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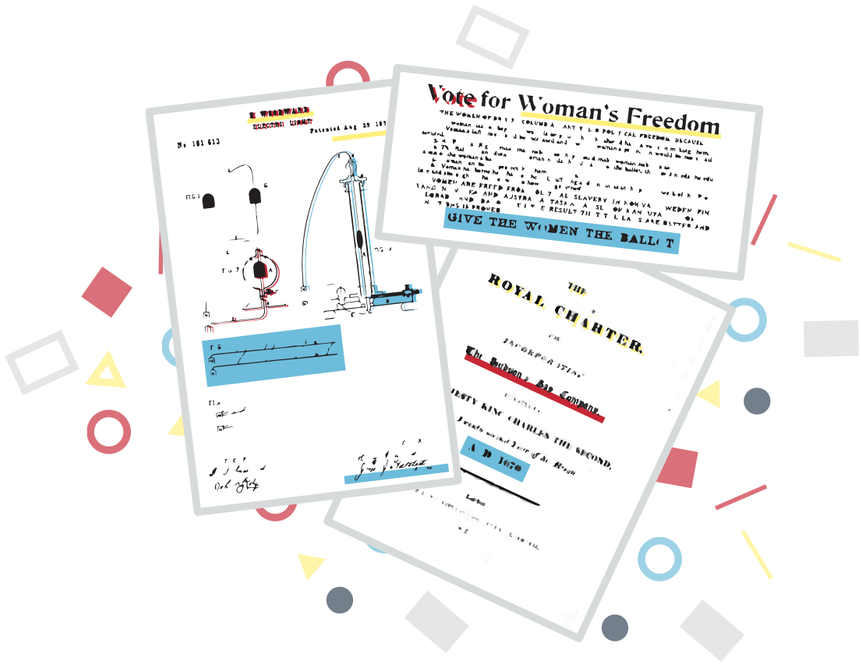
INNOVATION EDUCATION

Ryan J.A. Murphy 2016 MDes

INNOVATION EDUCATION



Innovation Education

Developing a curricula and systemic design strategies for innovation education in Newfoundland and Labrador.

Ryan J. A. Murphy

Submitted to OCAD University in partial fulfillment of the requirements for the degree of Master of Design in Strategic Foresight & Innovation.

Toronto, Ontario, Canada
December 2016

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Declaration

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Ryan J. A. Murphy

Abstract

Education reform presents an opportunity to improve innovation education and, in turn, advance innovation capacity. I synthesize the framing and strategy of resources from provincial, national, international, and theoretical perspectives on innovation in order to develop a holistic model of innovation and a curricula for innovation education. Then, I use systemic design to model Newfoundland and Labrador's current education system and to suggest strategies for reform to enable improvement in Newfoundland and Labrador's innovation education. Finally, I explore how systemic reform in Newfoundland and Labrador may serve as a systems laboratory for reform efforts in other jurisdictions.

Acknowledgements

Suz, for giving me a very long leash, letting me have my ambitions, and helping me to see them through.

Anna, for starting me on this path in many ways and, of course, for your last minute saving grace!

Alison, for everything, especially for not having word block about my word blocks.

Classmates, especially David and Robyn, who kept me motivated to try to write more than them and to finish first (hah).

The OCAD U SFI faculty, especially those that taught me directly: Greg Van Alstyne, Jeremy Bowes, Kate Sellen, Suzanne Stein, Stuart Candy, Peter Jones, Stephen Davies, Nabil Harfoush, and Alia Weston.

Lenore, for somehow always having an open door and the time to chat.

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Social Sciences and Humanities Research Council of Canada

Conseil de recherches en sciences humaines du Canada

Canada

Dedication

To myself. Yes, seriously, as a reminder: you can be proud of this, but it is not nearly the end.

There's much more to do!

//They say you can't boil the ocean, but I guess we kinda are, aren't we?

About the cover:

Pictured on the cover are three examples of innovation aligned with the three orientations outlined later in this paper: Canadian Henry Woodford's 1876 patent for an electric light bulb–later sold to Thomas Edison in 1879 and predating Edison's own patent filing by three years –corresponds with Technology and Science; a blotter discussing women's suffrage in British Columbia, circa 1917, symbolizes Social and Sustainability; and the title page of the Royal Charter incorporating the Hudson's Bay Company from 1670 symbolizes Commercialization and Entrepreneurship (Bowen, n.d.; Edison, 1880; Hudson's Bay Company, 1986; Woodward, 1876).

Bowen, A. (n.d.). H994.30.9 - Sufferage blotter c. 1917. openMOV. Retrieved from http://openmov.museumofvancouver.ca/node/57115

Edison, T. A. (1880, January 27). Electric lamp. Retrieved from http://www.google.com/patents/US223898

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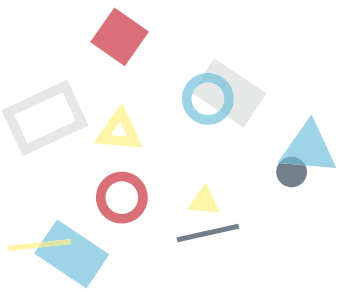

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Foreword

Let me begin this paper the same way any good project should be presented: with a couple of disclaimers.

First: I tend to skip forewords, personally, so feel free to skip this one yourself.

This foreword discusses the personal context that inspired this Major Research Project (MRP). The idea came from my peers, actually. As I spoke offhandedly about why I was interested in this research, another student stopped me to say that I should really articulate my ranting *in* the MRP itself. They thought that understanding my perspective might be useful to anyone reading the research. They also suggested that writing a foreword to discuss this perspective and reviewing it in an afterword after the project had been completed might be interesting.

I'm not convinced that my colleague wasn't just trying to make me do more work – but alas, here we are. Looks like I'm following the advice of that too-often-cited TED Talk after all (Simon Sinek's "Start With Why").

So, the second disclaimer: as you've probably noticed already, this foreword might be a little weird. I intend to espouse a little of my personal philosophy. There's even a mention of aliens. (On second thought, maybe you *should* skip the foreword, before I lose all credence…)

I start with these philosophical meanderings because these ideas are at the core of why I value education so much. I'll also spend a few paragraphs talking about why I had the gall to try to understand this complexity myself, and why I think my approach might be of value despite the densely-populated furor surrounding education and innovation in the present discourse.

The goal here is to provide you (and future-me!) with a little snapshot of my headspace before writing this MRP. It might help you to understand whether or not I'm about to write anything worth reading, and how my perspective is shaped and skewed. It might help *me* to remember my roots in a few months (or in a decade).

Why education?

There are two intersecting reasons.

First: aliens.

Or, rather, a lack thereof.

Fermi's paradox is a contradiction highlighted by its namesake in 1950. It goes something like this:

Given the ancient age and vastness of the universe, it is probable that somewhere else in the universe, intelligent life has come to be. It is also probable that some of those intelligent species developed technology –including communications and space travel capacity – more advanced than ours, even if they simply began development a millennia earlier than we have. On the scale of the size and age of the universe, then, it is likely that many alien races have begun colonizing the stars (and communicating between them). If that's the case, however, then "where is everybody?" (as Fermi himself supposedly put in 1950; "Fermi Paradox," 2016). Despite extensive efforts over the past century–let alone since we began watching the stars in pre-history–why have we yet to witness the communication or travel of extraterrestrial alien life?

I will return to this question in a moment. Regardless of the answer, though, if you accept the Fermi paradox, one thing is true: we are the most advanced intelligent life we have yet seen.

Obvious? Maybe. But why is this relevant to education?

Well, if we are the most advanced and intelligent life in the universe, then the thoughts, questions, and ideas we have are the most advanced thoughts, questions, and ideas in the universe. Our greatest discoveries and deepest understandings of life, the universe, and everything are the best the universe has had to offer thus far.

Put another way: if you have a unique thought, question, or idea, you're possibly the only thing ever to have those thoughts, questions, or ideas. (Note that, for once, the use of "ever" is not hyperbolic.) In other words, we need to think important thoughts.

So, I want to help ensure our education systems enable us to be the brightest we can be, because–for the sake of the universe–we need to think important thoughts.

The apparent loneliness of humanity is an important prompt for another reason: total existential terror.

One solution to the Fermi Paradox is called the Great Filter. The Great Filter theory suggests that the absence of advanced interstellar life in the universe is due to the fact that every civilization that reaches a certain stage of achievement is "filtered" by some unknown force(s). While many questions exist about the Great Filter theory, the most important question is arguably the most pragmatic (Hason, 1998):

Does the Great Filter lie in our past, or have we yet to meet it?

Many have speculated about the what the filter may actually be. Some cosmic demon? Simple bolide collisions? In my mind, only one possible threat is clearly on the horizon of the present day: ourselves. Indeed, it takes little more than a skim of Christakis' (2006) continuous critical problems to identify several handy levers by which to assure our own self-destruction. In fact, it was announced on the day of this passage's first writing that atmospheric carbon dioxide has reached 400ppm–making anthropogenic climate change a particularly salient option.

But again, what does all of this have to do with education?

I take it as intuitively true that many of Christakis' continuous critical problems have only grown more untamed since he authored his list in 2006. This means the world's problems have become even harder to solve, and it is becoming ever more paramount that we solve them. To do so requires that humanity work at its best. We need solutions to carbon sequestration, efficient sustainable energies, safe parameters on artificial intelligence, overpopulation, epidemic superbacteria, and hundreds of other challenges that could threaten the prosperity and survival of humanity. The brightest minds must find their way into roles that will allow them to develop true, implementable solutions to remediate and resolve these challenges. But–at the same time–other challenges such as the gap between rich and poor, discrimination, and many more create insurmountable barriers, preventing many from *becoming* those brightest minds.

I believe that the only solution to both of these categories of problems–existential threats and disabling barriers–is found in an accessible, effective education system. This system would simultaneously help people find their niche while enabling them to achieve their maximum potential in that niche. No, not everyone will invent the technology that will allow us to efficiently capture and store carbon from the atmosphere, but we all have a role to play in enabling those that do to succeed.

In sum: the Great Filter lies ahead of us, and only through excellent education systems will we have the capacity to get through it.

Why me?

By now, you hopefully acknowledge–at least to some humble extent–that our education systems are important structures. I have yet to talk about why the current systems are failing; I take it for granted that you agree with that notion, or you probably wouldn't be reading a paper about reform. (Not to worry: a broad discussion of this exact topic is central to the introduction of the Major Research Project itself.)

Still, why me? Surely many "bright minds" are working on education reform – why should I think I have anything to offer at par with their contributions?

At this point in my career, my work has intersected the notion of "education systems change" for almost ten years. I've been lucky to find myself in a myriad of roles and opportunities to engage with the system and its stakeholders, to play with it with small interventions, and to learn throughout this time what a nebulous and nefarious system it is. This is not to brag. To be honest, it'd be difficult for me to demonstrate any kind of concrete impact I've had. As I'm sure is common for anyone dealing in wicked problems, I often feel quixotic, swinging wildly at windmills with any chance I can muster.

Still, along the way, I think I've had the fortune to be able to witness a lot of the most important windmills. More to the point of this heading, however, I've also met many of the other Don Quixotes. In fact, I am constantly surprised–on a weekly basis, at least!–to come across yet another individual, organization, or movement focused on education systems change, or some subset of it.

Most of these are just like me: passionate people with a lot of gall and little expertise or leverage.

Others, however, are surprisingly prehensile. I have observed many and even participated in a few national and international initiatives aimed at transforming education. Resources, networks, experts, and imperative: these initiatives have had it all. And yet, nonetheless, little the needle moves on change. To be sure, change is slow – especially in these kinds of challenges. Still, one thing that has struck me about all these little and large attempts at reform is that they lack a truly systemic, strategic, and foresight-oriented perspective. Rarely have I observed a transparent theory of change; a database of foresight signals, trends, and drivers; or pre-existing system maps at play in the conference rooms or organizational resources that I've been privy to. (A few have, in fact, been introducing these tools of late, or creating them at the outset of a conference with the people in the room.)

It is with this in mind that I first discovered, with great excitement, the Strategic Foresight & Innovation Program that this MRP is being completed for. It is still with this in mind that I'm excited to depart on the research journey ahead of me. I believe that a systemic- and foresight-driven approach to education reform is crucial for success.

The only reason I think I'm the one that should be doing it is because I haven't found anyone else who is.

The approach

The precocious among you may have noticed at this point that the paper ahead doesn't include primary data beyond my own reflections and creative synthesis. This is deliberate, and I wanted to take some time to explain why–hopefully before anyone complained about my lack of originality.

First: I'm in this for the long haul! My current plan is to begin a PhD studying exactly this subject immediately following this Master's of Design. Thus, I wanted to take the time and opportunity provided by this MRP to develop a sound and powerful base of theory with which to begin that study. It should be of no surprise that this field is large and unwieldy: much has been written about education and education reform; to say nothing of systemic design, foresight and systems methods, and the other approaches I aim to integrate in this research. A light reading of this literature is likely to produce an unreliable representation of its contents. I did not trust myself to learn enough in a few months to design an effective primary research plan.

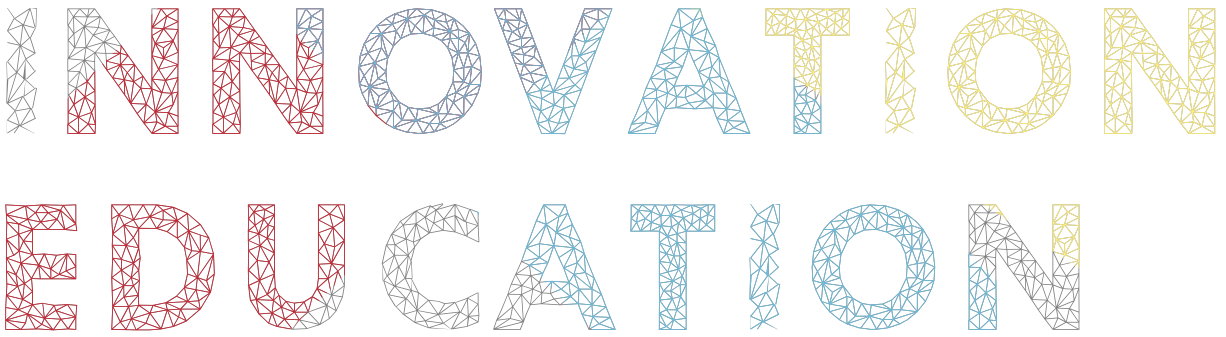
Second: ethics. As I am ultimately examining the performance of the systems in which they work and learn, both students and educators (that label includes teachers, professors, and administrators supporting education programs) would be vulnerable participants in any primary research I conducted. Of course, the rewards potentially gleaned from such research might be necessary–but I did not trust myself to develop primary research methods that would unearth those rewards within the time and resource constraints of this MRP.

So, the intent is for this project to help me define robust plans for a PhD. That will necessitate primary research, and this MRP will hopefully help me produce powerful research designs for that research.

Another thing is worth mentioning: the paper ahead explores the education of innovation. Education reform is my primary passion, and something that I've been working on for a long time. When I set out to start this MRP, however, I froze up at the idea of studying *all* of education. How does one even begin to articulate what is we should be learning? Other movements have tried at this, and failed (e.g., the 21st Century Learning movement, snarled up with the interests of a great number of private educational technology [edtech] "visionaries"; cf. Ehrcke, 2013). How would I succeed, in the run of a few months with a research project the size of an MRP, no less?

I think I'd fail, in fact, which is exactly why I elected to focus on innovation. This ambition is probably equally heady and overconfident, but it at least focuses the output a bit. On the other hand is somehow evaluating the current education system's impact on everything from STEM to STEAM to STEAM+D (that's Science, Technology, Engineering, and Mathematics; Science, Technology, Engineering, Arts, and Mathematics; and Science, Technology Engineering, Arts, Mathmatics, and Design; a set of movements attempting to emphasize "only" those disciplines in our curricula). Evaluating innovation seems more graspable, and plus, I've just completed a research project on Canada's innovation system for another course.

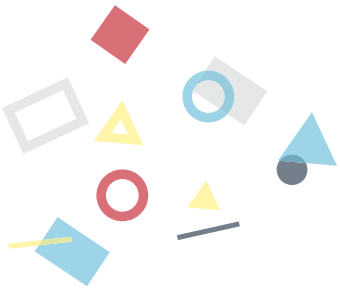
…What's to go wrong?


INNOVATION
EDUCATION

Part One: Framing

In part one, I frame the paper by introducing why this work is needed, discussing the premises on which it is based, outlining the overall purpose I aim to serve and the research questions I aim to answer, and discussing the approach I use to do so. Finally, I offer an explanation of how the paper is organized.

- *Why this research?*
- *What is my approach?*
- *What are my contributions?*



Introduction

What should education look like in Canada in the 21st century? Canada's systems have performed well when compared against other nations with a variety of measures, from the Organization for Economic Co-operation and Development (OECD) Program for International Student Assessment (PISA) rankings (Canadian students placed 9th in paper-based mathematics and in science, and 7th in reading, against 65 other nations; Brochu, Deussing, Houme, & Chuy, 2013) to equality of access and attainment (Canada is second in the world on the Social Progress Index's ranking of Access to Basic Knowledge; Social Progress Index, 2015). Yet countless individuals, groups, and initiatives have raised alarm in recent years about the lacking capacity of mainstream educational models to meet the needs of the 21st century.

In just the last two years, for instance:

- a group of professors and executives pointed to education as a powerful lever with which to build an "innovation ecosystem" in Canada's *Policy Options* magazine (Gold, Abraham, Gualtieri, and Gillespie, 2015);
- the J.W. McConnell Family Foundation, one of Canada's largest philanthropic organizations, invested $10 million to create the RECODE initiative to foster social innovation and social entrepreneurship in post-secondary institutions ("Public Launch of RECODE", 2014);
- the Waterloo Global Science Initiative, mandated "to promote dialogue around complex global issues and to catalyze the long-range thinking necessary to advance ideas, opportunities and strategies for a secure and sustainable future" ("About WGSI," 2016), convened a summit re-imagining high school for 2030 with the University of Waterloo (Turok & Hamdullahpur, 2013; Brooks & Holmes, 2014); and
- Canadians for 21st Century Learning and Innovation (C21 Canada) released a report calling for systemic transformation in Canada's school systems (Milton, 2015).

Further, each of Canada's Tri-Council Agencies have identified improvement in our education systems as critical to the country's success in their most recent strategic plans (Canadian Institutes of Health Research, 2015; Natural Sciences and Engineering Research Council of Canada, 2009; Social Sciences and Humanities Research Council [SSHRC], 2012). SSHRC in particular suggests that Canada has reached a "tipping point" in education, challenging researchers to imagine Canada's education futures as one of the six challenge areas of the Imagining Canada's Future initiative (Social Sciences and Humanities Research Council, 2012).

In parallel with this discourse on education reform, much has been said about Canadian innovation in the last two decades. Many forces have called out Canada's "innovation gap", suggesting that Canada is lagging behind its peers in taking advantage of 21st century opportunities (cf. Bloom & Watt, 2003; Council of Canadian Academies & Expert Panel on Business Innovation in Canada, 2009; Gold, Abraham, Gualtieri, & Gillespie, 2015; Loghmani, 2016; Stuart, Currie, Goodman, Ives, & Scott, 2015). These clarion calls have linked a lack of innovation capacity with growing economic threat, disparaging Canada's ability

to participate in the fourth industrial revolution (Leopold, Ratcheva, & Zahidi, 2016). The need to improve our capacity for innovation has also underscored a need to respond to the complex problems of the 21st century (Kolko, 2012).

Numerous innovation strategies on both provincial and national levels have responded to this clarion call (e.g., Government of Newfoundland and Labrador, 2006; Industry Canada, 2001, 2014; Innovation Government of Canada, 2016a). These calls to action for education reform and innovation capacity invariably intersect. These innovation strategies have often identified the significant role education plays in supporting an innovation system through highlighting the roles our educational institutions play in advancing knowledge, building partnerships, and creating fertile environments for innovative development. Likewise, education reformists link new directions for education with increased collaborative capacity, creativity, and more (e.g., the 21st Century Learning movement; cf. Milton, 2015).

Despite the fervour, however, we do not have a synthesis of how the modern education system might be reconstructed to encourage innovation. From misaligned strategies between institutions of higher education (Bramwell, Hepburn, & Wolfe, 2012) to innovation strategies that are aspirational but not concrete (Gold, Abraham, Gualtieri, & Gillespie, 2015) to contradictory policies on skill development (Gibb & Walker, 2011), we have placed significant emphasis on the importance of innovation capacity but lack a comprehensive understanding of how we will create it. We need a clear understanding of innovation, of how innovation relates to the needs and challenges of the 21st century, and of the skills and competencies required to practice and succeed at innovation.

Furthermore, as our education systems are massive, complex cornerstones of society, they do not change quickly. Many actors have substantial power and ownership over what change should look like or how it is implemented (Levin, 2000). Moreover, reform efforts are often caught up in a "'silver bullet' culture", where reformers cyclically adopt and abandon new 'best practices' without systemic coordination (Mehta, Schwartz, & Hess, 2012). These factors coalesce to create gridlock and quagmire in education reform, underlining the need for a systemic approach to strengthening Canada's innovation capacity.

So, while numerous initiatives have pursued reinvention of Canada's education systems, and national and provincial discourses have resulted in multiple innovation strategies, these conversations are not aligned. That is, we need to talk about the education *of* innovation. How exactly do people learn to be innovative, and how are our education systems currently facilitating that process? This research has explored those questions with one ultimate goal: to understand how we might transform Canadian education systems to improve their ability to produce innovators.

Approach

Why Canada?

The geographic focus of this work is Canada. The Canadian context has been a volatile one. As noted above, Canada's innovation capacity has been under intense scrutiny. A number of recent calls to action have focused on improving Canadian innovation, including ongoing consultations for a new federal innovation strategy:

> **Canada needs a** bold, coordinated strategy on innovation that delivers results for all Canadians. We need to move forward with fresh ideas and a joint action plan that will make innovation a national priority and put Canada on a firm path to long-term economic growth. (Government of Canada, 2016b)

At the same time, Canada's traditional education systems have also been under fire, increasingly lumped into critiques of the archaic status of the Western approach and threatened by disruption from "education technology" movements that use increasingly cheap and powerful computing to provide new education products and services (cf., Burwell, 2015; Bradbury, 2015). In the "creative destruction" of these two causes, an opportunity has emerged for Canada to feed two birds with one seed, to quell the concerns of education critics while advancing its innovation output in the long-run.

However, Canada's education system is actually composed of many systems that happen to suffer the same critics. Its traditional systems–that is, K-12 and post-secondary systems, often separately governed–are under provincial jurisdictions, and those systems themselves are further broken down into levels and localizations that are funded and governed in different ways. Thus, Canada has a system in which education in different provinces has been "generally similar" but in which each province and territory features differences from one another ("Education in Canada," 2009).

Why Newfoundland and Labrador?

This subtle provincial variation complicates systemic change. For this reason, I have chosen to study Newfoundland & Labrador's (NL) education system, using it as a test-case with which to model and strategize change for the rest of the nation.

This choice is a deliberate one, for two reasons. First, NL is my home province, and I am very familiar with the structure of and actors involved in the system here. This experience and these personal networks have made learning about (and potentially changing) the system more accessible to me than the systems of other provinces would have been. Second, NL's education system is much simpler than many other provinces. The K-12 system, for instance, has recently consolidated its regional school boards into one English school board and one French school board (Bartlett, 2013). Moreover the province has only one public University and one public College system (albeit each has several regional campuses; Advanced Education and Skills – Government of Newfoundland and Labrador, 2016). Thus, while most other jurisdictions in Canada have the same types of institutions, the relationships between those institutions may be harder to track. Therefore I have begun with a holistic understanding of NL's simpler model, with hope that the lessons

from this model may apply to others (with some modification, I'm sure).

In other words, this research aimed to examine a provincial solution (strategies for education reform) to a national problem (innovation skills and competencies). The resulting model of innovation education has application across the country (if not globally), but some variance in adoption may be appropriate given different provincial or national contexts. The model of education systems and strategies for reform, however, have been designed specifically for Newfoundland and Labrador; these concepts will need adaptation for cross-provincial use.

A walkthrough

I used a mixed-methods approach to develop a new model of innovation and innovation education for Canada and to suggest strategies for reform in Newfoundland and Labrador's education system to improve the province's innovation education. First, I reviewed governmental reports and strategies, the public work of a variety of organizations, and scholarly literature to inform a holistic definition of innovation in Canada, a model of the innovation process, and the skills and competencies used in the practice of innovation. I used this model to develop learning constructs and outcomes for a model of innovation education. Then, I employed systemic design techniques to map and query the processes and systems of education in Newfoundland and Labrador for opportunities for systemic reform to improve innovation education in the province. These opportunities have been summarized in a set of takeaways for Canada, for the province, and for innovation theory and practice.

Part two: What is innovation?

- *What is innovation?*
- *How do we practice it?*

Part two begins with an examination of the current literature on innovation itself. What is innovation? What kinds of innovation are talked about in provincial, national, global, and theoretical work on innovation? Further, what aspects of innovation might they be missing? In this chapter, I use literature from a variety of provincial, federal, and international sources to construct a model of innovation in the Canadian context, ensuring that the phenomena explored by this research is synonymous with the models of innovation used in government strategies and pundits' critiques. Then, I explore scholarship on innovation, refining our definition and developing a comprehensive model of innovation.

Part three: How might innovation be learned?

- *How does one become an innovator?*
- *What are the skills or learning outcomes required for innovation?*
- *How are these skills applied to the innovation process? How are they applied in different innovation orientations?*

In part three, I use the models developed in part two to explore how we might provide education on innovation itself. For each innovation skill or competency domain, how might it be taught (or learned)? Theory on instructional design informs this discussion and the synthesis of skill domains into a model of innovation education. This model includes the division of these domains into a set of learning constructs, each with learning outcomes that may be used to develop curricula and pedagogy to foster innovation capacity in Canada's students.

Part four: How is the education system changed?

- *How does our current system provide innovation education?*
- *How might we provide more innovation education for Newfoundland and Labrador learners?*

- *What are the mechanisms of education systems change?*
- *How might we use systemic design to power a reform movement?*

If we are to improve the ability of our education systems to produce innovators, we must talk about changing the education system. Here, however, it is worth noting that education systems change has been a nefarious and difficult prospect. Education reform is a "wicked problem" (ill-formed, unique-to-their-context challenges involving stakeholders with conflicting interests with no true solution, multiple explanations, and multiple causalities; Rittel & Webber, 1973) that has proven unyielding, despite a myriad of individuals, organizations, and movements that have tried to create change in our systems (Mehta, Schwartz, & Hess, 2012). Thus, in parallel with the study of innovation as a learning outcome, I explore the systemics of education systems reform in part four. I will describe what we mean when we talk about education systems and create systemic models of the systems explored in the research. This undertaking involves systemic analysis, using techniques of systems thinking to understand the whole system, not just curricula and programs.

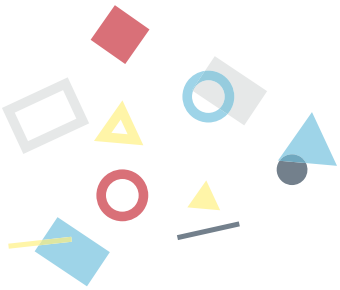
Using these models of innovation and education, I then explore how NL education systems might be providing opportunities for its learners to develop innovation capacity–and how it might be missing out. The result is a map of the present education system and an analysis of how systemic design might be applied to provoke reform.

Based on these models and analyses, I conclude with a set of recommendations for innovation practitioners and theorists, policymakers in Canada, and educators in Newfoundland and Labrador. Finally, I suggest directions for further research in these areas, and describe mechanisms for carrying this systemic change forward.

Part Two: Defining Innovation

What is innovation? How is it practiced? In Part 2, I outline various definitions and models of innovation from different perspectives. The different contributions of these perspectives are then synthesized into a model of innovation, the innovation process, and potential innovation skill domains.

- *What is innovation? How is innovation framed by different international, national, provincial, and theoretical perspectives?*
- *How do we practice it?*



Introduction

The resolution of a comprehensive definition of innovation–that is, a definition that captures what all the pundits, politicians, and self-identified innovators themselves are talking about when they are talking about innovation–has been no simple endeavour. Still, it was critical for the present research, as it was possible that the multitude of actors involved in this problem were all simply talking about different things. (That would explain the mess, wouldn't it?)

In this section, I aimed not only to define what innovation is–that is, as it is conceptualized by the thinkers mentioned above–but also to explore what it should be, in case the crux of our complex problem is some crucial assumption about Canadian innovation that has been missing. So, I started this discussion with reference to the definition of innovation used by international actors–namely the Organization for Economic Cooperation and Development (OECD) and the World Economic Forum (WEF)–in order to explore the perspectives that seed many examinations of Canada's innovation gap (the perceived incapacity of Canada to respond to and participate in the new economic opportunities of the fourth industrial revolution; Fascinato, McCallum, Murphy, and Berman, 2016). Next, I examined the Canadian context, reviewing federal and provincial strategies and those definitions used by critics when talking about innovation. From there, I reviewed existing scholarship on innovation, developing and refining our definition with useful concepts unearthed through that exploration.

Later, in part three, with this robust model of innovation in mind, I study how it is that people might learn to wield it.

Methods

My intent was to develop a model of innovation education valuable in practice and in theory. The development of this model thus evoked knowledge found in both. In practice, I sought out innovation strategies, reports, commentary, and other resources from international organizations, federal and provincial governments, think tanks and pundits, and other groups. In reviewing this material, I sought to learn how we talked about innovation in our strategies and actions. This *in situ* definition was then married with discourse on innovation in scholarly literature. I sought to learn what models exist, and how our strategies and actions might have drawn upon those models and theories (or not).

Therefore, this work began with the identification of several different sources of innovation strategy and theory:

- international agencies;
- government, both provincial and federal;
- third party organizations (e.g., the Conference Board of Canada);
- independent think tanks;
- editorials and articles written by pundits and thought leaders;
- educational institutions and related initiatives;
- other perspectives (e.g., indigenous, non-profit, policy, and social innovation); and
- innovation theorists.

I studied the Federal and Provincial innovation strategies of the last two decades, reviewing these documents and then the resources that they themselves reference. I repeated this pattern of reverse-referencing with subsequent levels of references until these sources were saturated; that is, until new resources referenced the same sources I had already discovered.

In parallel, with each of the above categories, I used the Google.ca, scholar.google.com, and WorldCat Library search engines to unearth further reports, articles, and presentations. Finally, to ensure I had a robust catalog of resources, I again explored the citations of each of these items. Thus, I could be sure that I had achieved saturation when the primary resources of the material I was reviewing were items that I had included in my search already.

Inspired by meta-analytical approaches and grounded field theory, I reviewed each of these materials in search of statements on how the authors defined innovation, referred to the development of innovation capacity in people, or discussed how innovation is achieved (and how that included the development of human resources). I coded these statements and summarized the documents in turn, compiling synthesized perspectives on innovation at each of the categorical levels I describe above. This collection of research memos on these perspectives can be found in Appendix A.

While some of the documents I reviewed were hefty reports on many dimensions of innovation, much of their content did not discuss these aspects of definition, skills, or process. That said, these determinations were often difficult and therefore relatively arbitrary, or open to interpretation. For instance, could the Federal Government's *Seizing Canada's Moment* discussion of improving access to global markets have anything to do with improving our learners'

innovation capacity, through perhaps improving global and intercultural competencies? Definitely! Yet, in order to avoid having my coding system become too unwieldy to be useful, I focused on how these reports made *direct* reference to developing innovation capacity in Canadians instead of making inferential assumptions about indirect possibilities.

After I reviewed these perspectives, I went back through the items and my own notes, extracting and synthesizing the key concepts from each piece below. These concepts were collected into a set of takeaways from each perspective. The aim here was not to make shrewd decisions about what should not be included, nor to prioritize the different components of innovation capacity–that is certainly a route of future research. Instead, my coding method was catch-all, in the aim of developing a modular, holistic model of innovation capacity that encompasses anything that might be important to Canadian innovators.

Next, takeaways in-hand, I re-examined my findings in order to understand the dimensions of innovation these authors and organizations focused on. The data attributed to these different aspects were indexed via the visual database and systems mapping software, Kumu.io. This allowed dynamic and computer-aided visualization and filtering of the multi-dimensional data set. These data were further synthesized, resulting in a model of innovation that intersects each of the perspectives studied and connects the components of that model to a framework of innovation skills and competencies.

56 different potential inputs for innovation emerged as concepts from the initial coding and indexing of the data. These concepts were first pruned for relevance. Some were actually environmental conditions, for instance, such as competitiveness. In these cases, since it was unimaginable for an innovator to develop a skill or competency in "competitiveness", the nodes were deleted. Others were not explicitly a skill or competency but related directly to one, such as "New technology". In these cases, these concepts were transformed into a relevant skill/competency ("New Technology" became "Environmental scanning").

Next, concept mapping (cf. Kolko, 2010) was used to sort and collate the remaining 52 elements. If two of these elements were relevant to one another, they were connected until 13 distinct, indivisible constellations remained.

Note, however, that this was not an algorithmic process: another author might relate different concepts, for instance. Thus, this collection of skills and competencies deserves further scrutiny, an area deserving of future research.

Findings – Defining Innovation

The full account of the organizations and resources I examined may be found in Appendix A. Here, I summarize the lessons learned from each perspective. In each section below, I summarize the sources indexed by each perspective, discuss the aims and implications of the documents I examined, and finally I outline the takeaways in list format. These takeaways are mid-point syntheses, surfacing the ways innovation is discussed by each perspective in terms of definition, process, and the skills and competencies required in practice. In the discussion following these findings, these takeaways are further synthesized into a holistic model of innovation.

International perspective

The OECD's *Oslo Manual*, a guide to the collection and analysis of technological innovation data, has seeded many of the definitions and approaches to innovation I observed elsewhere. The *Oslo Manual*'s definition described technological and commercial innovation, suggesting that innovation can result in new products, processes, marketing, or organizational changes that are new to the world, new to the firm, or somewhere in between. The authors listed four domains of innovation capacity in business: the environmental conditions of the firm, the science and engineering base of the firm, the ability of the firm to draw information and skills from innovation, and the firm's "innovation dynamo": direct factors affecting the firm's innovation capacity, including its structure and the technological skills of its employees.

The other resources I examined from the OECD explored the skills required for innovation, though the result was a catch-all list of skills and capacities with little direction as to how they might be effectively practiced or used in the innovation process.

In a more recent report, the WEF elevated the significance of innovation, going so far as to suggest that the world will no longer differentiate between "developing" and "developed" nations, instead perceiving countries as either "innovation poor" or "innovation rich" (Schwab & Sala-i-Martín, 2013). In line with the OECD, the WEF continued to separate innovation into technological and non-technological categories. The WEF expanded on these differences, however, suggesting that the success of technological innovation depends on a number of factors underscoring the importance of R&D, science, and industry, while non-technological innovation depends on a country's organizational networks, the operations and strategies of firms, and the existence of innovation clusters. Finally, the WEF recognized the importance of diligence and intention with innovation, highlighting adverse effects such as unemployment and underemployment, cyberattacks, and the rise of social unrest potentially brought into the world by relentless technological innovation.

Takeaways for defining innovation

- Innovation process steps:

1. sourcing and selection of ideas;
2. development of innovation ideas;
3. testing, stabilization, and commercialization; and
4. implementation and diffusion.

- Innovation involves:
  - basic literacies, including language, numeracy, and digital literacy;
  - academic skills;
  - technical skills, specific to an occupation, tools, or processes;
  - generic skills (in which the authors subsume problem solving, critical thinking, creativity, the ability to learn, and the ability to manage complexity);
  - soft skills (occasionally grouped with generic skills, this includes communication, collaboration, motivation, initiative, emotional intelligence, intercultural awareness, and receptiveness);
  - leadership (in which the authors include team building, coaching, ethics, charisma, negotiation, and advocacy);
  - managerial and entrepreneurial skills (this includes commercial acumen, the ability to manage and take risks);
  - creativity and design (which the authors consider the generation of ideas and the transformation of ideas into products or processes, respectively–the authors link this to art and culture);
  - learning and R&D;
  - societal skills (especially making connections and collaborating with people within and between firms);
  - consumer skills (the ability to involve consumers in innovation processes);
  - global and intercultural awareness;
  - multidisciplinarity; and
  - "green" skills (related to sustainability and environmental responsibility).

National Perspective

Government of Canada

I examined seven of the Government of Canada's recent strategies and other official publications on supporting innovation in the country. The approach of the Federal Government has shifted over time, with different emphases in different strategies and no clear pattern. Most reports at least imply what innovation is–many borrow from the OECD's definition (described above; cf. OECD, 2005). Though many resources emphasized the importance of education and especially "high skills" and science, technology, engineering, and mathematics (STEM) training, no resource directly addressed how to improve innovation capacity in an individual learner and most seemed to take for granted the conversion of high skills and research output into innovation.

Takeaways for defining innovation

- Innovation involves:
  - domain expertise;
  - digital literacies;
  - STEM literacies (in those that emphasized the OECD's technological innovation approach);
  - entrepreneurship, or the commercialization of the innovation (particularly in those that emphasized the OECD's technological innovation approach);
  - regional and sectoral clusters;
  - creativity (particularly in recent years);
  - management of risk and uncertainty;
  - financing; and

- collaboration between governments, public institutions, businesses, and individual innovators.

Conference Board of Canada

The Conference Board of Canada regularly uses international data to compare the performance of Canada and its provinces with the performance of 15 peer nations (i.e., other nations considered "high income" by the World Bank with over 1 million people, over 10,000 square kilometres in land mass, and real gross domestic product (GDP) per capita greater than the average of those remaining nations). Two of the Conference Board's indexes are Innovation performance and Education and Skills performance. According to the latest reports on these indexes, the Conference Board focused on an economic/business/commercial and technological view of innovation. The reports tended to emphasize the role of high skills in innovation capacity, and one report in particular examined how public education can be configured to support Canada's innovation policy, but did not go into detail in describing what the skills provided by that reconfigured education system might be. The Conference Board's Centre for Business Innovation has released an Innovation Skills Profile (cf. Conference Board of Canada, 2013a), the components of which are detailed below.

Takeaways for defining innovation

- Innovation involves…
  - Creativity, Problem-Solving, and Continuous Improvement Skills;
  - Risk Assessment and Risk-Taking Skills;
  - Relationship-Building and Communication Skills; and
  - Implementation Skills.

Other National Perspectives

I sought out more perspectives on national innovation (and innovation education) from arms-length government reviews, think tanks, associations, and other pundits and critics, uncovering ten such resources. Among the most striking conclusions found in these reports was the notion that innovation may require a broader conceptualization than found in the traditional commercial R&D view. As well, education was recognized as a potential solution to Canada's innovation problem, but the Federal Government has little control over using education and Provincial governments may not realize the connection between innovation and education.

Takeaways for defining innovation

- Innovation involves:
  - broad knowledge with distinct expertise;
  - new knowledge integration with existing work;
  - new ways of knowing;
  - strong personal networks;
  - complex problem solving;
  - a proactive futures-orientation;
  - resilience, adaptability, and creativity;
  - meta-innovation in how we work and make decisions;
  - effective investment in new technologies and effective use of existing technology, human, and financial resources;
  - vision for new approaches;
  - commitment to both doing and using the products of research and development;

- the ability to manage itself, e.g., through strategy, business, and law;
- Managing innovation requires competencies (e.g., strategic business environment assessment, strategic marketing, competitive intelligence, intellectual property and regulatory strategy, etc.) that are underrepresented in established resource and manufacturing industries. These competencies enable enterprises and investors to take the shrewd risks that give rise to new, innovation-driven businesses and the high-value jobs that they support.
- multidimensionality, manifesting differently in social, economic, policy, and cultural applications; and
- human-centredness, enabling the inclusion and autonomy of the middle and lower classes.

Provincial Perspective

Government of Newfoundland and Labrador

The Newfoundland and Labrador Provincial Government has recognized the crucial role of the education system in the innovation performance of the province, although primarily as a driver of R&D and potential commercial technologies through research and partnerships between community, educational institutions, government, and business. Nonetheless, the Provincial Government recognized a gap in people's understanding of innovation, albeit with a "more education begets more innovation" approach.

Takeaways for defining innovation

- Innovation involves:
  - the seeking out of solutions;
  - decision-making and synthesis around new ideas;
  - risk management;
  - collaboration;
  - lifelong learning;
  - creativity;
  - confidence; and
  - the incorporation of multiple perspectives.

