensure that research is geared towards their needs and designed to answer the questions for which they need data. It can streamline decision-makers' access to the information they need – e.g. through unmediated dialogue with researchers (Lavis et al. 2003 and Mitton et al. 2007).

Stakeholder engagement does not need to amount to fully fledged collaboration, as collaboration happens on a spectrum (Weaver 2021). Stakeholder engagement may extend to local communities, business organizations, civil service bodies, etc. (Aiello et al. 2021; Yarime et al. 2012). In the social sector, for instance, stakeholder engagement often involves representatives of the community being served, ensuring that they have a voice in the process to increase impact intentionally. At the policy interface, stakeholder engagement may take the form of a hybrid advisory committee or of expert advice, and along with other forms of evidence and knowledge, is intended to inform policy and decision-making, though it is not clear how often advice may be heeded (Krick 2015).

Intermediaries

Stronger networks and greater collaborative work efforts often require the involvement of individuals or organization whose role is to facilitate or act as intermediaries: knowledge brokers, bridging agents or bridging organizations. (Hughes and Romero-Lankao 2014; Kinnunen et al. 2018; Lavis et al. 2003; Mitton et al. 2007; Oliver et al. 2014; Stewart et al. 2022). Intermediaries, facilitators and bridging agents can play a role at any point in the process of co-creation to increase knowledge use and innovation. Knowledge brokers, for instance, do "boundary-spanning" work and act as communicators who can articulate information needs of decision-makers to knowledge producers as well as available information to decision-makers and (Hughes and Romero-Lankao 2014).

Diversity, inclusion, equity and accessibility

Diversity, inclusion, equity and accessibility also drive knowledge-use and innovation. The theme is most often discussed explicitly in the literature about social innovation. According to Taylor et al (2020) :

> "social innovation development is dependent upon the involvement of diverse actors who propel organizational learning through deliberately layered forms of perspective building and knowledge sharing... and it is this diversity that organizations carefully tap into when designing socially innovative programs."

But the benefits and significance of diversity, inclusion, and accessibility are not the prerogative of the social sector. Diversity, inclusion, equity, and accessibility need to be involved wherever collaboration, partnerships and stakeholder involvement revolve around individuals with varied expertise (Aiello et al. 2021; Huehback and Lambini 2021). That knowledge use and innovation benefits from the inclusion and participation of individuals with diverse backgrounds, expertise, and knowledge is a ubiquitous tacit assumption that would benefit to be fully unpacked. This is an aspect of the literature on knowledge use and innovation that that is clearly lacking.

SKILLS FOR INCLUSIVE AND COLLABORATIVE INNOVATION

Knowledge use is best understood as a feature of organizations/institutions, and strategies for knowledge use and innovation should be embedded in organizational routines. (Chalmers and Balan-Vnuk, 2012; Kong, 2013, Schröer, 2021; Shier et al., 2019) An organization's capacity for knowledge use and innovation also depends on features of the ecosystem that may impede or streamline the scaling or diffusion of innovation. But knowledge is ultimately used by people and, capacity for innovation therefore also depends, at the individual level, on the skills and attitudes of those at the interface between science and society.

Unfortunately, even though the importance of skills and attitudes is mentioned in the literature, there is little to be found about their exact nature. Discussions typically remain at the superficial level of mentioning the broad role of competency and motivation. However, more training is needed to support knowledge use an innovation on all sides of the science-society interface and this requires an answer to the following question:

What skills then are needed to reduce barriers and enhance knowledge use?

There is a tendency, in the literature, to think of specific skills as especially crucial on one side of the science-society interface. Kumari et al. (2019) argue that academics need to learn to communicate evidence and findings more effectively. Information needs to be packaged in a format that is adapted to the needs of knowledge users, which vary by audience (Kumari et al. 2019; Mitton et al. 2007; Stone 2009) But the fact that knowledge users/decision makers need increased ability to critically evaluate and integrate research in their work is also well documented. Authors stress that knowledge users often lack the skills needed to capitalise on evidence (McEwen et al. 2008; Molloy et al. 2020; Nardini et al. 2022; Newman et al. 2017; Oliver et al. 2014). The capacity to engage in deliberation, which requires good amounts of critical thinking and analytical skills, is a factor when dealing with research/evidence, and can impede or enhance results even when access to knowledge/research is free (McEwen et al. 2008; Molloy et al. 2020; Nardini et al. 2022; Newman et al. 2017;Oliver et al. 2014; Stone 2009).