Conference Board of Canada

I returned to the Conference Board of Canada's Innovation rankings and Education and Skills rankings in order to focus more on the Conference Board's conception of NL. The rankings did not favour the province: NL performed poorly on many relative indicators on both indexes, placing fourth-last in Innovation and third-last in Education and Skills of 26 overall (as the cross-provincial ranking included the ten provinces alongside the 15 peer countries of the international comparisons). The province has had some relative strengths, however: entrepreneurial ambition and enterprise entry rates were strong, indicating startup activity in the province. In addition, the province's rate of STEM graduates and the income advantage of post-secondary attainment were also relatively high. Nonetheless, a weak educational foundation threatens NL's ability to educate on innovation.

Takeaways for defining innovation

- Innovation involves:
  - a process;
  - the creation of economic or social value from knowledge; and
  - the generation, diffusion, and transformation of ideas.

The Harris Centre

The regional development and policy office of the province's only University (Memorial University of Newfoundland), the Harris Centre, published two recent documents on innovation in NL. These reports recognized the important role community plays in fostering innovation, and vice-versa; thus, the unique geographic constraints of NL demand contextual strategies in improving innovation performance.

For instance, the small scale and social connectivity of many of NL's regions demands more connectivity and initiative from the innovators of those regions. These innovators need to find ways to unlock "hidden diversity" in the people they do have while finding ways to identify and access resources important to their innovation ambitions.

The reports highlighted the province's role in understanding and removing the limits to innovative growth in NL, helping innovators stay in the province and ensuring the return of the innovators who leave. The province's "brain drain" problem (the emigration of highly skilled individuals) creates a (potentially false) dilemma: do we want our innovators to be world-leading (and therefore to potentially leave the province), or do we want our innovators to stay (and potentially be limited in their potential to scale)? Residents who participated in the Centre's studies admitted to a lack of confidence in and knowledge about their innovation activities. Additionally, some regions face an innovation paradox–additional innovation investment in those regions is not always absorbed as the capacity to use that investment is not there. Based on these problems, some authors called for innovation education in their recommendations for a provincial strategy, including introducing K-12 and post-secondary innovation curricula.

Takeaways for defining innovation

- Innovation involves:
  - connecting with other actors, both within and between their industries and regions, in order to share knowledge;
  - building an innovative culture;
  - navigating governance, brokering partnerships, and building coalitions;
  - discovering and leveraging the hidden diversity in their communities;
  - being open to new immigrants, supporting their integration into the innovation community; and
  - effectively connecting to networks beyond their region.

Innovation Theory

I incorporated two literature reviews of innovation and the management of innovation. Researchers Fagerberg (2006) and Eveleens (2010) provided a comprehensive overview of the history of innovation theory and a summation of these theories on both innovation itself and the innovation process. They noted that the study of innovation has been deliberately cross-

disciplinary. Further, the economic discipline often encapsulated innovation in a black box, concerned only with its outputs – it is imperative to combine this economic understanding of innovation with other disciplines in order to capture the concept fully.

Innovation has been defined as the implementation and/or commercialization of an invention – thus, every innovation has an invention, but invention does not necessarily mean innovation. Further, innovation manifests in different types (product, process, supply, market, and organizational); classes (incremental, marginal, radical, and revolutionary), and contexts (new-to-the-firm, new-to-the-region, and new-to-the-world).

Finally, innovation has been defined as a process, but this is a continuous, systemic process. Innovation involves a number of interlocking actors and forces, and one innovation usually begets others, each of which must be evolved in parallel for the collective set of innovations to succeed. Innovators are constantly examining their ideas with existing knowledge and research in order to advance the innovation process.

Takeaways for defining innovation

- Innovation involves:
  - cross-disciplinarity;
  - the need to navigate uncertainty;
  - the need to move quickly; and
  - the need to defeat social inertia.
  - Innovation process steps:
  - Generation of and search for ideas;
  - Selection of which ideas to pursue;
  - Development and testing of the selected idea(s), internally and externally;
  - Implementation;
  - Sustaining and scaling up; and
  - Learning.

Other perspectives on innovation

Two final perspectives offered new ways of looking at innovation: Indigenous innovation and social innovation. Indigenous innovation has been defined as values-driven, resulting in particular kinds of improvement; and purpose-driven, pursued with a vision. It "isn't always about creating new things [and] sometimes involves looking back at our old ways and bringing them forward to this new situation" ("Indigenous Innovation Summit Report 2015," 2015). An Indigenous innovation restores Indigenous ways of life.

In parallel, social innovations can take many forms–principles, legislation, business models, interventions–as well as products, processes, marketing, supply, or organizational changes. In fact, a social innovation is often some combination of all of the above. So, as it cannot be defined by output type, a social innovation has been defined as "a novel solution to a social problem that is more more effective, efficient, sustainable, or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals" (Phills, Deiglmeier, & Miller, 2008). Social innovations can lead to shifts in society, empower stakeholders, and create new roles and relationships.

Takeaways for defining innovation

- Innovation involves:
  - values;
  - purpose;
  - cross-sectoral effort;
  - context;
  - openness and collaboration;
  - grassroots and bottom-up involvement; and
  - mutualism.
- Innovation process steps:
  - Prompts;
  - Proposals;
  - Prototyping;
  - Sustaining;
  - Scaling and diffusion; and
  - Systemic change.

Findings – Modelling Innovation

The perspectives examined here intersect with and differentiate from each other in myriad interesting ways. Across ten different categorical perspectives and almost 100 reports, strategies, and other documents, I find many commonalities and a few unique ideas that should not be cast aside. These commonalities and unique contributions can be tied together across several dimensions of innovation: **the innovation process**, **innovation orientations**, **innovation outputs and impacts**, **the innovation environment**, and **innovation skills and competencies**. Each of these aspects of innovation interlock, leading to different inputs, pathways, and outputs in every instance of innovation.

Innovation Outputs & Impacts

Let us begin our discussion at the "end" of the innovation process. What is the result of innovation? How have we conceptualized the outputs and impacts of innovation? Many authors have observed that innovations come in a variety of forms. Perspectives that celebrate technology and commercialization innovation emphasize products and processes; add those to supply, market, and organizational to get Schumpeter's original model. Social innovation perspectives acknowledge that innovations can also be social movements, legislation, principles, business models, and beyond. It seems fair to say that innovation is not restricted to specific formats or typologies, and so I will not adopt one here. Instead, innovation is any kind of deliberate change.

Additionally, as several reports have pointed out, innovations do not usually exist in a vacuum. The development, diffusion, and implementation of innovations usually require *other* innovations in order to succeed, or result in other innovations as side-effects. Thus, one output of the innovation process is parallel innovations: changes that need to happen in other forms and contexts in order for the principal innovation to reach maximum impact. Another is spillover innovation: innovation opportunities that develop or are recognized as a result of the impact of the principal innovation.

Innovations happen at different scales. As articulated in the *Oslo Manual*, there is a substantial difference between an innovation that is new to the world, new to a region or cluster, and new to a firm (Oslo Manual - Proposed Guidelines for Collecting and Interpreting Technological Innovation Data, 2005). They may also be radical, resulting in dramatic shifts and paradigmatic changes, or incremental, with a small change leading to small gains. Many authors have pointed out the value of cumulative incremental innovation, however, noting that focus tends to be on radical innovation despite the major gains that come from many small innovations over time (Fagerberg, 2006).

Finally, innovation often has "non-innovation" returns. The innovation process results in new knowledge for the innovator, at least, and in some cases for the world. As well, the collaboration and the trade of knowledge and skills between people and organizations

frequently required in the innovation process results in gains in social capital for the sectoral or regional clusters involved.

So, what *is* an innovation? I adopt the following definition, emulating the abstract parsimony of Osterwalder, Pigneur, and Clark (2010) in their definition of a business model:

An innovation is a change that creates new value or improves the delivery or capture of value.

Innovations exist in many forms, from product to social movement; at many scales, from new-to-you to new-to-the-world; and in many degrees, from radical to incremental. The success of one innovation often requires the success of others in parallel.

Innovation often results in new knowledge, relationships, and spin-off innovations.

Innovation Orientations

Different perspectives emphasize slightly different innovation inputs, processes, and outputs. The dominant discourse elevates commercialization and entrepreneurship; technology and "high skills" knowledge has long been the focus of science and technology strategies; meanwhile social and Indigenous innovation is piquing attention of late. These different approaches to innovation are not mutually exclusive, however. They rely on many of the same conditions to succeed, from supportive cultures to financing to trust and knowledge exchange.

Moreover, as noted by Moffatt and Rasmussen (2016), Fascinato et al. (2016), and other authors, there is a growing need to bring these approaches together to foster human-centred innovation. If an innovation is not "social innovation", for instance, does that make it antisocial innovation? Of course not! Many businesses accrue social value in addition to their commercial pursuits, and the growth of social enterprise is resulting in a host of businesses whose priorities include social impact. Likewise, a technological innovation–say, electricity, for example–will sometimes result in immense societal benefits.

In order to synthesize these separate approaches, then, I argue that innovators may have different **innovation orientations**. Different innovation orientations may approach the processes and goals of innovation in different ways, while relying on many of the same foundational inputs, skills and competencies, and environments. An innovator's outputs may be primarily of their orientation, but will often result in parallel or spillover innovations in other orientations.

Three primary orientations seem to exist:

Technology & Science

A technology and science orientation implies that the innovator's primary purpose is to create new knowledge or technology. These innovators are likely to ignore the adage "fall in love with the problem, not the solution". They will rely on the high skill, technical knowledge emphasized in classical R&D paradigms. They focus on radical, new-to-the-world innovations, and are likely to be more concerned with the functional development and diffusion of their innovations than the scaling or sustaining of them.

Social & Sustainability

Social innovators are focused on solving a social or environmental problem. Their innovation journey is likely to start with the prompt of a challenge they are passionate about. They are liable to pursue radical new-to-the-world innovations despite the intractability of the wicked problems they rally against. Their primary goal is nonetheless the societal and social impact their innovations will have, and whether they serve those who need the innovations the most. To that extent, social innovators are likely to keep the inclusivity and side effects of their innovations top-of-mind, and will pursue solutions that have a minimal environmental impact, too. Their primary concern is likely to be the scaling and diffusion of their innovations in ultimate pursuit of systemic change.

Thinking and practice about Indigenous innovation is only recently beginning to emerge. Indigenous innovation is potentially a subset of this Social & Sustainability orientation, focused on reconciliation and reconnection with Indigenous ways of life. A challenge of reconciliation, however, is the frequent subsumption of Indigeneity within other perspectives – perhaps elevating Indigenous innovation into its own orientation is worthy of future exploration.

Commercial & Entrepreneurial

Commercial and entrepreneurial innovation is primarily concerned with gaining and maintaining competitive advantage in a business, from discovering and designing products for new markets to improving supply chain or production efficiencies to organizational changes that improve employee productivity and beyond. These innovators are likely to pivot whenever an innovation process unearths a new niche they can potentially fulfill. They will emphasize a rapid innovation process, and within that process the sustaining of their innovations through commercialization. Key to the success of a commercial or entrepreneurial innovator is the creation and capture of meta-innovative knowledge: how, given their experience in the innovation process, can they improve upon their innovation processes or develop new innovation pathways?

A lot more can probably be discussed about these orientations. Indeed, much has been written about each of them in their own specific niches in the literature. Moreover these orientations may not be complete (or even correct), and there may be other important orientations that are missing from this collection (e.g., Indigenous innovation, cultural innovation). Nonetheless, the important takeaway from this discussion is the notion that these orientations differ, but they overlap and intersect. In our pursuit of innovation education, we should not separate them completely.

The Innovation Process

Many authors and organizations touched on innovation as a process, some implicitly and some explicitly. By intersecting these perspectives, I define a universal process that includes each of the ideas presented in the literature. The model I have developed is illustrated and explained below.

Broadly, innovation happens in three overlapping, cyclical phases:

1. Purpose, problem, and/or opportunity realization: Why, what, where, and when to innovate

Depending on the innovator's orientation and context, they recognize the cause for or need for innovation. This may come from the generation of an idea itself, the identification of a specific problem important to the innovator that they believe they can contribute to, or–as in social and indigenous orientations–inspiration from particular values or a broader purpose.

2. Selection: What to try

In the second phase, the innovator identifies options for their innovative pursuit and chooses which ones they will move forward with.

3. Realization: How to do it

In the third phase, the innovator attempts to put their idea into practice: building it, sharing it, scaling it up (or deep), and finding ways to sustain it.

Within the three phases of innovation are nine steps. While some skills and competencies are important across the process, some will be required especially in certain steps. The steps and phases of the innovation process help us to identify what aspects of innovation education are important for in different stages and contexts.

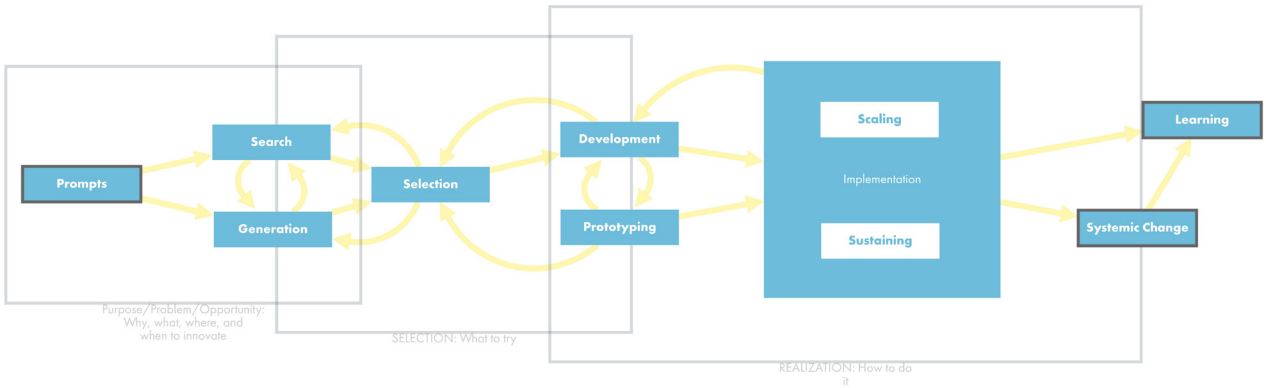


Figure 1. Innovation Process Model.

That these phases overlap and cycle is not to be understated: an innovator who begins with a specific solution-idea, for instance, may discover a more important problem through selection and implementation and therefore could restart the process over again. Likewise, discoveries during any of the phases may lead to new "child" or "sibling" innovation processes in order to develop spillover or parallel innovations (discussed in the innovation outputs and impacts section). Thus, pathways through the innovation process are rarely linear. Moreover an innovator may be working in multiple places at a given time, either in pursuit of one innovation or through the development of spillover or parallel innovations. So, the innovation process defined here is an idealized one.

Nonetheless, it is useful for an innovator to understand where they may be in the process such that they may know what they should do next and what to consider in order to move forward. This includes understanding their own innovation orientation, the innovation outputs they are prioritizing, the innovation environment they are working within, and which skills and competencies they may need to use or develop in order to succeed.

Some of these steps are optional and more likely to be pursued with different orientations, environments, outputs, and skills/competencies. Like the phases, they are cyclical. It is important to note that I have not included setback loops in this model: instead, I take it for granted that at any point in the innovation process, the innovator or the innovation may fail or the path may lead to a dead-end, at which point (should they wish to continue) the innovator must move backwards in the process and begin again at a different step. (Notably, this requires adaptability – one of the competencies described below.)

The nine steps in the process are:

Prompts

Not all innovators may begin with a prompt. A Prompt is the recognition of a problem or a cause worth innovating for, and is most relevant to innovators with a social or indigenous innovation orientation. Still, other orientations are not exempt from prompts: many famous scientists are known for their passionate pursuit of the natural laws, for example, and in this sense their pursuit of a variety of hypotheses according to the scientific method and the later dissemination of their theories follows the innovation process laid out here.

Search

Does a solution exist already that can be adopted or adapted into the given innovation context? In the Search step, innovators will seek out existing sources of knowledge and connections with others, collecting ideas on what innovation they will pursue.

Generation

In the Generation step, innovators come up with their own ideas to pursue.

Selection

Selection involves contrasting and validating an innovator's collected ideas in order to decide which to pursue through the rest of the innovation process.

Development

Development is perhaps innovation type-specific than other steps, involving the functional development of the innovation itself.

Prototyping

Prototyping involves testing and validating the innovation in real-world contexts in order to prove the innovation's viability, feasibility, and/or desirability (cf. Brown, 2009) before beginning full implementation or release.

Scaling

One of two components of implementation, Scaling means to propagate the innovation. "Scaling out" is what people typically mean by scaling: finding ways to diffuse the innovation and reach greater numbers (e.g., a process implemented in more factories, a product purchased by more consumers, or a policy adopted by more municipalities). However, Riddell and Moore (2015) outline two other types of scaling. "Scaling up" means to increase the power of the innovation, building the influence and impact (and in particular by influencing laws and policy). In other words, scaling up improves the innovation's efficacy. "Scaling deep", on the other hand, means systemic impact–shifting cultures, mindsets, and behaviours.

Sustaining

The second component of implementation. At the Sustaining step, innovators seek ways of ensuring the self-perpetuation of their innovation. For many, this means capturing value from the innovation's impact through commercialization or business development. Other methods might be encouraging the adoption of the innovation by other stakeholders or finding a philanthropic funder.

Systemic Change

Many innovations have lasting and/or ripple effects within their implementation environments. Sometimes this is necessary, as in Thomas Edison's efforts in the electrification of the US in the 19th and 20th centuries (Ventresca, 2011). At other times it may be unintentional, such as in the case of the creation of shopping malls (cf. Trufelman, 2015). In still other cases, it may be the entire point: many advocates for social innovation completely focus on systemic innovation (cf. Mulgan & Leadbeater, 2013). Thus, the Systemic Change step sometimes occurs after an innovation's implementation.

Learning

A final "optional" step is Learning. In Learning, innovators aspire to create new knowledge from their innovation and their innovation experience. This may mean meta-innovation, for example, changing the next innovation process undertaken by that innovator. It may mean contributing to existing knowledge bases about the technology, skills, or knowledge used in the principal innovation. Whatever the lesson, keen innovators seek to capture and (re) use the knowledge gleaned from the innovation process.

The Innovation Environment

Many aspects of the innovation environment play an integral role in the success of an innovator. I provide a brief overview of these environmental

factors to take into account in our model of innovation.

Authors in the reports and strategies studied here elevate the importance of sectoral and regional clusters: agglomerating social structures that tend to result in partnerships and knowledge sharing. These clusters are sometimes informal, existing before governments realize their potential and try to encourage their growth; in other cases they are the result of deliberate planning, policy, and funding efforts (Chatterji, Glaeser, & Kerr, 2013). The rising prominence of clusters is nonetheless a powerful indication of the strength of localized innovation environments.

From the perspectives surveilled here, a fertile innovation environment has three key ingredients:

Networks and relationships

Strong networks and mutual relationships between innovators facilitates the exchange of ideas. In fact, many perspectives see innovation as an ideally social activity, impossible without collaboration and partnerships. Some even argue that innovation is impossible if it is not pursued in parallel with your partners (Adner, 2012). Thus, innovation is most likely to occur and succeed in environments rich with networks between potential innovators.

Openness and trust

Bidault and Castello (2010) argue that partners can't succeed in innovation without enough trust – but that the same thing is true for too much trust. Authors focused on Newfoundland and Labrador specifically highlight the importance of openness and trust (Government of Newfoundland and Labrador, 2006; Greenwood, Pike, & Kearley, 2011; Hall, Walsh, Vodden, & Greenwood, 2014). A culture of sharing and openness is crucial to allow new ideas and different perspectives to emerge during the innovation process.

Financial, knowledge, and human capital

An innovator needs access to sufficient resources to explore and validate their ideas to succeed. Numerous perspectives have highlighted the crucial role access to financial, knowledge, and human capital plays in the success of an innovative cluster.

Innovation Skills and Competencies

The 13 distinct constellations of innovation skills and competencies synthesized from the data represent an initial collection of innovation skill **domains**. These domains are categories or disciplines of innovation practice.

In no particular order, they are:

- Collaboration, communication, and network building, which includes:
  - trust and community building;
  - network building;
  - relationship building;
  - political and bureaucratic acumen; and
  - communication.
- Design, which includes:
  - decision making and synthesis;
  - idea generation;
  - multidisciplinarity;
  - creativity;
  - critical thinking; and

    - problem finding, problem framing, and problem solving.
- Foresight and scanning, which includes:
    - proactive, futures orientation; and
    - environmental scanning.
- Vision and purpose, which includes:
    - strategic thinking and strategy development; and
    - visioning and goal setting.
- Initiative and learning, which includes:
    - motivation and initiative building;
    - self-directed and lifelong learning; and
    - continuous improvement.
- Ethics and responsibility, which includes:
    - ethics;
    - values; and
    - inclusivity.
- Adaptability and resilience.
- Risk and uncertainty, which includes:
    - risk taking;
    - management of uncertainty; and
    - risk assessment.
- Empathy, which includes:
    - appreciation of diversity;
    - finding hidden diversity;
    - intercultural awareness; and
    - emotional intelligence.
- Literacies and domain expertise, which includes:
    - basic literacies;
    - academic skills;
    - technical skills;
    - STEM literacies;
    - digital literacies;
    - contextual knowledge; and
    - domain expertise.
- Management, which includes;
    - meta-innovation;
    - resource management, including financial, material, and human capital;
    - management of complexity;
    - strategy execution; and
    - administration.
- Business and financial acumen, which includes:
    - financial literacy;
    - business operations;
    - commercialization and entrepreneurship;
    - market analysis; and
    - consumer skills.
- R&D:
    - context-specific implementation skills;
    - research and development skills.

At first glance, this list is not that different from the laundry list of skill groups developed for the OECD's (2011) *Skills for Innovation and Research*. The differences are nonetheless significant. First, the OECD's approach emphasized the technology and commercialization lens traditionally championed by the OECD. The list above is inclusive of the skills and competencies identified by the OECD with that lens in mind, but it also takes other innovation orientations into account. Second, where the OECD's categories are broad and impractical (e.g., "general skills" and "soft skills" are two ill-defined groups), the model above provides precision while remaining holistic.

These skills and competencies are sufficient but not wholly necessary for innovation. Different contexts, steps in the process, orientations, and outputs will require different subsets of these skills. In other words, a given innovation or innovator may not require all of these skills to succeed. That is why another affordance of this model is that, in the context of this research, I can tie these skills and competencies directly to the innovation orientations and the innovation process.

The relationship between skills, orientations, and process can be explored in the interactive

model developed using kumu.io at https://kumu.io/systemicdesign/innovation-learning-model. For each step in the process, I identify the most relevant skill or competency domain and orientations. This results in mutually defined relationships–thus, each skill or competency domain is linked to particular steps in the process and the innovation orientations. The interactive model allows users to showcase how different orientations or domains emphasize different parts of the process, and vice-versa.

This is an early model deserving of theoretical and empirical critique. It is certainly still a question as to whether some crucial skill or competency is missing from this list – I don't know what I don't (yet) know. Also, as suggested previously, other interpretations of the data and source material might yield different results. Further study of the model is an area for future research.

Case studies with innovators, for instance, might explore whether their success require skills or competencies that have not been outlined above, or whether they invoke them where and when I hypothesize they will. It may be possible, too, to recognize which skills or competencies are the most important to a given innovator, and therefore to develop a hierarchy within our skills model.

Additionally, each of the skill and competency domains I identify here have their own histories of research and theory. This model would be strengthened by an exploration into these literatures, critiquing the domains; refining the definition and scope of each domain; and populating the specific methods, tools, and techniques contained within them. Unfortunately, that research is outside of the scope of this paper, and so I leave it to the next researcher to pursue.

Discussion

I present one potential synthesis of the ideas and concepts this research unearthed, but doubtlessly there are other interpretations of the data and even the source material the data was mined from. Thus, the model developed here deserves further scrutiny, and I invite other authors to examine my conclusions and provide their own.

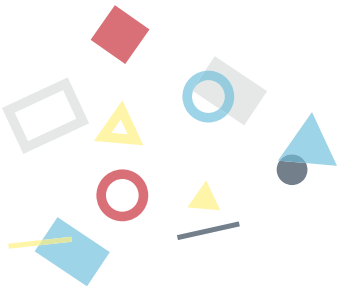
Nonetheless, this contribution is significant. Across the nearly 100 papers, reports, strategies, and presentations reviewed in this research, dozens called for education reform for innovation learning. Many authors held innovation education up as a core solution to Canada's innovation conundrum. Still others focused pieces of work entirely on how to do this. Yet, none – zero! – offered a holistic model of what innovation education was. Thus, this work is, in some ways, an "Innovation 1000", providing a foundation on which to build up our innovation education capacity.

The model seems intuitively intact. It offers substantial content for the purposes of the present research, at the very least, with a litany of potential innovation skills and competencies to develop in Canada's learners. That is the subject of the next section of this paper: what might a curricula and pedagogy for innovation education look like?

Part Three: Innovation Education

How might innovation be learned? The model of innovation developed in Part 2 is used to inform learning constructs and learning outcomes – outcomes that can later be used to develop pedagogy and assessment; a model of innovation education.

- *How does one become an innovator?*
- *What are the skills or learning outcomes required for innovation?*
- *How are these skills applied to the innovation process? How are they applied in different innovation orientations?*



Introduction

In this section, I connected the model of innovation skill and competency domains developed in part two to a variety of learning constructs and some potential outcomes that translate easily to teaching and learning activities and methods of assessment. I used theory on curricula and instructional design to inform this process, developing the domains of innovation skills and competencies with the capacities required to practice those skills. The result is a comprehensive model of innovation education that may be adopted to provide curricula on innovation education.

As explored a little in part 1, I am not the first to explore these ideas. The OECD has dedicated a whole Centre to education and innovation. Unfortunately, their definitions are grounded in the commercial and technological perspective trumpeted by the *Oslo Manual*. Further, Toner's (2011) exploration of innovation skills was chiefly economic. Their approach was to encapsulate what innovation skills might be in an undefined model, leaving it up to the nations under study to train "skilled" innovators Thus, Toner (2011) focused only on different economic trends that result in those nebulous "innovation skills". The *Skills for Innovation and Research* report, on the other hand, offered a rich collection of potential skills and competencies to include in a model of innovation learning, but did not attempt to build those skills and competencies into a model that articulates how they relate or contribute directly to the innovation process – much less how a learner might develop them (OECD, 2011). Robert Luke, now VP Research & Innovation at OCAD University in Toronto, also focused on innovation skills through a paradigm he calls "innovation literacy":

> **The ability to** think creatively, evaluate, and apply problem-solving skills to diverse and intangible issues within industrial problems and multidisciplinary contexts. (Luke, 2009)

Luke especially highlighted the potential of colleges and polytechnical institutes to offer innovation literacy. In fact, his call for innovation literacy was an answer to the same conditions that prompted the present research, offering a logic model that connects innovation education with pragmatic benefits to graduates and business alike (Luke, 2013). However, this notion of innovation literacy was rooted in the same commercial and technological approach of the OECD that so many others have been, and the skills of Luke's innovation literacy were not (publicly, at least) enunciated further than the definition offered above.

Thus, there has been a demonstrated interest in the skills and competencies of innovation, and there is still room to contribute a robust and well-defined model of innovation education. Below I develop such a model with reference to literature on instructional and pedagogical design. Note, however, that I am not a formally trained educator. This model for innovation education is offered as a draft that deserves greater scrutiny and further iterations before being placed into practice. Still, it informs the next chapter of this paper in which I assess how the system currently provides these learning constructs (if at all) while seeking new opportunities to introduce them into the education system.

The term "learning construct" has been used to refer to both the end-state of learning and the process (Kraiger, Ford, and Salas, 1993). A learning outcome, meanwhile, has been ascribed to an achieved state or proficiency of learning (Biggs, 1999). Here, I used the term "construct" to refer to the different aspects of the innovation skill domains developed in part two. In other words, learning constructs are the ultimate skills or competencies for each domain. Learning outcomes, meanwhile, are examples of the achievements required to perform in that construct. Thus, domains, constructs, and outcomes form a hierarchy, as illustrated below.

I must also discuss what effective learning outcomes look like. Biggs (1999) expanded on the notion of outcomes, arguing that learning outcomes should be seen as a function of students' activities, not the fixed characteristics of the learnings themselves. An educator's role is to organize the teaching/learning context such that all students will use higher order learning processes in their study. Biggs suggested that this is achieved by aligning the components of an educational experience for this purpose: objectives should describe the kind of understanding we expect from students, the learning context facilitates the learning activities that are likely to achieve those learning outcomes, and assessments explicate to students what is required of them while effectively informing the educator about how the learning objectives have been met.

To this end, Biggs (1993) offered a hierarchy of verbs that may be used to form increasingly higher-order learning outcomes, a host of teaching and learning activities and how they result in different forms of learning, and a set of assessment modes along with the kinds of learning those assessments can test. This learning architecture was originally articulated by Biggs and Collis (1982) as the Structure of the Observed Learning Outcome (SOLO) taxonomy, widely adopted in instructional design today (Gilchrist, 2015). In the taxonomy, *unistructural* learning outcomes describe when a concept or procedure is learned and identifiable. *Multistructural* learning is when a concept is expanded upon, becoming describable by the student. *Relational* learning is when students are able to structure and restructure knowledge themselves, applying their ideas to different contexts. Finally, *extended abstract* learning is when a learner begins to extend and abstract their knowledge independently, applying concepts to new problems and domains. Articulating learning outcomes according to this model gives us a tiered structure of learning: students will develop their capacity from unistructural through to extended abstract learning outcomes as they become more capable of practicing that learning construct.

Methods

With these frameworks in mind, I proposed a comprehensive set of learning constructs defining the skills or competencies that make up each of the innovation skill domains identified in part two. Then, for each learning construct, I developed a set of learning outcomes at multiple levels of the SOLO taxonomy. These outcomes, constructs, and domains then comprised a complete model of innovation education.

I used sensemaking to generate these constructs and learning outcomes from the innovation skills domains identified in part two. Sensemaking is "a motivated, continuous effort to understand connections … in order to anticipate their trajectories and act effectively" (Klein, Moon, & Hoffman, 2006). Kolko (2010) included sensemaking with abductive thinking in a methodology for design synthesis – the development of cohesive insights and solutions to design problems. Thus, sensemaking offers the tools necessary to comprehend and create these ideas at the same time. Of particular use in this study was the concept mapping technique, in which a designer scaffolds knowledge through visualizing and re-organizing mental models, shaping those mental models as they are being illustrated. In a concept map, entities are linked to other entities through relationships in order to understand the connections between those entities (Kolko, 2010).

The 13 domains of innovation skills and competencies identified from part two are listed below:

- Collaboration, communication, and network building
- Design
- Foresight and scanning
- Vision and purpose
- Initiative and learning
- Ethics and responsibility
- Adaptability and resilience
- Risk and uncertainty
- Empathy
- Literacies and domain expertise
- Management
- Business and financial acumen
- R&D

Recall that these domains were synthesized from many subcomponents in part two. Thus, for each of these domains, I enumerated these subcomponents and then, with concept mapping (cf. Kolko, 2010), generated a list of learning constructs from those subcomponents

First, however, I noticed that one of these domains is not like the others. The "literacies and domain expertise" domain–while as distinctly important as the other domains in the model–was not easily described in terms of learning constructs and outcomes. *Literacies and domain expertise* was found to be itself a superset of many other learning constructs, some of which were arguably predecessors of the other innovation learning constructs within the innovation education model (e.g., basic literacies, academic skills, and digital literacies). The other

components of this domain are circumstantial: technical skills and domain expertise were impossible to explicate in a learning construct as they depend on the innovation being pursued. For these reasons, I included this domain as the core of the model, and I did not lay out learning constructs or outcomes for it. This structure is visualized below.

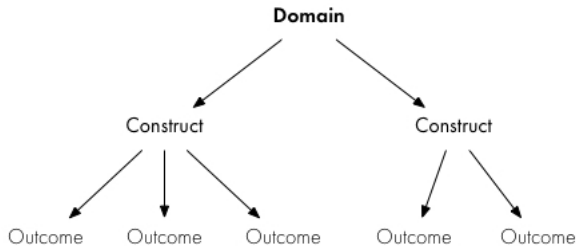


Figure 2. Domain, constructs, and outcomes hierarchy.

For the remaining twelve domains and the learning outcomes I generated, I used the SOLO taxonomy described by Biggs and Collis (1982) to inspire learning outcomes at different levels of proficiency. For instance, the "Trust and community building" aspect of **Collaboration, communication, and network building** included outcomes such as "Identifies cluster-like innovation communities" (which would represent a lower understanding of innovation communities) and "Analyze strengths and weaknesses of their communities" (a higher level of proficiency) within the *Community building* learning construct.

Findings

This process ultimately resulted in a hierarchical structure of innovation skills and competencies. At the highest level is innovation itself – the process, orientations, and outcomes defined in part two. Next are the 13 domains of skills and competencies practiced in innovation–at the core of which are literacies and domain expertise. These domains are then broken down into learning constructs. Constructs are subdivided into learning outcomes at different levels of understanding indicating proficiency in those constructs. This model includes 223 learning outcomes across 47 learning constructs in 12 different domains of skills or competencies.

This is a criterion-referenced instructional design: as described by Biggs (1999), structuring these outcomes as enactable verbs makes it easy to choose imagine approaches to pedagogy–students engage in activities that help them enact the verbs–and to choose methods of assessment.

The final set of domains, constructs, and learning outcomes is visualized interactively at https://kumu.io/systemicdesign/innovation-learning-model#domains-constructs-and-outcomes and described in full in Appendix B.

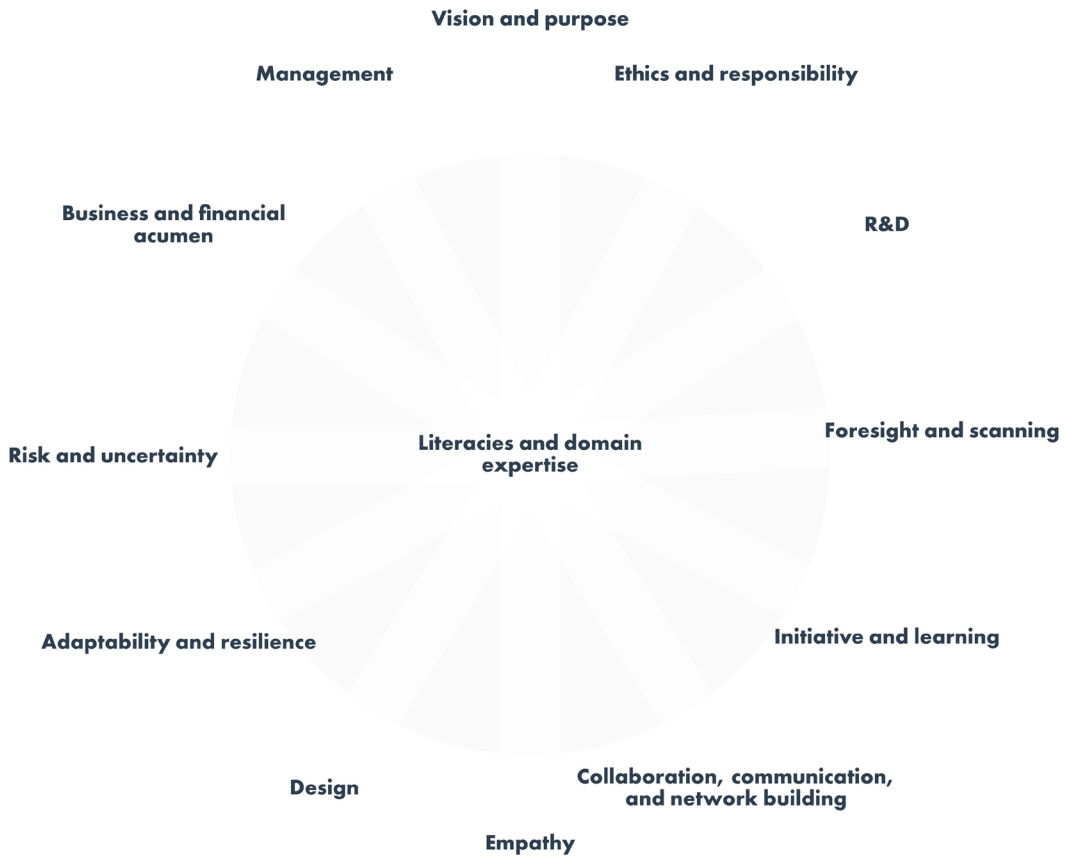


Figure 3. Innovation Domains.

I expected that after completing the process there would be substantial overlap of constructs between domains and of outcomes between constructs. However, that is not the case. This is because it was intuitive to prune redundant outcomes and constructs as the conceptual mapping process unfolded. The result is a robust set of well-defined outcomes without circular logic.

The interactivity of the model allows educators and policymakers to focus on the components that are important to them. Someone exploring the model can, for instance, filter the outcomes and only look at examples of unistructural learning, thus revealing a set of early and easier-to-access activities for an innovation learner to engage in. Users may also opt to focus on the domains emphasized by different innovation orientations, such that an innovator focused on one or the other can see what they might be able to improve in – or, on the other hand, an innovator who wants to explore options in a new orientation can examine the domains they haven't traditionally practiced.

Finally, the innovation process defined in part 1 was also added to the interactive visualization. This way, users exploring the model will see which aspects of the process are most important to which skills, and vice-versa.

Discussion

I have defined a model of innovation education, derived from a model of innovation that is itself distilled from a variety of perspectives on innovation, particularly those focused on the Canadian and Newfoundland and Labrador context. This is a robust collection of concepts providing educators and policymakers with a framework for assessing and improving innovation education in Canadian education systems.

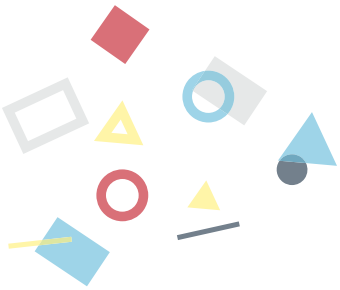
This model requires validation, however. How well do these domains, constructs, and skills represent the concepts behind them? Are any components unnecessary or redundant? Is anything missing? Are they disordered, or could they be better organized to inform pedagogy and curricula development? These are all good questions, unanswerable in the scope of the present research. Further research should explore these questions.

Nonetheless, this model provides a lens with which I can view the education system's current capacity to provide innovation education. In the next chapter, I begin to map the education system using systems thinking techniques. I explore where in the current system education on these domains, constructs, and outcomes might be provided – and I suggest systemic opportunities for introducing more innovation education into our systems.

Part Four: Systemic & Process Design of Innovation Education

Part four focuses on the challenges of education reform. Many proponents of change are currently working towards reform or have tried and failed. In this chapter, I aim to understand the systemics of education reform in order to inform strategies to improve Canada's capacity to deliver on the innovation education model developed in part three.

- *How does our current system provide innovation education?*
- *Who influences the student at the centre of this process? What are the steps a typical student takes throughout their innovation education journey?*
- *How might we provide more innovation education for Newfoundland and Labrador learners?*
- *What are the mechanisms of education systems change?*
- *How might we use systemic design to power a reform movement?*



Introduction

With a robust model of innovation education in hand, I turned to examination of the education system itself. Since innovation happens already, we must become capable of practicing innovation through the existing system; what are the sources of innovation education in the present day? More importantly, though: are there opportunities to shift pedagogy, curricula, or experiences such that Canadian students become better innovators? Finally, accepting the increasing importance of innovation in the 21st century, are there ways to pivot the culture of education as a whole to emphasize innovation more?

First, however, I acknowledged the complexity latent in the ambition of these questions. As Mehta, Schwartz, and Hess (2012) began their book on the subject, "if we keep doing what we're doing, we're never going to get there." Traditional education reform approaches have depended on a best practices approach in what is glibly called a "silver bullet culture". A single idea, found successful in a specific institution or district, becomes hailed as the be-all-end-all solution. This solution is then celebrated and championed across contexts until actors realize that expected results have not materialized, and reformers move on to the next silver bullet solution. This approach to education reform has not worked: "If we are to deliver transformative improvement, it is not enough to wedge new practices into familiar schools and districts; we must reimagine the system itself" (Mehta, Schwartz, & Hess, 2012). In other words, education systems change has been found to be more than difficult–it is a wicked problem: ill-defined, constantly fluxing, with many conflicting stakeholders and no true solutions (cf. Rittel & Webber, 1973). How can we provoke change in wicked problems?

I argue that reforming education is a sociotechnical problem, involving human psychology; social, political, and economic factors; and complex interactivity–what Norman and Stappers (2015) call a "DesignX" problem. These authors suggested that DesignX problems can only be solved through a process of muddling through, developing incremental sub-solutions through deep analysis. This deep analysis means partitioning the problem into modules and recognizing the intersecting dimensions of the problem.

Jones (2014) provided further advice for this kind of problem solving, defining an approach called systemic design. Systemic design integrates systems thinking and systemic methods–ways of understanding complex problems through the relationships of the phenomena and actors involved–with design thinking and design methods, applying human-centred design to these seemingly intractable, large-scale problems. Thus, with systemic design, we use "known design [tools] – form and process reasoning, social and generative research methods, and sketching and visualization practices – to describe, map, propose, and reconfigure complex services and systems" (Jones, 2014).

With this in mind, I turned to two types of modelling in order to use systemic design on the complex problem of education reform.

Process modelling has been defined as a method of explicitly illustrating reality in order to support complex design activities (Krogstie,

Sindre, & Jørgensen, 2006). By developing and reviewing process models of education, I am able to understand where and how a user of the education system–our students or our educators–interact with the system in order to teach or learn. Thus, in this section, I developed some process models of education in NL. These models helped to see opportunities for increased innovation teaching or learning from the perspective of our students and educators.

While process models helped us to understand an individual's experience within a system, I needed other tools to illustrate the system itself. Here, I adopted Meadows' (2008) definition of a system: a set of things whose interconnected relationships lead the whole system to produce its own internal dynamics. In the case of education, however, the system obviously involves people–and for that reason I also invoked Gharajedeghi's (2011) characterization of systems. Systems are open, purposeful, multidimensional, emergent, often counterintuitive, and take place at the intersection of technology and culture. Finally, Levin's (2002) description of complex adaptive systems also fits here: a complex adaptive system is made up of diverse, individual, autonomous components whose localized interactions are autonomously enhanced or suppressed by supercomponents in the complex adaptive system hierarchy.

Thus, in understanding the complex adaptive system of education, I sought to understand the subsidiary and supraordinal variables–and more importantly, the relationships between them–in a way that allowed me to identify intervention points within the system. My aim, then, was to be as simple as possible in our description of the system (but no simpler); to represent the system dynamically and prescriptively, not statically and descriptively; and to embrace uncertainty and unpredictability (Holling, 2001).

So, although discussions of the education system have often referred to exactly that–the education "system"–in this paper the choice of word is deliberate. However, as outlined by Jones (2014), systemic design cannot be practiced without making boundary judgments nor achieving requisite variety. The former refers to ensuring a flexible frame of the problem at hand, allowing the systemic designer to iteratively and creatively muddle through problem solving. The latter means having a holistic representation of the potential system-to-be-designed at hand during the process of systemic design. Therefore, I needed a robust but well-bounded understanding of the education system before I could continue in this process.

In most discussions of the education system, the mental model most people adopt is likely the structures and curricula of the public education system. Remember, though, that I am interested in a specific type of education: innovation education. As exemplified by Stauch and Cornelisse's (2016) cross-country survey, potential sources of innovation education are found in many places, some outside of the existing public K-12 and post-secondary programs. Thus, in pursuit of an effective boundary frame and to achieve requisite variety, I developed a broader definition of the education system for this research. I needed to ensure that my mental model was broad enough to include all significant opportunities for innovation education. Thus, I included additional actors and influences in my

conceptualization of the education system–not just schools, but after-school, leadership, and recreation programs too, for example.

Finally, sensemaking provided me with the methods needed to understand and conceptualize models of the system, following a similar approach as the sensemaking process described in part three. Crucially, Kolko defined the synthetic process as an iterative one that requires "perseverance"; thus, it took several steps before I could be satisfied with my characterization of the system. Gharajedeghi (2011) also offered a stepwise process and a set of dimensions useful for understanding systems. Thus, I combined these methods of synthesis and systemic inquiry in an iterative process to develop a holistic picture of the system of innovation education in NL. Through this modelling, I aimed to understand the system's leverage points–accessible points of strategic opportunity through which we may efficiently create systemic change (Meadows, 1997)–in improving innovation education in the province.

Methods

I sought out government reports and other literature that discussed the provincial education system's components and learning outcomes for data with which to populate the following models. This data, discussed below, was used to inform the development of process models of potential innovation education pathways for a student in NL, and systemic models of how that education is shaped and provided by educators and decision-makers. As suggested by Kolko (2009), Gharajedeghi (2011), and others, these models were developed iteratively, using design synthesis to draw out insights from one iteration with which to reframe and inform the next.

I began with the structure detailed by the Canadian Information Centre for International Credentials (2016), modelling the base stages that a student will likely take throughout their education and career (primary, elementary, intermediate, and secondary school, then career and work) and adding a variety of other activities they might engage in along the way (sports and recreation, hobbies, after school programs, self-directed learning, volunteer and extracurricular work, governance and leadership roles, university programs, and college).

I then used public curriculum guides and learning frameworks to map these activities with their expected learning outcomes, where those learning outcomes intersected with the constructs and domains identified in part 3 ("College of the North Atlantic - Programs & Courses," n.d., "Vision, Mission, and Core Values of the University," 2013; Department of Education and Early Childhood Development, 2016; The MUN Teaching and Learning Community, 2011).

Unfortunately, no database, strategy, or report offered insight for many of the activities I mapped, leaving only a sound articulation of the expected outcomes for the public K-12 school system, the College, and the University. I postulated that these unmapped activities are nonetheless important contributors to the experiential growth of our students, but without sufficient data, I was not able to examine their potential outcomes, and thus left them to be explored in future research. For the present discussion, I removed these activities from the map.

Another difficulty was found in mapping the complicated pathways of university education. The University's program offerings are quite comprehensive, and there is substantial versatility in many of these programs through different mixes of majors, minors, electives, and so on. Thus, I did not attempt to map expected learning outcomes for specific programs, and indexed only the University's Teaching & Learning Framework graduate outcomes. This versatility was not insignificant, however: some electives exist, for example, in entrepreneurship. Likewise, co-curricular programs offer leadership and collaboration experience. As these types of activities will not impact most students, they were not discussed here. Similar (though more rare) variance may occur in different K-12 schools (where instructors sometimes teach custom courses) and the College (between campuses and specific degrees). Here, however, I focused on how to improve innovation education across the board. Therefore I did not examine these optional pursuits. Further research should

explore the rich details of the system.

After indexing these learning outcomes, I examined each and attributed them to different components of the innovation education model defined in part 3. The result was an interactive map that showcases where the system was programmed to offer innovation education according to the different domains and learning constructs I have identified. An interactive version of this process model can be explored at https://kumu.io/systemicdesign/nl-education-system-mapping#education-process-modelling.

I next mapped the actors of the system using the data described above, and the result is pictured below. This process followed the methodology described by Gopal and Clarke (2015). Beginning with the actors included in the data, I identified key actors in the education system influencing a students' education. These actors then became prompts, allowing me to articulate additional supersets of actors and influencers. Many of these no longer directly influenced the student, but instead were strong influences on those that did. Once the map seemed saturated, it served to inspire the next phase of systems mapping.

Next, I used Gharajedaghi's (2011) "formulating the mess" approach for deeper analysis. In the *Searching* phase of formulation, the actor map developed above was used to inform the structure, function, and process of a refined systems model that more discretely indicated the nature and direction of the relationship between different actors. Further, I defined connections by the dimensions of wealth and power, two of Gharajedaghi's (2011) five systemic dimensions. These dimensions helped to illustrate how the map changes depending on which of these values you are interested in examining. After several iterations of development, this new map reached saturation.

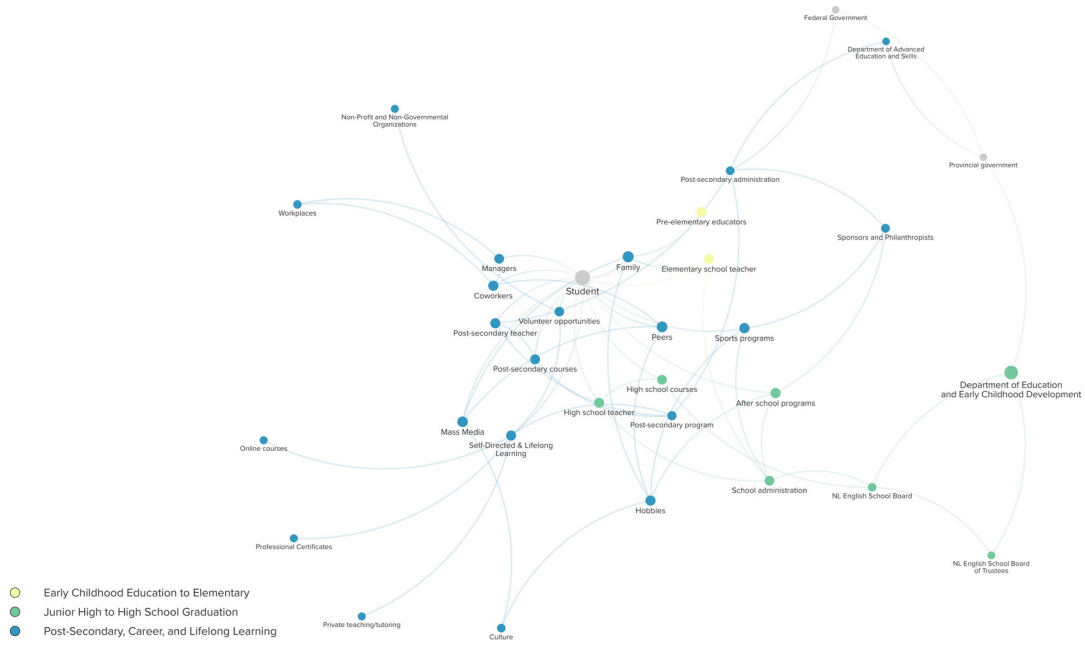


Figure 4. Basic map of the actors influencing students in Newfoundland and Labrador.

Second, according to Gharajedaghi's (2011) approach, I used the refined actor map to develop a causal loop diagram centred on the provision of innovation education in the province. I used concept mapping to develop from each stakeholder of the actor map phenomena affecting the delivery of innovation education in NL. These phenomena were defined and mapped, and salient feedback loops and systemic archetypes (patterns of system behaviour observed in different systems with similar consequences and potential solutions) were identified.

Finally, on both the actor map and the causal loop diagram, I used centrality analytics built into Kumu.io to uncover leverage points and bottlenecks in the elements of these systems. There are many types of centrality analysis. These tools, adapted from social network analysis, algorithmically examine the flow of connections in a systems map in order to detect how each element might influence the others. In each case, the size of an element in the map is scaled according to the resulting centrality ranking, revealing a visualization of each element's centrality in the context of the whole system.

I applied several metrics to these maps:

- *Reach efficiency* takes an element's *reach* (the proportion of the network within two steps of that element) and divides it by the number of neighbouring elements it has. Elements that score the most on this metric tend to be less connected but have high exposure to the rest of the system, making them low-hanging fruit for change efforts.
- *Betweenness* assesses the number of times an element lies on the shortest path between two other elements. Elements high on the betweenness metric are bridges throughout the map, controlling the flow of phenomena throughout the system. This means that these elements may be bottlenecks or single points of failure.
- *Eigenvector* centrality measures an element's connectedness to other well-connected elements, computing an overall value that is an indicator of the element's influence over the whole system.

Now, in order to complete Gharajedaghi's (2011) third step and tell the "story" of the system, I will discuss the findings from these models and this analysis.

Findings

The data

As noted previously, the Canadian education system is not governed federally. The provinces have ultimate jurisdiction over how their school systems work, and while differences exist between the provinces and the territories, the systems are generally similar (Government of Canada, 2009). The Canadian education system is often defined in terms of three major components: K-12, post-secondary, and adult learning (cf. Conference Board of Canada, 2013b; Conference Board of Canada, 2014). K-12 and post-secondary education can be further subdivided: K-12 into primary, secondary, intermediate, and high school in the NL system (grades K-3, 4-6, 7-9, and 10-12, respectively) and post-secondary into a variety of different degree types depending on the length and intensity of study. Exactly what subjects are taught when, at which age(s) students attend which grades, and other differences exist between the provinces. The Canadian Information Centre for International Credentials (2016) offered its own process models of how students proceed through their respective systems in each province/territory. The Council of Ministers of Education, Canada, additionally provided a detailed examination of what these differences are ("Education in Canada: An Overview," n.d.).

Exploring those differences and mapping separate systems would be an ambitious pursuit, falling outside of the scope of the present study. Instead, I focused only on the Newfoundland and Labrador English public system. The way students flow through the NL system, in terms of a process model and duration of study, is paralleled almost exactly in 9 other provinces and territories (Canadian Information Centre for International Credentials, 2016). However, the nature of the NL system makes it simpler than most other provinces: NL has only one public University, one public College, and one English School Board (Bartlett, 2013; Advanced Education and Skills – Government of Newfoundland and Labrador, 2016). I will return to discuss the curricula and programs of this system later.

In addition to NL's public education system, I hypothesized that students learn innovation skills and competencies from other sources as well. As suggested above, this could ultimately include the whole of a person's experience. However, no research seemed to exist on what these sources might be and how they contribute to innovation education. Thus, this study focused on the public education system and the learning outcomes articulated within that system.

Process Modelling

The notion of innovation itself as a learning outcome appears rarely throughout the public system. This is not surprising: as I have discovered in parts 2 and 3, innovation is quite complex. That few parts of the system suggest otherwise could indicate several things: this complexity is recognized implicitly by educators in the province, innovation is not valued as an education outcome, or that instructional design for teaching and assessing innovation learning is not available. Still, the term itself appears in a few

places: as an outcome of the high school physical education program, the high school enterprise education program (not surprising, considering the common conflation of entrepreneurship and innovation), and in the University's values. The latter, notably, asserts that the University itself is innovative–not that every student is.

The interactive map allows the user to showcase where in the system different domains and learning constructs are taught. The discernment reveals some concerning discoveries. First, while the map looks populous before showcasing, focusing on any given domain of innovation skill reveals sparsity. This indicates that our system does offer some deliberate innovation learning, but it is not a dedicated effort. A second discovery is that of the 47 learning constructs included in the model of innovation education developed in part three, five are not taught at all: meta-innovation, cultural and political savviness, management of complexity and systems thinking, ethnography and human factors, and scenario development. Are these constructs absolutely necessary for innovation? Probably not, but it is easy to imagine how students' capacity to broker new partnerships might be strengthened if we taught more about how to navigate cultural and political nuances (for example).

Three domains–foresight and scanning, vision and purpose, and adaptability and resilience–are each connected to only two learning outcomes in the public system. The lack of futures thinking is echoed by a previous author (Satterthwaite, 2015). This may have a direct impact on students' innovation capacity–by hampering their ability to take advantage of Drucker's (1998) sources of innovation through scanning, for instance. Likewise, an absence of education on developing and pursuing vision and purpose relates directly to whether students discover innovation prompts (the first stage of the innovation process defined in part 2) or can envision and plan for long-term, complex goals. Further, if our students are not capable of adapting or resolutely pursuing their purpose, they may undertake the innovation process only to give up when they inevitably encounter barriers.

Learning outcomes corresponding to the management domain are mostly found in the college curricula–particularly under programs in the area of business. Doubtlessly some aspects of management are taught throughout specific University programs as well. Either way, this implies that most students in the province fail to learn much about the management learning constructs unless they enrol in post-secondary studies. Even then, they may only pick up these competencies if they undertake specific programs.

Process mapping also reveals several important–but under-researched–potential sources of innovation education. These include school and sports programs, hobbies, volunteer work and governance roles, and self-directed learning. These sources must contribute to innovation learning somehow, but exactly how is not obvious. Still, they offer potential fulcra for levers of change: should I identify particular hobbies or recreation programs that foster learning in the domains of innovation skills, for instance, policymakers might offer incentives for parents to enrol their kids in them. Thus, these

arenas of education deserve more scrutiny in future research.

Systems mapping

Actor mapping

The initial actor map offers a simple picture of the components of this system, illustrating the complexity by defining the sheer quantity of actors influencing a student's learning. An interactive version of the refined actor map can be found here and is pictured below: https://kumu.io/systemicdesign/nl-education-system-mapping#nl-education-system-actor-mapping.

This actor map offers further insights when refined and analyzed through Gharajedaghi's (2011) iterative process of inquiry and multi-dimensional analysis. In the refined map, it became clear that the most prolific pathways between actors were wealth and power. This is intuitive: the governance of the other dimensions (beauty, or what we find joyful; knowledge, or what we find true; and values, or what we find morally right) are wrapped up in the wealth and power dimensions of this system. In other words, actors with power and wealth strongly influence the distribution and production of beauty, knowledge, and values.

Nonetheless, overlaying these two dimensions of the system essentially results in two interlinked subsystems. I will discuss them

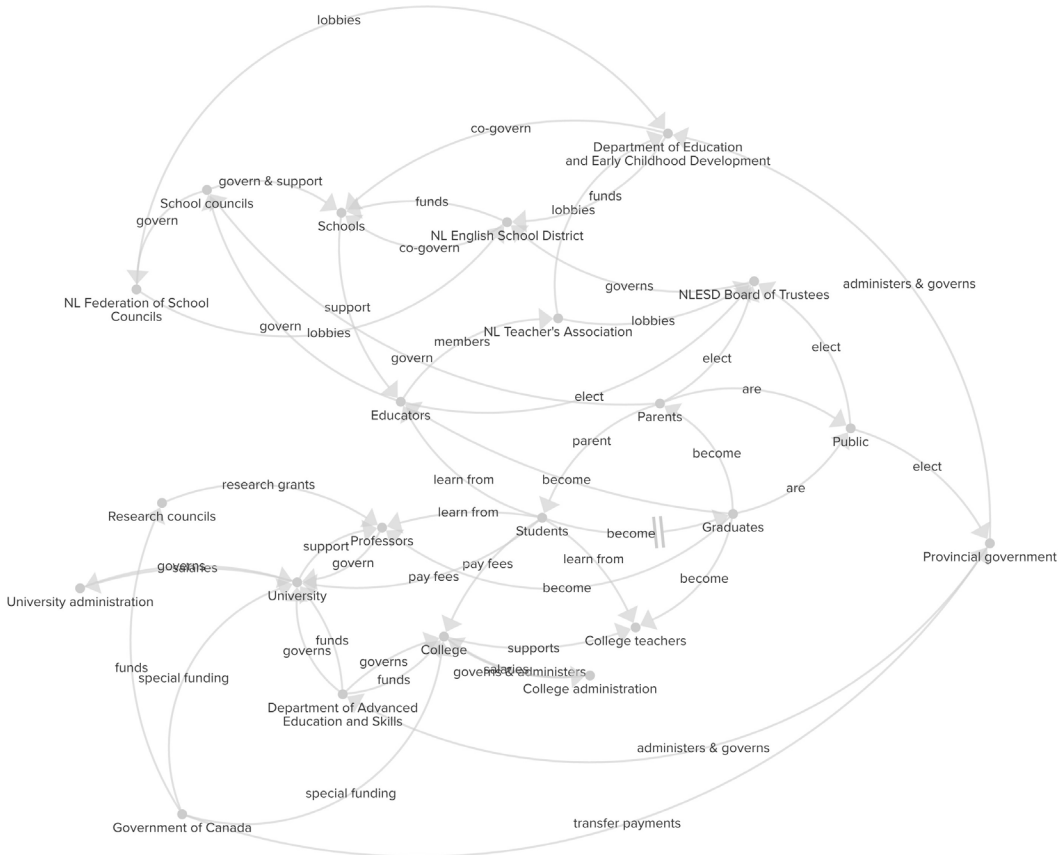


Figure 5. Refined actor map of the influencers in the Newfoundland and Labrador Education System.

separately.

The flow of power in the education system

Power is created and distributed in this system through the election, administration, governance, and lobbying of actors by one another. Thus, it is a highly political environment: issues prioritized by the electorate and leaders are the most likely to change.

A few features of the power subsystem are worth describing. First, the Government of Canada is fairly powerless, despite its symbolic position as the nation's leadership. This is because education is provincially governed. Second, both the University and the College are relatively independent. While the provincial Department of Advanced Education and Skills governs these institutions, they are also governed independently by their own internal leaders. Third, several advocacy organizations enact political lobbying in the K-12 system, namely the NL Federation of School Councils and the NL Teacher's Association. This gives these actors the appearance of power, but whether that power is realized depends–to a significant extent–the degree to which the actors they lobby allow their influence to hold sway. This is a complex interaction in and of itself, and it is liable that issues may need to be lobbied from multiple actors before any one lobbying effort would have success.

Centrality analysis reveals further salient insights. According to reach efficiency metrics, students themselves are significant actors–though this idea should be accepted with caution. Students retain a high level of influence because they will eventually become graduates themselves, and therefore will inherit the roles of all of the other actors of the system. This obviously takes time, and thus students may not be as useful for change as they appear. Parents place second on the reach efficiency ranking. This makes sense: parents are a substantial voting block in the elections of the province and play important roles on school councils. If a movement were able to mobilize parents to advocate for change throughout the rest of the system, they may have significant impact. The provincial government is also highly reach-efficient. Once elected on a four-year term, the politicians in the province's leadership roles make decisions from a fairly alienated seat of power, setting the agenda for the provincial ministries that oversee the public system.

Eigenvector analysis (as a reminder, eigenvector centrality approximately indicates an elements' overall influence) reveals that K-12 schools themselves are the most connected elements to other well-connected elements. Namely this is because schools administer and support educators themselves. This power may not translate directly into the potential for reform (schools themselves do not have jurisdiction over major curricula) but it does indicate the role school communities play in supporting movements for change within the system. The Board of Trustees, the governing body of the school district, is ranked second in eigenvector assessment. The Board makes ultimate decisions about operations, curricula, and other aspects of the K-12 system, so this is logical. Should the Board decide to prioritize reform, the change could quickly impact schools and educators. Finally, third on this list are

educators themselves, who play a substantial role in both of the above elements. The interplay of these actors should not go unnoticed: their interaction is apt to produce systemic behaviour, as I will explore with causal loop diagramming shortly.

Educators are also substantial bottlenecks for change within the system, according to betweenness analysis. This is intuitive: any curriculum change, for instance, would ultimately be implemented through the educators of the province. If teachers resist changes or are slow to adapt, it will buffer impact on the rest of the system. Schools and school councils are next on this list for similar reasons. Third is the Department of Education and Early Childhood Development: even if other actors press for change, anything official must come from the Department.

Before I end this discussion of power between actors in the system, it is worth noting that actors in the post-secondary system did not appear prominently on the above metrics. This is perhaps because of the independence of those institutions, as noted earlier. A standalone examination of the post-secondary system might reveal more nuanced mechanics of power. For now, I simply note that – from a provincial perspective – levers for changing these systems are not readily accessible. This may work both ways, however: the post-secondary system is less entrenched in provincial politics and bureaucracy, and therefore can change independently of the rest of the system should it choose to do so. Thus, while the provincial system may not have much holistic influence, a dedicated change agent may achieve success through engaging with these institutions on their own.

The flow of wealth in the education system

Doubtlessly the subsystems of power and wealth intertwine, as those who have power often decide where to spend resources. Still, a separate examination of the wealth subsystem has merit. Funding is a substantial incentive, both as a call-and-response mechanic for specific initiatives and in terms of the activities of different actors that the system is willing to resource. Policymakers might create project funding for educational institutions to apply to, for instance, or students may stop enrolling in particular programs if they deem those programs poor choices for post-secondary study.

The government is likely to be the biggest source of revenue for most of the actors in this system. Significant revenues for the government come from taxation, and thus there should be a "pays taxes" relationship between many of the actors in this system and the provincial and federal governments. I leave these links out, however, as the degree to which one pays taxes is not decided by the taxpayer. Here I am only interested in decisions about the distribution of wealth. Thus, the relationships observed in this subsystem are comprised of fees and funding.

Reach efficiency metrics on the wealth subsystem elevate the importance of students, parents, and the Government of Canada. The Federal Government can offer funding opportunities for institutions and the provinces to improve innovation education. The reach efficiency of parents and students relates to the post-secondary system: they decide which

schools and programs to enrol in, decisions that could become significant if the innovation education experiences provided by different programs are increasingly differentiated. The Department of Advanced Education and Skills, the main funder of the province's University and College, places fourth on the list, with mechanisms for change through funding similar to the Government of Canada.

Eigenvector metrics were not calculable, unfortunately, due to the nature of the cycles defined by the map. This is not meaningfully significant–eigenvector calculations simply could not be computed due to the map's structure.

Betweenness analysis found several bottlenecks at similar levels of betweenness centrality. The Provincial Government, the Department of Advanced Education and Skills, the Department of Education and Early Childhood Development, the English School District, Schools, the University and the College, and students and graduates themselves all ranked similarly. If anything, this means that the resources of the system are densely dependent on one another. The wealth distribution of the system is therefore potentially volatile, in which changes in the wealth of one element ripple to others.

Causal loop diagramming

A total of 31 elements are linked together with 50 connections depicting the phenomena contributing to innovation education in the public education systems of Newfoundland and Labrador. This interactive map is available at https://kumu.io/systemicdesign/nl-education-system-mapping#nl-education-system-mapping-causal-loop-diagram, and a static version is pictured here.

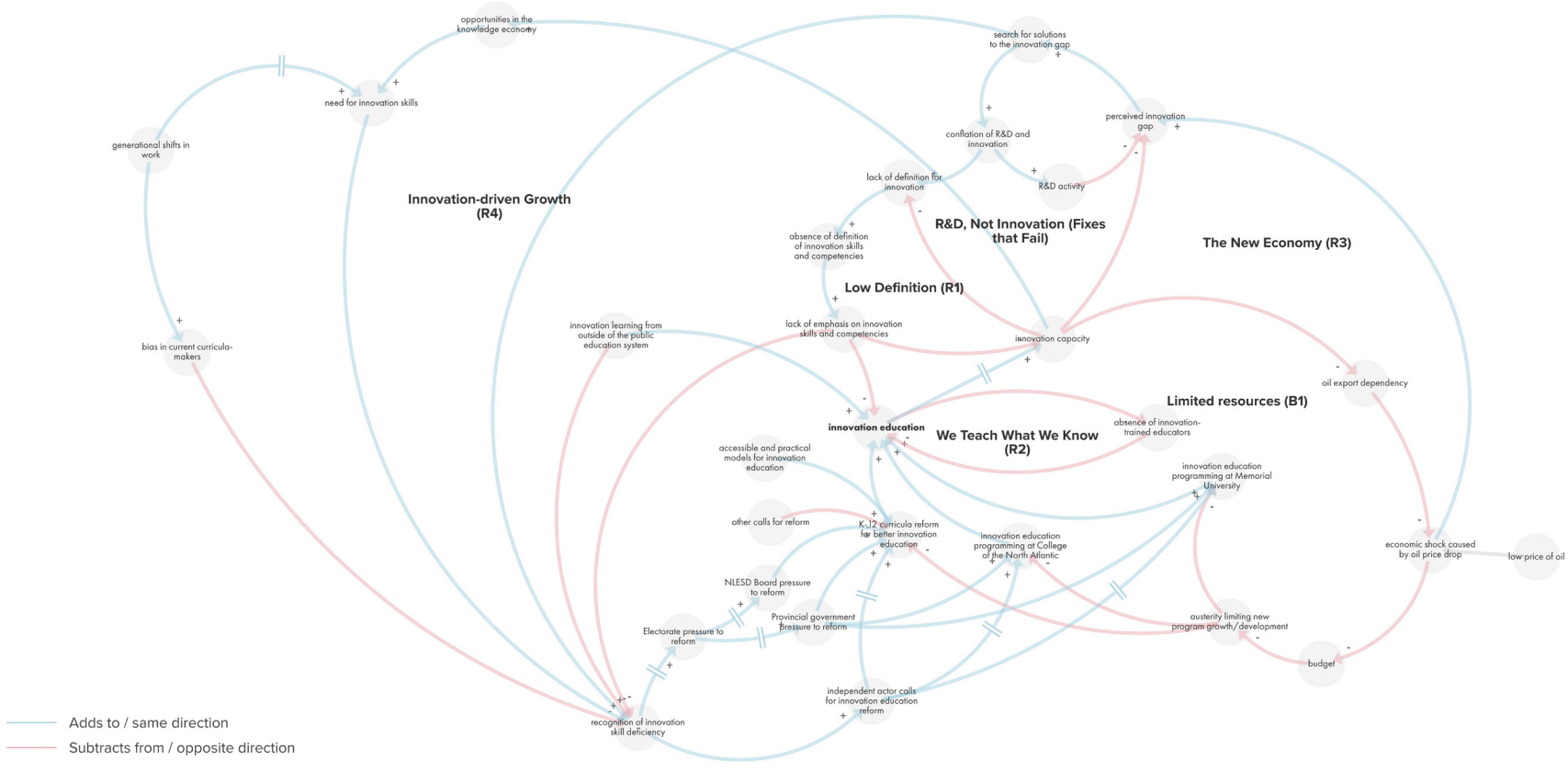


Figure 6. Phenomena of education systems change for innovation education mapped by causal loop diagramming.

Loops and archetypes

Immediately, several feedback loops are obvious. The **Low Definition (R1)** loop–arguably single-handedly responsible for the context of the present research–is a reinforcing cycle driving the current lack of emphasis on innovation skills. Low innovation capacity means that we are collectively lacking in our understanding of innovation, which leads to a lack of understanding of innovation skills and competencies and therefore a lack of emphasis on educating those skills and competencies, leading to poor innovation capacity. As this is a reinforcing cycle, however, improving innovation education may reverse the direction of this trend.

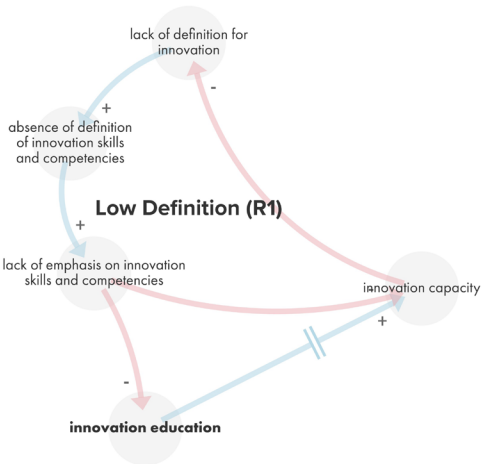


Figure 7. Low Definition loop (R1).

Figure 8. We Teach What We Know loop (R2).

A reinforcing loop linked to the Low Definition loop is **We Teach What We Know (R2)**, in which a lack of innovation education leads to a lack of innovation educators. This then doubles back, limiting our capacity for innovation education. As above, introducing more innovation education into the system will impede the force of this cycle.

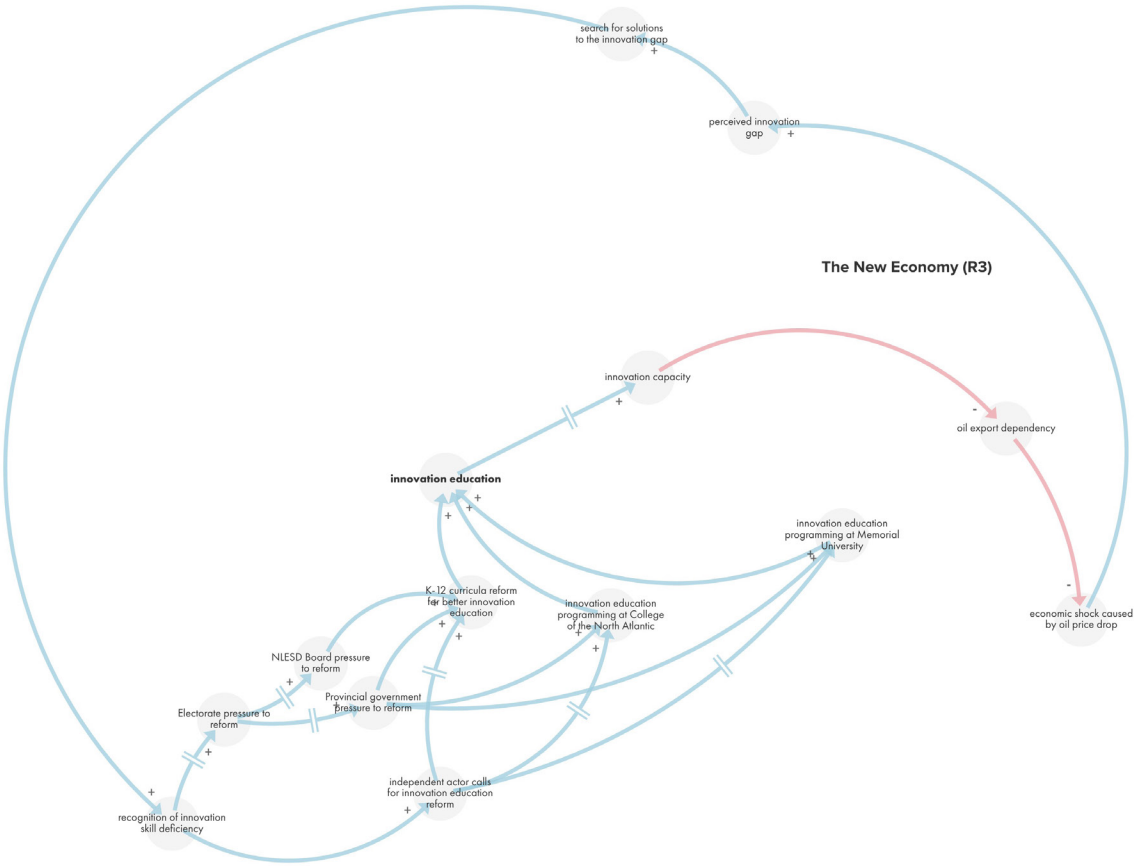


Figure 9. The New Economy loop (R3).

A third reinforcing loop is **The New Economy (R3)**, which links Newfoundland and Labrador's natural resource-dependent economy to the recognition of our limited innovation capacity. When oil prices drop, the provincial economy experiences economic shock, and the public becomes more aware of the degree to which the economy is tied to resource exports. This increases the public's perception of our innovation gap, spurring a search for solutions and thus a recognition that we can do more innovation education. Over time, this will result in reform for innovation education, improving our innovation capacity and reducing our dependency on resource exports.

Innovation-driven Growth (R4) is the fourth and final reinforcing loop of note. As with The New Economy, this loop explains how growth in innovation skills can lead to new innovation opportunities. As innovation capacity improves, it is likely that work in knowledge economy jobs will proliferate. This leads to a growing need for innovation skills, increasing pressure to produce more innovators, which leads to increased innovation capacity.

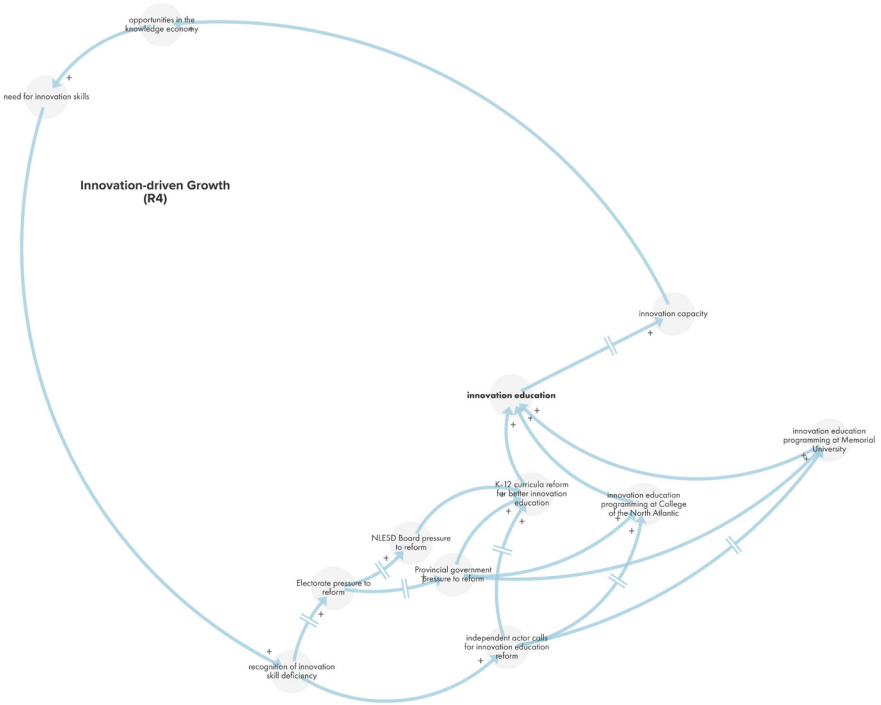


Figure 10. Innovation-driven Growth loop (R4).

One balancing loop is worth highlighting. The **Limited Resources (B1)** loop shows how our current natural resource-driven economy limits our ability to become an innovation-driven economy. When economic shock hits because the price of oil drops, public spending–the main source of education funding–becomes limited by austerity. This reduces the capacity for our educational institutions to spend time and resources on innovation education reform. In turn, our capacity to provide innovation education is limited, and so is our innovation capacity – leaving us continually linked to oil exports.

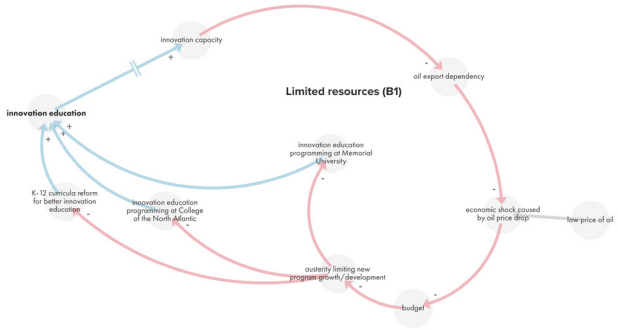


Figure 11. Limited Resources loop (B1).

A systemic archetype – a pattern of behaviour that appears across systems, with similar consequences and similar solutions – also appears. **R&D, Not Innovation** is a balancing loop nested within a reinforcing loop, an example of the Fixes that Fail archetype (cf. Braun, 2002). The perception of an innovation gap sparks a search for solutions. One of those solutions is to turn to the classical notion of innovation as R&D, and to increase R&D spending and activity in order to improve innovation capacity. This alleviates the perceived innovation gap, but does not produce meaningful gains in innovation itself. Meanwhile, the conflation of R&D and innovation takes us further away from a concrete definition of innovation, leaving us without a solid understanding of innovation skills and competencies and thus an under-emphasis of the provision of innovation education. Sulzenko (2016) discusses this tendency for policymakers to treat R&D as the solution, and suggests searching for other solutions to Canada's innovation gap instead.

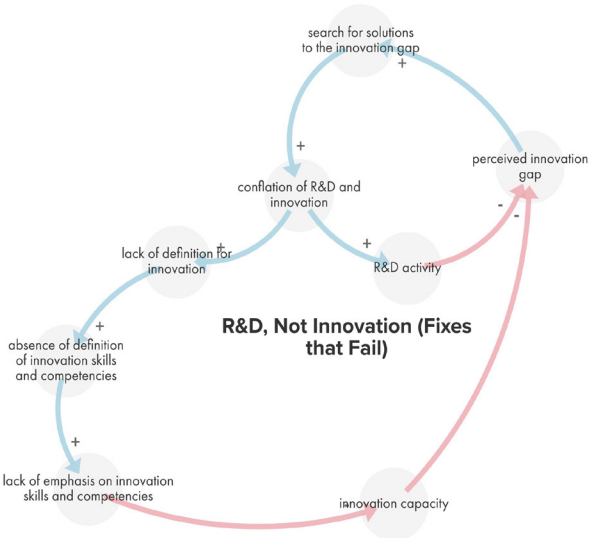


Figure 12. R&D, Not Innovation (Fixes that Fail archetype).