However, the idea that there is an asymmetry between the skills needed by knowledge-producers and those needed by knowledge-users should be pondered in light of the fact that main driver for knowledge use on both sides is connectivity.

Driving Connectivity

Given what precedes, it would seem that to overcome barriers to knowledge use and innovation, we should foster skills that can help increase knowledge flow and absorption in organizations and help transform institutional cultures accordingly. These skills seem to fall within the broader category of managerial skills and may also include leadership and entrepreneurial skills (Taylor et al. 2020).

However, the focus should be on building skills those skills that are critical to connectivity at the science-society interface need. (Aiello et al. 2021; Graham et al. 2006; Kirk 2015; Kumari et al. 2019; Lenz and Schier 2021; McEwen et al. 2008; Mitton et al. 2007; Molinengo et al. 2021; Molloy et al. 2020; Nardini et al. 2022; Oliver et al. 2014; Stewart et al. 2022; Taylor et al. 2020; Yarime et al. 2012). We will call those the "skills for inclusive and collaborative innovation".

Based on the previous sections, the skills for inclusive and collaborative innovation are those that are needed to contribute, in knowledge- and information-rich contexts, to:

- Building trust
- Supporting broad cross-sectoral networks
- Supporting effective collaborative practices, including stakeholder engagement

In some cases, because intermediaries are an important part of the knowledge use and innovation ecosystems, at least some individuals will need the skills that are required to act as facilitator and/or knowledge and connection brokers. Here we focus on the foundational skills individuals needs for inclusive collaboration.

Skills for the Science-Society Interface

What is important to note from the get go is that skills for inclusive and collaborative innovation are not domain specific. Inclusive, collaborative innovation is supported by clusters of "foundational skills" that can be seen as essential in any activity or interactive organizational settings that require high levels of cooperation, coordination and collaboration.

There is widespread agreement that some skills are "essential" or "foundational," as opposed to technical and occupation-specific. Literacy and numeracy, critical thinking, problem solving, causal reasoning, and intercultural awareness often make the lists, and the literature is pervaded by attempts to draw other types of distinctions, e.g. between skills and toolkits or between skills and competencies. (Shortt et al. 2020; Business Council of Canada 2018, World Economic Forum 2016; Advisory Council on Economic Growth 2018; The British Academy 2017) As such, inclusive and collaborative innovation skills are to be distinguished from occupation-based technical skills and knowledge acquired around professional training such as business, law, engineering, and nursing/medicine. Inclusive and collaborative innovation skills may of course be combined with cognitive toolkits designed, for instance, to support agile project management or strategic change leadership, but they are not reducible to them and cannot be acquired or honed in the same manner.

Inclusive and collaborative innovation skills are distinctively "human," "machine- or AI-resistant," "social," "transferable" and "essential." And while they fall into the category of "soft skills", it has been argued that they are among the hardest to cultivate. (Cukier et al. 2015) Consequently, inclusive and collaborative innovation skills are difficult to teach, or at the very least it's difficult to know exactly how to successfully teach them: they initially develop in early childhood education and are honed and specialised over time throughout an individual's educational pathway and beyond.

We draw on (Lapointe 2021) as well as a recent study of skills articulation programming to propose a framework for inclusive and collaborative innovation skills. Two points ought to be noted. First, the skills described below are generally understood to work in clusters, or to be connected by reciprocities or mutual occurrences. Second, the skills an individual has are not generally valued for their own sake, but rather because they are perceived to have a purpose: they enable targeted organizational- or system-level activities. In the present case, the purpose or target activity is inclusive collaboration. The question then is to describe the individual skills that provide the right equipment. We propose the following definitions.

Taxonomy of foundational skills

Growth Mindset: A growth mindset is essential to an individual's capacity for continuous learning. Having a growth mindset means being open to new ideas and opportunities for developing new skills as well as be willing to continue to work on improving oneself and take action to do so where possible. Having a growth mindset allows an individual to adapt and pivot in changing environments or circumstances. It is a skill that underlies an individual's ability for adaptability and resiliency. As such, a growth mindset is likely to draw on other skills like creativity, intercultural competence, good decision making, and self-management.