Leverage points and bottlenecks

Centrality analysis can also reveal insights in causal loop maps. Reach efficiency metrics, for instance, reveal several low-hanging fruit for changemakers in innovation education. One such element is *innovation learning from outside of the public education system*, circumventing the messiness of trying to change the public system by injecting innovation education directly into learners through other programs and services. This is easily done–there is little to stop someone from offering programs to those who want to take them–and could prompt public institutions to recognize the market and develop their own competing solutions for it. Another high reach efficiency element is the *lack of emphasis on innovation skills and competencies*. Increasing the public's awareness that innovation is something that can be learned may inspire other actors to recognize the deficiency of innovation education in our system, causing change. The third-most reach-efficient phenomena is a *low price of oil*–only appearing high on this list because the real complexity of influences impacting this phenomena is not included in this map. Still, it points to the significant impact an oil-driven economic boom can have on innovation education if its profits are spent on the right things.

Eigenvector centrality (how well-connected an element is to other well-connected elements; an element's overall influence within the system) does not highlight many elements of utility here. The results are intuitive: *innovation education*, *innovation capacity*, and the *perceived innovation gap* rank the highest on this metric, but these elements are difficult to impact (hence why they are the focus of the present research).

However, I can combine metrics by weighting one measure of centrality with another. One such measure, for instance, calculates each element's reach efficiency weighted by its eigenvector centrality (e.g., how influential that element is). I call this value the element's *torque*. Elements with high torque should be relatively easy to impact (as they are not densely influenced by other phenomena in the map), but will impact the rest of the map substantially. These are key leverage points of change.

Torque analysis highlights several key elements. First on the list is the *low price of oil*, which I will dismiss as it is not actually easy to influence (as described above). The foremost leverage points in the system, then, are *other calls for reform* and *accessible and practical models for innovation education* – both with identical torque.

Other calls for reform is actually a reverse-leverage point: it points toward the many forces trying to influence the education system at any given point. Examples might include the growth of both entrepreneurial programs and social entrepreneurship on Canadian campuses of late. These forces compete, making it difficult for decision-makers to prioritize any one reform movement. This means there is a need for "co-opetition" (co-operative competition): partnership between actors looking to change the system in order to link or at least weave together their efforts such that they do not undermine each other. The high level of torque this element has reveals its forceful potential to undermine reform efforts.

Accessible and practical models for innovation education, if accepted by reformers, would

eliminate confusion about innovation and its subsidiary skills and competencies, making it easy for educators to adopt and build innovation education into their curricula. The high torque value of this element certainly validates the present research, although I caution that this could be a case of "falling in love with the solution". It is certainly suspicious that research resulting in a model of innovation education would suggest that creating a model of innovation education is one of the most powerful forces available to change the system!

Ranked fourth for torque is *generational shifts in work*, a phenomena pointing to the need for futures analysis in this problem space. This element captures the notion that some economic changes will take place only as the previous generation exits the workforce. This particularly influences educators through a form of bias: current educators teach what they know, as the system worked for them, failing to recognize that the conditions of the world have shifted since they were educated and new approaches are necessary for the 21st century.

Finally, betweenness centrality helps to reveal potential bottlenecks in systemic change. *Innovation capacity* and *innovation education* rank high on the list, again potentially because these phenomena are central to the system I have mapped. This is not necessarily meaningless, however: it is also an indication that many influences hold these components in place, and they will likely change slowly as a result.

Three other high-betweenness elements are the *recognition of innovation skill deficiency*, the *perceived innovation gap*, and the *search for solutions to the innovation gap*. As suggested immediately above, their high levels of betweenness show that these elements are influenced by many forces. As such, they are bottlenecks or single points of failure in systems change. There is an intuitive to logic to this. If the system does not perceive an innovation gap, for instance, it is not likely to engage in any change effort, regardless of what else is happening in the system. The same is true for our recognition of a skill deficiency in innovation and for a single-minded search for solutions (e.g., R&D spending is the only answer). Thus, changemakers looking to improve the system's innovation education must monitor these phenomena closely, making sure to mitigate these forces' influence on any reform effort.

Discussion

In this chapter, I aimed to see the education system for what it is in order to describe strategies for the transformative reform that Mehta, Schwartz, and Hess (2012) called for. The education system is therefore composed of a number of interrelated components, organized in a hierarchy, whose emergent phenomena lead to its own dynamics. Yet, many might say that this systemic chaos implies a system of constant change, while education is hallmarked for its derelict stagnancy in the 21st century. How is it that such a system has not evolved?

Well, perhaps the system is not actually that broken. As eloquently argued by Ryan Burwell, an instructional designer at the MaRS Discovery District:

> **The school system** is not broken. It is perfectly aligned to provide equitable access to a canon of high-quality, standardized content with greater rigour and organization than any other knowledge delivery system we currently have. However, it is not designed to foster the problem-solvers, innovators and entrepreneurs that are becoming an increasingly significant part of the global economy. Incorrectly identifying this misalignment as a broken system has created a culture of fear and failure around education, leading to top-down reforms and increased numbers of mandatory programs. (Burwell, 2015)

I return to Mehta, Schwartz, and Hess' (2012) depiction of school reform's silver bullet culture. Many stakeholders with competing interests and different priorities are invested in every debate on education systems change. Thus, there are many potential silver bullets–and many advocates for them. The misunderstanding of the problem described by Burwell and the complexities of education reform described by Mehta, Schwartz, and Hess perfectly capture the need for a systemic design-based approach to change.

From process mapping, it is clear that while NL's education system currently offers some opportunities to learn certain constructs of innovation, the availability of these opportunities is not densely packed throughout their study. It is easy to recognize a dearth of access to the domains of Foresight and Scanning, Vision and Purpose, and Adaptability and Resilience. Further, the degree to students learn the domains and constructs of innovation skills from the public system remains unclear. Ultimately, now that these models exist, further analysis will be able to examine these constructs more closely as students progress through the system.

This is especially true for many of the "optional" components of the broader education system. After school programs, hobbies, sports and recreation, volunteer and extra-curricular roles, self-directed learning, and employer training could each be vital sources of innovation education, but it was impossible to study these aspects of the system in any meaningful way in the present study. A dedicated effort should examine the availability of these sources and assess their utility for innovation learning. One research approach would be to survey learners along the learning journey, testing their abilities in the different constructs I've outlined. This ethnographic approach could reveal hidden truths: perhaps, for instance, certain regional cultures in the province actually provide powerful learning in design through a community culture

alone.

Systemic modelling reveals the power and wealth subsystems active amongst the actors of the education system. Centrality analysis of the power subsystem illustrates that parents and the provincial government have efficient influence on the system, and change that can mobilize those bodies of actors will quickly take shape. Meanwhile schools, the School Board, and educators have substantial global influence over the system–change efforts that engage these actors may be slow but momentous. Finally, power bottlenecks are educators; schools and school councils; and the Department of Education and Early Childhood Development. This suggests that these actors will ultimately need to be involved if any reform effort were to achieve success.

Reach efficiency analysis of the wealth subsystem shows that the federal government, parents and students, and the provincial Department of Advanced Education and Skills each strongly influence the distribution of wealth. The Federal and Provincial Governments have powerful incentives with which to motivate and control reform efforts. Betweenness centrality revealed that the whole system is tightly linked, making it potentially volatile: economic issues in one component of the system may ripple out and impact the others.

Finally, these maps intimated a causal loop diagram illustrating how innovation education reform might happen in the public education system. Several loops and one archetype demonstrate significant effect over the system. The Low Definition loop describes an acceleration of the impact of ill-defined innovation on our ability to educate on it. The We Teach What We Know loop shows how a lack of innovation education leads to a lack of people capable of teaching it and vice-versa. The New Economy loop shows how economic shocks driven by drops in commodities pricing has raised our awareness of the importance of the innovation economy. The Innovation-driven Growth loop shows how innovation capacity will accelerate jobs in the knowledge economy, which will in turn drive our ability to create more innovators through education. The Limited Resources loop balances our ability to reform education for innovation due to a lack of funding for the reform effort due to austerity budgets, driven by drops in the price of oil. Finally, the R&D, Not Innovation archetype is an instance of the Fixes that Fail systems archetype, showing how a conflation of innovation with R&D efforts fails to improve our innovation capacity while also distracting from true innovation education.

The result of centrality analysis on these causally-linked phenomena is rich with pragmatic insight. Three phenomena with efficient reach over the whole system are *innovation learning from outside of the public education system*, *lack of emphasis on innovation education*, and *low price of oil*. The former points to an accessible lever of change: introduce innovation education through extra- and co-curricular programs, volunteer and leadership roles, sports and recreation, or self-directed learning, and the system may catch up by offering its own programming to match. The leverage of a *lack of emphasis on innovation education* offers another route: increase awareness on innovation education in order to encourage the system to improve on it. Finally, *low price of oil* retains leverage

as a dampener on the system: if the economy continues in recession, the system is less able to offer resources for reform efforts.

Other calls for reform is one force with substantial torque over the system, indicating that reformers must be co-opetitive with other education change efforts, else all reform efforts might fail due to competition with one another. The availability of *accessible and practical models for innovation education* is another high-torque element, however, elevating the potential of the present research to create change in the system. A third element with high torque is the *generational shift in work*, evidence that a substantial source of impetus for innovation education reform could come from changes in work and careers.

Finally, betweenness centrality offers a picture of the bottlenecks and points of failure within the system. *Innovation capacity* and *innovation education* are two forces semiotically central to the system, and thus it is intuitive that they will be slow to change, no matter what else is happening within the system. On the other hand, *recognition of innovation deficiency*, the *perceived innovation gap*, and the *search for solutions to the innovation gap* are three phenomena that are clear points of fragility in any systemic change effort. If the system does not recognize its deficiencies, perceive the gap in innovation capacity, or opt to search for solutions, reform efforts are liable to be frustrated.

Despite these clarion recommendations for systemic design, several limitations prevent wholesale adoption. One key limitation of the presented results of systems modelling is that the connections defined in these models are unquantified. In the refined actor map, for instance, it may be that educators have little power over their school councils, or perhaps the NL Federation of School Councils has far less lobbying capacity than the NL Federation of Teachers. Evaluating the strength of these connections and including these evaluations in our analytics would improve the acuity of those metrics substantially.

As previously mentioned, if innovation learning is not coming from the public education system, it must be coming from somewhere else. Yet, these potential sources arguably include the whole of the human experience – as we have, after all, been learning to innovate since pre-history (Eveleens, 2010). Future research might take on an ethnographic approach to understanding the system, investigating different student-innovators and where they learned their innovation skills, or a longitudinal approach, following students as they become innovators through their years in the education system. These exercises fell outside the limits of the present research, unfortunately.

Another limitation is that, while the scope and approach to mapping were designed to increase the variety of the system as much as possible, the mapping was still completed with the perspective of only this author. The representativeness of the systems models would therefore be strengthened considerably with Delphi-inspired methods as seen in Fascinato et al. (2016), bringing the mapping process to others in order to iteratively refine and the map from alternative stakeholders' points-of-view. Another potential future study is to bring the whole system into the room– literally, as advocated for by Jones (2014). This

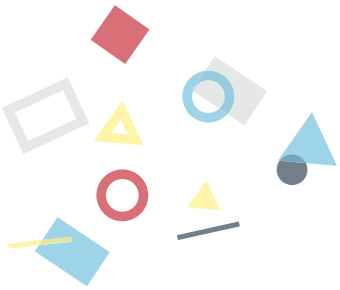
would mean convening a group of stakeholders who were holistically representative of the actors of the system, engaging them in a systems modelling process to develop a map with their collective perspectives.

So, with a holistic conceptualization of innovation and the skills and competencies that contribute to the success of the innovator and this sense of the system, what might we do to provoke systemic change? In the final chapter, I tie together our lessons with a set of takeaways, directions for further research, and a set of ultimate recommendations for policymakers, educators, and changemakers. How should we transform the education system? How might we resolve Canada's innovation gap? Perhaps I have found some answers to these questions after all.

Part Five: Conclusion

In the conclusion, I outline the key lessons of the paper, explore the limitations of the studies within, and offer some next steps (including further research directions).

- *What were the developments and contributions of this paper?*
- *What have we learned for Canada? For Newfoundland and Labrador? For innovation theory and practice?*
- *What are the next steps?*
- *How might we effectively carry this work forward?*



Summary

This research began as an exploration of the use of systemic design to facilitate education reform. A review of the many calls for reform in Canada and other Western education systems revealed a common theme: that the education system must do better to prepare our learners for the complex problems of the 21st century and the fourth industrial revolution. These calls for reform parallel a national discourse on Canada's "innovation gap": the notion that Canada has fallen behind our peer nations in our innovation capacity.

So, in this paper, I explored the following research questions:

1. How might we define innovation holistically, across many different perspectives and geographies?
2. What are the skills and competencies required to be an innovator? What are the learning constructs and outcomes we can design to help a learner achieve proficiency in these skill and competency domains?
3. How might we educate on innovation?
4. How might we provoke change in the Newfoundland and Labrador education system, in order to introduce this form of education into the system?

Below, I summarize the findings for each of these questions. I end this research paper with a discussion on lessons for innovation in general, for the country, for the province of Newfoundland and Labrador, and with directions for further research.

1. How might we define innovation holistically, across many different perspectives and geographies?

A survey of almost 60 reports, strategies, articles, and papers across 11 perspectives on international, national, provincial, and abstract approaches to innovation theory and practice was distilled into a holistic model of innovation. This resulted in the following definition of innovation:

An innovation is a change that creates new value or improves the delivery and capture of value.

Innovations exist in many forms, from product to social movement; at many scales, from new-to-you to new-to-the-world; and in many degrees, from radical to incremental. The success of one innovation often requires the success of others in parallel.

Innovation often results in new knowledge, relationships, and spin-off innovations.

I discovered that conversations about innovation often take place in disparate silos based on at least three orientations: **Technology & Science**, **Social & Sustainability**, and **Commercial & Entrepreneurial**. These orientations are rooted in the same processes and skills, but emphasize different components in the interest of achieving different outputs. Nonetheless, many approaches to innovation policy either conflate them or separate them entirely. This disorganization has grim potential: if policymakers fail to see these orientations and the holistic ways in which they intersect, or if they are too myopic and focus only on one (and its outputs), they might fail to see root-cause problems and high-leverage interventions deeply embedded in our

innovation systems.

For instance, innovation policy focused only on improving our technological outputs may seek solutions in patent reform and R&D activity. Likewise, policymakers preoccupied with entrepreneurial innovation may only focus on the investment environment. Both of these approaches, however, will miss policy shifts that can help more people be inventive and entrepreneurial. These approaches to improving innovation also risk ignoring the issues of inclusivity and sustainability. Instead, I advocate for a holistic approach, recognizing the shared foundation on which these orientations to innovation are built.

I consolidated the steps and phases of innovation I observed across perspectives and orientations into a universal model of the innovation process. This process is not drastically different from those previously defined in the literature (e.g., Kline & Rosenberg, 1986). Crucially, however, it is universal: it can be followed regardless of the orientation an innovator has adopted. Moreover, this model provides an explicit basis with which to explore the skills and competencies practiced by innovators throughout the process.

The process is non-linear and cyclical: an innovator who runs into trouble at one stage will often need to double-back in order to continue the process at an earlier stage. It is also fractal. The success of one innovation often requires the dovetailing success of others, and thus the innovator will actually end up pursuing parallel innovation processes for different interlocking innovations simultaneously.

The innovation process consists of nine stages across three overlapping phases. The phases are **purpose, problem, and/or opportunity realization: why, what, where, and when to innovate**, **selection: what to try**, and **implementation: how to do it**. In the purpose, problem, and/or opportunity realization phase, an innovator experiences or finds **Prompts**, in which they identify a purpose to innovate (e.g., a problem to solve); they **Search** for existing ideas and inventions to innovate with; and they **Generate** new ideas. **Search** and **Generate** are also a component of the selection phase, where innovators **Select** which innovations to pursue throughout the rest of the process. They then **Develop** and **Prototype** these innovations. Finally, **Development** and **Prototyping** overlap with the realization phase, in which the innovator finds ways to **Scale** and **Sustain** their innovations in the real world. Implementation can potentially lead to **Systemic Change** and **Learning**, the final two stages of the process.

The review of innovation perspectives also unearthed three environmental conditions that contribute to success in innovation. **Networks and relationships**, **openness and trust** in those networks and relationships, and readily available **financial, knowledge, and human capital** are each important aspects of the innovation environment. However, while most approaches to innovation policy focus on these environmental characteristics, I turned to the skills and competencies used in the innovation process.

2. What are the skills and competencies required to be an innovator? What are the learning constructs and outcomes we can design to help a learner achieve proficiency in these skill and competency domains?

Thirteen different domains of innovation skills and competencies were identified: literacies and domain expertise; collaboration, communication, and network building; design; foresight and scanning; vision and purpose; initiative and learning; ethics and responsibility; adaptability and resilience; risk and uncertainty; empathy; management; business and financial acumen; and R&D. These domains form a holistic model for innovation education, with literacies and domain expertise at the core. For the remaining twelve domains, I used data, coded from the literature review, in a conceptual mapping and synthesis process to identify learning constructs. With reference to instructional design frameworks, these constructs were further broken down into 223 pragmatic learning outcomes for innovation education. These outcomes provide both a set of curricular goals for innovation learners and a framework with which to build teaching and learning activities and methods of assessment.

As mentioned previously, different domains are emphasized by different orientations; the same is true for different stages of the innovation process. I developed an interactive visualization using Kumu.io that allows the user to filter and focus on these different alignments. This visualization can help educators and policymakers clearly identify where failures of innovation might be coming from in the process and what kind of skill development could help alleviate the failure.

3. How might we educate on innovation?

This model of innovation education was then used as a tool with which to investigate the education system itself. A process model of the education system in Newfoundland and Labrador provided a framework with which to examine where students currently learn the skills and competencies of innovation. The public system–K-12 and post-secondary institutions–was found to provide some of the innovation learning constructs to all learners, but only sparsely over the whole of a student's learning journey. I found that some learning constructs were not taught at all: meta-innovation, cultural and political savviness, management of complexity and systems thinking, ethnography and human factors, and scenario development. Moreover, I realized that three entire domains are linked to only a few constructs currently delivered by the system: foresight and scanning, vision and purpose, and adaptability and resilience.

If this theoretical modelling is an accurate representation of what happens in practice, it is not surprising our innovation capacity suffers. Without futures thinking and scanning capabilities, our graduates may not be as apt to notice changing aspects of their environment and the opportunities they present for innovation. An absence of vision and purpose education means that our graduates may lack the capacity to define long-term large-scale goals (and potential pathways to reach them). Finally, a lack of adaptability and resilience learning may manifest in the discontinuance of the innovation process when our graduates inevitably encounter barriers in their pursuits.

Several potential sources on innovation education could not be indexed or analyzed in this research. After-school programs, sports and recreation, volunteer and leadership roles, self-directed learning, and hobbies are each activities which may allow our students to develop the capacities defined by our skill and competency domains. These components of the education system are not officially mapped or regulated, however. Future research should examine them to understand what options are available and how they might be configured to improve their contribution to innovation education.

4. How might we provoke change in the Newfoundland and Labrador education system, in order to introduce this form of education into the system?

Centrality analysis of the actors involved in governing and funding the public education system revealed additional lessons for systems change. Both parents and the provincial government are efficiently connected to the rest of the system: change may quickly come about if they can be mobilized. Other strong influencers (although they are influenced by other components of the system) include schools, the Board of Trustees, and educators. Educators, schools and school councils, and the Department of Education and Early Childhood Development are also recognized as bottlenecks or single points of failure by betweenness analysis, implying that change movements should take care to facilitate the engagement of these actors. I found the post-secondary system of the province to be independent of these actors, however: the provincial system cannot heavily influence post-secondary changes, but at the same time, the post-secondary system may be more pliable than the system-at-large.

The flows of power and the flows of resources behave differently in the education system. When examining the wealth subsystem, I discovered that the Federal Government has efficient reach, potentially able to encourage change through the allocation of budgets. The provincial Department of Advanced Education and Skills has similar access to financial levers over the University and the College. Students and parents also hold sway over the post-secondary system, as they decide which post-secondary programs to enrol in (if at all). The resources of the actors of the system are densely interlinked, however, making each actor dependent on the resources of others and possibly leading the whole system to volatility.

This actor mapping process led to causal loop diagrams mapping the phenomena of reform in the provincial education system. This systems mapping revealed several important sources of systemic behaviour. These sources include four reinforcing loops, two of which are vicious cycles (**Low Definition** and **We Teach What We Know**) currently maintaining a low capacity for innovation education (and thus provincial innovation performance overall). The two others are potential virtuous cycles (**The New Economy** and **Innovation-driven Growth**) accelerating the importance of innovation education and the growth of innovation opportunities in the province. Each of these reinforcing cycles demonstrate the necessity of an "injection" of innovation education into the province to pivot the system's dynamics towards NL's favour.

However, these reinforcing cycles are

tempered by a balancing loop. This **Limited Resources** loop links NL's natural resource-dependent economy to an insufficiency in investments for education reform. An additional Fixes that Fail archetype of systemic behaviour (**R&D, Not Innovation**) is found in a myopic conflation of R&D efforts and innovation, leading interventions to focus on encouraging more R&D rather than directly address the root causes of poor innovation performance.

Several aspects of the system were highlighted through centrality analysis as potent leverage points for reform. One such low-hanging fruit for change is *innovation education from outside of the public education system*: that is, find ways to offer training in innovation through extra-curricular, career, or self-directed learning, and the system may respond by increasing innovation education in the public system, too. Another accessible effort is to *increase emphasis on innovation education*, thus enabling policymakers and educators to respond with programming.

Finally, I introduced torque analysis – a measure that evaluates elements' reach efficiency weighted by how influential it is – to identify phenomena that are both high-leverage and highly accessible. Three elements were ranked particularly high on this measure. *Other calls for reform* indicates that "competing" movements for change in the education system can actually substantially confound each other, demonstrating a need for co-opetition in education systems change efforts. On the other hand, the provision of *accessible and practical models for innovation education* also has a high level of torque: it would make it easy for educators and institutions to implement innovation education. Third, *generational shifts in work* represents how shifts in the way we learn and work may be buffered by the previous generation; the implication is that foresight studies on our workforce needs or, indeed, on the skill and competency needs of our graduates in the future would reduce our bias for past approaches to curricula and thus foster the adoption of innovation education.

Three bottlenecks identified through betweenness analysis of the causal loop diagram are *recognition of innovation skill deficiency*, *perceived innovation gap*, and *search for solutions to the innovation gap*. Any effort that fails to engage the system in recognizing a skill deficiency for innovation, perceiving a loss of potential innovation, or finding solutions for the innovation gap is likely to fail, no matter what might be happening elsewhere in the system.

So what?

Lessons for Innovation Changemakers & Strategists

We can't improve what we don't define

Our approaches to improving innovation have generally lacked a concrete definition of what innovators are or what they do. This absence of definition means, in turn, an absence of assessment: we can't observe nor deliberately improve the practice or process of innovation itself. Perspectives on improving innovation capacity rarely consider how we create innovators. Even in those that do take this concept seriously, little has been done to concretely explain what skills are used in innovation, when, and how those skills manifest across so many different presentations of innovation. This research breaks that mold, presenting a holistic perspective of innovation that synthesizes previously-separated discourses (technological, entrepreneurial, and social).

To make matters worse, a major theme running through our national discourse is that success in innovation will come innately to a country who attracts and retains "talent". This logic is tied directly to assumptions in our strategies, such as "increased PhD and STEM graduates will lead to increased innovation". Like innovation, the notion of talent and phrases like "the best and the brightest" are rarely defined. This gives the impression that we all mean the same thing when we talk about these concepts, as if identifying who might come up with the next radical innovation is computable through some kind of talent calculus.

Perhaps the most important contribution of this paper is that it directly challenges the assumption baked into most innovation strategies that innovation simply happens when the right environmental conditions exist. So many approaches – international, national, provincial, and beyond – take this for granted. This is insufficient. As a society, we must look more closely at whether we prepare people to be capable of what we hope they will achieve. Innovation does not have to be a buzzword. We can define it, model it, and clearly articulate what it means to *do* innovation. If we can model the steps of innovation, we can articulate what people must know to accomplish them. This is a necessary component of any innovation strategy.

Co-opetition is needed

Numerous groups work on education reform efforts, but in a wholly uncoordinated and sometimes adversarial fashion. This competition may slow progress. Education reform must become a process of co-opetition.

This means that the process of reform should be supported by a network facilitator or partnership broker. This broker would maintain a general theory of change for reform, mapping its partners and network to the different components of that theory of change. It would further promote its efforts (and the work of its network) such that new and yet-to-be-included actors can join the effort and symbiotically contribute to the reform process. Transparency and openness is paramount for such a facilitator;

anyone should be able to see its aims and activities in order to understand where they fit in and how they might be impacted by it.

The weakest form of innovation: new-to-the-moment

It has been said that incremental innovation is a substantial source of innovation-driven growth (Toner, 2011). Innovation is seen as ranging from radical/new-to-the-world to incremental/new-to-the-firm. Why, though, do we not also include new-to-the-moment innovation in our framework?

For instance, a shopkeeper who anticipates a growth in evening customers might expand their hours for an upcoming season, hiring a new part-time employee to run the shop during those evening hours. This change does not necessarily happen on a regular or seasonal basis-instead, it depends on the shopkeeper's ability to recognize a market opportunity and make intentional changes in the structures and mechanisms of their business. It has the hallmarks of Fagerberg's (2006) innovation framework: the innovation is made in uncertainty, it must be implemented before competing businesses also recognize the opportunity, and it must create a breakthrough in social inertia (e.g., existing employees may dislike the idea of a new hire; the customer base needs to learn about the new hours). This change requires the skills and processes of innovation, yet it would not fit in to our model of innovation-that is, most probably would not see it as innovative.

Granted, it is a weak form of innovation. Still, if these kinds of simple changes are necessary for the survival of our organizations, it is important that we recognize the need for people to be able to realize new-to-the-moment as well as new-to-the-firm, new-to-the-region, and new-to-the-world innovations.

Lessons for Newfoundland and Labrador

This research poses a provincial solution to a national problem in my advocacy for an education-based approach to resolving Canada's innovation gap. This is for two reasons: first and most obviously, education is a provincial responsibility. Second, however, Newfoundland and Labrador's education system is uniquely simple: one English school district, one University, and one College. This is not a weakness, but a strategic advantage: we can adopt new strategies more quickly than practically anywhere else in Canada.

Mandate, incentivize, and facilitate innovation education on all levels

The strategy this paper proposes is to look critically at how we are preparing our graduates for innovation. If the model articulated here is valid, the public education system does not provide enough opportunities for our students to learn the skills and competencies define within it. Particularly critical is a lack of the domains of foresight and scanning, purpose and vision, and adaptability and resilience. Our innovators need the other skills and competencies too, however.

Rectification is readily enacted through two systemic opportunities.

The first is to adopt an accessible and

practical model for innovation education – the one provided here is a good start. Our educational institutions and our educators can use this model to inform their curricula, finding ways to introduce the learning outcomes into courses and programs. At the political level, parents and policymakers alike will be the most profound allies (or enemies) of this movement. This intervention must engage these actors to in order to achieve systemic change. In the meantime, innovation education reformers will need to be cautious about other movements calling on change in the education system. A united front is critical.

The second is to develop innovation education opportunities outside of the public education system. How might volunteer and leadership positions, hobbies, sports and recreation programs, self-directed learning, and other forms of extra-curricular, co-curricular, and career-based learning be engaged to provide innovation learning? These programs and structures can be implemented more quickly than curricular change–moreover they may accelerate those changes. Funding incentives prove a powerful tool here, offering funding to winning proposals for new programs and initiatives that foster innovation learning in the province.

Now is not the time to increase fees

The province has okay PhD and great STEM graduation rates, but utterly fails at taking advantage of these graduates once they've finished their work. The province is missing enriching opportunities with this "brain drain", in both the ephemeral sense and in economic sense. Job creation for these researchers is essential in order to bolster NL's innovation system and create a more diverse and resilient economy, less dependent on natural resource booms.

Arguably, these graduation rates are due (at least in part) to the province's incredibly affordable tuition fees (Taber, 2013). However, at this time, economic pressures seem to be driving policy makers to increase those fees. Intuitively, while this may make the provincial post-secondary education system less of a budgetary burden, it may also reduce the graduation rates which are currently our only relative education strength. An alternative route is to keep the freeze and to put policies in place that expand R&D spending and support job creation – research and innovation roles – for these graduates. This would feasibly feed reinforcing feedback, as a growing knowledge-intensive industry is likely to attract more researchers and innovators, which will grow knowledge-intensive industry.

Vicious cycle of STEM education

Where most of our teachers come from our own education systems, our ability to teach a given subject is tied directly to our experience learning it. The worse our learning experiences are, the less likely we'll be to want to learn more and to practice the subject. This forms a fairly straightforward reinforcing loop.

NL's math and science literacy is relatively poor, in comparison to our peer countries and the other provinces. This low level of math and science acuity, fed into the reinforcing loop described above, may lead to ever worsening math and

science abilities. This is particularly problematic for NL's innovation capacity, as high levels of these schools of knowledge is thought to be a contributed for radical innovation, particularly developments in science and technology. This leads us deeper levels of feedback loops: the lower our ability to participate in the knowledge economy through our innovation system, the more we have to depend on our traditional resource economies. This dependency (when it succeeds because of resource booms) teaches us that our current approach is working–an example of the shifting the burden systems archetype. However – as we've repeatedly observed through both the cod moratorium of 1992 and more recent swings in oil prices – this leaves the NL economy vulnerable. It would be wise to leverage future resource booms by using the profits they generate to turn the vicious cycles described above into virtuous ones.

Innovation education may involve local knowledge, too

Revelations from the Harris Centre's efforts in understanding the innovation system across the regions of NL point toward the significance of local context. Each region and sector of the province have unique leaders and different resources and programs to support innovators. Moreover, innovation "clusters" (i.e., informal intersections of regions and sectors that agglomerate and share resources/knowledge, etc.) often have their own culture. Thus, as an innovator begins to bring their work into the real world, contextual innovation education can be crucial to their success. This means that teaching an innovator contextual knowledge is a potentially significant aspect of innovation education.

Perspectives on Indigenous innovation relate here, as well. Recall that Indigenous innovation is hallmarked by the notion that innovative ideas do not necessarily need to be new, but they may be "old", too. This requires a respect for and commitment to the past. I have discussed how innovation is a continuous, systemic process, requiring constant exchange with knowledge and research as the innovator makes progress. Indigenous innovation reinforces the significance of not just local knowledge, but old knowledge, too. Thus, we should strive to teach innovators to tap all wells of knowledge in these exchanges, and to respect different ways of knowing as they proceed through the innovation process.

Understanding the gaps

Much of the Conference Board of Canada's analysis of NL's performance in both Innovation and in Education and Skills is alarming. Several aspects of the NL contexts are surprising – the contrast between our STEM and PhD graduation rates, for instance, and the absence of R&D spending and research roles. Would more innovation education help job creators leverage these researchers, stopping them from moving away? This may be one of many answers. We need a deeper understanding of the subsystem at play here in order to effectively leverage our graduation rates to feed our innovation system.

Lessons for Canada

One thing is certain: if Canada is to become "A Nation of Innovators" (Innovation Government of Canada, 2016b), as articulated by the 2016 call for consultations, it must recognize what innovators are and help its students become them. The ongoing development of Canada's next innovation strategy presents a pivotal opportunity to raise alarm about innovation skills and the potential innovation skill deficits of many provincial education systems. The Newfoundland and Labrador model offers a point of departure: other provincial systems may be compared with what I have learned from NL in this study, and with what NL potentially learns over the coming years if the province attempts refining and adopting the models I provide here.

Too much focus on entrepreneurship as innovation

It is not difficult to find a program or service supporting entrepreneurs in Canada, but our emphasis on entrepreneurship over the past two decades may have blinded us to the need for education on skills and competencies necessary to become an entrepreneur: namely, innovation. Moreover, the commercial focus of entrepreneurship misses an opportunity to leverage millennial values and may exclude those who want to contribute to public and non-profit projects.

Access & equity in innovation education

As Burwell (2015) points out, Canada's existing education system was built for equity of access. The opportunity to receive high-quality K-12 education everywhere was built into the very fibre of our provincial systems post-World War II. The problem is that the definition of high-quality education has shifted; the system that scaled the same experience for everyone now struggles to provide unique, responsive, and self-directed learning for every learner. Moreover, the robust distributability of our earlier systems is what now slows reform efforts. It takes time, resources, and dedicated agency to implement reform agendas in our modern systems.

These challenges are compounded in innovation education. As I have discussed, innovation takes a remarkable alignment of competencies, often with circumstantial opportunity. It frequently requires people and communication skills, domain expertise, and generalist capabilities. Finding the opportunities to learn and practice these lessons and succeed in innovation is arguably a matter of luck as much as anything else: having the right idea, with the right resources, access to markets and audiences, and networks – all at the right time.

Luck – and privilege.

Innovation requires a confluence of capacities acting in parallel symmetry. As the development of each of those capacities is arguably tied to individual access to opportunity, and as individual access to opportunity is often determined by demographic factors as much as anything else, a "success to the successful" paradigm may operate in creating successful innovators. After all, you can't practice asking for grants or pitching to investors if you haven't built business plans, prototyped your idea, or found other ways to validate markets

and concepts. You can't build sound business plans or hack together prototypes or do market research without finding ways to learn how to do those things effectively and objectively. Those learning opportunities are less likely to present themselves to someone who has less opportunity to explore them due to health, socioeconomic pressures, or discrimination. Moreover, under-privileged demographics are more likely to suffer in educational performance and attainment (e.g., American Psychological Association, n.d.) These forces layer on top of one another, reducing innovation potential in those at our most vulnerable intersections.

If this is true, it would mean that innovators are unlikely to be a diverse group of people. As we know, diversity creates higher quality innovations (cf. Page, 2007). Perhaps solving the issue of access and equity in innovation education is a high-leverage opportunity for Canada's innovation capacity.

Innovation Conflation

Another important lesson is that the **R&D, Not Innovation** archetype discovered in systems mapping is not partial to Newfoundland and Labrador. This confusion was found across many of the reports and strategies surveyed on the national perspective. Policy approaches that do not holistically define innovation may not only fail to provide real solutions, but they also exacerbate the conflation of these definitions. This leads to a problematic emphasis on certain innovation orientations (e.g., technology and science, and commercial and entrepreneurial) and especially the business-based outputs of those innovation. As I have discussed, however, the innovation process requires parallel innovation processes; thus, non-commercial innovations may be just as important as distinctly commercial ones in order to achieve overall success in business innovation. New technologies in wind energy will fail, for instance, if there is no social appetite for renewable energy, if political interest protects alternative energies already embedded in the infrastructure, or if people think the windmill technology is bad for tourism. Only innovators prepared to deal with all of these barriers and more will fully succeed in scaling and sustaining their innovation.

Moreover, business innovation is not the only kind of innovation: social and sustainability perspectives offer substantial value as well, especially in the context of Indigenous reconciliation. Critically, innovation strategies that address only one of these orientations or address them separately will miss opportunities to improve each of them at once–namely the potential of innovation education.

College is an untapped wellspring

One cause for Canada's innovation gap may come from the skew of the global innovation narrative towards digital technology (Fascinato et al., 2016). Classical Canadian strategic competencies exist in industries like natural resource extraction and agriculture, where the incredibly physical problems to be solved resist digital solvents. Innovations in these industries are challenging to develop and are prone to risk.

These are also the industries of trades and college workers. Japan, a paragon of innovation,

has a formidable rate of per-capita patenting while also having a great quantity of college graduates in lieu of PhD graduates (Conference Board of Canada, 2016a). Indeed, this is exactly what Robert Luke, now Vice-President of Research & Innovation at OCAD University, argues colleges can do–by providing innovation literacy: "the ability to think creatively, evaluate, and apply problem-solving skills to diverse and intangible issues within industrial problems and multidisciplinary contexts" (Luke, 2009).

Perhaps Canada can emulate Japan's success, injecting innovation education directly into its college system and especially into those college graduates who are liable to work in Canada's traditional industries.

Lessons for researchers and theorists: further research

Combining data science and systems thinking for systemic design

The use of Kumu.io and centrality analytics to discover phenomenological forces of supreme influence in these systems has been crucial to the insights presented in this paper. The potential of these tools, however, is far greater than has been demonstrated here. As noted previously, the mapping of these influences is completely unquantified in this research. The maps and, in turn, the results of analysis can only grow more acute if combined with rigorous data about the phenomena and actors I examine. One obvious demonstration of this is found in the wealth subsystem: it should be possible–even easy–to identify where and how funding is distributed, to whom, and when. Centrality analysis can then take this concrete wealth distribution into concrete terms, revealing which actors in the system have the most freedom to influence and which are the most dependent beyond the inflows and outflows of directional connections.

This is not only possible with "hard" data such as funding, but can also be improved by integrating and quantifying qualitative data as well. This type of "data-driven theory" has been proposed before (e.g., Muller, Guah, Davis, Geyer, & Shami, 2015), in which machine learning augments grounded field theory for theory development from both bottom-up and top-down approaches. The application to systemic design has been further demonstrated in a private research project sponsored by RECODE, a national initiative to encourage social innovation and entrepreneurship in higher education, where researchers combined the iterative approaches of Delphi surveys with structured dialogic design and digital mapping. In the research, they asked respondents to provide challenges in supporting innovation in higher education, then tasked participants with relating the challenges to one another in order to develop a hierarchy of leverage points for change (Second Muse, Intel, & Vibrant Data, 2016; cf. Flanagan & Christakis, 2010; Trevino-Cisneros & Hisijara, 2013).

In other words, there exists a new potential approach to systems dynamics at the intersection of crowdsourcing, data science, and systemic design. As articulated by Jay Forrester (1994), systems thinking and soft OR approaches to systems lack rigour, discipline, and clarity in modelling the systems they seek to understand.

A systemic designer can use tools like natural language processing and machine learning to receive, collate, analyze, and synthesize a large number of qualitative data points collected through any number of means – workshops, Twitter, surveys, and beyond. These tools should allow said designer to funnel large numbers of expert opinions or public sentiment into data-driven models of the systems and theories of change they are using. For instance, it may be possible to use existing information systems to begin "polling" educators and students about their experiences within education, collating and analyzing the data they provide with natural language processing and database tools to create a living, realtime model of the system's phenomena.

A futures perspective

I originally set out to include a study in education futures in this research, but the scope proved to be too big to effectively complete it. Including this perspective moving forward is important, however. Education is a rapidly changing industry. New schools, credentials, pedagogy, methods of assessment, paradigms of curricula, and beyond are increasingly disrupting the long-stable system so many are used to. "What level of education are you researching?" is a question I've been asked often throughout this research process, the questioner expecting a response of "K-12" or "post-secondary". However, the different levels of education may be losing their credence, as self-directed learning, microcredentials, and online programs begin to blend K-12 learners with those in post-secondary or career-based learning.

Likewise, the "future of work" is a hot topic (Pittis, 2014). As offered by Klaus Schwab and Richard Samans of the WEF in their preface to the 2016 "Future of Jobs" report:

> **To prevent a** worst-case scenario—technological change accompanied by talent shortages, mass unemployment and growing inequality—reskilling and upskilling of today's workers will be critical. While much has been said about the need for reform in basic education, it is simply not possible to weather the current technological revolution by waiting for the next generation's workforce to become better prepared. Instead it is critical that businesses take an active role in supporting their current workforces through re-training, that individuals take a proactive approach to their own lifelong learning and that governments create the enabling environment, rapidly and creatively, to assist these efforts. (Leopold, Ratcheva, & Zahidi, 2016).

These changes are threats to the current models of education and work – but they are also opportunities for reformers. Online learning, for instance, offers a readily accessible venue through which to offer innovation education outside of the current public system.

In this moment, in the context of this research, these notions mean one thing: futures research is critical in moving innovation education forward.

Testing the system model

The systemic model of education reform developed in this study is a good foundation, but its accuracy must be proven, its assumptions contested, and its details further refined. Jones (2014), for instance, suggests that requisite variety can only be achieved through convening stakeholders representative of all of those that may be affected by the system–something that

was outside the scope of the present research. An effort in systemic ethnography–expert interviews, structured dialogic design, and other methods that allow the researcher to bring the real world into the model–would help further validate the accuracy of the model's representation of the world.

Testing the innovation model

I have set forth a model of the innovator and how they behave. However, this model is a fairly untested one, derived simply from passive research methods. Case studies offer a straightforward method for testing this model against real-world exemplars: a researcher simply needs to ethnographically review instances of innovations or the practices of identified innovators, looking for practices that either confirm or are antithetical to the model laid out here.

Defining the differences

As the goal of this research was to synthesize and interweave different perspectives on innovation into a holistic model, I did not attempt to differentiate between these perspectives, nor to discover the rationale for these differences. Another researcher may find great insights by connecting the different mental models used by different organizations or jurisdictions to the structures, demographics, activities, or other aspects of those institutions.

Defining routines for innovation

Eveleens (2010) attempts to define and index a set of comprehensive routines or activities an innovator can use during each phase of innovation – but the work is incomplete. Compiling tools and resources for would-be innovators aligned with these phases could be a worthwhile endeavour.

Exploring the paradox of Indigenous innovation

One aspect of Indigenous innovation is to pursue new solutions with old ways. Perhaps best pursued by an Indigenous researcher, understanding how the processes of Indigenous innovation might differ from "non-Indigenous" innovation is a rich pathway for future exploration. What strengths and weaknesses does this model have? Where might it fit where traditional approaches to innovation fail?

Co- and extra-curricular innovation education

How might influences from outside of the formalized public education system provide innovation education? It is intuitive that the volunteer experiences, hobbies, and after school programs many students take provide some form of innovation education, be it collaborative capacity through sports teams or prototyping skills through a robotics club. Still–in the Newfoundland and Labrador context, at least–these experiences are not well mapped and are therefore difficult to examine. A study indexing these opportunities and outlining their contributions to innovation education would offer some value.

Next steps

In the short term

A few immediate actions stem from this research.

First, we must adopt a model of innovation skills and competencies. Regardless of whether the adopted model is the one developed through this project or another alternative, it is imperative that we begin to recognize the skills and competencies used by successful innovators. By identifying these skills, we will be capable of examining our weaknesses and, in turn, developing ways of resolving those weaknesses. To spur this discussion, I plan on sharing the models developed here widely.

Second and in tandem, we must include the role of the education system in nurturing innovators in our provincial and national innovation strategies. Many approaches to innovation policy discuss the post-secondary education system with respect to its role in public-private partnerships and the commercialization of research. We must expand this role to include the development of innovation skills and competencies as well. In the near future I hope to meet with policymakers involved in the development of Newfoundland and Labrador's innovation strategies to advocate for this approach there.

Third, education reform movements must be united in their calls for change. A host of movements relate to the notion of innovation education, from code.org (a non-profit urging computer science and programming education in K-12) to the 21st century learning movement (a pedagogical framework for the skills and knowledge necessary for the 21st century; cf. http://www.p21.org). This research shows that these reform efforts may conflict, however, if they are brought forward asynchronously by their champions. It is therefore crucial that these efforts learn to "co-opete" (as in "co-opetition") and engage educators and policymakers with aligned advocacy. I hope to work with the education systems change movements I already have relationships with in the immediate future in order to begin this dialogue.

In the long term: a systemic design science approach to muddling through

As explored by David Stroh in *Systems Thinking for Social Change* (2015), systems change is only possible when the actors of the system collectively recognize the tension between where the system is and where they want it to be. That realization isn't possible, however, before the actors have even talked to one another – let alone come to consensus about a shared vision for the future.

We realize that Canada's future prosperity is predicated on our ability to leverage the boons of our resource economy and evolve it into an "innovation rich" leader in the knowledge economy. Yet, as discussed at the beginning of this paper, the danger is that education's role in this transformation has yet to be recognized in full. We are not talking about how to create innovators, let alone what strategies we should employ in doing so, or how the system is stuck in becoming better at innovation education. Worse, there are many simultaneously conversations happening in both education reform and innovation – conversations that compete with one another, threatening the potential of the whole.

This research contains a convening of perspectives, resulting in a holistic theory of innovation and innovation education. It offers a model of the education system in Newfoundland and Labrador. Yet these models are untested, and as I have noted, the research is sorely lacking a futures perspective that observes both threats and strategic opportunities in our changing environment.

How might we spark a collective, integrative discourse on innovation and innovation education? Then, how might we elevate its importance such that collective action is taken – before we've missed the opportunities of the knowledge economy? How might we refine the systemic models, and how might we augment this work with a futures perspective, using environmental scanning to develop and integrate changing trends for strategic leverage?

These questions point toward a need for a powerful, strategic theory of change, and the willingness to muddle through. In other words, this change will not come about through the efforts of ad hoc standalone initiatives like this one.

We need a sustained effort. We need a lab that brings together design science and systemic design, creating and testing designs of the system itself, making sure they are valid constructs of the concepts they are intended to represent, all while obeying the principles of systemic design.

This is not a new idea. Many have articulated the notion of social labs (cf. Hassan, 2014; Mulgan, 2014), design or change labs (cf. Bellefontaine, 2012), or social innovation labs (cf. Riddell, 2016). In fact, the OECD's Centre for Educational Research and Innovation seems to operate such an approach for systemic innovation in education (cf. Working out change, 2009).

I argue that Canada–or at least, Newfoundland and Labrador–needs to take a lab-based approach to navigating complex education reform in education. This lab must unite the perspectives, strategies, and actors currently engaged in similar pursuits; build, maintain, and refine models of the systemic change taking place; be engaged in environmental scanning and strategic foresight to monitor for both threats and opportunities; and prototype change initiatives, taking lessons back to these models and strategies.

Only a dedicated, intelligent effort will help us build the education systems that will develop the skills and knowledge we need to answer the 21st century.

Afterword

Amy Satterthwaite, alumni of the Master of Design in Strategic Foresight & Innovation (SFI) for which this Major Research Project (MRP) is being completed, once offered a roomful of current students some advice for research. It's stuck with me. I'll paraphrase:

> **This research –** your Master's – will not give you answers. That's what a Ph.D. is for. Instead, your Master's project will help you find the right questions to ask.

I began this project with a passion for the potential for education – one that brought me to Toronto to complete the SFI program in the first place – and a curiousity about whether education can help us (society, that is) solve our biggest challenges.

It was accidental that I came upon the notion of innovation education. Studying Canada's "innovation gap" was simply the subject of previous work (cf. Fascinato et al., 2016). It didn't seem as if anyone was talking about education as a solution to our innovation troubles, so I wanted to explore what's been said.

Only as I approached the end of the project – and as Anna Smith joined my MRP committee as a second reader (hi, Anna!) – did I realize that this was, in some ways, predestined.

In 2012, Anna and I spent a year working together with a host of colleagues from across the nation on a tumultuous project under the purview of Engineers Without Borders Canada called the Youth Venture. That team set out to define opportunities for systemic change in how our country engaged and developed youth as leaders and global citizens. We developed a framework for global leadership development (professionally illustrated by Anna below) that defined skills and competencies we thought were necessary for global leadership: courage and critical thinking, informed by awareness, motivation, débrouillardise (a French term that roughly translates to "bootstrapping"), and curiousity, leading to collaborative action. We sought ways to encourage these competencies in Canadians, and we realized that the systems of education Canada has were not doing a great job of it as yet.

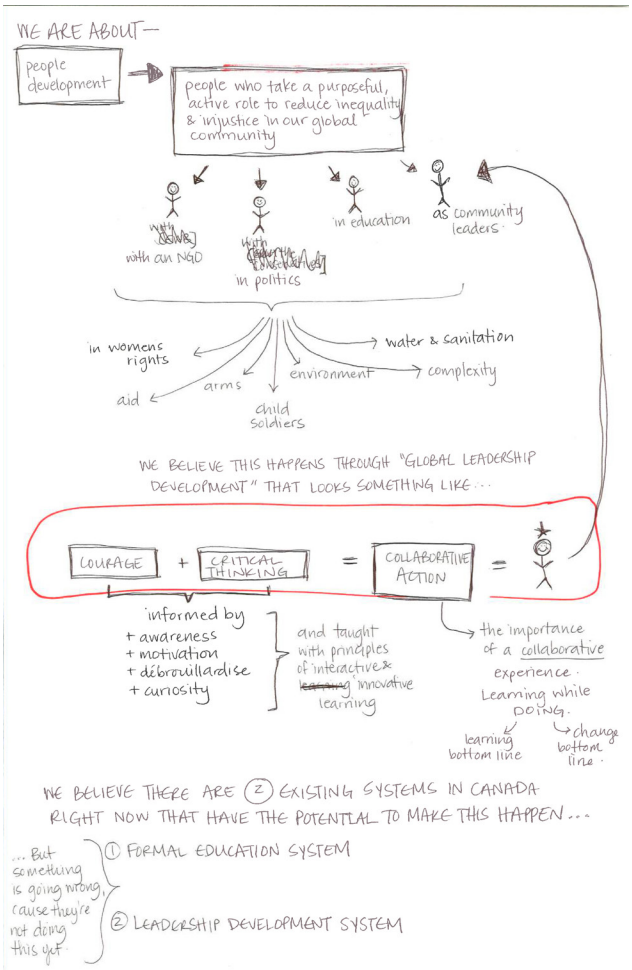


Figure 13. Global leadership framework sketch.

The competencies of our framework were not derived in the most rigorous of senses. Now, though, I see parallels with many of the domains defined in the model I proposed in this research. Sadly, the Youth Venture did not last beyond 2012. We were, effectively, a bunch of kids playing around with ideas – but now I see that we got a lot "right". In the context of this research, I see that the practice of global leadership we were pursuing is akin to the social and sustainability orientation described by the innovation model of part 2.

So, something about this troubles me deeply, and leaves me a little resentful. If a group of early-20's students recognized these issues almost half a decade ago, why has so little changed since?

I recognize the grave naïvety of this question. I hope that my self-awareness of this naïvety was adequately expressed in the foreword – which is exactly why I was keen to start this project and to search for examples of change, to find some crystalline examples of success in the literature.

That's why, at this point, the question feels less naïve. I have collected over 300 references on these ideas, authored 40,000 words of my own on them, and over the past year I've been whisked from my little corner of the Atlantic to the SFI program, MIT, MaRS, and the Muskokas to work with great, likeminded people on exactly this problem.

My biggest disappointment over the past six months was the realization that so many conversations about these challenges happen in parallel. Not collaborating, not competing… just… simultaneously. I am still finding new sources on defining innovation and on innovation education, days before my deadline. These separate conversations fail to reference one another. Every collaboration seems to begin from scratch, with its own theory of change, its own sensemaking, its own systems mapping.

No one seems to know anyone else is–or was–talking.

This is not a critique. Brilliant people work on education reform. Seriously. The brilliant-est. And yet so little seems to change.

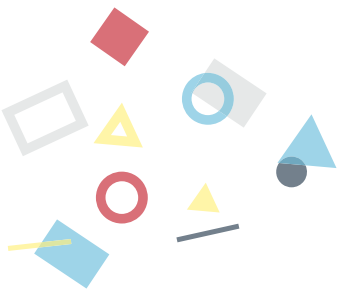
I end the conclusion with a call for a sustained systemic design effort – what I called systemic design science – because of exactly this phenomena. We must develop sustained, useful, interactive, transparent–open source, even–models to understand these problems. We need to share those models widely, to allow others to respond, contribute, and critique what we think we know. And we need to experiment with the real world, knowing how those experiments fit into the model and making sure to trap and share the learning we get from them.

I never again want to begin a conference by working with my peers to map the system. We should have the system in the palms of our hands.

I remain resolute. As I mentioned in the foreword, (action) research is the life for me. My next (hopeful) step is to begin an interdisciplinary PhD, finding ways to tie together design science, data science, citizen science, gamification, futures, and systemic design to facilitate change in innovation education in Newfoundland and Labrador.

I dream, day and night, of platforms for data-driven, interactive systemic change.

So, Amy was right. The MRP did give me a question: how might we make this happen?



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Appendix A: Perspectives on Innovation

International Perspectives

OECD

Resources reviewed

- *Oslo Manual – Proposed Guidelines for Collecting and Interpreting Technological Innovation Data (2005)*
- *Workplace Skills and Innovation: An Overview of the Major Themes in the Literature (Toner, 2011)*
- *Skills for Innovation and Research (OECD, 2011)*
- *Skills for Innovation (Green, Jones, & Miles, 2007)*

Discussion

In 1992, later updated in 2005, the OECD published what is known as the *Oslo Manual: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data*. Crucially, the Manual sought to lay out processes and analysis of "technological product and process (TPP) innovation", it focused on understanding innovation in business, and it emphasized innovation at the level of the firm (Oslo Manual - Proposed Guidelines for Collecting and Interpreting Technological Innovation Data, 2005). As the Manual was put to use in understanding the innovation data of many OECD member nations, the Manual became the root of many of the models of innovation discussed thus far. Thus, could it be that "what is measured is improved"? As the Manual became a dominant force in our nations' mental models of innovation, could it have overemphasized these aspects of innovation in our strategies? These are important questions for innovation historians, perhaps.

Still, the OECD took great lengths to index existing models of innovation into a coherent, measurable one for TPP innovation at the firm. This framework identified four domains for TPP innovation in business: the environmental conditions of the firm; the science and engineering base from which the firm draws knowledge; the transfer factors that impact how the firm can draw information and skills for innovation; and the firm's "innovation dynamo", direct factors affecting the firm's innovative ability (Oslo Manual - Proposed Guidelines for Collecting and Interpreting Technological Innovation Data, 2005). The notion of the innovation dynamo directly involves the skilled employees of the firm, among other factors such as the strategy, organizational structure, financial structure, competitors, and more. In keeping with the *Manual*'s commercialization-of-technology focus, however, the authors only emphasize the importance of technological capacity in these high-skill employees:

> **"Without skilled workers** a firm cannot master new technologies, let alone innovate. Apart from researchers, it needs engineers who can manage

> manufacturing operations, salespeople able to understand the technology they are selling (both to sell it and to bring back customers' suggestions), and general managers aware of technological issues." (Oslo Manual - Proposed Guidelines for Collecting and Interpreting Technological Innovation Data, 2005)

Notably, these domains go beyond just R&D: in fact, the authors stated that innovation activities include "all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations" (Oslo Manual - Proposed Guidelines for Collecting and Interpreting Technological Innovation Data, 2005). The authors went on to develop a robust framework of innovation type and level of novelty, namely differentiating between product, process, marketing, and organizational innovation, and the degree to which it is new to the firm or to the world (Oslo Manual - Proposed Guidelines for Collecting and Interpreting Technological Innovation Data, 2005).

Remember, though, that we are interested in the innovator. Thus, my question for these frameworks was how people fit into them. What are the skills and competencies that they point towards that we can develop in Canadians? Rather than attempt to draw out these skills and competencies from the *Oslo Manual* through raw inference, I turned to two other OECD reports for exactly this purpose.

Workplace Skills and Innovation: An Overview of the Major Themes in the Literature is focused on the "meta": it is an international examination of different approaches to defining skills and policy differences in training and education structures. To this extent, it remained entrenched in the approaches of the *Oslo Manual* and did not focus on explicating what innovation skills may be (Toner, 2011).

On the other hand, the OECD's 146-page *Skills for Innovation and Research* offered material of some relevance to the present research. Indeed, the body of the document began with the statement "Innovation depends on people who are able to generate and apply knowledge and ideas in the workplace and in society at large" (OECD, 2011). Authored to support the developing innovation systems of its member nations, it outlined current understanding of the links between skills and innovation and it provided direction for further research. The authors simplified the *Oslo Manual's* typology of innovation, saying instead that "innovation is about the creation, diffusion, and use of new knowledge and technology" (OECD, 2011). Further, they broke these components of innovation down into stages, suggesting that people can contribute to the innovation process at any given stage. The stages identified in *Skills for Innovation and Research* include:

- generating new knowledge;
- adopting and adapting ideas;
- enabling the process through learning and adaptation;
- complementing other inputs to innovation (e.g., by using new resources);
- generating spillovers (accelerating development in other workers and improving innovation culture); and
- adding to social capital (e.g., developing relationships between actors; OECD, 2011).

The authors went on to explore the theory on skill and innovation. The result was a realization that "skills for innovation could be any ability, proficiency, competency or attribute that contributes to the implementation of new products, processes, marketing methods, or organizational methods in the workplace" (OECD, 2011). With this breadth in mind, the authors articulated a host of families of skills that may be necessary for innovation:

- basic literacies, including language, numeracy, and digital literacy;
- academic skills;
- technical skills, specific to an occupation, tools, or processes;
- generic skills (in which the authors subsume problem solving, critical thinking, creativity, the ability to learn, and the ability to manage complexity);
- soft skills (occasionally grouped with generic skills, this includes communication, collaboration, motivation, initiative, emotional intelligence, intercultural awareness, and receptiveness);
- leadership (in which the authors include team building, coaching, ethics, charisma, negotiation, and advocacy);
- managerial and entrepreneurial skills (this includes commercial acumen, the ability to manage and take risks);
- creativity and design (which the authors consider the generation of ideas and the transformation of ideas into products or processes, respectively–the authors link this to art and culture);
- learning and R&D;
- societal skills (especially making connections and collaborating with people within and between firms);
- consumer skills (the ability to involve consumers in innovation processes);
- global and intercultural awareness;
- multidisciplinarity; and
- "green" skills (related to sustainability and environmental responsibility; OECD, 2011).

It is quite the list, isn't it? Unfortunately, the all-encompassing nature of this list of skills and capabilities reduces its utility for innovation education. It seems that innovation requires everything–how can we educate on everything? It is still possible, however, to make use of this list. As I will explore later, parsimony can be obtained by comparing these skills with those distilled from other perspectives.

Finally, the authors suggested that different mixes of innovation skills will be needed at different times in the innovation process and in different contexts (such as organizational level or geography). Adapting the work of Green, Jones, and Miles (2007), who consolidated the work of several theorists in their own exploration of skills for innovation, the authors asserted four phases of innovation:

- sourcing and selection of ideas;
- development of innovation ideas;
- testing, stabilization, and commercialization; and
- implementation and diffusion.

Likewise, different skills may be required for different innovation types (e.g., product vs. process), the industry, the organizational strategy, and in different geographies. In line with Green, Jones, and Miles (2007), the authors argued that different innovation skills apply in

different circumstances, while a set of generic skills can be applied across the board (OECD, 2011).

Takeaways

- The *Oslo Manual's* technology and commercial focus combined with its dominant position in the mindset of the OECD's nations may have exerted extensive influence over our mental models of innovation for the past few decades.
- There are four domains involved in technological product and process innovation in business: the environmental conditions of the firm; the science and engineering base from which the firm draws knowledge; the transfer factors that impact how the firm can draw information and skills for innovation; and the firm's "innovation dynamo", direct factors affecting the firm's innovative ability.
- Innovation can result in new products, processes, marketing, or organizational changes.
- Innovations can be new to organizations, new to the world, or somewhere in between.
- Innovation skills may manifest differently across different stages, including:
  - generating new knowledge;
  - adopting and adapting ideas;
  - enabling the process through learning and adaptation;
  - complementing other inputs to innovation (e.g., by using new resources);
  - generating spillovers (accelerating development in other workers and improving innovation culture); and
  - adding to social capital (e.g., developing relationships between actors.
- Innovation occurs over a set of discrete but interrelated phases, including:
  - sourcing and selection of ideas;
  - development of innovation ideas;
  - testing, stabilization, and commercialization; and
  - implementation and diffusion.
- Innovation skills can come from a variety of skill categories, including:
  - basic literacies, including language, numeracy, and digital literacy;
  - academic skills;
  - technical skills, specific to an occupation, tools, or processes;
  - generic skills (in which the authors subsume problem solving, critical thinking, creativity, the ability to learn, and the ability to manage complexity);
  - soft skills (occasionally grouped with generic skills, this includes communication, collaboration, motivation, initiative, emotional intelligence, intercultural awareness, and receptiveness);
  - leadership (in which the authors include team building, coaching, ethics, charisma, negotiation, and advocacy);
  - managerial and entrepreneurial skills (this includes commercial acumen, the ability to manage and take risks);
  - creativity and design (which the authors consider the generation of ideas and the transformation of ideas into products or processes, respectively–the authors link this to art and culture);
  - learning and R&D;
  - societal skills (especially making connections and collaborating with people within and between firms);
  - consumer skills (the ability to involve consumers in innovation processes);
  - global and intercultural awareness;
  - multidisciplinarity; and
  - "green" skills (related to sustainability and environmental responsibility).

World Economic Forum

Resources reviewed

- *World Economic Forum 2013-2014 Global Competitiveness Report (Schwab & Sala-i-Martín, 2013)*
- *World Economic Forum 2016 Global Risks Report (World Economic Forum, 2016)*

Discussion

In parallel with the OECD's work, the World Economic Forum (WEF) regularly conducts its own research on these topics. To the WEF, innovation emerges from both technological and non-technological knowledge. The WEF's 2013-2014 *Global Competitiveness Report*, for instance, identified technological innovation as the twelfth pillar of national competitiveness and collapsed non-technological innovation underneath the eleventh pillar, business sophistication. This is because they argued that non-technological innovation comes from the know-how, skills, and working conditions of the nation's organizations. Thus, to the WEF, non-technological innovation is a product of the quality of a country's organizational networks and the quality of operations and strategies in its organizations, as well as the existence of innovation clusters (under business sophistication). Technological innovation, on the other hand, comes from an innovation-facilitating environment, the support of private and public sectors, investment in R&D, the presence of high-quality scientific research institutions, collaboration between post-secondary and industry, the protection of intellectual property, high levels of competition, and access to capital (Schwab & Sala-i-Martín, 2013).

While this did not offer much for a model of innovation education, the WEF recognized the role education plays in these pillars. In fact, in the foreword of the 2013-2014 *Global Competitiveness Report*, Klaus Schwab–Executive Chair of the WEF–writes that the ever-increasing significance of innovation:

> **"means that the** traditional distinction between countries being 'developed' or 'developing' will become less relevant and we will instead differentiate among countries based on whether they are 'innovation rich' or 'innovation poor.' It is therefore vital that leaders from business, government, and civil society work collaboratively to create enabling environments to foster innovation and, in particular, to create appropriate educational systems" (Schwab & Sala-i-Martín, 2013).

Innovation appeared in a surprising place in another WEF publication. The 2016 *Global Risks Report* recognized the adverse effects of technological advancement as a potent global risk. It linked technological innovation to potential unemployment and underemployment, infrastructure breakdown, data fraud/theft/cyberattacks, and the rise of social unrest and citizen disempowerment (the latter due to a feeling of social/political powerlessness despite increasing access to information). The authors noted that these interacting risks are not well understood and prone to volatility, complexity, and ambiguity (World Economic Forum, 2016). The parallel to a Canada2020 report that called for new emphasis on "human-centred innovation" and previous research on misinnovation is not

lost, however (discussed later; cf. Fascinato et al., 2016; Moffatt & Rasmussen, 2016).

Takeaways

- The WEF divides innovation into technological and non-technological categories.
- Technological innovation comes from:
  - innovation-facilitating environments;
  - private and public sector support;
  - investment in R&D;
  - high-quality scientific research institutions;
  - collaboration between post-secondary and industry;
  - intellectual property protections;
  - high levels of competition; and
  - access to capital.
- Non-technological innovation comes from:
  - the quality of a country's organizational networks;
  - the quality of operations and strategies in its organizations; and
  - the existence of innovation clusters.
- The distinction between "developed" and "developing" nations will disappear as we begin to differentiate between "innovation rich" and "innovation poor" nations.
- Schwab calls directly for the creation of "appropriate educational systems" in his foreword to the 2013-2014 Global Competitiveness Report (Schwab & Sala-i-Martín, 2013).
- The 2016 *Global Risks Report* links technological innovation to adverse effects, such as unemployment and underemployment, infrastructure breakdown, data fraud/theft/cyberattacks, and the rise of social unrest and citizen disempowerment. These risks are not well understood and prone to volatility, complexity, and ambiguity. This elevates the significance of "human-centred innovation" (e.g., Perelman, 2007; Moffatt & Rasmussen, 2016) and misinnovation (e.g., Fascinato et al., 2016).

National Perspectives

Government of Canada

Resources reviewed

- *The Government of Canada's* Canada's Innovation Agenda *website (Innovation Government of Canada, 2016a)*: a website built to create dialogue around Canada's 2016 innovation strategy
- *An Inclusive Innovation Agenda: The State of Play (Innovation Government of Canada, 2016b)*: a presentation on the state of innovation in Canada used to inform the consultations on the development of Canada's 2016 innovation strategy
- *Seizing Canada's Moment (Industry Canada, 2014)*: the Government of Canada's 2014 Innovation Strategy
- *Science and Technology Strategy (Industry Canada, 2007)*: the Government of Canada's 2007 Innovation Strategy
- *Survey of Innovation and Business Strategy (Innovation Government of Canada, 2010)*: A survey conducted in partnership between several federal ministries examining the entrepreneurial and innovation strategies of Canadian organizations

- *Achieving Excellence (Industry Canada, 2001)*: the Government of Canada's 2001 strategy focused on driving Canada's innovation capacity in general
- *Knowledge Matters (Public Works and Government Services Canada, 2002)*: the Government of Canada's 2001 strategy focused on improving skills and learning nationally, in parallel with the *Achieving Excellence* strategy

Discussion

> **Our creativity and** resourcefulness define us. Innovation is a Canadian value. It's in our nature, and now more than ever, it will create jobs, drive growth and improve the lives of all Canadians. It's how we make our living, compete and provide solutions to the world.

So read the first headline on the 2016 Federal Government's "Canada's Innovation Agenda" webpage (Innovation Government of Canada, 2016a). Thus, we know innovation is a "Canadian value", that it is "in our nature", and that it will result in a plethora of positive inroads for the nation.

But *what is it?* How do we do it?

The site cited above was built as an interactive platform to engage Canadians in developing a new innovation strategy. It included several resources explaining why the agenda is significant. A presentation file, for example, talked about the rapidly changing conditions of the 21st century, and how these changes imply a new industrial age–and a global "innovation race" to go along with it ("An Inclusive Innovation Agenda: The State of Play," 2016). Later, the presentation highlighted six action areas for Canada's state of innovation:

1. Entrepreneurial and Creative Society;
2. Global Science Excellence;
3. World-Leading Clusters and Partnerships;
4. Grow Companies & Accelerate Clean Growth;
5. Compete in a Digital World; and
6. Ease of Doing Business

Notably, the first of these pillars seems to point towards the location of a firm definition: "Foster a culture of innovation and entrepreneurship, build skills to embrace global changes, leverage Canada's diversity and attract top global talent" ("An Inclusive Innovation Agenda: The State of Play," 2016). Yet, while this section of the document pointed toward indicators that would contribute to a *culture* of innovation (e.g., educational attainment, literacy levels, equity of access, and skills gaps), it does not attempt to define how to improve innovation itself.

This, perhaps, is why innovation is often considered a buzzword. The term seems to mean something important, and yet we rarely pause to make sure we all know what exactly that is.

There is, of course, at least one other interpretation for the Government's avoidance of a definition. It could be that *Canada's Innovation Agenda* accepted innovation only as a collective competency. In other words, only by combining things like a creative society, scientific excellence, and world-leading clusters can a definition of innovation be truly captured.

This avoidance of a definition is, interestingly,

in stark contrast with the innovation strategies of earlier governments. Take this excerpt from 2014's *Seizing Canada's Moment* report:

> **Successful innovation by** businesses, not-for-profit organizations and governments requires that we put into place corporate strategies based on fostering innovation. However, innovation is a complicated process that is neither defined by a simple formula or playbook, nor easily measured.
>
> Sometimes, innovation comes directly from advances in science and technology, but it can also stem from other sources. Even innovation that comes from R&D rarely follows a straight path from lab to marketplace. The results of curiosity-driven research are not known in advance, so capitalizing on the outcomes is risky and depends as much upon the skill, vision and adaptability of the innovator, as on the quality of the research itself.
>
> An idea or invention, however radical or creative, is not an innovation unless it is put to use. A strong science and technology base supports innovation but alone is not its cause and not all innovation has a base in science and technology. Innovation requires creative firms or individuals to see an opportunity, take a risk, and often it involves experimenting with different practices, methods and processes. (Industry Canada, 2014)

Seizing Canada's Moment thus seemed much more self-aware than Canada's currently-developing innovation strategy. I observed that, according to the 2014 Federal Government, innovation is complicated, resists assessment, is risky, comes from science and technology (but also other sources), must be an idea put to use, and requires experimentation. Innovation also crucially depended on the "skill, vision, and adaptability of the innovator". The broader strategy, however, had an explicit bias: it was focused entirely on facilitating business innovation, and therefore assumes that all innovators of importance ultimately aim to commercialize their efforts (Industry Canada, 2014). This is a significant assumption.

Still, the Strategy contained a wealth of useful information about how Industry Canada viewed innovation (and innovators) in 2014. It built on the 2007 *Science and Technology Strategy* by dividing Canada's approach into three pillars: People, Knowledge, and Innovation. (2007's Strategy, instead, had People, Knowledge, and *Entrepreneurship* pillars; Industry Canada, 2014.) These pillars unfolded into three strategic directives: Growing Canada's Talent, Maintaining Canada's Leadership in Knowledge, and Encouraging Canada's Business Innovation, respectively. In each of these directives, the Strategy laid out further plans giving us a clearer idea of what the authors mean.

Growing Canada's Talent began with the following vision statement:

> **Canada will be** a place where curiosity is encouraged, our youth are inspired by science, technology and innovation, and where the best and brightest minds from around the world come to share in our aspirations of pushing the frontiers of knowledge and making ground-breaking technology advancements to help Canada succeed in the global economy. (Industry Canada, 2014)

These concepts populated how the Government plans to grow Canada's talent through the following priorities: preparing our people for innovation; encouraging science-to-industry jobs; supporting global connections; and fostering

an innovation culture. These plans, however, centred on encouraging Science, Technology, Engineering, and Mathematics (STEM) education and entrepreneurial opportunities; the implication was that these were the core competencies required for (business) innovation. Likewise, discussion of the competencies and skills required for innovation are scarcely found in the Maintaining Canada's Leadership in Knowledge and Encouraging Canada's Business Innovation Pillars–although the latter briefly mentioned supporting skill development around digital technology as in order to "become a digital nation" (Industry Canada, 2014).

The 2014 Strategy otherwise made reference to the Organization for Economic Cooperation and Development's (OECD) Oslo Manual on technological innovation (cf. OECD, 2005).

The Manual was also used to inform the 2009 *Survey of Innovation and Business Strategy*. This Survey–a joint project of the ministries of Industry Canada, Foreign Affairs and International Trade Canada, and Statistics Canada–studied the entrepreneurial and innovation-oriented strategies of organizations in Canada. This strategy was again business-focused, and explicitly divided innovation into several types (product or service, process, marketing, and organizational innovation). Notably, the survey illustrated a framework for how these components of innovation might relate to one another, asking businesses to report when innovations in one type required further innovations in others. It also unearthed nine significant barriers to innovation reported by Canada's enterprises (Innovation Government of Canada, 2010):

1. Uncertainty and risk (36.6% of all firms)
2. **Lack of skill (26.0%)**
3. Internal financing (22.8%)
4. Market size (17.2%)
5. External financing (16.2%)
6. Regulatory issues (15.9%)
7. External collaborators (11.0%)
8. IP protection (4.5%)
9. Government competition policy (3.9%)

Regrettably, the report did not go into greater detail as to what skills might be lacking (Innovation Government of Canada, 2010).

Two more documents are worthy of substantial attention in this discussion. In 2001, the Federal Government's innovation strategy was composed of two documents: *Achieving Excellence* and *Knowledge Matters*. *Achieving Excellence*, focused entirely on driving Canada's innovation capacity, defines innovation directly:

> **Innovation is the** process through which new economic and social benefits are extracted from knowledge capacity. Through innovation, knowledge is applied to the development of new products and services or to new ways of designing, producing or marketing an existing product or service for public and private markets (Industry Canada, 2001).

This strategy document highlighted three challenge areas: Knowledge Performance, Skills, and the Innovation Environment. Still, across these priorities, the initiatives that the Government identified underscore only the importance of advancing skills and knowledge in broad terms. The assumption was that by improving the production of knowledge itself

(and those who create and use that knowledge), we will achieve innovation (Industry Canada, 2001).

Finally, *Knowledge Matters*–on title and premise alone–seemed like it would be a proverbial gold mine for our pursuit. Authored to "engage Canadians in a national dialogue on skills and learning" as part of the innovation strategy and in the face of the looming knowledge economy, the Government went to great lengths to recognize the need to strengthen our learning system (Public Works and Government Services Canada, 2002). While this provided a powerful foundation on which to build the case for education reform (as I shall discuss in a later chapter!), the report was again lacking in specifics on what 21st century education should look like in terms of learning outcomes. Instead, it positioned innovation as an outcome of high levels of educational performance and attainment. The report took it as axiomatic that more knowledge, in general, is the key. Thus, its focus was on improving equity of access; an important effort, to be sure, but not one that related directly to defining innovation (Public Works and Government Services Canada, 2002).

Takeaways

- The Federal Government's approach to innovation (and innovation strategies) has evolved over time, with each opportunity for a new strategy taking a slightly different tack on how to describe and model Canada's innovation capacity.
- Most reports at least imply what innovation is. Some provide their own definition; several borrow an approach from the OECD.
- No report directly addresses how to improve innovation capacity in an individual learner. In other words, while being supremely concerned about Canada's capacity to do innovation, no federal government in the last two decades has explicitly concerned about what capacities Canadian innovators lack.
- Ensuring Canadians are as skilled as possible is generally in every Innovation Strategy.
- Maximizing research output and the creation of new knowledge is generally in every Innovation Strategy.
- From the Federal Government's perspective, innovation is often a commercial endeavour.
- How exactly high skill and new knowledge creation is turned into or used in innovation is generally taken for granted.
- Across the reports reviewed, innovation involves (in no particular order):
  - domain expertise;
  - digital literacies;
  - STEM literacies (in those that emphasized the OECD's technological innovation approach);
  - entrepreneurship, or the commercialization of the innovation (particularly in those that emphasized the OECD's technological innovation approach);
  - regional and sectoral clusters;
  - creativity (particularly in recent years);
  - management of risk and uncertainty;
  - financing; and
  - collaboration between governments, public institutions, businesses, and individual innovators.

Third-party perspectives

The Conference Board of Canada

Resources reviewed:

- *How Canada Performs 2009: A Report Card on Canada (Conference Board of Canada, 2010)*
- *International Rankings – Innovation (Conference Board of Canada, 2013c)*
- *Provincial and Territorial Rankings – Innovation (Conference Board of Canada, 2015)*
- *International Rankings – Education and Skills (Conference Board of Canada, 2013b)*
- *Provincial and Territorial Rankings – Education and Skills (Conference Board of Canada, 2014)*
- *Researchers - Innovation Provincial Rankings (Conference Board of Canada, 2013d)*: an in-depth exploration of international rankings on the employment and activity of researchers
- *PhD Graduates - Education Provincial Rankings - How Canada Performs (Conference Board of Canada, 2011)*: an in-depth exploration of international rankings on the graduation and employment of PhD students
- *Hot Topic: Advanced Skills & Innovation (Conference Board of Canada, 2016a)*: an in-depth report on the relationship between skills and innovation capacity for Canada
- *Solving Canada's Innovation Conundrum: How Public Education Can Help (Bloom & Watt, 2013)*: a report on reform opportunities to improve innovation education in Canada
- *Skills Make Innovative Companies (Conference Board of Canada, 2013e)*: a press release announcing the launch of the second version of the Conference Board of Canada's Innovation Skills Profile
- *Innovation Skills Profile 2.0 (Conference Board of Canada, 2013a)*: the Conference Board of Canada's privately-developed skills profile, to help businesses assess their innovation skill strengths and weaknesses

Discussion

The Conference Board's many analyses and outtakes on Canada's innovation performance have been the source of much alarm in recent years (cf. Loghmani, 2016). The Conference Board has been conducting semi-regular indexes of Canada's innovation performance against 16 international peers for over a decade. In 2009 and 2013, Canada's ranking was dismal: 14th and 13th, respectively (Conference Board of Canada, 2010; Conference Board of Canada, 2013c). Recent years have seen a more dramatic slope of improvement, and the Conference Board's provincial index–completed in 2015–mentioned that Canada has climbed to 9th of 16 (Conference Board of Canada, 2015). This development is reason for optimism, though the Conference Board noted that emerging and persistent weakness in some areas of Canada's innovation indicators are still cause for concern. But what are those indicators?

According to the Conference Board itself:

> **To measure innovation** performance, we evaluate Canada, its provinces, and 15 peer countries on the following 10 report card indicators:

public research & development (R&D), researchers engaged in R&D, connectivity, scientific articles, entrepreneurial ambition, venture capital investment, business enterprise R&D (BERD), ICT investment, patents, and labour productivity. We also evaluate the performance of the provinces on enterprise entry rates; unfortunately, there are no comparable international data for this indicator.

Thus, the vision of innovation assessed by the Conference Board parallels that of the Federal Government. Research and development, science and invention, entrepreneurship, and investment were the general themes–more of these will generally lead to more innovation. This again reflected a business- and technology-focused view, but as mentioned previously–and as I shall explore through later perspectives–innovation comes from other sources and manifests in other outputs as well.

It's worth noting the Conference Board's methodology was rooted in measuring outcomes: what the actual, measurable outputs are in a given area of study. This could explain the absence of indicators outside of business and technology. Still, there may be aspects of Canada's innovation performance (or lack thereof) that may be missed in a framework emphasizing economic outputs; including the notion of social innovation, which is explored later.

As the present research is focused on the education of innovation, it is also worth exploring the Conference Board of Canada's literature on education and skills in Canada. Two recent profiles saw Canada slip compared to the same 15 peer countries in terms of education–from 2nd place in 2013 to 6th place in 2014 (Conference Board of Canada, 2013b, Conference Board of Canada, 2014). That is a precipitous drop, relatively, but Canada's absolute position is nonetheless something to celebrate. Still, did the Conference Board's analysis have anything to do with innovation or related skills and competencies?

The assessment was based on 21 total indicators–as above, measurable outcomes of education, such as graduation rates–indexed across three levels of educational attainment: basic, mainstream, and advanced. These indicators included factors such as "students with low-level reading skills", "… math skills", and "… science skills"; "adult participation in non-formal job-related education", and others that explored equity issues such as differential effects of gender or disadvantaged schools. There were also some indicators that intertwine, to some extent, with other perspectives on innovation: college and university completion, PhD graduates, and STEM graduates. Regardless, there was no elucidation on how these outcomes might be linked to overall innovation performance, if at all (Conference Board of Canada, 2013b; Conference Board of Canada, 2014).

However, more detail about the intersections of the Conference Board's analyses is revealed in an in-depth report on advanced skills and innovation released in 2011. In this document, the authors discussed the skills required for innovation, citing a 2011 OECD report on the same subject (cf. OECD, 2011). Crucially, the authors noted that the application of innovation skills and competencies in business is contextual, and that different circumstances will require different skills. For this analysis, the Conference Board focused only on advanced

skills–notably in line with other perspectives on national innovation discussed previously–emphasizing the important role advanced skills play in both the development and use of new technologies. With this lens, the intersectional analysis focused on the correlations between university completion, PhD graduates, STEM graduates, knowledge-intensive services (as a share of GDP), high-technology manufacturing (as a share of GDP), patents per population, R&D expenditures, and the country's overall ranking on innovation (Conference Board of Canada, 2016a).

The full (and, in places, interactive) analysis is quite remarkable and worth visiting in full for anyone interested in these issues. The authors demonstrated extensively how these different indicators correlate. Indeed, for instance, university completion and knowledge-intensive services are generally positively related. There is also a relationship between college completion and high-technology manufacturing (Conference Board of Canada, 2016a).

In all, though, the report did not have any definitive answers for how to improve innovation through education–at least, through these outcomes. The authors expressed some frustration with some of the indicators, e.g., "the number of science and engineering PhD graduates may be a misleading indicator of Canada's innovation potential since a large number of graduates leave Canada to pursue post-doctoral studies or work in the United States", and there were important exceptions to the relationships they do find (e.g., patent rates are strongly correlated with PhD graduation rates, except that Japan has the second-lowest PhD graduation rate and the second-highest patent rate; Conference Board of Canada, 2016a). Previous research has suggested that Canada's innovation gap–Canada's perceived lag behind other nations in the fourth industrial revolution–might come from failure to leverage its strategic competencies in its innovation strategies, some of which are rooted in the trades – maybe this is an opportunity for the nation (Fascinato et al., 2016).