Deliberative Skills: The capacity to deliberate, i.e. to engage in careful and at meticulous consideration, rests on a cluster of skills that combine both "analytical skills" and "critical thinking". Analytical skills revolve around the ability to gather and assess data. They are an important aspect of what is required to conduct research, from the determination of a research question to the collection of the relevant information/data. Key aspects of analytical skills include the ability to assess a situation and identify a problem, to filter information and determine what is relevant or irrelevant, and to analyse and draw meaning from data. Critical thinking is the complementary process that is involved when putting information together to create an argument or demonstrate a point, when putting information into practice, or when engaging in evaluation and reflection. Characteristics of critical thinking include being able to construct reasoned arguments, to apply the information relevant to solving problems or addressing issues, to challenge the way things are currently done or see where change can be implemented, and to reflect on past actions to learn how to improve on ways of doing. Deliberative skills are also closely related to creativity and problem solving.

Problem Solving: Effective problem solving requires the ability to recognise a problem, identify what information is needed to solve it, and the aptitude to put that information to use toward a resolution. People who are effective at problem solving are generally able to question and reassess common sense assumptions, they 'think outside the box', and are resourceful, i.e. they have the ability to work within the constraints and resources at hand. As such, problem solving is closely connected to creativity, but in teams setting it requires good deliberative skills and effective communication as well. When making decisions, problem solving requires the ability to weigh risks, respond to evolving situations, judge the significance of actions, anticipate outcomes, and assess ethical implications, all the while taking into consideration other relevant perspectives. Problem solving is associated with integrity, deliberative skills and self-management.

Creativity: While creativity is perceived to be especially useful in the arts, it is in fact an essential feature of all problem solving. Creativity includes the ability for an individual to see beyond current ways of doing things, to make connections, come up with innovative solutions and produce valuable change. Creativity can take many forms, for instance: reimagining routines, being open to new experiences, the ability to devise novel ways of addressing an issue or being able to come up with original ideas. In addition to its role in problem solving, creativity is involved in deliberative thinking and a growth mindset.

Teamwork: Teamwork revolves around the cluster of skills that one needs to fully participate in projects that require cooperation and collaboration. It takes more than "people skills" and a congenial attitude to be able to collaborate, although the two are connected. It requires an understanding of relationships and dynamics that exist in group settings, the ability to communicate clearly and consistently with team members while accommodating diversity, equity, inclusion, and accessibility. Teamwork involves creating a shared understanding of objectives and responsibility. For those who are in charge of coordinating the efforts of a team, or group, it requires familiarity with a broad range of techniques associated with strategic leadership and agility in management, including the ability to build trust and teamwork.

Communication: Effective communication is an essential aspect of what is involved in "social-emotional skills". It includes the ability to comprehend what others are saying and to respond effectively in turn, but effective communication is also what makes it possible for one to cooperate and connect with others meaningfully. Effective communication, then, requires more than the ability to successfully convey one's message verbally, in writing, or through other means. To know what message one wants to convey, one needs to understand who the audience is and tailor the message accordingly. This is the reason why some qualities associated with "people skills" can be helpful in communication, for instance: empathy, showing respect for others, recognising others' good efforts, the ability to negotiate with others, and communicate your own positions or ideas persuasively. Communication is thus connected to teamwork and integrity as well as intercultural competence and problem solving.:

Integrity: Integrity is at play in all aspects of one's interactions with others. It is involved in a wide variety of situations, for instance when someone takes responsibility for their own actions, shows respect to others or uses deliberation to make complex choices, especially when these choices have ethical consequences, i.e. consequences on relationships with others. Integrity is what drives us to seek processes that avoid biases and that are fair, as well as to show accountability in situations of leadership. Integrity is needed to adopt a genuinely reflective attitude and learn from one's actions. As such, integrity is connected to intercultural competence, problem solving and teamwork. It also can be a driver of inclusion, diversity equity and accessibility.

Intercultural Competence: Intercultural competence requires both the ability to recognise cultural differences in a broad variety of contexts and to acknowledge and make space for these differences so environments that are diverse, inclusive, and equitable can be fostered. It requires awareness of the fact that you are yourself influenced and that

you live in ways that are shaped by specific cultures and beliefs. It involves openness to learning about different ways of doing or different ways of understanding the world, as well as the capacity to make place for this diversity. It is connected to both growth mindset and integrity, but it can also promote problem solving and deliberation. Intercultural competence is especially important to streamline communication and teamwork in cross-cultural and cross-sectoral settings. Intercultural competence plays a crucial role in one's ability to design and navigate collaborative environments that seek to foster inclusion, diversity, equity, and accessibility. In turn, it can make an environment favourable to deliberation and creativity by increasing psychological safety.