In the conclusion, the authors recognized that advanced educational attainment is not enough to improve Canada's innovation performance. In fact, one of their final points was that "innovation skills need to be infused in school curricula at all levels of education" (Conference Board of Canada, 2016a). To that end, the Conference Board of Canada has actually published another report on how public education can help solve Canada's "innovation conundrum" (Bloom & Watt, 2003). That report should have been fundamental to the present research, but it stops short of providing a model of what innovation education is. Instead, Bloom and Watt discussed the imperative for innovation education and suggest higher level strategies for increasing innovation education in Canada–including defining innovation. Those strategies included a pan-Canadian branding framework that elevates Canadians' (and Canadian organizations') understanding of innovation; the recognition and credentialing of innovation skills; increasing the links between education, business, and community; and adding innovation training to the curricula of our pre-service and in-service educator (Bloom & Watt, 2003). Enabling Canada to achieve some of these objectives is what the present research aimed to

achieve.

Finally, the Conference Board of Canada also created the Innovation Skills Profile, "designed to be used by employees, employers, educators, students, governments, labour and communities to become more innovative" (Conference Board of Canada, 2013e). This consulting product identified a host of skills, attitudes, and practices necessary for innovation, organizing them under four categories:

- Creativity, Problem-Solving, and Continuous Improvement Skills;
- Risk Assessment and Risk-Taking Skills;
- Relationship-Building and Communication Skills; and
- Implementation Skills (Conference Board of Canada, 2013a).

The Profile offered a powerful and concrete list of competencies for innovation. It is not sufficient to accept this model wholesale and standalone, however, for several reasons. First, it is a private product. While it was developed in consultation with many partners–presumably with amicable intent–the research that led to its development is obscured and cannot be verified or judged. Further, the impact the model has had has not been shared by its progenitors. Second, the group behind the Profile was the Conference Board of Canada's Centre for Business Innovation, and while the profile is offered for use by anyone, its primary goal is to support business innovation. Thus, there may be aspects of a holistic view of innovation missing in its framework. Finally, while it is a profound resource, the competencies described by the Profile are sometimes vague. Three examples, for instance, are "Put forward your own ideas with confidence", "Take appropriate risks and keep your goals in sight", and "Nurture and promote creativity and inventiveness" (Conference Board of Canada, 2013a). How might one measure confidence, appropriate risk, or the ability to nurture creativity? For these reasons, the Profile is an excellent resource for the development of our model, but it is not the model I have been looking for.

I will revisit the Conference Board's work later, in examining innovation in the Newfoundland and Labrador context.

Takeaways

- The Conference Board of Canada emphasizes an economic/business/commercial and technological perspective on what innovation is.
- Canada has a high college graduation rate, but Canada has low patenting rates. Maybe imbuing college graduates (or all Canadians) with better innovation education could turn this negative correlation around.
- The Innovation Skills Profile 2.0 provides a potentially excellent foundation on which to build a robust model of innovation (and innovation education). This includes skills and competencies in the categories of:
  - Creativity, Problem-Solving, and Continuous Improvement Skills;
  - Risk Assessment and Risk-Taking Skills;
  - Relationship-Building and Communication Skills; and
  - Implementation Skills.
- The imperative to teach innovation has long been recognized by the Conference Board of Canada.

Other National Perspectives

Resources reviewed

- *Innovation and Business Strategy: Why Canada Falls Short (Council of Canadian Academies & Expert Panel on Business Innovation in Canada, 2009)*: The report of an expert panel mandated to deepen the understanding of business innovation in Canada
- *Innovation Canada: A Call to Action (Nicholson & Cotê, 2011)*: A report commissioned by the Government of Canada to examine Canada's support for R&D
- *Canada's Innovation Conundrum (Sulzenko, 2016)*: A review of progress made on the objectives outlined in *Innovation Canada: A Call to Action* by one of the panellists of the original report
- *Age of Disruption (Stuart, Currie, Goodman, Ives, & Scott, 2015)*: a Deloitte Canada report examining the preparedness of Canadian businesses (and Canada in general) for the potential technological disruptors of the 21st century
- *Digital Talent: Road to 2020 and Beyond (Information and Communications Technology Council (ICTC), 2016)*: A report of the ICTC that explores digital skills and literacies as the route to innovation capacity
- *A New Magnetic North (Canada25, 2001)*: A strategy and call to action on talent attraction and retention for innovation capacity from a think-tank composed of recent graduates
- *The Role of PhDs in the Smart Economy (Forfás, 2009)*: a commentary on and response to the growth of PhD graduates in Ireland and their potential contribution to Ireland's innovation capacity
- *Building Canada's Prosperity in a New Century (Nixon, 2002)*: a speech from Gordon Nixon, then President and CEO of RBC Financial Group, calling for action on Canada's innovation performance
- *Innovating a Canadian innovation ecosystem (Gold, Abraham, Gualtieri, & Gillespie, 2015)*: an article in Canada's *Policy Options* magazine discussing Canada's innovation gap and policy opportunities to reinvigorate Canada's stake in the innovation economy
- *Towards an Inclusive, Innovative Canada (Moffatt & Rasmussen, 2016)*: a report from Canada2020, a think tank focused on the role of the Federal Government, emphasizing the adverse consequences of non-inclusive innovation

Discussion

The Council of Canadian Academies published a report in 2009 titled "Innovation and Business Strategy". The outcome of that report was to recognize that problems with the Canadian innovation system stem from an absence of Canadian businesses pursuing innovation strategies themselves. For a host of reasons (the structure of their sector or business, the competitive intensity of their market, the climate for new ventures, public policies on innovation, and overall lack of business ambition), Canadian companies seemed to decide not to pursue innovation as a core strategy. The authors concluded by noting that there is no root cause

and therefore no silver bullet to the innovation problem in Canada, suggesting that policymakers adopt sector-specific policies to encourage innovation in those sectors. Finally, they noted that innovation is a complex challenge, and solving it requires a much broader conception of innovation than the traditional view that emphasizes R&D. Critically, they noted that low business R&D expenditures may be a symptom, not a cause, of weak innovation. To this end, the authors articulated a logic map of business innovation and R&D, defining how a variety of factors influence the choice to innovate and the inputs and outputs of that innovation process (Council of Canadian Academies & Expert Panel on Business Innovation in Canada, 2009).

Innovation Canada: A Call to Action (also known as the Jenkins Report, named after P. Thomas Jenkins, chair of the panel who oversaw the report) was the report of a comprehensive review of Canada's support for R&D completed between 2010 and 2011 by appointment of the Government of Canada. The reviewers adopted the OECD's definition of innovation in their approach, but had some additional insight to offer to the present research. First, like many perspectives, the panel combined R&D and innovation–but they do not conflate the two. Instead, the panel expanded the logic model of business innovation defined by the Council of Canadian Academies in 2009 with a higher degree of acuity for innovation's inputs. The inputs to innovation activities added to the model were knowledge and ideas; talented, educated, and entrepreneurial people; networks, collaborations, and linkages; and capital and financing (Nicholson & Côté, 2011).

Of particular interest to the present research was a study the panel then undertook of businesses in Canada, asking them what their source of innovation ideas were and noting their foremost response. 37% said employees and 25% said clients/customers. In fact, R&D takes ninth place in line, behind employees; clients/customers; internet/general research; other businesses; industry sources/itself and identified industrial needs; market research, targeting, and competition; themselves/self-directed; and universities, colleges, and polytechnic institutes (Nicholson & Côté, 2011). This implied that the innovation capacity of our employees was our most substantial contributor to business innovation–at least, in terms of ideas. Unfortunately, the reviewers did not dive deeper into exploring these concepts, instead returning to their focus on R&D.

The authors went on to discuss where "talented, educated, and entrepreneurial people" come from. As with so many other perspectives, the primary source they identified was from Canada's post-secondary graduates (Nicholson & Côté, 2011). This was stated matter-of-factly, however, and exactly how post-secondary graduates become innovators was not explored. Still, the authors recognize the important role education plays in supporting innovation:

> **Since Canada's innovation** gap is partly an education gap, improving our global performance will require the right mix in both the quantity and quality of talent. This demands a collaborative approach that brings together our post-secondary institutions, federal and provincial agencies as well as industry and other partners to ensure appropriate recruitment, training and deployment for industrial innovation needs. (Nicholson & Côté, 2011)

Five years later, the new Liberal government commissioned one of the panellists of the Jenkins Report–Andrew Sulzenko–to review progress made on the report's recommendations and to support the development of a new innovation agenda. This report–titled *Canada's Innovation Conundrum*–extended the conceptualization of innovation used by the Jenkins Report, so there was nothing strictly new unearthed there. Sulzenko did, however, make sure to re-emphasize the conflation of R&D and innovation observed by the *Innovation Canada* panellists:

> **Although Canada's innovation** challenge has long been recognized … [t]he public debate has nevertheless remained largely ill-informed, aided and abetted by the politically palatable convenience of equating improved innovation performance with increased R&D spending rather than a more complex interplay of difficult public policy issues. (Sulzenko, 2016)

Sulzenko went on to discuss a host of new directions for the Federal Government's policy approach. One of the directions he explored is "invest in highly skilled people", in which he included scathing commentary on the contributions of the education system to Canada's innovation challenge:

> **At its root,** the problem lies with the education system itself, which has not yet come to grips with the urgent need to educate for the competencies required for participation in the innovation-driven economy. … The situation constitutes a public sector failure requiring urgent remediation because supply from the PSE system in Canada either is not adequately meeting existing business demand or is responsible for capping investments in future growth. (Sulzenko, 2016)

Finally, Sulzenko noted that the problem is a difficult one: education is in the jurisdiction of the provinces, not the Federal Government ("unlike virtually every other advanced-economy federation"; Sulzenko, 2016). In fact, he stated that the provincial and territorial governments seem not to recognize that there is a problem at all.

In a recent instalment of the consulting firm's "Future of Canada" series, Deloitte explored whether Canadian firms are prepared for disruption. In this report, titled *Age of Disruption*, the authors focused on five technological drivers: "artificial intelligence, advanced robots, networks, advanced manufacturing, and collaborative connected platforms" and whether Canadian businesses were prepared for disruption coming from these forces (chosen for their supposed disruption potential; Stuart, Currie, Goodman, Ives, & Scott, 2015).

Their analysis returned several recommendations relevant to the scope of the present study. First, Stuart et al.'s four recommendations for Canadian firms pointed toward the kinds of competencies and cultures Canadian learners might be preparing for. Those recommendations were to *cultivate awareness* (essentially, for firms to have proactive, futures-oriented perspectives on what's happening in their industry), to *build the right culture for preparedness* (imbuing more resilience, adaptability, and creativity in organizational culture), to *foster organizational agility* (essentially, adopt innovation in firms' work and decision making practices), and to *develop effective resources* (effective investment in new technology and use of existing technology,

human, and financial resources; Stuart et al., 2015). If firms are to be capable of these competencies, the people that run them will have to develop them–thus, these attributes may help inspire our model of innovation education.

Further, Stuart et al. noted that Canadian firms were woefully underprepared for disruption, and highlighted several key recommendations for government and academia to support preparation efforts. Key to this report is a call to "evolve education at all levels" (Stuart et al., 2015). To Deloitte, this means:

- an overhaul of K-12 education to improve the diversity of subjects studied throughout primary and secondary education and to include hands-on learning in innovation, new technologies, and lateral thinking;
- the reform of universities and colleges to become more nimble (rapidly refreshing course content and providing more flexible program options) and more cross-curricular (creating direct links to the world outside of the ivory tower);
- a new orientation towards commercialization in post-secondary (introducing more applied research, partnerships with industry, and invention and patenting capabilities).

The Information and Communications Technology Council (ITCT) is another industry group that recently published on Canada's innovation gap. Their *Digital Talent: Road to 2020 and Beyond* strategy focused on digital skills and literacies as the route to innovation. The authors wrote:

> **Despite the importance** of technology adoption to business sector innovation and competitiveness, Canada's adoption rate remains low compared to our international counterparts. One of the principal reasons for this is the lack of skilled workers who can assess and implement technological innovations. This is particularly vital for small and medium-sized enterprises (SMEs) that acutely need skilled digital talent, but have limited means to train or find a job-ready workforce to respond to the fast changing reality of the global economic landscape. It is, therefore, critical that skilled digital talent is available so that companies can effectively adopt and leverage digital technologies. (Information and Communications Technology Council (ICTC), 2016)

The report may be victim to the law of the instrument (i.e., "when the only tool you own is a hammer, every problem begins to resemble a nail") and some of the recommendations were unhelpfully obvious (e.g., "Education, industry and government should strategically enhance their work together to build education programs that better align with industry needs and improve student employment outcomes") or overwrought lobbying, advocating for precisely the needs of the industry the Council represents (e.g., mandating computer science education throughout the K-12 curricula; Information and Communications Technology Council (ICTC), 2016). Still, the group presumably understands its industry, and the notion that better skills in the assessment and use of technological innovation will benefit innovation capacity overall is an important takeaway that parallels that of Deloitte, above.

A New Magnetic North, published by the now-defunct Canada25, sought to understand and resolve Canada's "brain drain" problem in 2001. Authored by a group of recent graduates from Canadian universities, the report cast the

challenge of attracting and retaining talent to our country as one that is directly related to our ability to solve our problems through innovation:

> **More than ever,** we need innovative solutions in all facets of our lives: social innovation to build a fair and equitable society; economic innovation to foster investment; policy innovation to solve the challenges of our demographic profile; and cultural innovation to strengthen our national pride. Innovation is at a premium - and the fuel for innovation is talent. (Canada25, 2001)

With this in mind, Canada25's delegates argued that while Canada is delivering on its promise for a strong social orientation and a healthy cultural and physical environment, Canada's innovation culture is weak.

Unfortunately, while the report discussed a wide range of recommendations across sectors to improve Canada's innovation culture, nowhere do the authors explore what they mean by innovation in specific. Implicit in the text was the notion that innovators are simply brilliant people, and that instead of cultivating innovation capacity in everyone, we need to attract and keep those brilliant people here. Their calls to action to do so centred on incentives–often financial ones–and structural changes.

This approach to innovation sounds like another "great man" theory (cf. Hoffman, Woehr, Maldagen-Youngjohn, & Lyons, 2011). Before I accepted that premise, however, I noted some potential flaws in Canada25's methodology. First, the report lacked peer-review, avoiding an evidence-based approach in favour of reliance on the agreement of the Canada25 delegates and a laundry-list cohort of contributors. The selection of these contributors and delegates was not made transparent, either, and so it is possible that selection biases impacted those who could contribute to the report.

Survivorship bias is one important source of skew that is patently evident in the paper: of course it avoided the topic of facilitating talent, as the authors are already talented. To put it another way, I would prefer to ask those who are not "top talent" why they were not successful (in order to develop solutions to the barriers they faced) before I asked "top talent" how to be more successful. Thus, *A New Magnetic North*'s recognition of Canada's challenges and the power of multidisciplinary innovation to solve them was appreciated, but the report otherwise had little to offer our model of Canadian innovation.

A non-Canadian but tangential report of interest was *The Role of PhDs in the Smart Economy*, a joint publication of Ireland's Advisory Council for Science, Technology, and Innovation (ASC) and Forfás, a national policy advisory board. The report was a commentary on and response to the growth of PhD graduates Ireland has seen since 2004, when an OECD review of the nation's higher education system recommended PhD graduate growth as a key force for Ireland's economy. It positioned PhD graduates as the ultimate innovators, arguing that these graduates bring new knowledge, ways of working, personal networks, and complex problem solving to the organizations of the knowledge economy. These PhD students should be "inverted T" shaped graduates, developing a broad base of knowledge with a distinct expertise in relevant and crucial areas. In addition, it suggested that awareness of and links between industry and academia

is critical to leveraging the potential in PhD graduates and the programs that create them. The authors supported these links so strongly that they recommended the introduction of industrial PhD programs, allowing workers to earn a PhD through research relevant to their work (Forfás, 2009).

I came across *A New Magnetic North* through reference to it in a curious place: a speech from Gordon Nixon, then President and CEO of RBC Financial Group in Montréal in 2002. Nixon's speech, titled *Building Canada's Prosperity in a New Century*, mentioned the exact phrase about the multidimensionality of innovation quoted from Canada25's report above. He provided a unique perspective, rooted in an industry that is decidedly commercial and technological. Thus, his choice to celebrate Canada25's multidimensional perspective on innovation was telling. Nixon went on to describe innovation in his own words:

> **Innovation is about** having a vision of where a company wants to be, about developing new products and services, about creating new relationships with suppliers and customers, and about new ways of delivering value. It's also about commitment to research and development, and putting the results of that R&D to work. (Nixon, 2002)

This characterization rings familiar, but introduced new language: innovation became not just about skills and competencies, but also vision and commitment. Nixon's speech emphasized the importance of innovation as a driver of Canada's competitive performance–even in 2002, he was worried about Canada standing still in the emerging economy (Nixon, 2002).

In a letter published on *Policy Options*, Gold, Abraham, Gualtieri, and Gillespie (2015) elevated the significance of education in building the Canadian innovation system. In specific, they emphasized the role management plays in accelerating innovation:

> **Managing innovation requires** competencies (e.g., strategic business environment assessment, strategic marketing, competitive intelligence, intellectual property and regulatory strategy, etc.) that are underrepresented in established resource and manufacturing industries. These competencies enable enterprises and investors to take the shrewd risks that give rise to new, innovation-driven businesses and the high-value jobs that they support. To respond to this, Canada not only needs to develop a cadre of individuals with these capacities through university and community college programs but the networks that sustain them. (Gold et al., 2015)

Thus, we also need to support managers of innovation as well as innovators themselves.

A final, sobering perspective on what we might mean when we talk about innovation came from Canada2020, an independent think tank focused on the role of the Federal Government. Canada2020 launched *The Innovation Project* in 2016 to examine how to make Canada more innovative. To this end, the think tank commissioned a report on how to foster innovative growth in Canada. *Towards an Inclusive, Innovative Canada* is a paper that combined the economic themes of traditional innovation research with social and political research on who benefits from innovation. The result was a focus on "economically inclusive and autonomy-enhancing innovation": innovation

that elevates quality of life for the middle and lower classes while also enabling greater choice and opportunity for those classes (Moffatt & Rasmussen, 2016). This emphasis, they argued, results in innovation that is "human-centred". Innovation from any other perspective is potentially "misinnovation": creating economic growth while also leaving many behind (cf. Fascinato et al., 2016).

Takeaways

- Solving innovation may require a broader conception of it than traditionally found in the commercial R&D view. In fact, low R&D spending may be a symptom of weak innovation, not a cause.
- Innovation inputs in the R&D process include:
  - knowledge and ideas;
  - talented, educated, and entrepreneurial people;
  - networks, collaborations, and linkages; and
  - capital and financing.
- Though the education system has been recognized as an important answer to Canada's innovation problem, the Federal Government has little leverage and the Provincial governments may not even realize the connection.
- Innovation might include:
  - a proactive futures-orientation;
  - resilience, adaptability, and creativity;
  - meta-innovation in how we work and make decisions;
  - effective investment in new technologies and effective use of existing technology, human, and financial resources;
  - vision for new approaches;
  - commitment to both doing and using the products of research and development;
  - the ability to manage itself, e.g., through strategy, business, and law; and
  - Managing innovation requires competencies (e.g., strategic business environment assessment, strategic marketing, competitive intelligence, intellectual property and regulatory strategy, etc.) that are underrepresented in established resource and manufacturing industries. These competencies enable enterprises and investors to take the shrewd risks that give rise to new, innovation-driven businesses and the high-value jobs that they support.
- Innovators:
  - are "inverted T" shaped, with a broad base of knowledge and distinct expertise;
  - bring new knowledge to their work;
  - use new ways of working;
  - have strong personal networks; and
  - are capable of complex problem solving.
- To help Canada prepare for disruption, education reform is needed at all levels, especially through the diversification of subjects and introduction of hands-on innovation learning in K-12 school systems and an increase in agility, cross-curricular programming, and the commercialization of research in post-secondary institutions.
- Innovation is multidimensional, manifesting differently in social, economic, policy, and cultural applications.
- Innovation should be human-centred, enabling the inclusion and autonomy of the middle and lower classes.

Government of Newfoundland and Labrador

Resources Reviewed

- *Innovation Newfoundland and Labrador: A Blueprint for Prosperity (Government of Newfoundland and Labrador, 2006)*: NL's 2006 Innovation Strategy

Discussion

The most recent government-official publication on innovation in NL was the 2006 Innovation Strategy, *Innovation Newfoundland and Labrador: A Blueprint for Prosperity*. It detailed the Government's then-analysis of the province's innovation status, outlined the model of innovation the government is using, and discussed four strategic directions for the province: Fostering a Culture of Innovation, Building a More Competitive Newfoundland & Labrador, Strengthening Education and Skills Development, and Supporting and Expanding R&D and Commercialization. Finally, it discussed the actions and initiatives planned for those directives and lays out an accountability framework for assessing the strategy's eventual performance (Government of Newfoundland and Labrador, 2006).

The NL Government explicated a clear and holistic vision of innovation. In her opening message, the then-Minister Kathy Dunderdale wrote:

> **Innovation is not** something done only by scientists and engineers. Innovation is the creation, sharing and implementation of new ideas resulting in economic value or social gain. It may be developing a new, high-tech piece of navigational equipment or computer systems, but it is also about finding better ways to provide daycare so that people can work comfortably knowing their children are safe. Successful innovation can, and should, reach into all aspects of our lives. (Government of Newfoundland and Labrador, 2006)

This kind of thinking was found throughout the document. The NL Government offered a multidimensional view of innovation, seeing it as a multidisciplinary, collaborative effort that can be leveraged by anyone to improve quality of life for all. This theme stood in deep contrast to many of the Federal Government's more recent strategies, which emphasized technological and business innovation created by highly educated experts.

The Government's official definition of innovation was "the creation, sharing, and implementation of new ideas resulting in economic value and social gain" (Government of Newfoundland and Labrador, 2006). It offered this definition alongside a model of the province's innovation performance that emphasized multi-sectoral collaboration and identified a host of factors that contribute to that performance. Two of these were Skills and Knowledge and a Culture of Innovation.

To these ends, each of the four strategic directions the Government laid out in its plans directly involved the province's education system. Under the Fostering a Culture of Innovation

directive, for example, the authors wrote:

> **The level of** awareness of the nature and value of innovation within our culture establishes the baseline for how we think about and respect innovation and innovators. It affects how likely we are to seek innovative solutions or consider and incorporate new ideas. It also influences our attitudes towards risk, collaboration with others, our working relationships, education and development. A well-established culture of innovation will enable the openness and independent thinking required to be truly creative. It will also help us have confidence in our ability to be the best, to welcome the ideas and experiences of others, and to seek and incorporate global perspectives. (Government of Newfoundland and Labrador, 2006)

Thus, the Government recognized a gap in people's understanding of innovation. It also described several components of innovation: the seeking out of solutions, decision-making and synthesis around new ideas, risk management, collaboration, lifelong learning, creativity, confidence, and the incorporation of multiple perspectives.

This recognition of innovation skills and competencies was only found implicit in the writing, however. A structured understanding of how these components might fit together (and how we might help people develop them) was not included in the document. In their discussion of skill development and education in the remaining strategic directives, the authors returned to the dogmatic "more innovation requires more education" approach. Still, even the latent impression that innovation may be a nuanced construct is heartening. It is a foundation for a more deliberate effort to understand and build upon these pieces.

Takeaways

- The Government of NL recognizes innovation as a multi-stakeholder and multi-dimensional concept that can be practiced by all.
- The province's education system is integral to each directive of the overall Strategy.
- According to the NL Government, innovation involves:
  - the seeking out of solutions;
  - decision-making and synthesis around new ideas;
  - risk management;
  - collaboration;
  - lifelong learning;
  - creativity;
  - confidence; and
  - the incorporation of multiple perspectives.

Conference Board of Canada

Resources reviewed

- *Provincial and Territorial Rankings – Innovation (Conference Board of Canada, 2015)*
- *Provincial and Territorial Rankings – Education and Skills (Conference Board of Canada, 2014)*

Discussion

My research returned briefly to the Conference Board of Canada to focus on their provincial

and territorial ranking reports. As with the international reports, the Conference Board completes these rankings on a semi-regular basis. The last update to the Innovation rankings was September 2015; the Education and Skills ranking was last updated June 2014 (Conference Board of Canada, 2014, Conference Board of Canada, 2015).

Intriguingly, the Innovation provincial/territorial report offered a new definition of innovation:

> **The Conference Board** defines innovation as a process through which economic or social value is extracted from knowledge—by creating, diffusing, and transforming ideas—to produce new or improved products, services, and processes. (Conference Board of Canada, 2015).

The authors went on to say that innovation can be both radical and incremental–and that both of these scales are important. They noted, for instance, that "substantial productivity gains can be achieved through the adoption and use (rather than creation) of new information and communication technologies (ICTs) or by implementing a more efficient approach to knowledge management" (Conference Board of Canada, 2015). This bore a slight shift from the business and technology innovation focus of previous reports by the Conference Board, opening up space in their definition for innovations outside of those scopes.

Still, the indicators used to assess innovation were roughly the same: "public R&D, researchers engaged in R&D, connectivity, scientific articles, entrepreneurial ambition, venture capital investment, business enterprise R&D (BERD), ICT investment, patents, and labour productivity", alongside the entry rates of new enterprises (Conference Board of Canada, 2015). Thus, the Conference Board's analyses of provincial innovation performance was still anchored in a commercialization perspective.

According to this analysis, NL placed fourth-last of the provinces (oddly, the Territories were not mentioned), in 22nd place of 26 overall (the ranking included the ten provinces, the 15 peer countries ranked against Canada in the national rankings, and Canada itself). The authors noted that while NL performed well in terms of entrepreneurial ambition and enterprise entry rates, it performed poorly on all other measures, particularly so in terms of the quantity of researchers engaged in R&D, private investment in R&D, patent rates, and ICT investment (Conference Board of Canada, 2015). (Perhaps with better overall innovation education, NL could turn these numbers around.)

NL performed even worse in the mid-2014 ranking of the provinces' Education and Skills. NL was the second-worst region for education according to the Conference Board's review, scoring above only France and PEI in their comparison (Conference Board of Canada, 2014). As discussed previously, this analysis was based on 23 indicators measuring educational outcomes, categorized across K-12, Post-Secondary, and Adults & Work.

At the K-12 level, the highest score NL received was in high school attainment – a "B". However, this grade was still lower than all of the other provinces. Other indicators included "equity in outcomes" (for which no data could be attained for the province), resilient students

(NL scored a "C", the average score across the country), and student reading, math, and science skills (for which NL scored less than average compared to the rest of the country; Conference Board of Canada, 2014).

At the post-secondary level, the picture was a little more complicated. The province's scores were about average or worse with the other provinces on most of the six measures (college attainment, university attainment, PhD graduates, STEM graduates, international students, and the gender gap). However, it did seem to have a strength relative to the country as a whole in STEM graduates, obtaining a "C" grade where the national average is a D. No other province scored better than a "C" grade, indicating that NL was at least on par with Nova Scotia and Ontario in graduating students in these fields (Conference Board of Canada, 2014).

NL again fared poorly in the Adults and Work indicators, earning below average scores ("D" grades, with one "D-") in adult literacy skills, numeracy skills, and problem solving skills. In only two indicators was NL doing exceptionally well in this category: the income advantage granted to college and university graduates in the province, where NL earns an "A" compared to the country's average of "D" (Conference Board of Canada, 2014). The authors noted that this was a powerful illustration of the (then) strength of the provincial economy; it makes sense that as an economy booms, those who are best equipped to take advantage of higher-income opportunities are the most likely to benefit from their growth. The stark difference between these income advantage indicators and the rest of NL's Innovation and Education and Skills indicators was also an important, latent lesson for provincial decision-makers: economic strength was clearly not coming from our knowledge economy. As natural resource profits give us investment opportunities, it would be wise to use them to bolster these economic drivers that are more self-reliant, increasing the province's resilience by diversifying the economy.

A deeper analysis of how these measures were obtained and what they may mean is certainly necessary, but is outside the scope of the present research. For now, I took the lessons in these provincial scores for granted. These measures were relative: even if there were issues with the Conference Board's methodology, the methods were the same for each province and country assessed (save, perhaps, for discrepancies in how and what data in each region was collected). Thus, even taken with a grain of salt, the notion that the province was performing relatively poorly should still raise alarm.

But what does this have to do with the education of innovation? It is worth noting that few of the measures assessed relate to the skills or competencies that have arisen from the definitions of innovation I have reviewed thus far. However, if our province does not have a solid foundation–arguably language, math, and scientific skills, for instance–developing skills and competencies for innovation will be challenging.

It was somewhat striking that NL's STEM graduation rates were relatively high (in the Education and Skills indicators) and its PhD graduation rates were average while its rate of researchers and rate of private R&D were both relatively low (Innovation indicators). Before

I discuss this further, it is worth revisiting the Conference Board's explanation of its researchers indicator:

> **The indicator includes** individuals classified as "researchers" but excludes those classified as "technicians" and "other R&D personnel." Researchers are defined as scientists and engineers "engaged in the conception or creation of new knowledge, products, processes, methods and systems" and includes managers "engaged in the planning and management of the scientific and technical aspects of a researcher's work."
>
> We include researchers employed in government, higher education, and business. Focusing on only the business sector would create a measurement bias against those provinces and countries whose innovation ecosystems place more emphasis on research conducted in government and higher-education labs and facilities. We calculate the rate as the number of researchers per 1,000 individuals employed, rather than per total population, because we are interested in capturing how research-intensive the employed labour force is, rather than the research capacity of the population more broadly. (Conference Board of Canada, 2013d)

This must mean that NL's STEM graduates were either moving away, were not becoming employed in research roles, or were unsuccessful in using their STEM skills for research purposes. Alternatively, it could also indicate of the number of research jobs available in the province. The answer seemed to be a mix of all of these factors. In 2011, for instance, NL had the lowest percentage of PhD graduates in the country – thus, while the province was doing okay in its graduation of PhD students, the graduates seemed to be leaving (Conference Board of Canada, 2011). Likewise, the Conference Board has found a correlation between R&D spending (both private and public) and researcher employment. NL spent less on researchers, and thus had less research roles. This is a rich area for future research and intervention for the province.

Takeaways

- According to these perspectives, innovation:
  - is a process;
  - creates economic or social value from knowledge;
  - involves the creation, diffusion, and transformation of ideas;
  - results in new or improved products, services, and processes; and
  - can be radical or incremental.
- NL performs poorly on many relative indicators of both Innovation and Education and Skills in the Conference Board of Canada's 2014 analysis.
- The province has some areas of relative strength: entrepreneurial ambition and enterprise entry rates in Innovation, and STEM graduates and income advantages of post-secondary attainment in Education and Skills.
- A weak educational foundation could reduce NL's ability to effectively educate on innovation.
- A contrast exists between NL's STEM and PhD graduation rates and the number of researchers and private R&D that happens in the province. Understanding why research jobs aren't being created in NL is an important area for future research.

The Harris Centre

Resources reviewed

- *A Commitment to Place: The Social Foundations of Innovation in Newfoundland and Labrador (Greenwood, Pike & Kearley, 2011)*: An assessment of the social foundations for innovation in Newfoundland and Labrador, completed as part of a national project examining the same subject nationally
- *Challenges, Opportunities, and Strategies for Advancing Innovation in Newfoundland and Labrador (Hall, Walsh, Vodden, & Greenwood, 2014)*: A report examining how government, community, business, and innovators themselves can work together to advance innovation in the province

Discussion

The Harris Centre is the regional development and policy office of Memorial University (Newfoundland and Labrador's only University), established to leverage the University's people, resources, and knowledge to inform and engage the public on important issues in the province ("Mandate, Visions and Values," 2014). Over the last five years, the Centre has completed two projects exploring innovation in Newfoundland and Labrador.

The first, *A Commitment to Place: The Social Foundations of Innovation in Newfoundland and Labrador*, was completed as part of a cross-Canada study on the social foundations of innovation. The national project focused on how innovation and its predicate factors are linked to the social dynamics of a region (Wolfe & Bramwell, 2008). The framework they developed divided these factors into three categories:

- The social dynamics of innovation, which included:
  - local knowledge circulation processes within individual industries/clusters;
  - local knowledge circulation among individual industries/clusters; and
  - knowledge-based linkages between local and non-local economic actors.
- The quality of place tying innovators to a geography, which included:
  - cultural dynamism;
  - social diversity;
  - openness and tolerance;
  - social inclusion; and
  - cohesion.
- Inclusive governance, which included:
  - government; and
  - collaborative leadership (Wolfe, n.d.).

From this framework I divined a few lessons for would-be innovators. According to this theory, innovation requires the ability to connect to other actors within and between industries and clusters in order to share knowledge. In the long-term, it also seems to involve being able to build an innovative culture, as each innovator invested in the system is rewarded as the system develops the elements of quality of place identified above. Innovators should also be adept at navigating governance on multiple levels: engaging decision makers to accelerate their projects, to find funding, to partner on initiatives, and so on. Finally, through collaborative leadership, innovators should be capable partnership brokers or network weavers within their regions and sectors. Wolfe's theories offered unique additions to the skills and competencies I have

collected already; in this view, the successful innovator is as much about community as they are about ideas and implementation.

Researchers at the Harris Centre sought to understand these themes of the national project in Newfoundland and Labrador's context. Ultimately, the authors of *A Commitment to Place* saw trust as the key ingredient for innovation. They wrote:

> **The driving assumption** is that the innovation process is people communicating with people in a social process. And through this interaction the economic players in a given region build social capital and trust. Trust is a basic condition for letting down your guard, thinking of what colleagues may need to succeed, and getting together to brainstorm. (Greenwood, Pike, & Kearley, 2011).

They unearthed some important takeaways for the province. First, there was a lack of social mobility–the movement of people–between organizations in most sectors and most regions of the province. Participants in the study also noted difficulty in engaging with public research hubs (namely the University and College of the province) with the flow of knowledge (Greenwood, Pike, & Kearley, 2011). These challenges increase the need for innovators to be highly capable connectors, sharing knowledge within and between sectors. They must also be able to identify and find ways to access institutions and people important to the flow of knowledge.

NL's smaller communities were found to lack diversity and some social amenities, but the people that live in them expressed a strong sense of belonging and commitment to place (Greenwood, Pike, & Kearley, 2011). Therefore, it is important for an innovator in these regions to find ways to discover and leverage the hidden diversity in their communities. Likewise, they should be open to new immigrants, supporting their integration into the innovation community. It is also important for these innovators to find ways to effectively connect to networks beyond their region.

NL's intense communities were also found to be hard to integrate into (Greenwood, Pike, & Kearley, 2011). Would-be innovators immigrating to these regions should therefore be socially apt and interculturally aware, able to understand the culture and build relationships in a new region.

The "brain drain" (talented people leaving the province) issue loomed large. The researchers have shown that people in certain sectors see NL's small regions as a limit to their own growth, and see their work in these communities as a staging ground for larger impact in a bigger urban centre in other geographies (Greenwood, Pike, & Kearley, 2011). Finding ways to understand and remove those limits–and to get these innovators to stay, or to get them to return if they leave–was therefore noted as critical for NL's innovation capacity. If these limits are not eliminated, innovation educators face a dilemma (albeit potentially a false one): do we want our innovators to be world-leading (and therefore to potentially leave the province), or do we want our innovators to stay (and potentially be limited in their potential to scale)?

Finally, Greenwood, Pike, and Kearley (2011) noted the significance of good governance and collaboration, commenting that many innovators depend on specialized infrastructure, supportive regulatory environments, and the

community itself – each of these being, at least to some degree, the responsibilities of municipal, provincial, and federal governments. The positive contributions of governance and collaborative leadership varied greatly from region to region. Some participants in the study noted certain leaders were key to the success of their sector/region, enabled by their abilities to build coalitions, strengthen networks, align government, and get results (Greenwood, Pike, & Kearley, 2011).

In 2014, the Harris Centre published a second work on innovation in NL. *Challenges, Opportunities, and Strategies for Advancing Innovation in Newfoundland and Labrador* explored the question "What can firms, community organizations, all levels of government, Memorial University, and the College of the North Atlantic do to advance innovation in Newfoundland and Labrador?" (Hall, Walsh, Vodden, & Greenwood, 2014). This research again emphasized the social process of innovation, exploring how NL's regional innovation systems engaged with the "quadruple helix" of stakeholders (business, community, governments, and post-secondary institutions; Leydesdorff, 2012). The authors emphasized the OECD's product, process, marketing, and organizational innovation, highlighting that the concept that an innovation can be locally new as well as globally new is important in many of NL's regions, where innovation as "new to the region" could be significant (Hall et al., 2014).

The report further underlined the challenges unique to rural innovation. One important revelation from the literature for innovation education was Oughton, Landabaso, and Morgan's (2002) innovation paradox: the need to invest more in innovation in lagging regions is contradicted by the inability for these regions to absorb and leverage these investments, as the institutions and communities of those regions lack the infrastructure (social, economic, and so on) to be able to effectively use those investments. The major role human capital plays in complementing innovation capacity (cf. OECD, 2011) may mean that supporting innovation education could address a root cause of regional innovation lag.

Through a literature review, participatory workshops, and a pan-Provincial innovation summit, Hall et al. (2014) sought to unearth challenges and opportunities both common across the province and unique to the province's separate regions. This resulted in a plethora of findings; here I discussed only those relevant to the scope of innovation education.

First, it seemed as though there was a disconnect between funding opportunities and participants' abilities to reach those funding opportunities. Participants from business indicated a dearth of funding opportunities, while participants from government stated that funding was plentiful (Hall et al., 2014). It seemed that there exists an accessibility gap between those seeking funding and those offering it. On a related note, participants also complained about the complicated paperwork and processes of government funding (Hall et al., 2014).

Participants in the study also admitted a lack of confidence in their innovation activities. Further (and perhaps worse), participants shared that they lacked of understanding of what innovation is. This theme arose at multiple points in the study, both in regional workshops

and in the provincial summit, in which "a lack of awareness, knowledge, and culture around innovation" was the first of five critical gaps. Third on that same list was "a lack of business and management skills necessary to foster entrepreneurship, intrapreneurship, and innovation" (Hall et al., 2014). This was a clear indication that better innovation education is needed in the province.

Ultimately, it would seem that the researchers behind *Challenges, Opportunities, and Strategies for Advancing Innovation in Newfoundland and Labrador* would be enthusiastic about the aim of the present research to find strategies to improve innovation learning in NL. One of Hall et al.'s (2014) five categorical recommendations for the province was to make NL "a leader in innovation education". Indeed, several of the discrete outcomes they suggested relate to innovation education. Several examples included:

- organize an innovation awareness campaign that fosters understanding about the various aspects and definitions of innovation (including a diversity of sectors and regions);
- organize training within government to increase knowledge and awareness about innovation;
- expand voucher programs for training;
- introduce innovation in K-12;
- offer specialized post-secondary courses and programs in innovation; and
- introduce innovation and business "tours" to allow businesses to learn from one another (Hall et a., 2014).

Takeaways

- Innovators are as much about building community as they are about generating and implementing ideas.
- Strong innovators should be capable of building trust in multiple arenas:
  - connecting with other actors, both within and between their industries and regions, in order to share knowledge;
  - building an innovative culture; and
  - navigating governance, brokering partnerships, and building coalitions.
- The limited scale and social connectivity of many of the province's regions mean that innovators in the province must be highly capable connectors, finding ways to share knowledge both within and between sectors. They must also be able to identify and find ways to access institutions and people important to the flow of knowledge.
- In smaller regions, innovators must:
  - find ways to discover and leverage the hidden diversity in their communities;
  - be open to new immigrants, supporting their integration into the innovation community; and
  - find ways to effectively connect to networks beyond their region.
- The scale of some of NL's communities leads some to see limits to growth in innovation in NL, viewing their work here as a staging ground for larger impact elsewhere. Therefore, we must:
  - find ways to understand and remove those limits;
  - help innovators stay in the province; and
  - find ways to ensure the return of innovators who leave.
- Because of brain drain, innovation educators face a dilemma (albeit potentially a false one): do we want our innovators to be world-leading (and therefore to potentially leave the province),

or do we want our innovators to stay (and potentially be limited in their potential to scale)?

- The innovation paradox of certain regions suggests a higher need to provide innovation education in those regions, bolstering the human capital such that other innovation policies and programs gain increasing returns.
- Residents admitted a lack of confidence in their own innovation activities and a lack of understanding of what innovation is, as well as gaps in their knowledge of entrepreneurship and intrapreneurship.
- Hall et al. (2014) call for innovation education in their provincial recommendations, including introducing innovation in K-12 programming and the creation of courses and programs at the post-secondary level.