Self-Management: Self-management rests on a number of practical abilities that include the ability to plan and keep track of one's time, pursue one's own goals and continue to grow, stay motivated and regulate one's emotions. Self-awareness is a critical aspect of self-management, and it includes being able to recognise and assess one's own strengths and weaknesses, identify areas for improvement, and continue to set and fulfill meaningful objectives even in light of setbacks (i.e. resiliency). Self-management is crucial to a growth mindset.

Inclusive and Collaborative Innovation

There are two very broad dimensions to inclusive and collaborative innovation:

1. The capacity to use knowledge and/or innovate, i.e. to demonstrate high levels of ability for problem-solving, deliberation, reflection and creativity
2. The capacity to collaborate and foster inclusive team or organizational cultures, which requires high levels of intercultural competence, integrity, communication and teamwork.

In that context, a growth mindset and high levels of self-management can be seen as a catalyst: they are lubricants in the operationalization of the skills for inclusive and collaborative innovation.

Unlike many other type of activities, inclusive and collaborative innovation is extremely skills-intensive: it engages the largest number of foundational skills at the highest level. And it also engages these skills together and organically. For instance, deliberative skills allow people to anticipate where conflict or tension may arise in collaborative settings and work to address them before they happen (Molinengo et al. 2021). Additionally, in a collaborative setting problem-solving is arguably a key skill (Molinengo et al. 2021). This is especially so for the types of collaboration being called for at the science-society interface - those with diverse stakeholder involvement, people from different organizations and thus organizational cultures, and knowledge producers across disciplines. Collaborations of these types will necessitate strong problem-solving skills in order to balance the different needs and desires of these actors to produce successful collaborations (Krick 2015). A growth mindset and creativity are jointly needed to find compromise and collaboration. Collaborative innovation can then be seen as a collection of competencies that benefit from a holistic approach to foundational skills-building.

CONCLUSION

Ensuring that the individuals working at the science-society interface have and are rewarded for inclusive and collaborative innovation skills is important. It is also critical that organizations are equipped to support those who have those skills sets (Lapointe 2021; Molinengo et al. 2021). Individual actors may have these skills but be unable to effectively operationalise them in contexts in which organizational cultures present barriers. This issue of individual skills vs. organizational behaviors is touched upon in the discussion of social innovation where rigid hierarchies in social organizations prevent the adaptability and flexibility required for social innovation (Schröer 2021). There policy is needed that does not just ensure that individuals build and are rewarded for the foundational skills required of them, but also ensures that organizations build, support, and operationalise these skills by creating adequate institutional infrastructure and managerial cultures. This is especially true of in context where institutional policies are not setup to foster equity, diversity and inclusion.

It would be reasonable to expect postgraduate training to be part of the solution. But skills development often falls within the purview of centralised university and college learning units whose offerings are not integrated to program curriculum. (Martini and Clare 2014; Sarkar et al. 2021). More importantly, skill-development programs offered by universities and colleges may be voluntary and created and offered on an ad-hoc basis rather than part of an intentional institutional strategy (Haviland et al. 2021). More importantly, skills articulation is not a common aspect of skill training in many university settings (Lapointe and Turner 2020). Consequently, even when students develop collaborative innovation skills, they may be unable to articulate what those skills are, why they are important, how they enhance their work abilities, where/how they use these skills, and how they can work on continuing their skill development. (Haviland et al. 2021; Jorre de St. Jorre and Oliver 2018; Martini and Clare 2014). It is therefore critical that policy initiatives support intentional, rather than latent, skill development of individuals working at the science-society interface, that addresses both skills

APPENDICE

METHODOLOGY

Given the scope and complexity of the question, our strategy was to leverage the evidence from 4 separate literature reviews conducted by Dr Lapointe's team all of which converge to provide elements of the answer to our question and to supplement these results as needed.

These include:

- A scoping review of the literature on community-focused knowledge mobilisation in social science, humanities, and arts (SSHA);
- A rapid review of the literature on needs in social sector organizations around capacity for social innovation
- A scoping review of the literature on the science-policy interface, looking at knowledge mobilisation strategies, barriers, and facilitators for social sciences, humanities and arts specifically;
- A narrative review of the literature on strategies and structures for teaching and learning skill-development and articulation.

Because the evidence gathered through these four substantial projects focus on community-focused (social sector) and policy-focused knowledge mobilisation, the synthesis we propose here is also biased toward the two broad zones of impact that correspond to the social and political sectors. This however should not be seen as a shortfall, but rather a promissory note. We supplemented the evidence as needed to provide some contrasting illustration of research knowledge use in the technological sector (e.g. implementation of IP, commercialization), but we recognise that more would be needed .

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