Innovation Theory

Resources reviewed

- *Innovation: A Guide to the Literature (Fagerberg, 2006)*: a comprehensive literature review of innovation theory
- *Innovation management; a literature review of innovation process models and their implications (Eveleens, 2010)*: a literature review on innovation management focused especially on innovation process theories

Discussion

Two literature reviews offered substantial coverage of mainstream innovation theorists. Thus, I focused on the work of Fagerberg (2006) and Eveleens (2010) in this adjunct discussion of innovation theory. This was because, as Fagerberg (2006) describes, "[t]oday, the literature on innovation is so large and diverse that even keeping up-to-date with one specific field of research is very challenging." Note, however, that while this section is brief (which, as an aside, is very negatively correlated with the size of scholarship on innovation) the majority of the international, national, and provincial perspectives discussed above also referred to their own review of innovation theory.

Fagerberg's (2006) *Innovation: A Guide to the Literature* was both a historical and cross-disciplinary examination of the literature, examining how our understanding of innovation has shifted through different theorists over the years. The cross-disciplinarity is important: innovation cannot be understood through only one discipline. In fact, one intriguing takeaway was the notion that economic studies of innovation (the primary perspective of many of the reports reviewed above) have tended to treat the innovation process as a black box (Fagerberg, 2006). Introducing other disciplines is therefore crucial if we are to understand what happens within that black box.

Fagerberg (2006) differentiated between invention and innovation with the notion that an invention is the first occurrence of an idea, while innovation is the first successful attempt to put that idea into practice. "To be able to turn an invention into an innovation, a firm normally needs to combine several different types of knowledge, capabilities, skills, and resources" (Fagerberg, 2006). Thus, the role of the innovator can actually be substantially different from an inventor. Therefore innovation can only be truly observed from a systemic perspective, as a host of interlocking actors and forces are often

required to make up the "innovator". This is why an invention often requires complementary inventions and innovations to succeed (or why "even your best ideas will fail if your partners don't innovate too", cf. Adner, 2012). A single innovation is also not a solitary event; instead, it is the result a continuous process, involving many of these interrelated innovations (Fagerberg, 2006).

Fagerberg (2006) leveraged the work of Schumpeter and a number of other theorists to divide innovation by a variety of categories. Innovation may be typified, for instance, as I have observed from the popular OECD definition. The types articulated by Fagerberg included new products, new methods of production, new sources of supply, new markets, and new ways of organizing. Innovations may also be classed from incremental to marginal to radical or revolutionary; Fagerberg (2006) noted that while it is tempting to focus on radical and revolutionary innovations, the cumulative impact of incremental innovation is just as important (if not moreso, as incremental innovations are often requisite for the success of radical ones). Finally, innovations may occur in different contexts; the new-to-the-world vs. new-to-the-region vs. new-to-the-firm view that the OECD adopted is an example of this. Fagerberg (2006) considered the former to be true innovation and the latter imitation, though not without recognizing the important impact of imitative innovations.

In his description of the process of innovation–that is, how innovation comes to be, and arguably the activities innovators engage in–Fagerberg (2006) again honoured the contributions of Schumpeter. Schumpeter's "mark I" model of the process of innovation suggested that all innovations share the same three attributes: navigating uncertainty, the need to act quickly on new inventions, and the defeat of social inertia that resists the adoption of the innovation. Fagerberg connected these aspects to other theorists who also emphasized the imperative and the challenge of dealing with uncertainty (e.g., Van de Ven, Polley, Garud, & Venkataraman, 2008). These studies highlighted the need for a would-be innovator to know how to assess sources of innovation and to manage the uncertainty of the innovative process, balancing the pursuit of promising paths versus keeping options open. Van de Ven et al. (2008) suggested that this balance requires pluralistic leadership providing competing perspectives.

To this end, Fagerberg (2006) also emphasized the need for openness to ideas and variety. Innovators therefore need to pursue new areas of knowledge, for instance by being effective at environmental scanning (cf. Choo, 1999; there is a potent link between this issue and Newfoundland and Labrador's regional innovation system social dynamics).

Finally, Fagerberg (2006) noted the need for innovative organizations to maintain an absorptive capacity for innovation, avoiding the paralytic effects of routinization as the organization strives to integrate innovations efficiently. This is possible through learning and through language, for instance: see Weick and Westley's (1999) work on organizational learning and Dubberly, Esmonde, Geoghegan, and Pangaro's (2002) "little grey book" on organizational language. Van de Ven et al. (2008) noted that some organizations have had

success in this aspect by encouraging freedom and experimentation in their employees. Other theorists have observed that innovative organizations have a unique capacity to mobilize their collective knowledge in solving new challenges. Still others recognized the importance of maintaining both strong and weak ties to other actors in innovation systems: the former to encourage clustering, and the latter to ensure that new ideas continue to enter the cluster (Fagerberg, 2006).

Eveleens' (2010) comprehensive literature review was complementary to Fagerberg's work. In a wide-ranging examination of the literature on innovation management, Eveleens presented and synthesized 12 existing models, distilling these models into six separate phases and 150 different concrete routines to complete within those phases. These phases and some examples of their subroutines were:

1. The generation of and search for ideas:
   - market studies;
   - technical studies/R&D;
   - internal generative activities (e.g., brainstorming); and/or
   - external generative activities (e.g., engagement with lead users or other organizations).
2. Selection of ideas to be pursued:
   - analysis of viability, desirability, and feasibility; and/or
   - analysis of the fit with the organization's existing strategies, resources, and structures.
3. Development and testing of the selected idea(s), internally and externally:
   - pilot project teams;
   - idea champions;
   - incubation structures;
   - beta testing; and/or
   - prototyping.
4. Implementation of the developed innovation:
   - (The routines for this phase are logistical and typical of business activities elsewhere.)
5. Sustaining and scaling up the developed innovation:
   - evangelist efforts;
   - infrastructure development; and/or
   - growth hacking.
6. Learning about the innovation *in situ* and reflecting on the innovation process:
   - monitoring and evaluation; and/or
   - impact assessment (Eveleens, 2010).

It may be intuitive that additional scholarship in innovation and design has a lot to offer in terms of routines and activities for these phases. Drucker's (1998) seven sources of innovation, for instance, are powerful wells from which to draw ideas in the first phase (they are: unexpected occurrences, incongruities, process needs, industry/market changes, demographic changes, changes in perception, and new knowledge). Likewise, the notion of framing (and reframing, cf. Paton & Dorst, 2011) is a practice deeply invested in phases 1 and 2. Norman and Verganti (2014) offered a useful framework with which to weigh potential ideas in the selection phase (by intersecting whether the innovation will make an incremental and radical change in either technology or meaning).

Eveleens' (2010) penultimate discussions explored when and how to use which routines. He admitted that the options are messy. For another perspective, Kline and Rosenberg's (1986) "Overview of Innovation" offered a

model that closely follows Eveleens' synthesis, linking each stage to each other stage. One unique contribution of Kline and Rosenberg was their framing of how innovation begins: not with research but with design. Further, Kline and Rosenberg's model linked each stage to an exchange with what they call two components of science: existing knowledge and further research when that existing knowledge is inadequate. Thus, perhaps Eveleens' model – despite his recognition that it was non-linear – lacked interstitial phases where the innovator engages with these components of science.

This parallels Fagerberg's (2006) emphasis on the interlocking actors and forces of innovation. For this reason, Fagerberg (2006) cautioned against studying the innovation of individuals, as innovation does not happen in isolation. Indeed, with this in mind, I aim to model innovation education systemically in order to understand these actors, forces, and the relationships between them.

Takeaways

- The study of innovation is deliberately cross-disciplinary; it cannot be understood from one discipline alone.
- Economic perspectives tend to encapsulate the innovation process within a "black box", concerned only with its outputs. This is an important notion as many of the governmental and think tank dialogues on innovation come from an economic point of view, making the study of innovation from other perspectives imperative for innovation education.
- Invention and innovation are different things: innovation is the implementation and/or commercialization of an invention.
- There are different types (product, process, supply, market, and organizational), classes (incremental, marginal, radical, and revolutionary), and contexts (new-to-the-firm, new-to-the-region, and new-to-the-world) of innovation.
- Innovation always includes three needs: the need to navigate uncertainty, the need to move quickly, and the need to defeat social inertia.
- Innovators must:
  - be pluralistic leaders, able to manage uncertainty and balance pursuit of a path with keeping options open (this may be fostered through competency in environmental scanning); and
  - maintain absorptive capacity, continually seeking out and integrating new perspectives and ideas.
- Innovation is a continuous, systemic process resulting from a number of interlocking actors and forces. "One" innovation often requires other, complementary innovations to succeed. The innovation process broadly follows six phases. Between each of these phases, the innovator exchanges with existing knowledge and research to advance their ideas. The phases are:
  - Generation of and search for ideas;
  - Selection of which ideas to pursue;
  - Development and testing of the selected idea(s), internally and externally;
  - Implementation;
  - Sustaining and scaling up; and
  - Learning.

Other perspectives

As observed by Fagerberg (2006), the amount of research and writing on innovation is staggering. This review has emphasized innovation in the Canadian context in an attempt to focus the effort, and the result has been a host of takeaways that seem to echo throughout the scholarship. Still, as several authors have noted, in the process of innovation it is critical to seek out inputs from outside your own system. Thus, in this last section, I searched for perspectives that may be so different from the many I have reviewed thus far that their lessons have yet to be included in the mix.

Indigenous Innovation

Resources reviewed

- *Indigenous Innovation Summit Report 2015*
- *Indigenous innovation (Waterloo Institute for Social Innovation and Resilience, 2014)*: a research website describing studies on Indigenous innovation

Discussion

Indigenous innovations look back to old traditions and rediscover how these teachings show Indigenous communities the way forward. ("Indigenous Innovation Summit Report 2015," 2015)

Canada's first and second Indigenous Innovation Summits were held in November 2015 and November 2016. The Summits aimed to bring together the concepts of Indigenous innovation, social innovation, and social entrepreneurship to "find ways to improve lives", especially in the context of Canadian reconciliation ("Indigenous Innovation Summit Report 2015," 2015). In doing so, the Summit created a platform for Indigenous innovation–but what is Indigenous innovation, and how is it different from any other kind of innovation?

In his keynote address at the first Summit, Justice Murray Sinclair described Indigenous innovation:

[I]nnovation isn't always about creating new things. Innovation sometimes involves looking back at our old ways and bringing them forward to this new situation. ... each time that you are called on to make a choice about whether you should do this or you should do that, you will make your decision based upon an understanding of what it is that your purpose is for the community. ... We need to figure out how to make things better we need to figure out how to use the tools that we have or that we need to have. ... We will do this again, and we will do it again, and we will do it again. Not so that we can get it right each and every time but that so we can check in with ourselves to remember the vision that we set and do not lose sight of that vision. ("Indigenous Innovation Summit Report 2015," 2015)

Thus, Indigenous innovation is values- and purpose-driven innovation. This is a stark contrast from the definitions I have collected thus far, many of which have emphasized uncertainty and have been absent of purpose, committed only to advancing the enterprise of the innovator. Doubtlessly many innovators will innovate in pursuit of a greater purpose, but it has only been in Indigenous innovation that this has not been assumed. Interestingly, the Justice's

definition also included iteration, a feature common to many other models.

Another unique aspect of Indigenous innovation is a respect for or commitment to the past. This offers innovators a paradox: in pursuit of the new, how can we use the old? This may be another way of thinking about Kline and Rosenberg's (1986) integration of science into their model. Perhaps Indigenous innovation emphasizes different modes of knowledge and research to be tapped into during innovation processes.

Indigenous innovation is also sometimes used to describe the result of the innovative process. As put by researchers at the Waterloo Institute for Social Innovation and Resilience, Indigenous innovations are "informed by the application of indigenous knowledge to promote the resurgence of indigenous knowledge and practices" ("Indigenous innovation," 2014). Likewise, the authors of the Indigenous Innovation Summit Report 2015 (2015) discussed examples of Indigenous communities using innovation to reclaim their traditions.

Takeaways

- Indigenous innovation differs from other models of innovation in three ways:
  - It is values-driven, and should result in particular kinds of improvement;
  - It is purpose-driven, and should be pursued with a vision; and
  - It uses Indigenous ways of knowing, leveraging the past.
- An Indigenous innovation is the result–one that restores Indigenous ways of life–of an innovative practice.

Social Innovation

Resources reviewed

- *Rediscovering Social Innovation (Phills, Deiglmeier, & Miller, 2008)*: a seminal article from three Directors of the Center for Social Innovation at Stanford (the publisher of the Stanford Social Innovation Review) examining the definition of social innovation in 2008
- *Social Innovation Overview: A deliverable of the project: "The theoretical, empirical and policy foundations for building social innovation in Europe" (TEPSIE; Caulier-Grice, Davies, Patrick, and Norman, 2012)*: a literature review of social innovation

Discussion

Social innovation is a field of its own accord that seems to be as unmanageable as innovation itself. A number of theorists and researchers have attempted to define and describe social innovation in recent years. Here I briefly discuss two views: one concise, comprehensive definition and one resulting from a substantive meta-analysis.

> **A novel solution** to a social problem that is more effective, efficient, sustainable, or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals. (Phills, Deiglmeier, & Miller, 2008)

Perhaps the most concise yet comprehensive definition I have discovered is quoted above. In the article that lead to that definition, Phills, Deiglmeier and Miller (2008) stated that social innovations can take many forms. Not only may they be products, processes, markets,

or organizational changes (as in traditional innovation), but they may also be principles, legislation, movements, business models, interventions – or some combination of all of the above. In fact, as with Fagerberg's (2006) model, most social innovations are some combination of forms (Phills, Deiglmeier, & Miller, 2008).

Caulier-Grice, Davies, Patrick, and Norman (2012) offered further precision by indexing and synthesizing many other works on social innovation. In their review, they found that social innovations may also be cross-sectoral, contextual, and value-driven. They can lead to shifts in society and to the empowerment of their stakeholders. They create new roles and relationships, are open and collaborative (and often grassroots or bottom-up) and come from a place of mutualism.

Caulier-Grice et al. (2012) also offered a six-stage process of social innovation:

1. Prompts (identifying needs);
2. Proposals (generating ideas);
3. Prototyping (testing the idea in practice);
4. Sustaining (developing a business model);
5. Scaling and diffusion (growing social innovations); and
6. Systemic change (the ultimate goal of social innovation: to change how society itself perpetuates the needs that originally prompted the social innovation).

This model has some unique features that differ from Eveleens' (2010) process: namely, the first phase and the sixth phase. In Eveleens' synthesized model, innovation simply begins with the idea – yet I have learned that social innovation (as with Indigenous innovation) begins with a purpose or vision. Likewise, Eveleens' model ends with the innovator learning about the innovation's success and reflecting on the process of innovation. In Caulier-Grice et al.'s model, that "learning" is manifested in the system-at-large, resulting in changes in the behaviour that perpetuated the prompt for the social innovation in the first place.

Takeaways

- A social innovation is novel, addresses a social problem, is more effective, efficient, sustainable, or just than existing solutions, and the value of the innovation accrues primarily to society.
- Social innovations can take many forms: they may be a product, process, market, or organizational (as with traditional innovation) but also a principle, movement, legislation, business model, etc., or some combination of many of these forms.
- As a process, social innovation is:
  - cross-sectoral;
  - contextual;
  - value-driven;
  - open and collaborative;
  - grassroots and bottom-up; and
  - mutualistic.
- Social innovation can:
  - lead to shifts in society;
  - empower stakeholders; and
  - create new roles and relationships.
- Social innovation follows six phases:
  - Prompts;
  - Proposals;
  - Prototyping;
  - Sustaining;
  - Scaling and diffusion; and
  - Systemic change.

Appendix B: A Curricula Guide for Innovation Education

This appendix provides an executive summary of the insights and models on innovation education uncovered through this research and guides educators to put these concepts and tools to use.

What is innovation? How do we define innovation, its outputs and processes, and what are the skills and competencies necessary to practice and excel in innovation?

Many strategies and policies, both federal and provincial, have attempted to improve Canada's innovation capacity in the last few decades. Rarely, however, is the role of education mentioned in creating a nation of innovators. This is counterintuitive: education is an obvious mechanism with which to develop the knowledge and abilities of a population. Yet we lack a holistic understanding of what it takes to practice innovation, let alone the kinds of curricula that might provide those skills and competencies. Moreover, we are inconsistent in the definitions and language we use to define innovation–often obsessing over technology and commercialization. We tend to assume innovation comes from research and development processes, and that innovators are simply highly skilled people.

This document is the result of an intensive review of reports, strategies, policy, and theory on innovation in the Canadian context. This literature was scanned and coded–inspired by the ethnographic methods of grounded field theory–in order to synthesize a holistic theory of innovation. This theory includes a universal definition of the innovation process, a recasting of different focuses of innovation as innovation orientations, a comprehensive model of the innovation process, and a synthesis of innovation skills and competencies into 13 learning domains, 47 learning constructs, and 227 learning outcomes. These tools provide utility for policymakers and educators in pursuit of understanding and improving innovation capacity. In particular, the model of innovation education is the most comprehensive of its kind, providing an extensive set of concepts with which to understand education gaps and build curricula.

Perhaps the most important contribution of this research, however, is the recognition that our conversations about innovation strategies and education reform must be aligned. How exactly do people learn to be innovative, and how are our education systems currently facilitating that process? With this study we have begun to seek answers to these questions, but there is much more work to do. If you use these ideas and learn something from your experience, or if you have thoughts on how to improve them, don't hesitate to make suggestions and to share your work.

Below, I describe in detail the definitions and models of innovation developed through this research and how these concepts may be applied in innovation education programming.

How might these models be used in programming?

The definition of innovation and the components of the innovation environment provide a grounding for the educator, framing their approach and providing context for the models offered here.

Second, the model of the innovation process allows educators and their students to understand the phases and steps of innovation activity. Should a particular phase or step be particularly important for program outcomes, the model allows the educator to focus on the most appropriate skill and competency domains.

Third, the innovation orientations show how different approaches to innovation emphasize different outcomes, different parts of the innovation process, and different skills and competencies. For the educator focused on a particular orientation, these models highlight the components of the process and the skill/competencies domains they should focus on in their programs, allowing them to build curricula dedicated to those orientations. Otherwise, understanding the different orientations helps students link different types of innovation outputs to the relevant components of the process and the skills involved.

Finally, the in-depth discussions of innovation learning domains provide educators with a deep understanding of the skills and competencies practiced in innovation – including where and how in the innovation process and innovation orientations these skills are put to use. The learning constructs and outcomes connected to these domains in turn provide quick and accessible inspiration for curriculum development.

With these frameworks and models, educators can easily build general, holistic programs; specific curricula focused on particular components of the innovation process; or simply introduce innovation learning into existing programming. Thus, little stands in the way of innovation education.

Definition of Innovation

An innovation is a change that creates new value or improves the delivery or capture of value.

Innovations exist in many forms, from product to social movement; at many scales, from new-to-you to new-to-the-world; and in many degrees, from radical to incremental. The success of one innovation often requires the success of others in parallel.

Innovation often results in new knowledge, relationships, and spin-off innovations.

The Innovation Environment

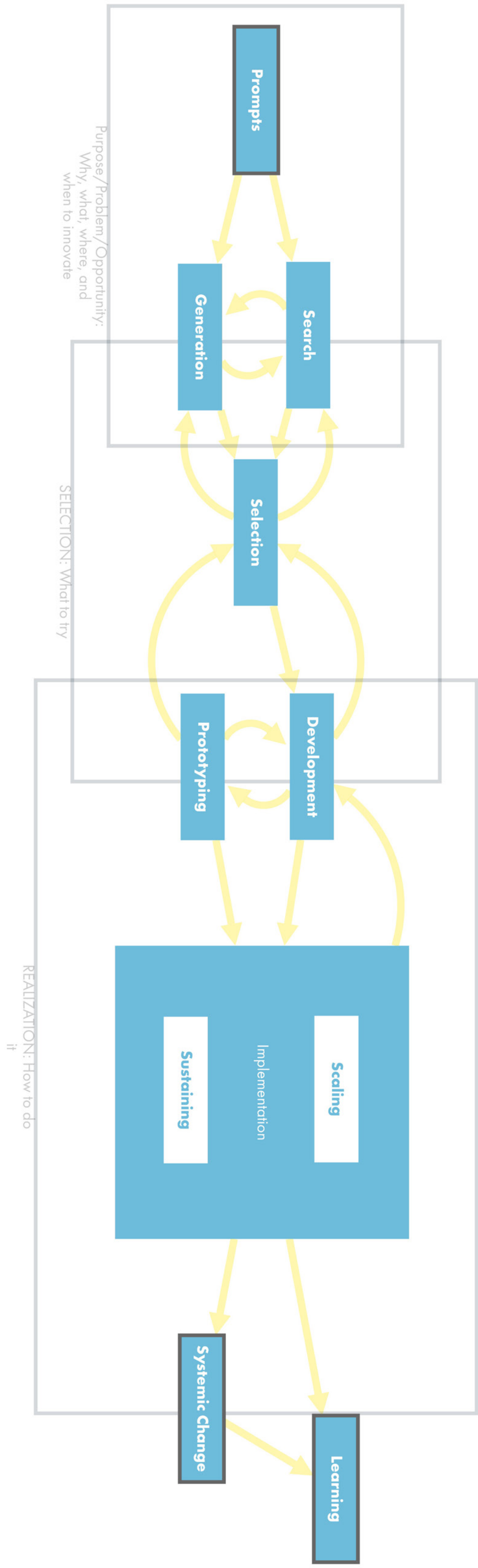
The review of innovation perspectives also unearthed three environmental conditions that contribute to success in innovation. Networks and relationships, openness and trust in those networks and relationships, and readily available financial, knowledge, and human capital are each important aspects of the innovation environment.

The Innovation Process

I consolidated the steps and phases of innovation I observed across perspectives and orientations into a universal model of the innovation process. This process is not drastically different from those previously defined in the literature. Crucially, however, it is universal: it can be followed regardless of the orientation an innovator has adopted. Moreover, this model provides an explicit basis with which to explore the skills and competencies practiced by innovators throughout the process.

The process is non-linear and cyclical: an innovator who runs into trouble at one stage will often need to double-back in order to continue the process at an earlier stage. It is also fractal. The success of one innovation often requires the dovetailing success of others, and thus the innovator will actually end up pursuing parallel innovation processes for different interlocking innovations simultaneously.

The innovation process consists of nine stages across three overlapping phases. The phases are purpose, problem, and/or opportunity realization: why, what, where, and when to innovate, selection: what to try, and implementation: how to do it. In the purpose, problem, and/or opportunity realization phase, an innovator experiences or finds Prompts, in which they identify a purpose to innovate (e.g., a problem to solve); they Search for existing ideas and inventions to innovate with; and they Generate new ideas. Search and Generate are also a component of the selection phase, where innovators Select which innovations to pursue throughout the rest of the process. They then Develop and Prototype these innovations. Finally, Development and Prototyping overlap with the realization phase, in which the innovator finds ways to Scale and Sustain their innovations in the real world. Implementation can potentially lead to Systemic Change and Learning, the final two stages of the process.


Purpose/Problem/Opportunity:
Why, what, where, and
when to innovate
Prompts
Generation
Search
SELECTION: What to try
Selection
Prototyping
Development
REALIZATION: How to do
it
Implementation
Scaling
Sustaining
Systemic Change
Learning

Innovation Orientations

Conversations about innovation often take place in disparate silos based on at least three orientations: Technology & Science, Social & Sustainability, and Commercial & Entrepreneurial. These orientations are rooted in the same processes and skills, but emphasize different components in the interest of achieving different outputs. Nonetheless, many approaches to innovation policy either conflate them or separate them entirely. This disorganization has grim potential: if policymakers fail to see these orientations and the holistic ways in which they intersect, or if they are too myopic and focus only on one (and its outputs), they might fail to see root-cause problems and high-leverage interventions deeply embedded in our innovation systems.

For instance, innovation policy focused only on improving our technological outputs may seek solutions in patent reform and R&D activity. Likewise, policymakers preoccupied with entrepreneurial innovation may only focus on the investment environment. Both of these approaches, however, will miss policy shifts that can help more people be inventive and entrepreneurial. These approaches to improving innovation also risk ignoring the issues of inclusivity and sustainability. Instead, I advocate for a holistic approach, recognizing the shared foundation on which these orientations to innovation are built.

Innovation Learning Domains

Thirteen different domains of innovation skills and competencies were identified:

- literacies and domain expertise;
- collaboration, communication, and network building;
- design;
- foresight and scanning;
- vision and purpose;
- initiative and learning;
- ethics and responsibility;
- adaptability and resilience;
- risk and uncertainty;
- empathy;
- management;
- business and financial acumen; and
- R&D.

These domains form a holistic model for innovation education, with literacies and domain expertise at the core. For the remaining twelve domains, I used data, coded from the literature review, in a conceptual mapping and synthesis process to identify learning constructs. With reference to instructional design frameworks, these constructs were further broken down into 223 pragmatic learning outcomes for innovation education. These outcomes provide both a set of curricular goals for innovation learners and a framework with which an educator may build teaching and learning activities and methods of assessment.

This model of innovation learning has been interactively visualized at https://kumu.io/systemicdesign/innovation-learning-model. There, the reader can explore these concepts at their leisure, using on-screen controls to filter and showcase different components of the model in order to understand how these domains relate to and intersect with the innovation process. Below, the domains are explained in more detail and the learning constructs and outcomes of each domain are outlined in full.

Literacies and domain expertise

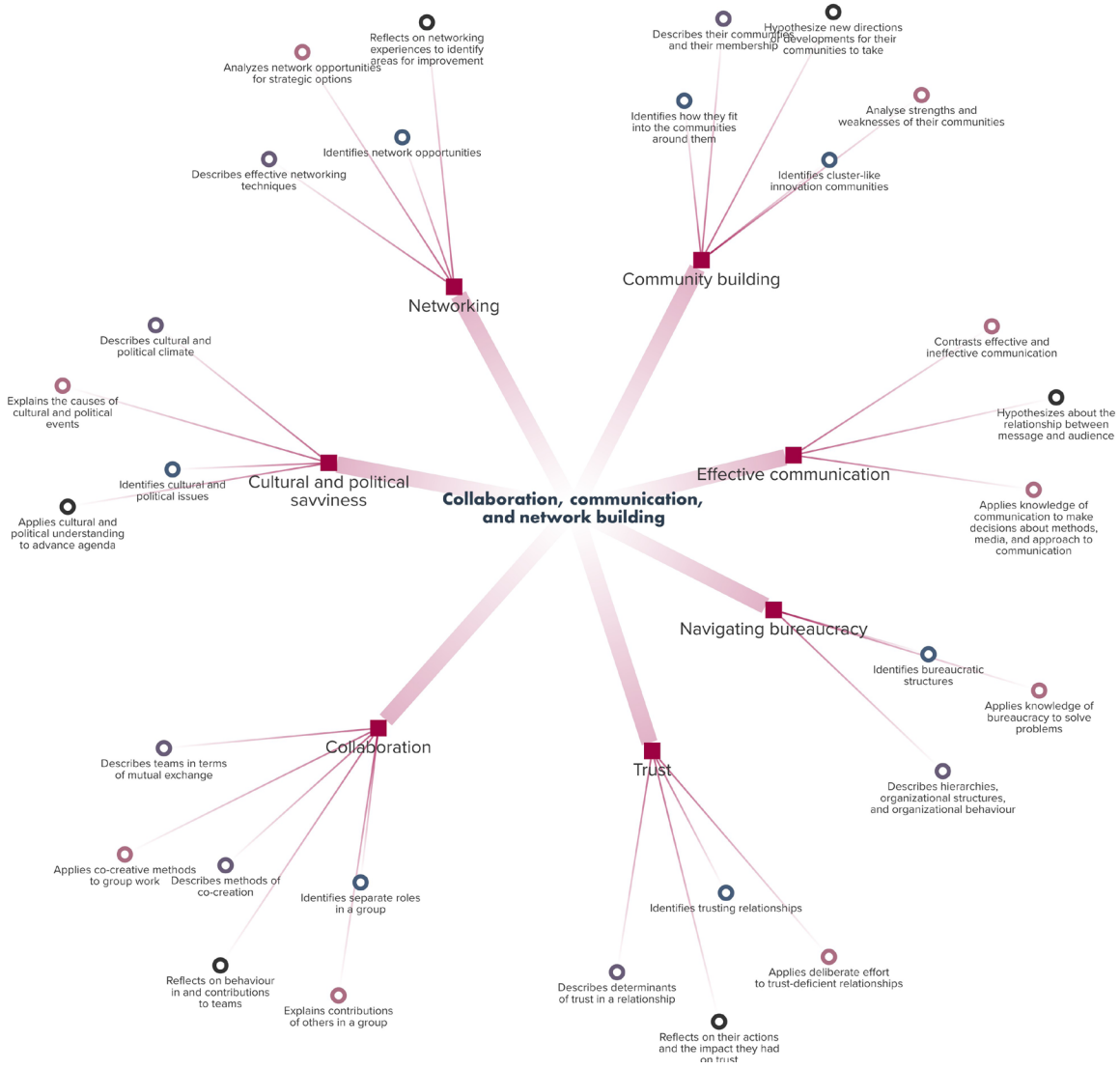
This domain is the most basic. It captures the core competencies necessary to develop and use the other 12 domains – from basic reading and writing to academic skills to digital literacies. It also encompasses knowledge and ability appropriate to the context, signifying the importance of expertise in any given innovation arena. Concrete learning constructs and outcomes are not defined for this domain as these details are both too general and too specific to be easily used in the development of programs and curricula.

Collaboration, communication, and network building

Many of the steps of the innovation process involve working with others, presenting and sharing ideas, and building and maintaining relationships across disciplines, cultures, and challenges. These capacities are collapsed into the Collaboration, communication, and network building learning domain, essential throughout the innovation process and in all of the innovation orientations.

Collaboration

- Identifies separate roles in a group (Unistructural)
- Describes methods of co-creation (Multistructural)
- Describes teams in terms of mutual exchange (Multistructural)
- Applies co-creative methods to group work (Relational)
- Explains contributions of others in a group (Relational)



- Reflects on behaviour in and contributions to teams (Extended abstract)

Trust

- Identifies trusting relationships (Unistructural)
- Describes determinants of trust in a relationship (Multistructural)
- Applies deliberate effort to trust-deficient relationships (Relational)
- Reflects on their actions and the impact they had on trust (Extended abstract)

Navigating bureaucracy

- Identifies bureaucratic structures (Unistructural)
- Describes hierarchies, organizational structures, and organizational behaviour (Multistructural)
- Applies knowledge of bureaucracy to solve problems (Relational)

Effective communication

- Applies knowledge of communication to make decisions about methods, media, and approach to communication (Relational)
- Contrasts effective and ineffective communication (Relational)
- Hypothesizes about the relationship between message and audience (Extended abstract)

Cultural and political savviness

- Identifies cultural and political issues (Unistructural)
- Describes cultural and political climate (Multistructural)
- Explains the causes of cultural and political events (Relational)
- Applies cultural and political understanding to advance agenda (Extended abstract)

Community building

- Identifies how they fit into the communities around them (Unistructural)
- Identifies cluster-like innovation communities (Unistructural)
- Describes their communities and their membership (Multistructural)
- Analyse strengths and weaknesses of their communities (Relational)
- Hypothesize new directions or developments for their communities to take (Extended abstract)

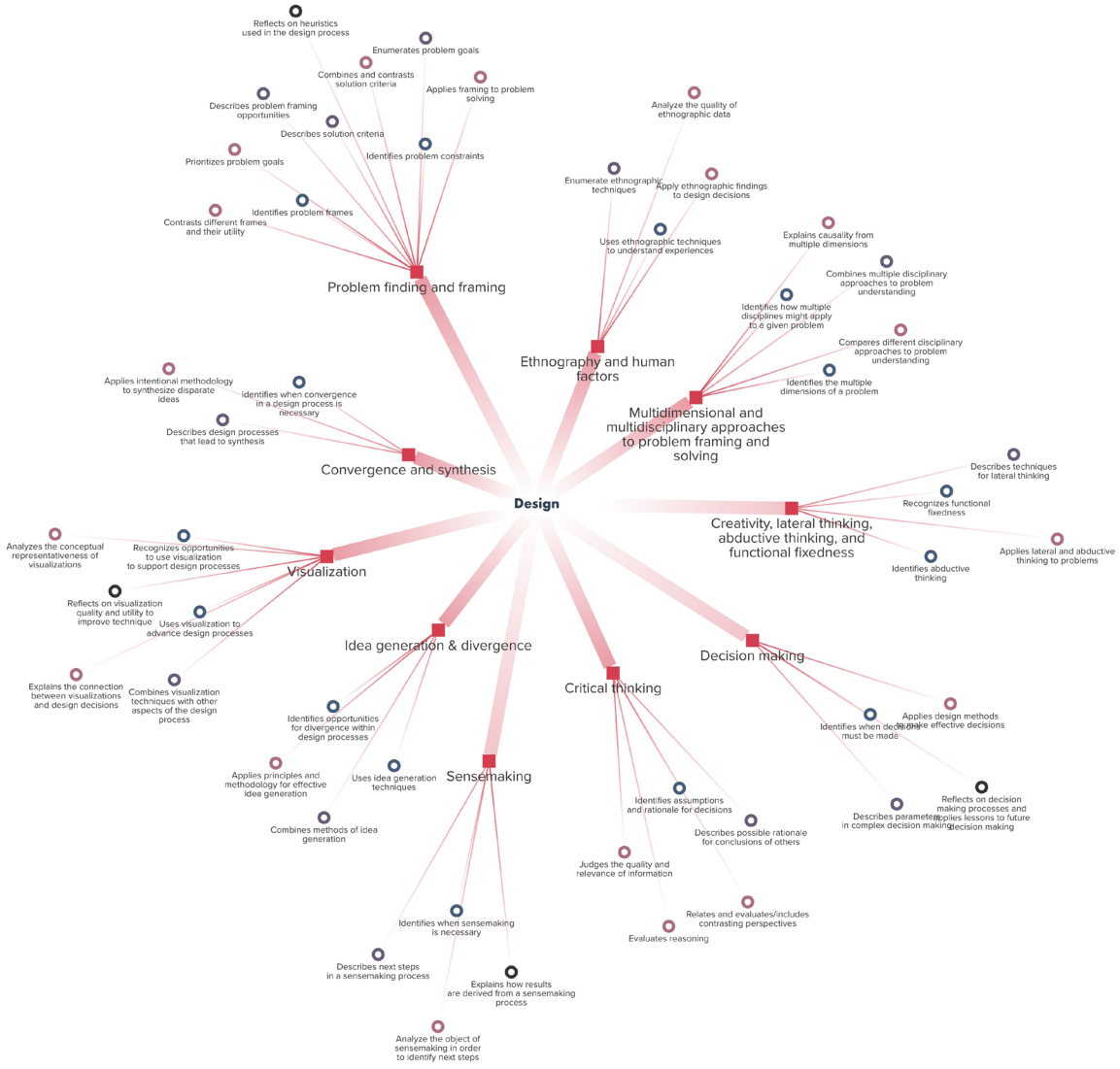
Networking

- Identifies network opportunities (Unistructural)
- Describes effective networking techniques (Multistructural)
- Analyzes network opportunities for strategic options (Relational)
- Reflects on networking experiences to identify areas for improvement (Extended abstract)

Design

Design is the discipline of decision making. In the use of design, the innovator leverages abilities that help make sense of the complex, abstract, and uncertain. This means employing multiple disciplines and perspectives in order to make sense of the problem, generating divergent possibilities in problem frames and in solutions, and converging on the best option of these creative choices for the context.

Design is used across all innovation process steps and orientations, but is perhaps most effective in the cycles of the Problem/Purpose phase as opportunities are connected to the potential for innovation and as the innovation itself is conceptualized.



Ethnography and human factors

- Uses ethnographic techniques to understand experiences (Unistructural)
- Enumerate ethnographic techniques (Multistructural)
- Analyze the quality of ethnographic data (Relational)
- Apply ethnographic findings to design decisions (Relational)

Problem finding and framing

- Identifies problem constraints (Unistructural)
- Identifies problem frames (Unistructural)
- Enumerates problem goals (Multistructural)
- Describes solution criteria (Multistructural)
- Describes problem framing opportunities (Multistructural)
- Contrasts different frames and their utility (Relational)
- Applies framing to problem solving (Relational)
- Prioritizes problem goals (Relational)
- Combines and contrasts solution criteria (Relational)
- Reflects on heuristics used in the design process (Extended abstract)

Sensemaking

- Identifies when sensemaking is necessary (Unistructural)
- Describes next steps in a sensemaking process (Multistructural)
- Analyze the object of sensemaking in order to identify next steps (Relational)
- Explains how results are derived from a sensemaking process (Extended abstract)

Convergence and synthesis

- Identifies when convergence in a design process is necessary (Unistructural)
- Describes design processes that lead to synthesis (Multistructural)
- Applies intentional methodology to synthesize disparate ideas (Relational)

Visualization

- Recognizes opportunities to use visualization to support design processes (Unistructural)
- Uses visualization to advance design processes (Unistructural)
- Combines visualization techniques with other aspects of the design process (Multistructural)
- Analyzes the conceptual representativeness of visualizations (Relational)
- Explains the connection between visualizations and design decisions (Relational)
- Reflects on visualization quality and utility to improve technique (Extended abstract)

Idea generation and divergence

- Uses idea generation techniques (Unistructural)
- Identifies opportunities for divergence within design processes (Unistructural)
- Combines methods of idea generation (Multistructural)
- Applies principles and methodology for effective idea generation (Relational)

Decision making

- Identifies when decisions must be made (Unistructural)
- Describes parameters in complex decision making (Multistructural)

- Applies design methods to make effective decisions (Relational)
- Reflects on decision making processes and applies lessons to future decision making (Extended abstract)

Multidimensional and multidisciplinary approaches to problem framing and solving

- Identifies the multiple dimensions of a problem (Unistructural)
- Identifies how multiple disciplines might apply to a given problem (Unistructural)
- Combines multiple disciplinary approaches to problem understanding (Multistructural)
- Explains causality from multiple dimensions (Relational)
- Compares different disciplinary approaches to problem understanding (Relational)

Critical thinking

- Identifies assumptions and rationale for decisions (Unistructural)
- Describes possible rationale for conclusions of others (Multistructural)
- Judges the quality and relevance of information (Relational)
- Relates and evaluates/includes contrasting perspectives (Relational)
- Evaluates reasoning (Relational)

Creativity, lateral thinking, abductive thinking, and functional fixedness

- Recognizes functional fixedness (Unistructural)
- Identifies abductive thinking (Unistructural)
- Describes techniques for lateral thinking (Multistructural)
- Applies lateral and abductive thinking to problems (Relational)

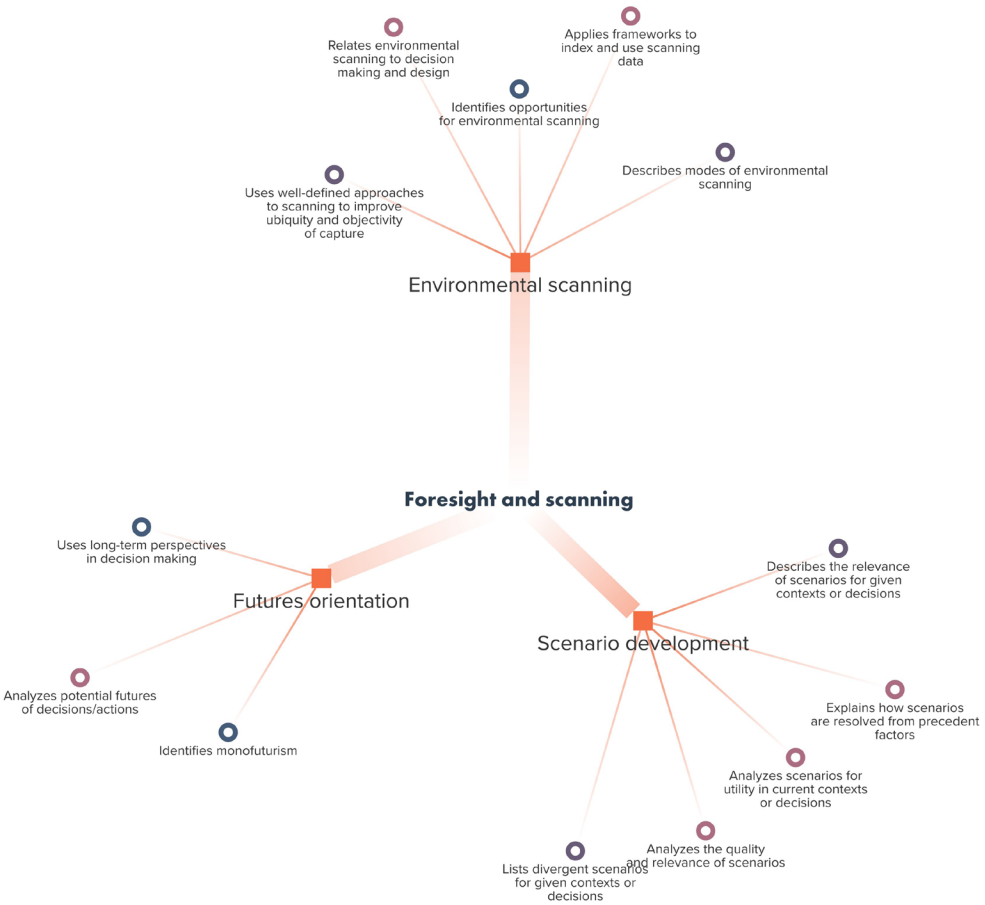
Foresight and scanning

Futures thinking involves recognizing the ingredients of the future found in the present. Through identifying these signals, trends, and drivers of change, we can describe the potential futures ahead of us, incorporating these scenarios into strategy and planning.

While Foresight and scanning skills are useful across orientations, they are most emphasized by the front- and back-ends of the innovation process. At the front-end, embarking on the innovation process means attempting to solve a need, cause, or problem. Foresight skills help the innovator identify important outputs with these in mind. Likewise, the use of futures thinking and scanning helps the innovator to determine proto-innovations with the greatest potential and the smallest barriers to implementation in the Prompts, Search, and Selection steps. At the back-end of the innovation process, Foresight and scanning skills to anticipate the systemic change that will come from the innovation's impact.

Futures orientation

- Identifies monofuturism (Unistructural)
- Uses long-term perspectives in decision making (Unistructural)
- Analyzes potential futures of decisions/ actions (Relational)



Environmental scanning

- Identifies opportunities for environmental scanning (Unistructural)
- Describes modes of environmental scanning (Multistructural)
- Uses well-defined approaches to scanning to improve ubiquity and objectivity of capture (Multistructural)
- Applies frameworks to index and use scanning data (Relational)
- Relates environmental scanning to decision making and design (Relational)

Scenario development

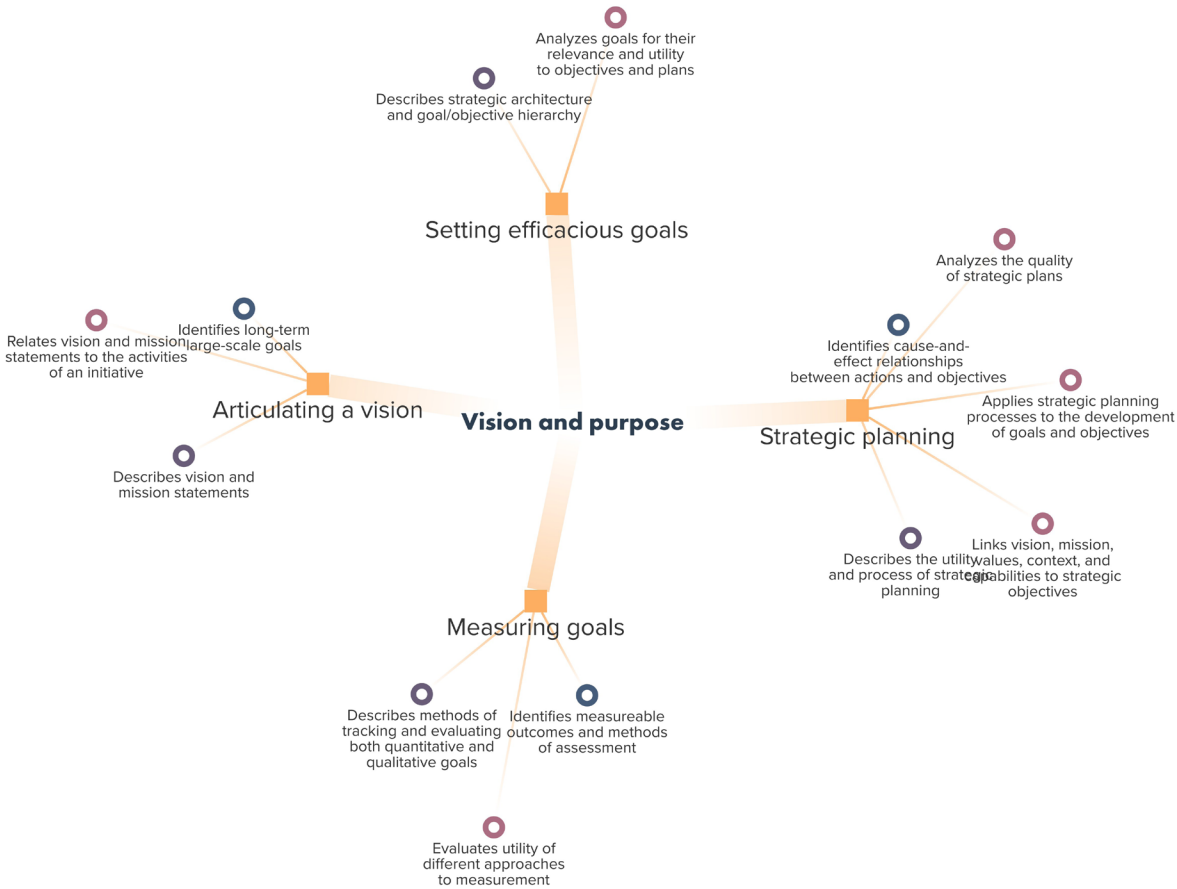
- Lists divergent scenarios for given contexts or decisions (Multistructural
- Describes the relevance of scenarios for given contexts or decisions (Multistructural)
- Explains how scenarios are resolved from precedent factors (Relational)
- Analyzes scenarios for utility in current contexts or decisions (Relational)
- Analyzes the quality and relevance of scenarios (Relational)

Vision and purpose

The Vision and purpose domain includes strategic thinking and long-term visioning. Developing the abilities of this domain will help an innovator recognize and articulate their long-term goals in meaningful, useful ways.

The Vision and purpose domain is most emphasized in the Social and Sustainability and Technology and Science orientations, through their focus on solving particular problems or advancing specific initiatives. Commercialization and Entrepreneurship-oriented innovators are still liable to use vision and purpose, however–but key to success in many business endeavours is the ability to pivot, leveraging existing resources and competencies in new, more valuable ways.

Likewise, Vision and Purpose skills and competencies is best used in the earliest step of the innovation process: Prompts. Developing a well-defined concept of the purpose of the innovation is key to success in later stages. Vision and Purpose skills are also heavily used in the Selection step as the innovator chooses among alternatives, evaluating each choice's later impact on the overall goal. Finally, the Systemic Change step involves Vision and Purpose as the innovator attempts to build (or change) systems around their innovation in order to achieve propagating and emergent impact.



Strategic planning

- Identifies cause-and-effect relationships between actions and objectives (Unistructural)
- Describes the utility and process of strategic planning (Multistructural)
- Links vision, mission, values, context, and capabilities to strategic objectives (Relational)
- Applies strategic planning processes to the development of goals and objectives (Relational)
- Analyzes the quality of strategic plans (Relational)

Setting efficacious goals

- Describes strategic architecture and goal/objective hierarchy (Multistructural)
- Analyzes goals for their relevance and utility to objectives and plans (Relational)

Measuring goals

- Identifies measureable outcomes and methods of assessment (Unistructural)
- Describes methods of tracking and evaluating both quantitative and qualitative goals (Multistructural)
- Evaluates utility of different approaches to measurement (Relational)

Articulating a vision

- Identifies long-term large-scale goals (Unistructural)
- Describes vision and mission statements (Multistructural)
- Relates vision and mission statements to the activities of an initiative (Relational)

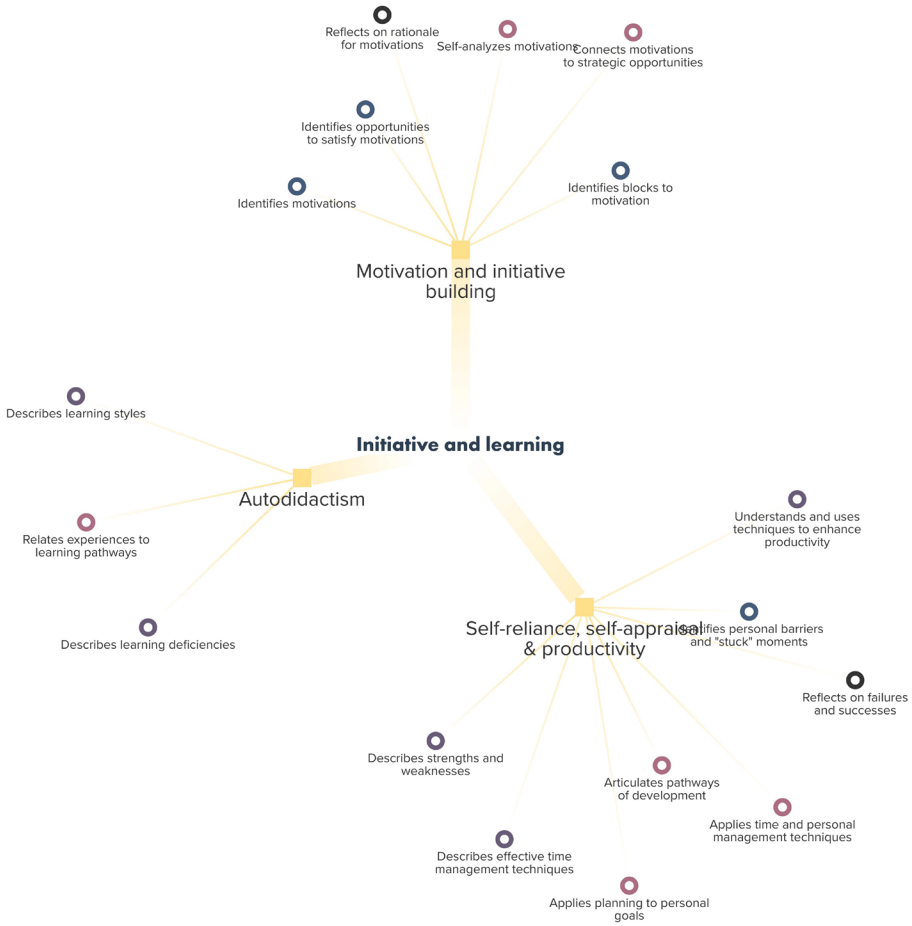
Initiative and learning

Initiative and learning captures the capacity for self-direction. The skills and competencies involved in this domain connect an innovator's desires and goals to their activities, including the ability to evaluate progress and identify gaps and barriers in development toward these aims.

Initiative and learning is an important skill for most innovators and across the innovation process, but it is particularly important in the Social and in the Technology and science orientations. The discovery of innovation Prompts are often self-directed exercises; likewise, Learning from the process and impact of an innovation requires self-direction. These steps are particularly important to these two orientations, hence the focus.

Motivation and initiative building

- Identifies opportunities to satisfy motivations (Unistructural)
- Identifies blocks to motivation (Unistructural)
- Identifies motivations (Unistructural)
- Self-analyzes motivations (Relational)
- Connects motivations to strategic opportunities (Relational)
- Reflects on rationale for motivations (Extended abstract)



Self-reliance, self-appraisal & productivity

- Identifies personal barriers and "stuck" moments (Unistructural)
- Describes strengths and weaknesses (Multistructural)
- Describes effective time management techniques (Multistructural)
- Understands and uses techniques to enhance productivity (Multistructural)
- Applies time and personal management techniques (Relational)
- Articulates pathways of development (Relational)
- Applies planning to personal goals (Relational)
- Reflects on failures and successes (Extended abstract)

Autodidactism

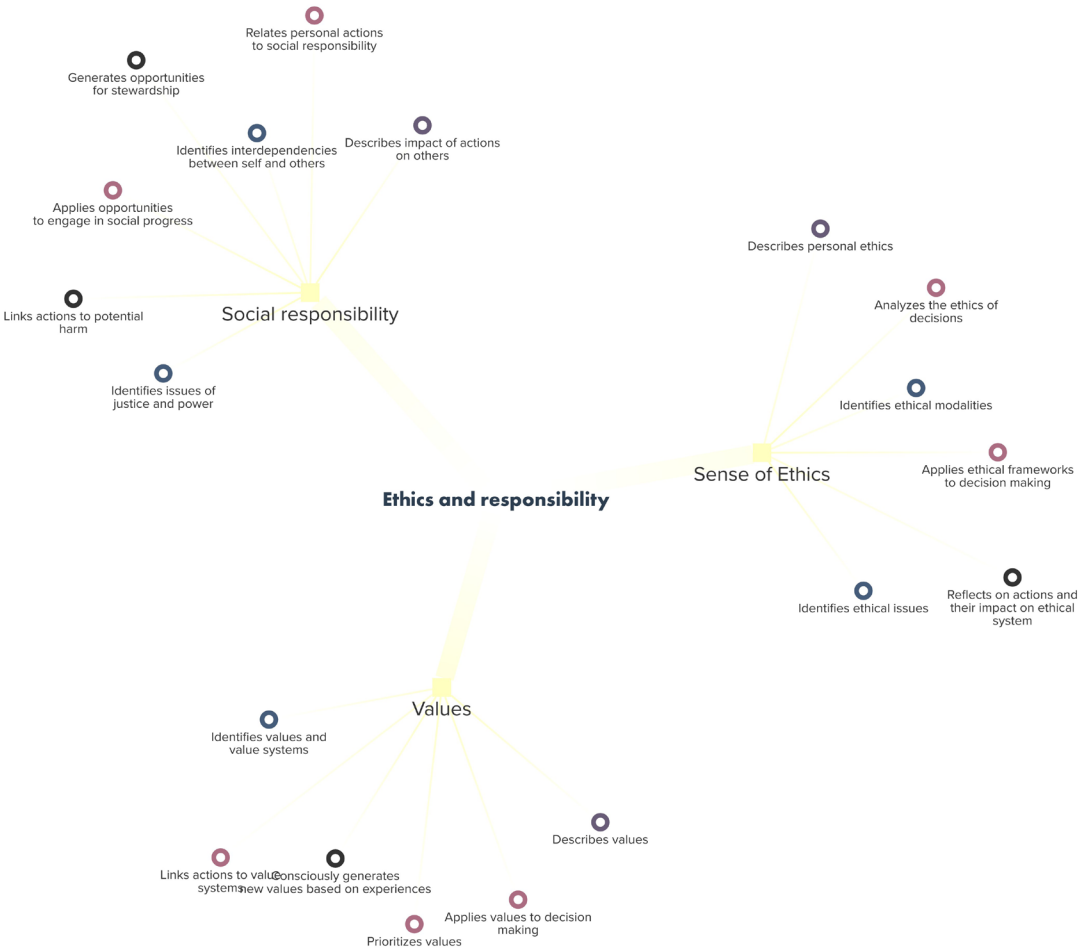
- Describes learning styles (Multistructural)
- Describes learning deficiencies (Multistructural)
- Relates experiences to learning pathways (Relational)

Ethics and responsibility

What are the values and ethics of the innovator? How do they assess their responsibility for the world around them? These questions are answered by the Ethics and responsibility domain, with which the innovator develops their sense of rights, justice, and social responsibility. These competencies include developing and reflecting on the innovator's systems of ethics and values, connecting the innovators' actions to ethics and to consequences.

Ethics and responsibility is a learning domain particularly important to the Social innovation orientation. This is intuitive: an innovation intended to accrue social benefit requires the ability to take responsibility and to have a sense of ethics about the social problem at hand. Though these skills are required for Social innovation, they are important across the orientations: any innovation developed without these skills may have harmful social side-effects.

Ethics and responsibility capacity is particularly important to the Realization stage: as innovations become Scaled and Sustained (and as they begin to have Systemic effects), the knock-on ramifications become scaled and sustained as well. It is at this time that any issues of ethics or responsibility become intractably embedded



within the innovation. For this reason, Ethics and responsibility skills are critical in the Selection step such that the innovator makes responsible decisions about the innovations they choose to scale. Another step in the process relevant to Ethics and responsibility skills is the Prompts step, when it is the innovator's capacity for this domain is likely to attune them to the kinds of causes and problems that act as prompts.

Values

- Identifies values and value systems (Unistructural)
- Describes values (Multistructural)
- Prioritizes values (Relational)
- Applies values to decision making (Relational)
- Links actions to value systems (Relational)
- Consciously generates new values based on experiences (Extended abstract)

Social responsibility

- Identifies issues of justice and power (Unistructural)
- Identifies interdependencies between self and others (Unistructural)
- Describes impact of actions on others (Multistructural)
- Relates personal actions to social responsibility (Relational)
- Applies opportunities to engage in social progress (Relational)
- Links actions to potential harm (Extended abstract)
- Generates opportunities for stewardship (Extended abstract)

Sense of Ethics

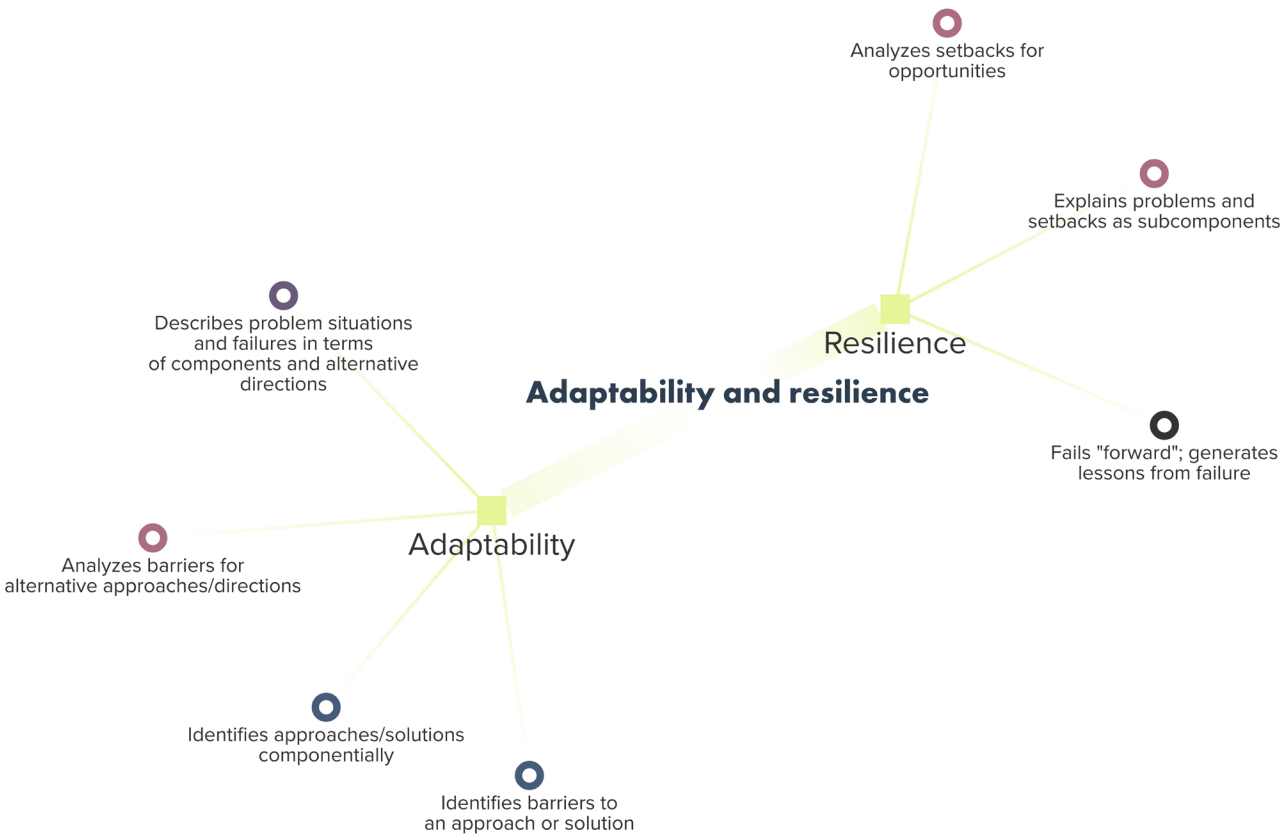
- Identifies ethical modalities (Unistructural)
- Identifies ethical issues (Unistructural)
- Describes personal ethics (Multistructural)
- Applies ethical frameworks to decision making (Relational)
- Analyzes the ethics of decisions (Relational)
- Reflects on actions and their impact on ethical system (Extended abstract)

Adaptability and resilience

The components of Adaptability and resilience define how the innovator deals with challenges as they design, develop, and realize their innovations. One component, Adaptability, captures the innovator's ability to pivot or change their approach in order to succeed. The other, Resilience, examines the innovator's ability to withstand setbacks–and how they internalize these setbacks.

The skills and competencies of Adaptability and resilience are critically important in the Realization phase. This is when unexpected setbacks are most likely to occur throughout the cycles of the Selection, Development, Prototyping, Scaling, and Sustaining steps. Realization (and getting set back) is important to all innovation orientations–thus, so are the skills of Adaptability and resilience.

Likewise, Systemic change requires extensive Adaptability and resilience capacity–systemic change is complex and arduous, emerging in unpredictable (and often slow) ways.



Adaptability

- Identifies approaches/solutions componentially (Unistructural)
- Identifies barriers to an approach or solution (Unistructural)
- Describes problem situations and failures in terms of components and alternative directions (Multistructural)
- Analyzes barriers for alternative approaches/directions (Relational)

Resilience

- Explains problems and setbacks as subcomponents (Relational)
- Analyzes setbacks for opportunities (Relational)
- Fails "forward"; generates lessons from failure (Extended abstract)

Risk and uncertainty

Innovation is an uncertain process. Decisions, actions, and environment often have uncertain outcomes on outputs, on the innovation process, and on the innovator themselves. Risk and uncertainty defines how the innovator approaches the risks of innovation. How the innovator understands these risks, assesses their probability, and acts regardless is defined by the skills and competencies of this domain.

The ability of the innovator to grapple with Risk and uncertainty is most important in the Selection, Prototyping, Implementation, and Systemic Change steps of the innovation process.

The orientations that most depend on this capacity, however, are Social and Sustainability and Commercial and Entrepreneurial. The experimental, methodological approaches often used in Technology & Science innovation encapsulate the uncertainty of the process by default.

Risk assessment

- Identifies issues of risk (Unistructural)
- Assesses and describes risks associated with given actions or circumstances (Relational)
- Analyzes risks for their potentiality and consequence (Relational)

Risk taking

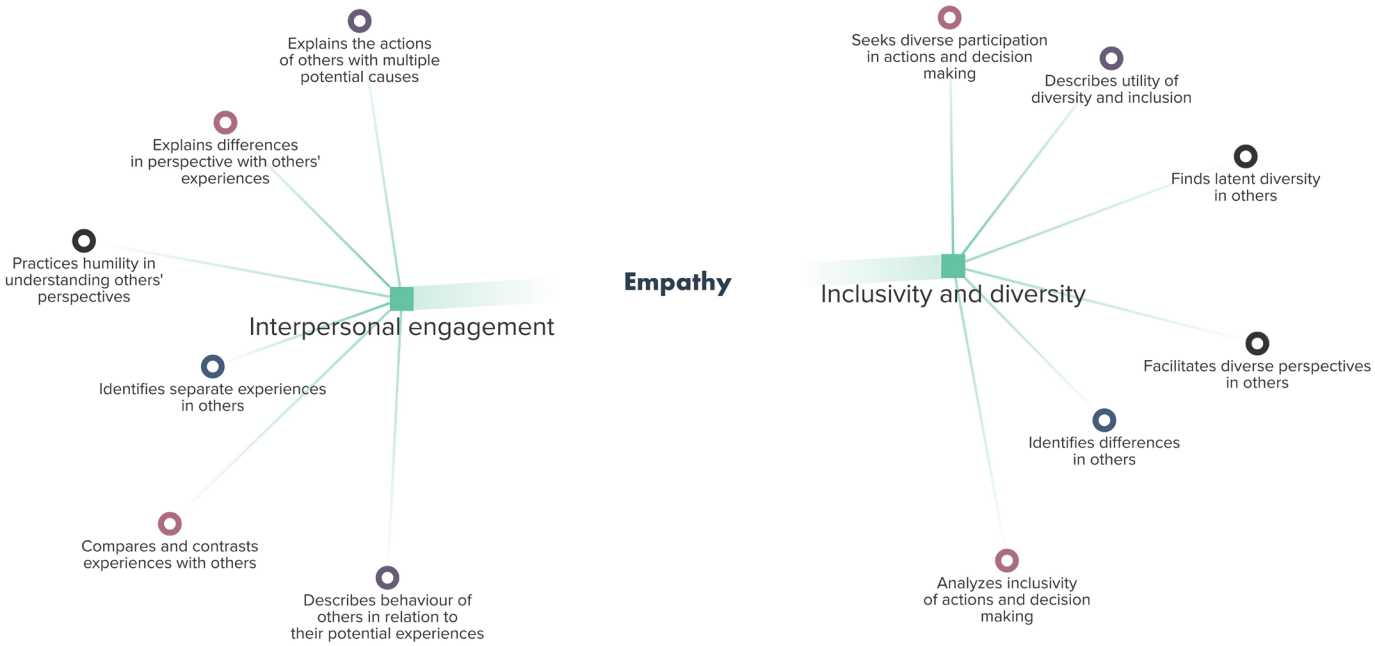
- Identifies alternative options in the face of uncertainty (Unistructural)
- Compares different approaches to a risky situation to evaluate the best strategy (Relational)
- Balances caution and a bias towards action in the face of uncertainty (Relational)
- Analyzes opportunities for learning from prototypical action before taking action (Relational)

Empathy

The ability to relate with and understand other people is requisite for many activities of innovation. This ability is captured by the Empathy innovation learning domain. The constructs and outcomes of this domain define how an innovator perceives and understands the similarities and differences between themselves and others, and how these differences might manifest in different experiences and perspectives.

Empathy is emphasized by two of the orientations in different ways. Social & Sustainability innovators must empathize with the stakeholders they aim to serve in order to understand their problems and values. With their perspectives, the outputs of innovation are more likely to be real solutions with minimal side effects on the oft vulnerable and volatile stakeholders. Commercial & Entrepreneurial innovators use empathy to understand their markets, the problems those markets have, and the value of solving those problems.

The skills and competencies of Empathy are used in the Purpose/Problem phase. During the Prompts step, an innovator's empathetic ability allows them to perceive opportunity through the eyes of others. During Search and Generation, an empathetic innovator is better able to build revolutionary ideas through engaging the diversity of those they are working with. Empathy also becomes useful in the Prototyping step, helping the innovator to understand how the tests of their ideas engage with the world. Finally, the domain of Empathy is necessary for Systemic Change and for Learning. In the former case, successful systemic change is often



predicated on the ability to get diverse systems to concur with the innovation at hand. In the latter case, the innovator must empathize with the process, everyone involved, those influenced by the outputs, and even themselves in order to fully learn and adapt their innovative ability to future applications.

Inclusivity and diversity

- Identifies differences in others (Unistructural)
- Describes utility of diversity and inclusion (Multistructural)
- Seeks diverse participation in actions and decision making (Relational)
- Analyzes inclusivity of actions and decision making (Relational)
- Facilitates diverse perspectives in others (Extended abstract)
- Finds latent diversity in others (Extended abstract)

Interpersonal engagement

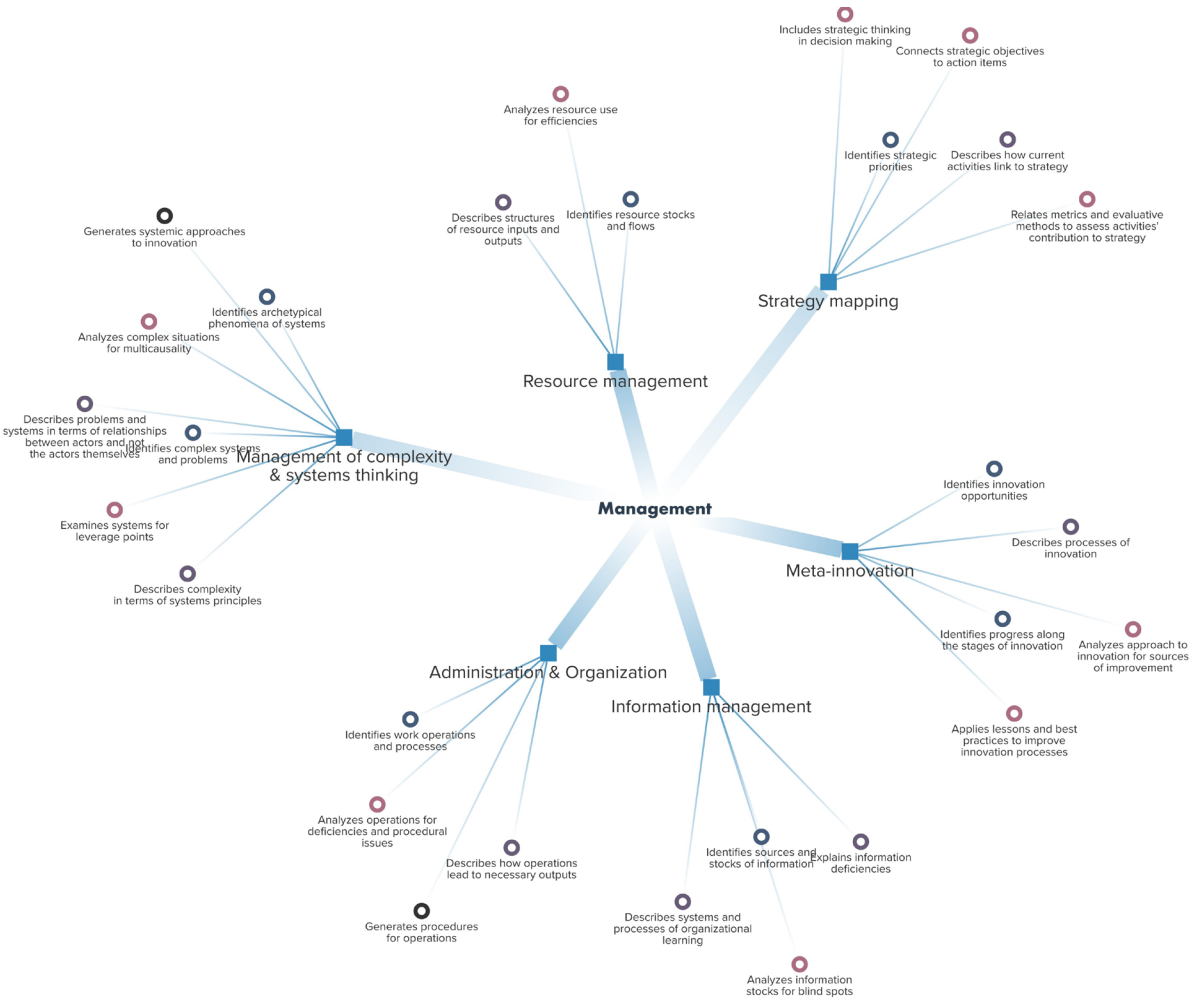
- Identifies separate experiences in others (Unistructural)
- Describes behaviour of others in relation to their potential experiences (Multistructural)
- Explains the actions of others with multiple potential causes (Multistructural)
- Explains differences in perspective with others' experiences (Relational)
- Compares and contrasts experiences with others (Relational)
- Practices humility in understanding others' perspectives (Extended abstract)

Management

Organized planning and action involve intensive Management capacity. The constructs and outcomes of this learning domain include how an innovator relates process to output. This allows them to execute on strategy, deal with complexity, develop efficient workflows, and maintain their information and resources. The capacity to manage is therefore an influential ability, critical to every step in the innovation process save Prompts and Generation and important to each of the innovation orientations.

Management of complexity & systems thinking

- Identifies complex systems and problems (Unistructural)
- Identifies archetypical phenomena of systems (Unistructural)
- Describes problems and systems in terms of relationships between actors and not the actors themselves (Multistructural)
- Describes complexity in terms of systems principles (Multistructural)
- Analyzes complex situations for multicausality (Relational)
- Examines systems for leverage points (Relational)



- Generates systemic approaches to innovation (Extended abstract)

Administration & Organization

- Identifies work operations and processes (Unistructural)
- Describes how operations lead to necessary outputs (Multistructural)
- Analyzes operations for deficiencies and procedural issues (Relational)
- Generates procedures for operations (Extended abstract)

Strategy mapping

- Identifies strategic priorities (Unistructural)
- Describes how current activities link to strategy (Multistructural)
- Relates metrics and evaluative methods to assess activities' contribution to strategy (Relational)
- Includes strategic thinking in decision making (Relational)
- Connects strategic objectives to action items (Relational)

Information management

- Identifies sources and stocks of information (Unistructural)
- Describes systems and processes of organizational learning (Multistructural)
- Explains information deficiencies (Multistructural)
- Analyzes information stocks for blind spots (Relational)

Meta-innovation

- Identifies innovation opportunities (Unistructural)
- Identifies progress along the stages of innovation (Unistructural)
- Describes processes of innovation (Multistructural)
- Applies lessons and best practices to improve innovation processes (Relational)
- Analyzes approach to innovation for sources of improvement (Relational)

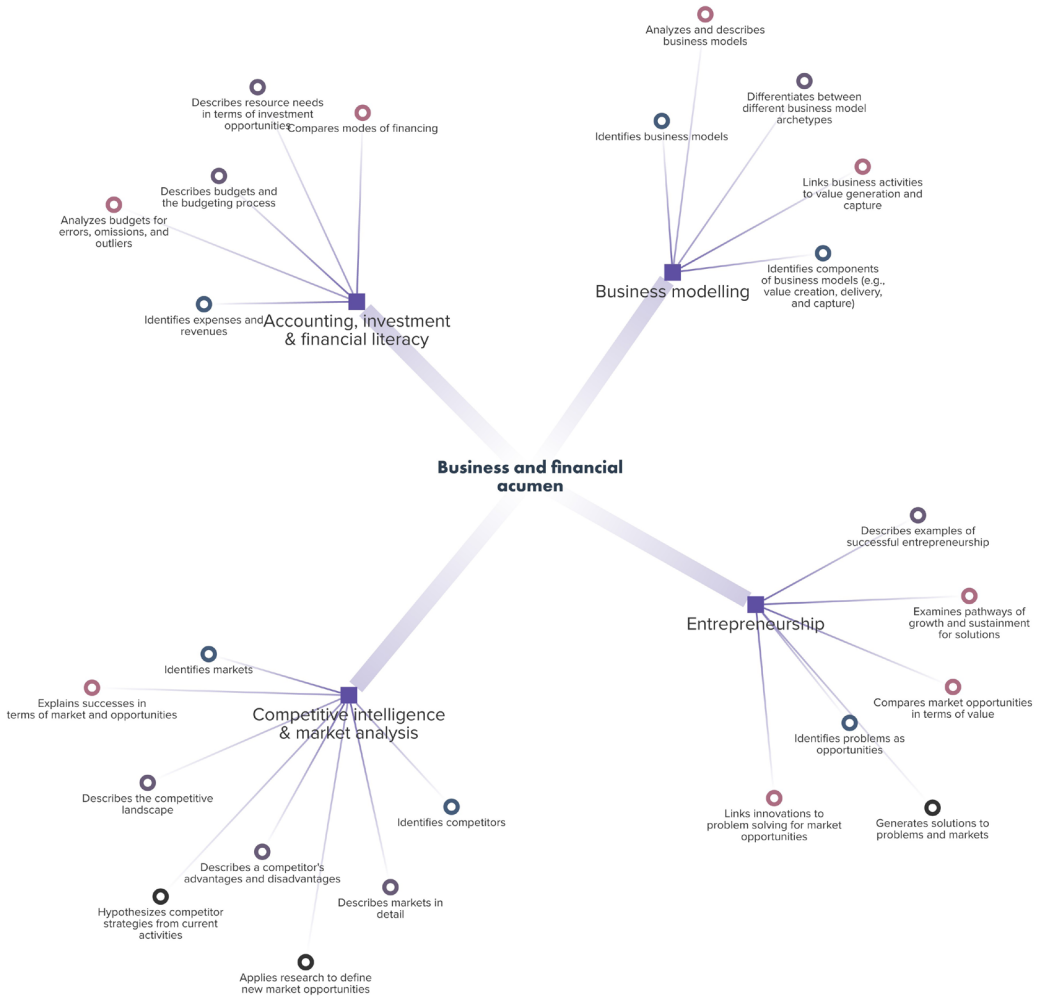
Resource management

- Identifies resource stocks and flows (Unistructural)
- Describes structures of resource inputs and outputs (Multistructural)
- Analyzes resource use for efficiencies (Relational)

Business and financial acumen

What problems does the innovation solve–and for whom? What other solutions exist? How does it create, deliver, or capture value–and use that value to sustain itself? These questions are answered through the skills of the Business and financial acumen domain. With the skills of this domain, the innovator connects innovation to value creation, identifies how this innovation connects with its audience and fits with other "competing" innovations, and understands the costs and revenues associated with its development and implementation.

Perhaps intuitively, this domain is crucial to the Commercial & Entrepreneurial orientation. As well, these skills and competencies are especially crucial to the Selection, Development, and Implementation process steps. Through these steps, Business and financial acumen skills and competencies are used to align the outputs of innovation with market needs, build financial sustainability, and grow the innovation's exposure to customers and stakeholders.



Entrepreneurship

- Identifies problems as opportunities (Unistructural)
- Describes examples of successful entrepreneurship (Multistructural)
- Links innovations to problem solving for market opportunities (Relational)
- Examines pathways of growth and sustainment for solutions (Relational)
- Compares market opportunities in terms of value (Relational)
- Generates solutions to problems and markets (Extended abstract)

Competitive intelligence & market analysis

- Identifies markets (Unistructural)
- Identifies competitors (Unistructural)
- Describes markets in detail (Multistructural)
- Describes the competitive landscape (Multistructural)
- Describes a competitor's advantages and disadvantages (Multistructural)
- Explains successes in terms of market and opportunities (Relational)
- Applies research to define new market opportunities (Extended abstract)
- Hypothesizes competitor strategies from current activities (Extended abstract)

Business modelling

- Identifies business models (Unistructural)
- Identifies components of business models (e.g., value creation, delivery, and capture) (Unistructural)
- Differentiates between different business model archetypes (Multistructural)
- Links business activities to value generation and capture (Relational)
- Analyzes and describes business models (Relational)

Accounting, investment & financial literacy

- Identifies expenses and revenues (Unistructural)
- Describes budgets and the budgeting process (Multistructural)
- Describes resource needs in terms of investment opportunities (Multistructural)
- Analyzes budgets for errors, omissions, and outliers (Relational)
- Compares modes of financing (Relational)

R&D

Advancing through the innovation process–particularly in the Selection and Realization phases–often requires solving specific problems through investigation and experimentation. The R&D (research and development) domain identifies the skills used in these inquiries. Does a solution to the challenge at hand already exist? What data is needed to answer the question? How might that data be obtained–and in what fidelity? An innovator experienced in R&D will be able to answer these questions easily.

The Search step depends on R&D skills and competencies in the seeking out and evaluation of potential answers to whatever call started the innovation process. Later in the process, Development and Implementation use the R&D domain to overcome limitations and obstacles as the innovation is realized. Finally, the Learning step depends on this domain in order to analyze, comprehend, and crystallize lessons learned from the innovation process and outputs.

Both Technology & Science- and Commercial & Entrepreneurial-oriented innovators would suffer without the domain of R&D. These capacities are crucial to the methodologies of the former and the intellectual property development of the latter.

Research & development

- Identifies opportunities for problem solving through research and development (Unistructural)
- Describes experimental procedures and prototyping (Multistructural)
- Examines existing technology and approaches in problem solving (Relational)
- Evaluates the quality of data and research (Relational)
- Combines concepts in developing solutions (Relational)

Resources

- Futura PT: Headings, blockquote
- PT Serif: Headings, body text
- Arcly: Title

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